By Mark Thompson, WB9QZB

DIGITAL RADIO

Digital Technology on VHF, UHF, and Microwaves

Digital Voice and Data Modes The Way Forward

I recently was recently asked by Joe Lynch, N6CL, the Editor of *CQ VHF* magazine, to do a column about digital technology on VHF, UHF, and the microwave bands. I have experience writing many editorials over the last 20 years for the "RAIN Report." I decided that with the help of the digital ham community there is an important role for this new column.

First, a little background about me: I was first licensed in 1975 in Wisconsin. I am an active ham who reads all of the ham radio publications and belongs to three radio clubs in the Chicago area. I also attend the Dayton Hamvention® every year.

I first became interested in digital technology in the late 1970s while a student at the University of Wisconsin, Madison. Our student ham radio club was given a Teletype Model 15 that we cleaned and adjusted. We got the loop current for the Model 15 from a Johnson T/R switch we were no longer using. We then acquired a HAL ST-5000 terminal unit that we used on both HF and 2-meter auto-start. The Model 15 handled only the Baudot format of RTTY.

In the mid 1980s I bought my first Kantronics TNC (terminal node controller) and became active in packet radio. I became involved with the Chicago Area Packet Radio Association (CAPRA) and I founded a separate packet radio frequency coordination group. CAPRA was a very active club and built many of the packet radio networks in the Chicago area in the 1990s. In 1998 Carl Bergstedt, K9VXW, and I, along with CAPRA, were the co-hosts for the ARRL/TAPR DCC (Digital Communications Conference) in Chicago. We will host the 2008 DCC in Chicago in September. There will be more about the DCC in a future column.

At the Dayton Hamvention® in 2004 and 2005, I noticed the new D-STAR digital voice and data technology at the ICOM booth. In early 2006 I became more interested in D-STAR. I educated myself about the technology and met and talked with hams who have been experimenting with and deploying the technology. Although I had given many presentations in my work, I had never given a presentation to a ham radio group. In spring 2006 I began to give D-STAR Introduction/Overview presentations at ham club meetings and hamfests in northern Illinois, southern Wisconsin, and northern Indiana. The presentations were well received, with large attendance. There is a great deal of interest in digital voice. During 1 1/2 years I have given over three dozen presentations and met many hams. In addition, I have been directly involved with the deployment of D-STAR technology in the Chicago area.

A year and a half ago I started a new Yahoo group focusing on digital voice and data technologies. Entitled the "illinoisdigitalham," the group has dozens of files and links covering all the digital ham modes and now has approximately 2400 members. More information on the group can be found at: <http://groups.yahoo.com/group/illinoisdigitalham>. As its moderator, it has given me exposure to many digital technologies and different points of view.

History of Digital Modes

For most of the history of ham radio digital has meant data. RTTY Baudot and then RTTY ASCII were the mainstay of digital until AX.25 packet radio was developed in the early 1980s. The packet radio TNC (terminal node controllers) led to multi-mode controllers that could handle CW, packet, AMTOR, RTTY, and other modes.

These multi-mode controllers were quite popular until the sound-card modes such as PSK, MFSK, Olivia, etc., were developed. Sound-card modes run on any Windows® PC using the PC's sound-card and require an interface to the radio. Several firms have developed interface units to allow connection to the radio with the correct cable. Both packet radio and the sound-card modes are backward compatible with existing analog radios in that they operate on FM and SSB radios. Sound-card modes can transmit and receive both voice and data.

They used to tell us that CW got through when nothing else could. Then they invented narrow-band data modes such as PSK, which gets through at barely detectible signal levels. Other weak-signal data modes have been developed for meteor-scatter use. These modes prove digital data can bring new capabilities to ham radio. There are now several different digital data modes, each of which has distinct advantages, disadvantages, and applications for use. One of the most popular is WSJT, which was developed by Joe Taylor, K1JT. More on WSJT can be found at: <http://physics.princeton.edu/pulsar/K1JT>.

Some hams have been experimenting and using high-speed data called HSMM, High Speed Multi Media. In some cases HSMM has been implemented using off-the-shelf Wi Fi technology. D-STAR has a high-speed data capability on 1.2 GHz utilizing a data access point allowing connectivity to internet or intranet resources.

Digital Voice

In most sectors of commercial communications technology—from public safety two-way radio to cellular phones to broadcasting digital technology—digital is the future. The conversion from analog to digital if not complete, is well under way.

