

# Introduction to Digital Mobile Radio (DMR)

By John S. Burningham, W2XAB

w2xab@arrl.net

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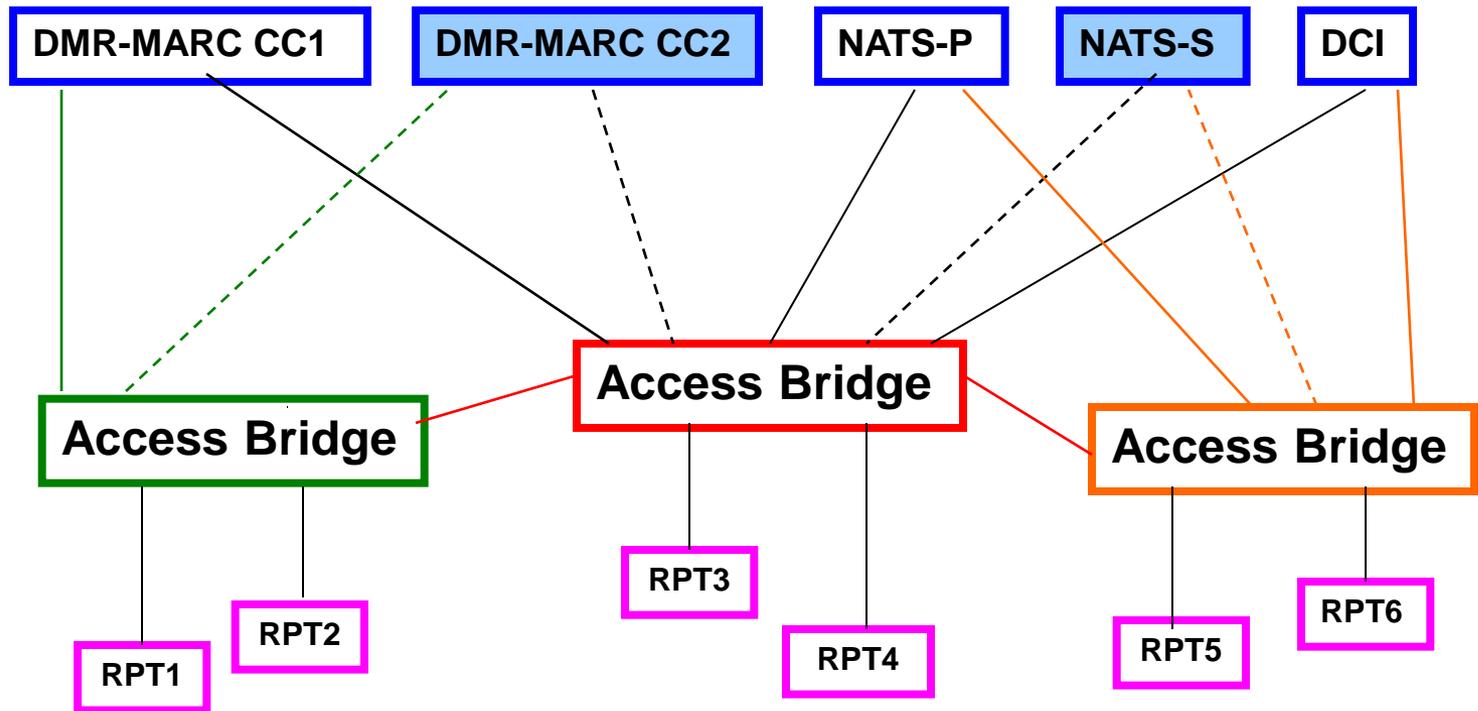
# The Amateur DMR Networks

- Over 1,275 registered repeaters.
- Over 14,738 registered radios.
- The Networks are divided by infrastructure
  - Mototrbo (Motorola Solutions)
    - Most common around the world, about 95%.
  - Hytera

# Major Mototrbo Networks

- Wide Area Networks
  - DMR-MARC (Motorola Amateur Radio Club)
    - Radio registration
    - Network Pin Maps
    - <http://www.dmr-marc.org>
  - DCI (Digital Communications Interconnect)
    - <http://www.trbo.org>
  - DMR-NA (DMR Core Talkgroup Server Project)
    - <http://www.dmr-na.com>
- Regional Groups
  - Typically associated with one or more of the wide area networks which supply Talk Group interconnections.

