Digital Mode Primer

By Tom Smerk, AA6TS

You may have heard someone talking about using “digital” modes on their ham radio but wasn’t sure what they meant by that. You are not alone! Digital mode are a mystery to many until they explore the options and begin using digital modes themselves. What makes things even more confusing is that there is not just one description of “What does digital mean?” Digital communications is a term that covers a variety of activities. While these various activities are related in certain ways, they are also different from one another in other ways.

While there are more uses of digital communications than these, the following list covers some of the basic, most useful and most popular digital activities:

- Packet
- RTTY
- Winlink Email
- “Soundcard” modes
- Digital voice
- APRS

Let’s take a look at each of these to see the purpose of each and also what you would need to do to set this up on your radio and computer.

Packet: Packet is a method to transfer data across radio waves, similar to how you might transfer data from computer to computer. If you send a file on a computer, the computer “digitizes” the file (converts it to binary form – a series of “0’s” and “1’s.”), and in most cases encrypts it to a degree. The file, once converted, is sent in binary form from the sending computer to the receiving computer. To accomplish this, the computer must have a device called a *modem*, which is a combination of the two words *modulate* and *demodulate*. When you send a file on ham radio using packet, everything happens in the same way. The modem used by a ham radio is usually referred to as a TNC (Terminal Node Controller), or loosely called a *packet modem* by most hams that use one. To accomplish this on either a computer or a radio, you need, in addition to the modem, a software program running on your computer called *file transfer* software (also known by many other names, the most popular of which is *terminal software* or *terminal emulation* software.

There are several good software choices, depending on what you want to accomplish. The older and original program we used was Microsoft Windows *Hyper-Terminal*. This used to be a free program included with older versions of Windows, but now was removed from Windows and is commercial software. There are other free terminal programs available, and you can download and install a few of these until you find one that works suitably with your computer and TNC and is easy for you to use. Using a terminal program requires you to learn a long list of commands because there is no

graphic interface, just a command prompt. My manual for the TNC I use included a list of all the commands, and I have also seen these command lists available online.

A simpler approach to packet, and one that is very popular, is to use the *Winlink* system for email exchange. *(See "Winlink Email" below for more information.)*

If you wold like to get started using packet, you will need to purchase a TNC. Some of the more popular TNC's available are from Kantronics, Timewave, Farallon and MFJ. A company called AEA used to also make some good units. They were absorbed by Timewave, and some of the current Timewave models are similar to the older AEA. The MFJ TNC currently available only uses a generic mode called *KISS*. While this should work well for you, it lacks some of the features available in the Kantronics and Timewave TNCs. The 1200 bps (bits-per-second) are more popular and less expensive while the 9600 bps models are more costly. There are some that fell that 9600 bps is too much to expect from the slower over-the-air speeds of ham radio, but under good conditions, 9600 bps transmissions are possible. If any of you used computer modems in the early days, you probably recognize these terms. If not, don't worry about it, just understand that a 9600 is faster than a 1200!

There are other uses for packet. To learn more, you can either refer to the manual that comes with your packet TNC controller or look at some of the books available on the subject, such as ARRL's *VHF Digital Handbook*. In my ham shack at home, the two digital modes that get used the most are packet email (through Winlink) and HF "soundcard modes." A lot of hams I have discussed digital communications with seem to agree and also use the same setup of a TNC (packet modem) and a *soundcard interface*.

RTTY: RTTY stands for *Radio Teletype*, and was originally a method of exchanging typed messages between two radio teleprinters. There is a small segment of ham radio enthusiasts that own one of these old teleprinters and keep the old methods alive as a historical hobby. Most people that are currently using RTTY will access it as one of the many *digital modes* (see "Soundcard modes" below) that are available from software programs such as *FLDigi* or *Digipan* or one of the many others that are available.

