Newcomers and Elmers Net: DMR **Robert AK3Q 5/8/16**

D-STAR

D-STAR (Digital Smart Technologies for Amateur Radio) is a digital voice and data protocol specification for amateur radio.
- The system was developed in the late 1990s by the Japan Amateur Radio League and uses frequency-division multiple access (FDMA) and minimum-shift keying in its packet-based standard.
- There are newer digital modes (Codec2, for example) which have been adapted for use by amateurs, but D-STAR was the first designed specifically for amateur radio.
- Several advantages of using digital voice modes are it uses less bandwidth than older analog voice modes such as amplitude modulation, frequency modulation, and single sideband.
- The quality of the data received is also better than an analog signal at the same signal strength, as long as the signal is above a minimum threshold, and there is no multipath propagation. Do not miss these last two conditions, as they are significant!

Digital signals of all kinds must reach the "minimum threshold" of the respective mode, and this is one of the limiting conditions of any digital mode.
- If signals are right at or just slightly below the minimum threshold there will be signal distortion, described by many as "Donald Ducking" (from the cartoon character), or "R2-D2ing" (from Star Wars, of course).
- These colorful descriptions approximated the sounds of digital signals breaking up before dropping out altogether.

The other aspect of possible distortion or signal interruption is multipath propagation. Broadly speaking this is true for nearly any modulation mode in radio, but is especially significant in digital modes as the codecs used to convert the digital signal back to analog are easily overwhelmed by the intermixing of packet data.

DMR

Digital Mobile Radio (also referred to MotoTrbo) or **DMR** is a digital radio standard specified for professional mobile radio (PMR) users developed by the European Telecommunications Standards Institute (ETSI), and first ratified in 2005.

According to the dmrassociation.org:

> The standard is designed to operate within the existing 12.5kHz channel spacing used in licensed land mobile frequency bands globally and to meet

future regulatory requirements for 6.25kHz channel equivalence. The primary goal is to specify affordable digital systems with low complexity. DMR provides voice, data and other supplementary services. Today, products designed to its specifications are sold in all regions of the world.

The DMR protocol covers unlicensed (Tier I), licensed conventional (Tier II) and licensed trunked (Tier III) modes of operation, although in practice commercial application is today focused on the Tier II and III licensed categories.

Tier II covers licensed conventional radio systems, mobiles and hand portables operating in PMR frequency bands from 66-960MHz. The ETSI DMR Tier II standard is targeted at users who need spectral efficiency, advanced voice features and integrated IP data services in licensed bands for high-power communications. ETSI DMR Tier II specifies two-slot TDMA in 12.5kHz channels.

DMR Tier III covers trunking operation in frequency bands 66-960MHz. The Tier III standard specifies two-slot TDMA in 12.5kHz channels. Tier III supports voice and short messaging handling similar to MPT-1327 with built-in 128 character status messaging and short messaging with up to 288 bits of data in a variety of formats. It also supports packet data service in a variety of formats, including support for IPv4 and IPv6.

Other key technical features of the DMR standard are:

- Two-slot Time Division Multiple Access (TDMA) operation
- 4 level FSK modulation
- State of the art Forward Error Correction

One of the principle benefits of DMR is it enables a single 12.5kHz channel to support two simultaneous and independent calls, achieved using TDMA. Under the DMR standard, Time Division Multiple Access (TDMA) retains the 12.5kHz channel width and divides it into two alternating timeslots A and B where each timeslot acts as a separate communication path.

In this setup each communication path is active for half of the time in 12.5 kHz of bandwidth and so each uses an equivalent bandwidth of 0.5 x 12.5 kHz or 6.25 kHz .

While having the ability to use one talk path per 6.25kHz of spectrum, the DMR the channel as a whole maintains the same profile as an analog 12.5kHz signal.

One of the reasons DMR is becoming more and more popular with amateur radio folks is because the prices are more affordable than D-STAR capable radios. The widespread commercial use of DMR is likely the main reason equipment prices are more reasonable, as D-STAR has a fairly limited market (developed specifically for amateur use) and there is only one main radio manufacturer licensed for the necessary D-STAR codecs.

Conversely DMR equipment is available from a number of manufacturers because of the broad commercial market, and thus prices are lower. An interesting potential benefit from DMR is extended battery life.
- Because the transmit time is reduced by using the TDMA approach, the drain on the power resources is less.
- A user is typically only going to transmit on one of the two available frequency slots. This means when using the radio in emergency or public service situations, there could be as much as a 40% increase in operating time between battery charges.

Also users get two communications channels with one repeater, one antenna and a simple duplexer, which should cut down on infrastructure expense, or at the least, make more efficient use of facilities.

Another interesting aspect of DMR and it two-slot capability is to communicate back to a radio while it is in a call. The DMR standard allows for the ability to use the second time-slot for reverse-channel signaling – that is, instructions in the form of signaling being sent to the radio on the second time slot channel while the first channel is in a call.

This would allow, for example, a priority or emergency message to come through to alert the caller to the developing situation, without having to wait for the transmission to end.

Audio quality is, to be sure, a personal judgment call. What is good quality to one person may not be acceptable to another. Only actual use over time of a given system or of multiple systems for comparison purposes can really tell the real story, but I have included the DMR Association's comments about quality just for the technical information it provides:

> DMR digital technology provides better noise rejection and preserves voice quality over a greater range than analogue, especially at the farthest edges

of the transmission range. One of the reasons that DMR has an excellent range performance is that a great deal of effort was put into selecting Forward Error Correction (FEC) and Cyclic Redundancy Check (CRC) coders when developing the standard. These coders enable receiving radios to detect and automatically correct transmission errors by analyzing bits inserted into messages that enable the receiving radio to tell if there is an error.

The DMR standard specifies over 14 different coders to be used, each matched to different types of traffic that is being transmitted. Through the use of coders and other techniques, digital processing is able to screen out noise and re-construct signals from degraded transmissions. Users can hear everything being said much more clearly — increasing the effective range of the radio solution and keeping users responsive to changing situations in the field.

There is some discussion about which digital system gives the best coverage, a 12.5 kHz or a 6.25 kHz channel based system. Both have advantages and disadvantages. 6.25 kHz based systems are disadvantaged because when you squeeze multiple high power transmissions in 6.25 kHz channels into the spectrum, it is necessary to limit the modulating signal of each transmission quite tightly (in technical terms reduce the signal deviation) so as not to cause interference in the next channel along in the spectrum. This limit on the signal deviation means the receiver is less able to distinguish whether it is being sent a one or a zero when the signal is weak – i.e. at the edge of the system's range. This, in theory, impacts the coverage of 6.25 kHz systems.

Wrap-up

There are some significant differences between the FDMA-based D-STAR and the TDMA-based Digital Mobile Radio, both in terms of data handling and the ability to make use of RF spectrum most efficiently. D-STAR has a well-established following with many inroads into emergency services, while DMR has the advantage of lower hardware costs and more efficient energy use. DMR is also more limited (at this point) in widespread connectivity, and the use of talkgroups will be something of a learning curve for those unfamiliar with the concept.