DMR: Introduction to a New D/V Mode for AMATEUR Radio

HamSCI 2018-02
Kai Chen, K2TRW
Presentation Summary

Summary

- DMR Requirements
- DMR Tiering and ETSI DMR Standard Parts
- DMR Technology Overview
- DMR Tier II Features
- Benefits of DMR
Digital Mobile Radio

- An ETSI published global standard
- Many manufacturers
- Longer battery life
- Supports multiple talk groups
- Supports DATA applications (IoT)
DMR Association
Equipment Mfg Members

aselsan
AVTEC
BFDX
emc

Fylde Micro
Harris
HQT
Hytera

ICOM
JVC Kenwood
Kirisun
Larimar

Motorola
Omsk Manufacturing Association named after A.S. Popov

Radio Activity

RADIODATA

Selex ES
A Finmeccanica Company

Sepura
Tait Communications

Vertex Standard
Zetron
Intellectual Property Licensing

MOTOROLA SOLUTIONS

MOTOROLA DMR LICENSEES
(as of 01 September 2017)

- 3M Innovative Properties Company
- ASELSAN Elektronik Sanayi ve Ticaret A.Ş.
- Extera Technology Co., Ltd.
- Fujian Baofeng Electronics Co., Ltd.
- Fujian Beifeng Telecom Technology Co., Ltd.
- Guangzhou Victel Technology Co., Ltd.
- Hytera Communications Corporation Limited
- JUSTON Electronic Equipment Co., Ltd.
- JVCKENWOOD Corporation
- Kirisun Communications Co., Ltd.
- Leonardo S.p.A.
- Lisheng (Fujian) Communications Co., Ltd.
- Qixiang Electron Science & Technology Co., Ltd.
- Quansheng Electronics Co., Ltd.
- Quanshun Communication Technology Co., Ltd.
- Quanzhou City New Century Communication Electronics Co., Ltd.
- Quanzhou Feijie Electron Co., Ltd.
- Quanzhou Risen Electronics Co., Ltd.
- Quanzhou SFE Electronic Technology Co., Ltd.
- Quanzhou Tietong Electronic Equipment Co., Ltd.
- Radio Activity S.r.l.
- Shenzhen COVALUE Communications Co., Ltd.
- Shenzhen Samhoo Science & Technology Co., Ltd.
- Tait Electronics, Ltd.
- TTG Global Ltd.
- TYT Electronics Co., Ltd.
- Uniden America Corporation
- Xiamen Puxing Electronics Science & Technology Co., Ltd.
- ZTE Trunking Technology Corporation
DMR Standards

ETSI DMR Standard Parts

DMR Tier I: Unlicensed
- Products for license-free use in the 446 MHz band.

DMR Tier II: Conventional
- Licensed conventional radio systems operating in LMR frequency bands 30 to 1000 MHz. Targeted at users who need spectral efficiency, advanced voice features and integrated IP data services in licensed bands.

DMR Tier III: Trunked
- Trunking operation in frequency bands 30 to 1000 MHz. The ETSI Tier III standard supports voice and short messaging handling similar to MPT1327.
DMR Standard

- **DMR Tier II: Conventional**
  - Licensed conventional radio systems, mobiles and hand portables operating in PMR frequency bands 30 to 1000 MHz
  - Targeted at users who need in licensed bands:
    - Spectral efficiency;
    - Advanced voice features;
    - Integrated IP data services.

- **Tier II Supports Tier I, not converse!**
DMR Standards Public Access

All DMR standards are available on the DMR Associations website
http://dmrassociation.org/

The DMR Standard

Digital Mobile Radio (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 2004.

The standard is designed to operate within the existing 1.25kHz channel spacing used in licensed land mobile frequency bands globally and to meet future regulatory requirements for 2.5kHz 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 licence-free (Tier III) modes of operation, although in practice commercial application is today restricted to the Tier II and III licensed categories.