Winlink Email: Winlink 2000, also known as WL2K, is a worldwide system of volunteer sysops, radio stations and network assets supporting e-mail by radio with non-commercial links to internet e-mail. My favorite Winlink client program is a Windows program called *RMS Express* which works with either VHF packet or a HF soundcard interface. It can also work over a *Telnet* connection on a computer connected to the Internet for those times when you prefer to use the Internet rather than your radio to exchange email. Configuration is accomplished from a setup menu, and the rest of what you can do is menu driven – no commands to type! It works very much like your favorite email program. In fact, Winlink can also be configured to use Microsoft Office Outlook or Outlook Express as your Winlink client email program. There are many instruction handouts available online to help you configure and use Winlink email. A good place to start is http://www.winlink.org. From here you can download the software you need, get

training, and download documents to study or to help you configure your setup. An online search will also turn up many other documents from independent hams who have written some excellent tutorials on this popular system.

Since RMS Express will use the Internet as well as a radio to send and receive messages, you could install it and begin learning how all of this works even before you purchase a packet TNC or a soundcard controller, as long as you have an Internet connection. Then later, when you purchase your additional ham radio hardware, you can switch to sending and receiving messages over the radio instead of over the Internet.

Soundcard modes: The reason we use this name for the system of using digital modes over ham radio is because it is possible to encode and decode the digital signals using only the soundcard built into your computer and a software program to make it all happen. There are many instructions and tutorials available online, so I won't go into the details here, but I will explain a little about the process and also make a recommendation of a better way to do this.

As I explained earlier, digital signals that are transmitted and received over ham radio are messages, files or data that has been *digitized*, in other words, converted to a binary system of 0's and 1's (on and off states – 0 is like a switch being off and 1 is like a switch being on). Using the proper software, this can be accomplished by the soundcard in your computer. A digital signal transmitted over a radio sounds like a series of squawks and buzzes. To capture this signal, you place a microphone in front of your radio speaker. The microphone is plugged into your soundcard through your computer's microphone input jack. If you wanted to start simply, you can install a software program such as *FLDigi*, tune your radio to one of the frequencies commonly used for digital transmissions (see your amateur radio bandplan – there are sections at the bottom of most bands authorized for digital transmissions. An online search will also produce documents containing a list of the most popular frequencies.) With the digital sound coming from your radio and the software running, the software will "decode" the signal and print out text on your screen. Many times these are QSO's similar to a voice QSO. The advantage of using digital modes rather than voice is that digital modes have a way of getting the signal through with less power or when band conditions are poor. A digital contact can be made at times when a voice contact is impossible.

If you want a two-way QSO, you will need a way to send your outgoing signal through your transceiver. One way of accomplishing this is to key your radio microphone and hold it next to your computer's speaker when the message is being sent. The microphone will pick up the digital squawks and buzzes coming from your computer speaker and send it out over the radio. If you are careful, you can use this "no cost" method of beginning to use the digital soundcard modes. Sometimes this procedure is referred to as *acoustic coupling*. Many hams have started this way. It is important to have the opportunity to try this before you spend money for a soundcard interface to see if these modes are something that you would like to do with your ham radio set.

A much better way to enjoy the digital *modes* on your HF radio is to use a special product, usually referred to as a *soundcard interface*, to connect your computer to your radio. The dedicated interface contains its own soundcard, which not only makes it less confusing but also allows for easier configuration and takes some of the work away from your computer's soundcard. A very popular example of a soundcard interface used by many hams is the *Tigertronics Signalink USB*. This little box connects to your computer with a USB cable and to your radio using a special cable that is made specifically for the make and model of your radio. The USB cable is included, and the radio connection cable should be purchased along with the Signalink unit. There are controls on the unit to adjust the level of the incoming and outgoing signals. While you want to make sure that enough signal gets through to be heard, you also want to be sure not to send or receive too much signal which would cause distortion and decrease the accuracy of the transmission. In addition to the excellent Signalink product from Tigertronics, there are also some excellent soundcard interfaces available from West Mountain Radio and Timewave.