# The Bridged Network Example



# What is DMR?

- Digital Mobile Radio (DMR) was developed by the European Telecommunications Standards Institute (ETSI) and is used worldwide by professional mobile radio users.
- DMR is divided into three tiers.
  - Tier I
  - Tier II
  - Tier III

# Tier I

- Tier I is a single channel specification originally for the European unlicensed dPMR446 service. It is a single channel FDMA 6.25 kHz bandwidth; the standard supports peer-to-peer (mode 1), repeater (mode 2) and linked repeater (mode 3) configurations. The use of the Tier I standard has been expanded into radios for use in other than the unlicensed dPMR446 service.

# Tier II

(The Standard for Amateur Networks)

- Tier II is 2-slot TDMA 12.5 kHz peer-to-peer and repeater mode specification, resulting in a spectrum efficiency of 6.25 kHz per channel. Each time slot can be either voice and/or data depending upon system needs.
- IP Site Connect (IPSC) for interconnecting repeaters over the Internet is vendor specific and not part of the ETSI standards at this time. Most amateur radio implementations of DMR are using voice on both time slots.

# Tier III

- Tier III builds upon Tier II, adding trunking operation involving multiple repeaters at a single site. Not all manufacturers' trunking implementation is Tier III compatible. Vender specific protocols have expanded the trunking to multiple site operations.

# Vocoder

- The current implementation of DMR utilizes the DSVI AMBE+2™ vocoder by agreement of the manufactures; it is not specified in the ESTI standard. Most of the radio manufacturers have implemented the vocoder in licensed software. The forward error correction in the AMBR+2™ this is an improvement of the voice quality of older vocoders such as used by D-Star™.

# DMR 2-Slot TDMA

- DMR Tier II/Tier III occupies a 12.5 kHz bandwidth with two channels sharing using Time-Division Multiple Access (TDMA), this results in spectrum efficiency of 6.25 kHz per channel.
- Comparing the spectrum efficiency of DMR to a wideband analog FM, DMR only uses 25% of the bandwidth per talk channel.
- Each channel can carry either voice and/or data depending on system design.
- The two time slots are called Time Slot 1 (TS1) and Time Slot 2 (TS2).

# DMR 2-Slot TDMA

- For the amateur, this means one repeater allows two separate channels at the same time.
- Currently most amateur DMR repeater system implementations utilize both channels for voice and some limited text messaging.
- Typically one channel (time slot) is used for wide-area and the second is local and regional talk groups.
- For repeater operators, a single two-slot TDMA repeater offers a significant savings over two standalone repeaters to obtain two separate communication channels as only one repeater, one duplexer, and one antenna system is required.

# DMR 2-Slot TDMA

- The two-slot TDMA implemented in DMR uplinks (portable/mobile to repeater) uses a 30-ms window for each time slot, the 30-ms is further divided into a 27.5-ms frame and a 2.5-ms gap. This means when transmitting, your transmitter is only turned on for 27.5ms every 60ms resulting in extended battery life for portables.
- The DMR repeater (downlink) transmits a continuous data stream even if only one timeslot is being used; the 2.5-ms uplink gap is replaced with a CACH burst (Common Announcement Channel) that is used for channel management and low speed signaling.

# The Frame

- The 27.5-ms frame consists of a total of 264-bits; 108-bit payload, 48-bit SYNC or embedded signaling, and a second 108-bit payload for a total of 216-bits of payload per frame.
- The vocoder must compress 60-ms of audio with FEC (forward error correction) into 216-bits of data for transmission.
- The 2.5ms-gap is used for guard time to allow PA ramping and propagation delay.

# DMR Terminology

- Talk Groups
- Zones
- Color Codes
- Code Plugs
- Scanning
- Roaming
- Simplex
- Admit Criteria

# Talk Groups (TG)

- Talk Groups (TG) are a way for groups of users to share a time slot (one-to-many) without distracting and disrupting other users of the time slot.
- It should be noted that only one talk group can be using a time slot at a time.
- If your radio is not programmed to listen to a talk group, you will not hear that talk group's traffic.