The standards that define DMR consist of four documents. These can be downloaded free of charge from the ETSI website. If you go to the site and click on the "Digital Mobile Radio - DMR standards" link, you’ll find the following:

- TS 102 361: The DMR air interface protocol
- TS 102 361-2: The DMR voice and generic services and facilities
- TS 102 361-3: The DMR data protocol
- TS 102 361-4: The DMR trunking protocol

There is also a designer’s guide encompassing elements from all standards parts that is an easier read:

TR 102 390: DMR General Systems Design

For your convenience, all our documents are available in Adobe Acrobat PDF format. The reader is available free of charge.

Languages:

English -

News Room:

Search Category:

Upcoming Events:

- No events

Log in to the Members Area:

Username:

Password:

Login:
DMR Main Characteristics

- 12.5 kHz channel
- 9.6 kbps gross bit rate
- 4-FSK modulation (constant envelope)
- 2-slot TDMA channel
  - Built around a 30 ms slot structure
  - 50% duty cycle slot structure
    - Forward and reverse transmission on a time division basis
- Voice, data or generic signaling
- Designed for frequency bands from 30 to 1000 MHz
Half the Channel Bandwidth

Traditional Analog
25 kHz
Channel Bandwidth
1 Channel
1 Repeater

DMR
12.5 kHz
Channel Bandwidth
2 Channels
1 Repeater
More Spectrum Efficient than Older Digital Modes

Guard Band as large as 10 kHz between channels
Total BW = 22.5 kHz

No Guard Band between 2 channels
Total BW = 12.5 kHz
TWO Repeaters in One!

Lower infrastructure cost, 1 box in rack
TWO voice/data channels from one repeater
Digital Voice CODECs

- D-STAR (Icom)
  - GMSK/AMBE Vocoder
- P25 Phase 1 (Multi-Vendor)
  - FDMA/IMBE Vocoder
- System Fusion (Yaesu)
  - FDMA/C4FM/AMBE+2 Vocoder
- DMR (Multi-Vendor)
  - 2-slot TDMA/AMBE+2 Vocoder
- Digital Voice CODEC Not Specified
  - Flexibility for EXPERIMENTATION
Longer Battery Life

Older Digital Modes (FDMA)  DMR (TDMA)

“For each hour of usage the TDMA radios show between 19% and 34% less battery capacity is required than for the FDMA models.”

“40 percent improvement in talk time in comparison with analog radios “

http://dmrassociation.org
Better Speech Clarity

- No hiss/pop/static
- Forward Error Correction (FEC), Cyclic Redundancy Check (CRC) encoding
- Better RF range due to processing gain
### S unit, dBm, milliWatt

<table>
<thead>
<tr>
<th>S</th>
<th>dBm</th>
<th>mW</th>
<th>mV at 50 ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0</td>
<td>-127</td>
<td>0.00000000000000199526</td>
<td>0.00009988149</td>
</tr>
<tr>
<td>S1</td>
<td>-121</td>
<td>0.00000000000000794328</td>
<td>0.00019928977</td>
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<tr>
<td>S2</td>
<td>-115</td>
<td>0.00000000000003162278</td>
<td>0.00039763536</td>
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<tr>
<td>S3</td>
<td>-109</td>
<td>0.0000000000012589254</td>
<td>0.00079338686</td>
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<tr>
<td>S4</td>
<td>-103</td>
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<td>0.00158301490</td>
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<td>S5</td>
<td>-97</td>
<td>0.0000000199526231</td>
<td>0.00315852997</td>
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<td>S6</td>
<td>-91</td>
<td>0.000000794328235</td>
<td>0.00630209582</td>
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<td>S7</td>
<td>-85</td>
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<td>S8</td>
<td>-79</td>
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<td>0.02508909536</td>
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<td>S9</td>
<td>-73</td>
<td>0.050118723363</td>
<td>0.05005932649</td>
</tr>
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</table>
Better Audio Quality