Ham radio voice traditionally has been an analog technology, but over the last few years it has started to change. Implementing digital voice on VHF and UHF is reasonably straightforward, but implementing digital voice on HF poses several more significant challenges,

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including multi-path, fading, QRM, and QRN. Digital data on HF faces some of these same challenges, but due to its typically narrow bandwidth the problems in many cases are not as significant. HF digital voice has been implemented using either a separate device or PC sound-card modes, such as WINDRM or FDMDV, attached through an interface to a traditional analog radio. This same approach could be used on VHF and UHF SSB.

In 2007 the ARRL conducted an RFI (Request For Information) to learn what ham radio operators wanted in an open-source digital voice protocol. The results were presented at the ARRL/TAPR DCC in September in Hartford, Connecticut. I hope to review those findings in a future column.

Digital voice on VHF, UHF, and the microwaves so far has taken two similar, but different approaches—Project 25, more commonly known as P25, and D-STAR. P25 is an open standard developed by APCO, an association of public safety professionals. P25 radios are commercial grade and can be expensive if new. They typically need special software and interface cable to program them.

D-STAR is an open protocol defined by the JARL (Japan Amateur Radio League). D-STAR digital voice radios are capable of both digital voice and concurrent low-speed data, as well as traditional analog FM. In addition, on 1.2 GHz there is a separate high-speed data (128 KB) capability. Built into D-STAR technology is the ability to interconnect D-STAR repeaters seamlessly to the internet using a D-STAR internet gateway PC. While ICOM is the only commercial manufacturer making radios for D-STAR at this time, other manufacturers can utilize the standard. A new product, the DV Dongle, has been developed by Robin, AA4RC. The Dongle plugs into the USB port of a PC and allows voice calls over the internet to D-STAR repeaters with gateways running the dplus software.

Two advantages of digital voice are: the bandwidth is significantly narrower than analog FM; and there is greater effective range because of the lack of path noise as the signal becomes weaker, making weak digital voice signals more readable. I have found that many hams are under the mistaken impression that under weak-signal conditions digital voice will be garbled and less intelligible than analog voice. It appears this impression has been gained due to digital cellular phones becoming garbled when the signal is weak. However, since you can't switch to FM at the same power level while making a cell call, there is no real basis for this assumption other than the observation that digital gets garbled when weak.

There is a recording available at the illinoisdigitalham group that dramatically demonstrates the difference between digital voice and analog FM under weak-signal conditions. Also available is a white paper in which Motorola has articulated the technical reasons for this dramatic difference. In order to access these one must join the group. Visit the digital ham group at: <http://www.yahoogroups.com/illinoisdigitalham> to join the group and learn more about the ham digital voice and data modes.

The Future of Digital Ham Radio

We are in the infancy of the implementation of digital voice and data in ham radio. From spark to CW, AM to SSB on HF, AM to FM on VHF, hams historically have embraced new technology. I believe it is critical to amateur radio that we embrace digital technology to keep us in the forefront of technology. There are very legitimate reasons to use digital technology, since it brings capabilities unavailable using traditional analog technology. It is the goal of this column to explore those new technologies and the new applications that use them.

Your Digital Column

I want this column to be *your* column. There are many of you who have extensive knowledge of many of the digital modes. I plan to include your experiences with digital voice and data in this column. Please e-mail me your thoughts and ideas regarding the topics you would like covered and how you might contribute your knowledge and expertise.

73, Mark, WB9QZB

Belgian Satellite Features D-STAR Technology

Students at the Universite de Liege in Belgium have built OUFTI-1 <http://www.leodium.ulg.ac.be/cmsms/>, a new amateur radio CubeSat featuring D-STAR digital-communication protocol that is used for control and telemetry. Amateur radio operators from all over the world are able to listen in on the ONØULG D-STAR repeater on 70 cm <http://www.jfindu.net/dstarlh.aspx?rptr=ON0ULG>. On 70 cm the output frequency is 439.525 MHz, and they are using a 7.6-MHz shift. By the time you read this, 2 meters should be operational.

The objective of this nanosatellite project is to provide hands-on experience to students in the design, construction, and control of complete satellite systems that will ultimately serve as the basis for a variety of space experiments. The first satellite in the series is a CubeSat, which is a cube with dimensions of $10 \times 10 \times 10$ cm and a weight of at most one kilogram.

The key innovative feature of OUFTI-1 is the use of the D-STAR amateur-radio digital-communication protocol. This means of radio communication will be used for control and telemetry, and will be made available to ham radio operators worldwide. In the future, it will also be used to control space experiments.

This project is a student project. Students thus are encouraged to join the project. Please contact Gaetan Kerschen at <g.kerschen@ulg.ac.be> or Jacques Verly at <Jacques.verly@ulg.ac.be> for further information. Portions of this report previously appeared in the April 4, 2008 *ARRL Letter*.