# Zones

- User DMR radios support Zones, a Zone is just a grouping of individual channels. Some model radios may limit the number of channels per Zone and the number of Zones allowed.

# Color Codes (CC)

- DMR repeaters use Color Codes (CC) much like analog repeaters use CTCSS or DCS.
- To access a repeater you must program your radio to use the same CC as the repeater.
- There are 16 different CCs (CC0-CC15). The factory default is CC1.
- The use of Color Codes is not optional on DMR systems.
- If your Color Code is not set correctly, you will not be able to access the repeater.
- The only real purpose of using different Color Codes is when multiple repeaters operating on the same frequency have overlapping coverage areas.

# Code Plugs

- A code plug is simply a radio's configuration file.
- Using a manufacturer's programming software you configure the channels and operating parameters of a radio, this file is uploaded to the radio.
- Building a code plug can take many hours, especially if you want to program hundreds of channels.
- The code plug can also contain a Contact List of Radio IDs, call signs, and names to be displayed.
- You can find copies of configured code plugs on the web for different models of radio; check out the different Yahoo DMR groups.
- All DMR radios support a limited number of entries in the Contact List.

# Scanning

- All DMR radios allow you to configuring scanning of channels.
- Remember, you will only hear traffic on the frequency, time slot, and talk groups you have programmed on a channel.
- I typically scan both time slots on my local repeater and a simplex channel I use.
- You can also scan analog channels mixed with the digital channels.
- Scanning will decrease the battery life on your radio.

# Roaming

- Roaming is NOT scanning, roaming is similar but different.
- Roaming is designed to have your radio automatically select a better channel if your current channel's Receive Signal Strength Indicator (RSSI) falls below a defined level as you move throughout the coverage area of a group of repeaters that carry the same talk groups on the same time slots.
- Roaming is not supported on all DMR radios, check your owner's manual or manufacturer website to see if roaming is supported; in some radios it may be an additional cost option.

# Roaming & Beaconing

- To fully support roaming, a group of repeaters must be programmed to BEACON a short announcement at regular intervals to allow roaming clients to identify possible candidates.
- Roaming does not select the best candidate, it selects the first candidate that exceeds a specified signal level.

# Simplex

- In the professional side of DMR, *Talk-Around* refers to operating simplex on a repeater output channel
  - this allows a direct communication while still being able to hear the repeater
  - this allows users to directly contact other users listening on the repeater output frequency who may be local and out of range of the repeater.
- Amateurs typically use dedicated simplex channels so as not to interfere with repeater traffic.

# Simplex

- The amateur DMR community has published a list of recommended simplex frequencies:
- UHF
  - 1) 441.000
  - 2) 446.500
  - 3) 446.075 (most common in NA)
  - 4) 433.450 (common in non-NA countries)
- VHF
  - 1) 145.790
  - 2) 145.510
- Use TG99 / CCI / TSI / Admit Criteria: Always / In Call Criteria: TX or Always

# Admit Criteria

- The Admit Criteria determines when your radio is allowed to transmit.
- The recommended setting for repeater channels is **Color Code Free**
  - this configures your radio to be polite to your own digital system.
- You should configure your In Call Criteria to **Follow Admit Criteria**.
- Simplex channels should be configured as **Always** for both Admit Criteria and **Always** or **Follow TX** for In Call Criteria.

# Accessing a DMR Repeater

- When you want to access a DMR repeater, you must have the frequency, color code, TS and TG set correctly.
- When you key your transceiver, you send a signal to the repeater and the repeater responds back to acknowledge you can transmit your message.
- If you do not receive the repeater's acknowledgement your radio will stop transmitting and you will hear a negative confirmation tone.
- This is one of the advantages of TDMA, allowing bidirectional communications between user and the repeater when transmitting. The repeater can also signal your radio to stop transmitting if there is contention on the network because more than one station is transmitting at a time.