- Listen for yourself. DMR does sound better than older digital technologies.
Better Performance

- DMR radios share basic processing, resulting in
  - Better sensitivity/selectivity;
  - Better spurious/intermodulation rejection;
  - Better blocking;
  - Better adjacent channel power;
  - Better adjacent transient channel power.
- More rugged
  - IP54/IP65/IP67 (dust tight/splash to immersion)
- Polite Access
  - Blocks TX into existing QSO, override available
Substandard Terminals

- No FCC Certification
  - Searchable on FCC Database?
- Support Tier I (Only)
  - Radio-to-radio?
- Simultaneous Double Time Slot
  - No sync, interferes with repeater
- Works with hotspot only
  - Questionable Performance
- Bargain Price
Simultaneous Data/Voice

Slot 1 Voice

Slot 2 GPS Location
(or second channel voice when not sending GPS data)

Give your location WHILE talking!
Dynamic Mixed Mode

Analog

OR

Slot 1 TDMA

Slot 2 TDMA

Analog

Slot 1 TDMA

Slot 2 TDMA

Repeater dynamically detects the type of input
IP site connect is supported on digital modes

This is an option for a phased migration from
analog to networked DMR repeaters.
IP Site Connect
1 or 2 slots (channels)

Link statewide/regionwide systems
IP Site Connect

- A peer can participate with one or both time-slots
- Peers register with the Master
- Master keeps peers informed about other peers
- Master/Peers function as a fully meshed network for voice and data traffic
- If the Master fails, the fully meshed network continues to operate, but new peers can not join nor are changes announced
- A third-party bridge is used to interconnect IP Site Connect networks
Text Messaging

Send to one person, or a group of people.

- Weather Alerts
- Club Meetings
- Announcements
3100 Site network in 48 US States, 63 Countries
- ND(6) and SD(12) not [yet] deployed
- Also bridged to other Motorola Repeater-Based DMR networks
- 100% Pure Digital
- 82,000+ registered user IDs
- To register or learn more
  - http://dmr-marc.net
DMR-Plus Network

- <100 Site network in the US and Europe
- Bridged to other Hytera repeater-based DMR networks
- 100% Pure Digital
- Allows interface to Motorola Repeaters (via R-pi & app)
- Shares user and repeater registration with DMR-MARC
- To register or learn more http://ham-dmr.de
BrandMeister Network

- Rival to DMR-MARC
- Bridged to other non-Motorola DMR networks
- 100% Pure Digital
- Allows and supports Multi-Vendor DMR repeaters
- Scanner-like monitoring via PC and Internet link
- Shares user and repeater registration with DMR-MARC
- This is the network to watch!
- To learn more https://brandmeister.network
WW Networked Repeaters
BrandMeister Home Page

User Dashboard

- **INDUSTRIAL**: 912 (Full report)
- **HOMEBREW**: 854 (Full report)
- **DV4MINIS**: 192 (Full report)
- **HOMEBREW**: 5174 (Full report)
- **MASTERS**: 43 (Full report)
- **VOICE CALLS**: 42 (Full report)

Map
Bronx TRBO Repeater Map
West Orange, NJ

name
West Orange, NJ

description
West Orange, NJ KC2NFB 446.225 - 5 MHz
Color Code 1

Time Slot
#1 - Group Call TG 444 Bronx Trbo System
Wide - FT
#2 - member only private Talk Groups

coverage: http://www.k2hr.com/W%20Orange.html
Talkgroup Support DMR-MARC

KB2RF Howell, NJ

description
KB2RF Howell, NJ

name
440.3000 +5 MHz Color Code 1
(Bridge Partner of DMR-MARC)

