

## Digital Repeater Operations in Helena

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Please accept our apologies for not spreading the word sooner about the new digital repeaters in Helena. We have been busy all summer with equipment installations and turn-ups as well as resolving multiple problems associated with this new gear. Our thanks to Julie for giving us this forum to spread the word.

You might be asking "Why digital? Is it really better than FM?" It is not a secret, there is a performance price to pay when switching repeater operations from FM to narrow-band digital. A more illuminating question might be "Is digital worth the price?" In one case, we think it is.

Digital repeater communications isn't new to ham radio. D-Star, Icom's digital format, has been in existence for over 15 years. It is mature and has a large world-wide base of users and infrastructure. Yaesu, with its C4FM Fusion and WIRES-X networking, is much newer but has spread rapidly due to Yaesu offering its digital repeater at a low price. One of our digital repeaters is a Yaesu DR-1X operating on 147.100 at Mac Donald Pass. As of a few weeks ago, it is operating in Automatic Mode Select, which allows it to switch from digital to analog on the fly. This makes it easy to compare performance between the two modes. Other digital repeater formats include P25 (APCO Project 25) and DMR (Digital Mobile Radio), both of which were created for the Part 90 world (business & government.) There are some ham radio P25 networks but we expect limited adoption due to the pricing of P25 subscriber equipment. DMR, on the other hand, is an open format that is marketed to the more cost-conscious business world. It is DMR that has something to offer ham radio and is also affordable, both with the repeaters and with the subscriber equipment.

Most of the digital radio formats, ham-specific and business-oriented, are really just digital versions of what we are already able to do with analog FM repeaters. Hams have been networking their repeaters with IRLP, EchoLink, and AllStar for many years with great success. That takes us back to the "is digital worth the price" question. DMR brings three things to the ham radio table: affordable radios, time-slots, and talk-groups. It is these three things together that let us answer with a "yes!"

**Affordable:** DMR is an open standard so DMR radios are available from many manufacturers. Within ham DMR, the most popular radio is the Tytera MD-380. It is available in 2 meter and 440 band versions. Typical pricing on eBay is about \$120 so DMR is within reach of most hams.

**Time-slots:** DMR repeater operations is 2-slot TDMA, time division multiple access. The output of a DMR repeater is divided in time, alternating between two 30 ms long time slots. This allows for two simultaneous conversations on a single repeater that transmits and receives on a single pair of frequencies. The repeater input is also time slotted so your radio transmits for 30 ms then receives for 30 ms. Of note, simplex does not have time slots so only one conversation per frequency is possible when not operating through a DMR repeater.

**Talk-groups:** This is probably a completely new concept. Hang in there, you need to know this for DMR to make sense. A talk group is a logical grouping to enable communications among the radios of a specific group of radio system users. Or, you could look at it as a way of ensuring that you hear and participate in the communications only among your group, filtering out the traffic of all the other users on a given repeater. In your radio, you have programmed in each channel, the frequency for the repeater you intend to communicate through, a talk group number and time slot number. When all of those parameters are valid, then you can monitor and transmit through a given repeater to a specific group. The participants in this group could be local to your repeater or they could be on the other side of the planet. Or, you could have multiple participants local to you AND multiple participants on multiple repeaters that are located in other states and countries.

You would be right if you are concerned about the complexity of programming a radio for DMR operations. Unlike with most ham-oriented radios, DMR radios are programmed exclusively using programming software, called CPS (Customer Programming Software). CPS is used to generate a code plug, which is a radio programming file containing frequencies, talk groups, address books, and other such details specific to your radio. Most DMR repeater groups, including ours, make available for download a sample code plug so all you have to do is add your specific radio ID number before stuffing it into your radio. This gets you started operating on the local repeaters right away then later you can customize it or create from scratch a code plug to match your interests.

Although DMR mobile and portable radios of any brand can operate on any brand of repeater, the networking of repeaters has until recently, been divided among brand lines. The original ham DMR network was for Motorola

repeaters only. Later came a world-wide network for Hytera repeaters. This hard division was a limit of the technology available, not any desire to discriminate. A new network called BrandMeister accommodates three brands of commercial DMR repeaters, homebrew DMR repeaters using an available kit modem and open source software, and also Hotspots (very low-power, very short-range simplex digital radio) including DV4mini, DVMega, and openSPOT. Our four Helena-area UHF DMR repeaters are connected to the BrandMeister network, which gives you easy talk-group access to hams all over the world as well as some ability to cross-connect to the other two DMR networks.

Our first DMR repeater was installed at our Mac Donald Pass site back in May. It replaced an analog FM Motorola MSF-5000 repeater that has been on the air for about 12 years. Since then, we have installed DMR repeaters, replacing the existing FM repeaters, at Boulder Hill and at Helena North Hills. In the shop being tested is a fourth DMR repeater that will soon be installed at our Toston site. Together, we expect the four repeaters to provide quality DMR coverage throughout the Helena Valley, south to Boulder, southeast toward Bozeman, and much of the Deer Lodge valley.

Yes, you are still hearing analog FM activity on all four repeaters. All four are operating in Dynamic Dual Mode. This is analog or digital repeating on-demand. This allows for easy comparing of analog and digital performance and also lets us keep the existing EchoLink networking for analog operations. The two modes are blind to each other and also, users of different talk-groups can at times compete for the same time-slot so patience and understanding that your conversation might suffer a delay is important. On the repeaters, in both analog and digital modes is a tail time, although you can't hear it in digital mode. As long as you transmit before the tail time expires, you keep possession of the repeater resources. If you let the tail time expire during a digital conversation, another person wishing to talk on a different talk-group but with the time-slot you were using can then initiate a conversation. At your next PTT, you will hear a deny tone so you will have to wait until the time-slot is again free. Note that different users with different talk-groups selected on their radio can't hear each other so this "stealing" of resources is not really theft, its just bad timing. The same thing can happen with an analog conversation where once you let the tail drop, a digital user can grab the repeater. Again, the DMR user can't hear your analog conversation so their grabbing the repeater during your conversation isn't a lack of manners. Another possible clash is during your DMR transmission, an analog user makes a call on the same repeater. The repeater is in digital mode so it won't repeat their analog signal but they might interfere with your DMR transmission. All you will know is the people in your digital conversation will complain about your sounding bad or dropping out. Although this clashing can be annoying, it is a small price to pay so we can operate the repeaters in both analog and digital modes. Given our normal level of analog and digital activity, it really hasn't been a problem, but you need to know clashing can happen.

This was a major project for us, and it was a group project. Don W7MRI, Dale KA7MHP, and Bill K7MT all had a hand in making this new digital radio network possible.

We hope this has stimulated interest about DMR. You are invited to visit our web site to learn more about DMR and about our repeater network in Montana. <http://www.dmr-montana.net>

Table 1. Details about the five repeaters referenced in the article.

Mac Pass	DMR + analog FM	444.100 MHz +5 MHz	131.8 Hz
Mac Pass	Fusion + analog FM	147.100 MHz +600 KHz	100.0 Hz
Boulder Hill	DMR + analog FM	449.200 MHz +5 MHz	131.8 Hz
North Hills	DMR + analog FM	448.900 MHz +5 MHz	131.8 Hz
Toston	DMR + analog FM	449.300 MHz +5 MHz	131.8 Hz