Once your Signalink or other soundcard interface is installed, you install fldig, Hamscope, Digipan, MixW or whatever software program you choose to use onto your computer and run the software. After investigating what software in this category was popular, I discovered that most hams around the world are using *FLDigi* available from http://w1hkj.com. *FLDigi* allows your software to decode many digital modes that come over your radio, including RTTY, CW and the popular PSK-31. (*See below for more information.)*

FLDigi is part of a suite of soundcard digital software programs called NBEMS (Narrow Band Emergency Messaging Software) which is free open-source software available from http://w1hkj.com. I mention this for two reasons – one is that if you see NBEMS, you will not think that you are in the wrong place, as this is where you will find the FLDigi software; and two, so that you will understand that in addition to FLDigi, you may want to install some of the other software programs from this group that will give you additional features and capabilities. The W1HKJ web site gives good descriptions of each of the available programs and will help you decide what you will need. There are also excellent tutorials available there.

Once the software is installed, you then tune your radio to one of the frequencies set aside for digital transmissions and set the software to match this frequency. You will see a colorful blue band at the bottom of your screen called the *waterfall*. If there are signals being transmitted within this frequency, they will appear on the waterfall as yellow stripes. Clicking your mouse on one of the *stripes* will *fine-tune* your software to match the exact fraction of the frequency. When you set your frequency on your software and radio, it gives you a certain *bandwidth*, and many signals can share this bandwidth – one of the nice features of the digital modes!

There are at least 16 popular digital *modes* and many more less popular modes that are in use. Some of the more popular modes include Amtor, Pactor, G-tor, RTTY, PSK-31, Packet, MT-63, MFSK-16, JT-65, Olivia, Domino and Contesia. It is beyond the scope

of this introductory article to explain these modes, but I will say that each mode has a distinct sound if you were to listen to the digital signal coming from your radio, and sometimes they look a little different when viewed on the waterfall. An experienced user can often hear the sound from the radio and recognize which mode it is! The important thing to remember is that the sender and receiver must have your software set to the same mode. This is accomplished from a drop-down list in the software. Sometimes you might just have to try a few different mode selections from the menu before you discover the correct one to use! By the way, when your soundcard interface is bringing these radio signals up on your software window, you can turn the volume off on your radio as it will not affect the volume of the digital reception because that is being controlled by the soundcard interface. Those squawks and buzzes can quickly get annoying to listen to!

Besides sending text between computers over a radio wave (which is similar to *Instant Messaging* or *chat* on computers since the inception of the Internet), you can also transfer files, photos and other data. These types of file transfer are not as popular as *texting* because of the slower speeds afforded by amateur radio – it take much longer to send a file on the radio than it would over the Internet. The benefit is that ham radio can be used as an alternative to the Internet for email and file transfer at times when the Internet is not available, such as during a disaster.

Digital Voice: There are several digital voice modes available, but the only one that seems to have caught on in the USA is one called *D-Star*, an Icom trademark. In addition to D-Star, Yaesu has a system of sending radio signals through the Internet in a digital format using a system called *Wires*, and there are also some new all-digital Yaesu radios beginning to appear that seem to use a method similar to D-Star. Whether this new digital voice mode catches on is yet to be determined.

The main feature of digital voice is that the voice is sent as a *digital* signal rather than an *analog* signal. Typically, in digital mode there is no degradation of sound quality – it is either “on” or “off,” so when the signal makes it through, it is 100% crystal clear, and if it doesn’t make it through, it sounds like a garbled mess. You may have noticed this effect if your television reception at home is digital. When the TV signal is received, the screen picture is perfect, but under bad conditions, what you see is a frozen, pixelated mess!

The digital signal from the radio is then picked up by a repeater which sends the signal into the Internet where it can travel for great distances until it is received by someone on the other end using a digital radio listening to a digital repeater connected to the Internet. Another way of saying this is that the D-Star repeaters are linked over the Internet. So the advantage of digital voice would be clear voice transmissions over long distances. By clear, I mean no QRM or QRN, no hiss, and no static. Lovely!