# IPSC and Bridges

- IP Site Connect (IPSC) is a vendor specific repeater feature offered by some manufacturers.
  - Allows a fully-meshed network of a limited number of repeater (15 is considered the maximum).
  - One repeater or bridge is the Master, the other are Peers.
  - The Master's duty is to inform connected Peers of how to communicate with other Peers.
- Bridges are used to interconnect IPSC networks.
  - It is common in the amateur networks for each repeater to be directly connected to a bridge instead of utilizing a fully-meshed IPSC network; this reduces bandwidth requirements for the repeater sites.

# Bridges for Mototrbo™

- **Ravennet Systems (Developer)**
  - Rayfield Communications c-Bridge™
  - Bridgecom Systems MV-DMR™
  - Linux Based
  - Available in hardware and virtual configurations
  - Defacto Standard in the Americas
- **SmartPTT** (Russian Product)
  - Windows based
  - Common in Europe

# User Radios

- There are many sources of DMR radios, both new and used.
- As of this date, you can't walk in to an amateur radio store and buy a DMR radio but that could soon change.
- All the DMR radios are professional (commercial) radios for the greater professional market.
- If you want to purchase a new radio you can easily find a dealer, some are "ham friendly" and will offer reasonable discounts to hams; check with your local DMR users or the websites for further information.

# Buying a Radio

- New or Used
- VHF, UHF, or 900 MHz
- Programming Software
- Programming Cable
- Number of Channels
- Display or Non-Display
- DTMF Keypad
- GPS
- Bluetooth
- Analog capable
- Mobile or Portable

# External Amplifiers

- Most external amateur amplifiers will **NOT** work with DMR user radios!
  - It must be designed to switch fast enough for the TDMA on/off keying of the transmitter.
- If you need more power than a handheld, consider purchasing a mobile and **NOT** using an external amplifier connected to a handheld.
  - Not all handheld are designed for connection of an external antenna.

# Suppliers of DMR Radios

- Motorola Solutions \$\$-\$\$\$\$  
<http://www.motorolasolutions.com>
- Hytera \$\$-\$\$\$\$  
<http://www.hytera.com>
- Vertex Standard \$\$-\$\$\$  
<http://www.vertexstandard.com/lmr/Digital>
- Connect Systems \$  
<http://www.connectsystems.com/>
- BeiFeng Telecom Technologies (BFDX) \$\$-\$\$\$  
<http://www.bfdx.com/en/products.php?listid=60>
- Kenwood \$\$-\$\$\$  
<http://www.kenwood.com>
  - Note: Kenwood has already released DMR radios in other parts of the world, when they will arrive (if ever) in the US market has not yet been announced.

# Good Operating Practice

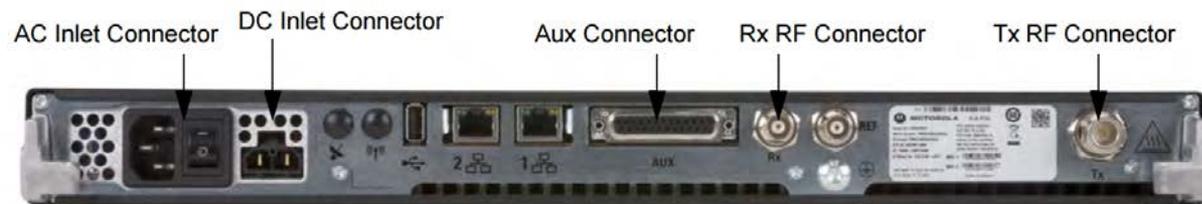
- Examples of good operating practice for initial calls on the DMR networks include:
  - ***This is W2XAB monitoring Southeast Regional***
  - ***N5ITU this is W9JW on North America***
  - ***This is NØYNT for a radio check on Local***
  - ***WB8FXJ this is WB8SCT on Ohio State***
- Spend most of your time listening, not talking.
- Be a good neighbor and don't hog the network.
  - ***Move off the wide area Talk Groups for long QSOs.***
- Don't over ID!
- Help the new users develop good operating practices.
- Promote DMR to your friends.

# Amateur Radio Guide To DMR

- For further information please read the *Amateur Radio Guide to Digital Mobile Radio (DMR)*
- Available free online at:
  - <http://www.dmr-marc.net>
  - <http://guide.trbo.org>

# New Mototrbo SLR-5700 Repeater

(Scheduled to be released June 2015)



# Questions?



**Ham on DMR!**