Digital voice modes also have the ability to send files, photos, and other information when properly implemented and utilized. The disadvantage of digital voice, such as D-Star, is that the necessary equipment is usually at a higher cost than *standard* AM, FM

or SSB radios. Many hams feel that there is not enough advantage to offset the cost. The jury is still out on D-Star and similar digital modes, but there is a rumor circulating that all of the companies might someday settle on a common protocol for digital voice so that any make of digital radio could talk to any other make. Right now, with some rare exceptions, Icom D-Star can only talk to other Icom D-Star radios, Yaesu to Yaesu, and so on.

APRS: - APRS stands for Automatic Packet Reporting System. Wikipedia defines APRS as "an amateur radio-based system for real time tactical digital communications of information of immediate value in the local area." APRS data is also ingested into the Internet. The most visible example of APRS is *position reporting*. A ham radio station capable of APRS sends out a signal which is picked up by other APRS stations and by the Internet, and the position of the sending station can be pinpointed on a map. This is useful to keep track of vehicles dispatched to an area, and to account for everyone's safety and whereabouts. It can also be used to locate other hams, and track vehicles on the move. To implement this feature, you would need a special transceiver with APRS built in, or you would connect a GPRS device to your radio. APRS is transmit only – not a form of two-way communication. APRS packets are transmitted for all other stations to hear and use. Packet repeaters, called digipeaters, form the backbone of the APRS system, and use store and forward technology to retransmit packets. All stations operate on the same radio channel, and packets move through the network from digipeater to digipeater, propagating outward from their point of origin. All stations within radio range of each digipeater receive the packet. If you have a packet TNC that you use for packet communications (see above), it can most likely also be configured to send and receive APRS data, or in other words, function as a digipeater.

In addition to real-time position reporting capabilities using attached Global Positioning System receivers, APRS is also capable of transmitting a wide variety of data, including weather reports, short text messages, radio direction finding bearings, telemetry data, short e-mail messages (send only) and storm forecasts. Once transmitted, these reports can be combined with a computer and mapping software to show the transmitted data superimposed with great precision upon a map display. Positions of fixed stations are configured in the APRS software. Moving stations (portable or mobile) automatically derive their position information from a GPS receiver connected to the APRS equipment.

Some of the more sophisticated digital radios that have APRS capabilities build in also contain their own computer microprocessor so that many of the options afforded through the use of APRS can be enjoyed without the necessity of always having to be connected to a computer.

In conclusion, what I hope to have accomplished through this article is to illustrate that when hams refer to "digital," it could mean one of many different things. No wonder this term is often confusing and misunderstood! I have attempted to show you the most popular forms of digital communications with the hopes that you might see something interesting that you would like to explore further. The next step would be to read some

of the excellent information available on the Internet, but it is up to you to separate the good from the bad as you research any of these topics. I wish that I could recommend a good book to read, but all of the books that I have been able to check out seem to be "dated" and tend to confuse more than to enlighten. Perhaps the best way to learn more about digital amateur radio is to find a patient "elmer" who will sit with you, demonstrate in their ham shack what is possible and how to do it, and then turn the controls over to you and let you try your hand at it.

If I can help in any way, please feel welcome to email me at aa6ts@arrl.net, and, within reason, I will do all I can to answer your questions and help you get started. Personally, my interest in digital amateur radio came from my involvement in emergency disaster communications. When the Internet is taken down by a disaster, it is necessary to get important information through, and without the Internet, ham radio operators can step in and help by using packet radio and Winlink email. This initial involvement, combined with my interest in "DX" (making long-distance radio contacts) led me to explore the soundcard modes on my HF radio. I've found that I can establish contacts over greater distances using less power than what is possible with SSB voice or even with CW! I previously never got in to "texting," but I must admit there is some fun associated with typing a message on my computer keyboard which goes out over the ham radio, and then shortly, a reply shows up on my screen. Not only that, but seeing the signals appear as yellow lines on the *waterfall* makes it easier to *spot* contacts. I realize that many good HF transceivers have a *band scope* that accomplishes the same thing, but mine is not one of them!

Good luck, and I will look forward to having a digital contact with you someday soon, either on HF soundcard modes or on packet Winlink email! (By the way, to address a Winlink email message, you just send it to the recipient's callsign. Easy?)