TS #2 - TG 2 = Tri-State (ON)
TS #1 - TG 3 = N. America (PTT)
TS #1 - TG 9 = Local Repeater (PTT)
TS #1 - TG 1 = World Wide (PTT)
TS #1 - TG 13 = WW English (PTT)
TS #1 - TG 95 = TAC 1 95 (PTT)
TS #1 - TG 3172 = Northeast Reg. (PTT)
TS #1 - TG 310 = TAC 310 (PTT)
TS #1 - TG 311 = TAC 311 (PTT)
TS #1 - TG 8951 = TAC 1 (PTT)
TS #1 - TG 8952 = TAC 2 (PTT)
TS #1 - TG 8953 = TAC 3 (PTT)
TS #1 - TG 3134 = NJ State (PTT)
TS #1 - TG 3136 = NY State (PTT)
TS #1 - TG 3142 = PA State (PTT)
TS #1 - TG 3125 = MA State (PTT)
TS #1 - TG 31121 = First - Coast - FL (PTT)
### BM Repeater Info 1

#### Repeater N2DMJ

<table>
<thead>
<tr>
<th>Repeater Info</th>
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<tbody>
<tr>
<td>Number</td>
<td>313442</td>
</tr>
<tr>
<td>City</td>
<td>Newark, New Jersey</td>
</tr>
<tr>
<td>Country</td>
<td>US</td>
</tr>
<tr>
<td>Website</td>
<td>Click here</td>
</tr>
<tr>
<td>Sysops</td>
<td>N2USB</td>
</tr>
<tr>
<td>Hardware</td>
<td>MMDVM (Repeater)</td>
</tr>
<tr>
<td>Firmware</td>
<td>20180222_Pi-Star</td>
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<tr>
<td>Power (EIRP)</td>
<td>10 Watt</td>
</tr>
<tr>
<td>Status</td>
<td>Slot 1 &amp; 2 linked</td>
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<tr>
<td>Master</td>
<td>BM3108</td>
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#### N2DMJ

<table>
<thead>
<tr>
<th>Time</th>
<th>Master</th>
<th>My call</th>
<th>Destination</th>
<th>Options</th>
<th>RSSI</th>
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</thead>
<tbody>
<tr>
<td>+ 87 Seconds</td>
<td>3108</td>
<td>N2DMJ [Daniel (3134893)]</td>
<td>Skynet (37030)</td>
<td>TS1 DMR</td>
<td>★</td>
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<tr>
<td>+ 18 Minutes</td>
<td>3108</td>
<td>N2DMJ [Daniel (3134893)]</td>
<td>Skynet (37030)</td>
<td>TS1 DMR</td>
<td>★</td>
</tr>
<tr>
<td>+ 21 Minutes</td>
<td>3108</td>
<td>N2DMJ [Daniel (3134893)]</td>
<td>Skynet (37030)</td>
<td>TS1 DMR</td>
<td>★</td>
</tr>
<tr>
<td>+ 21 Minutes</td>
<td>3108</td>
<td>N2DMJ [Daniel (3134893)]</td>
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<td>TS1 DMR</td>
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<td>★</td>
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Showing 1 to 5 of 5 entries
## BM Repeater Info 2

### Frequency Details

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<tr>
<td><strong>TX</strong></td>
<td>443.0900 MHz</td>
</tr>
<tr>
<td><strong>RX</strong></td>
<td>448.0000 MHz</td>
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<tr>
<td><strong>Shift</strong></td>
<td>5.000 MHz</td>
</tr>
<tr>
<td><strong>CC</strong></td>
<td>1</td>
</tr>
</tbody>
</table>

### Location

![Map of BM Repeater Location](map.png)

### Slot Details

- **Timeslot 1**: 370
- **Timeslot 2**: 37030

### Reflector

- **Disconnected**

### Antenna Details

<table>
<thead>
<tr>
<th>Antenna Height (AGL in m)</th>
<th>60 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna Height (AGL in ft)</td>
<td>196.8 ft</td>
</tr>
</tbody>
</table>
Motorola CPS
Connect Systems CPS
BFDX CPS
Anytone CPS
DMR Commercial Radios
DMR Amateur HTs
DMR Amateur Mobile
K1MOT Hudson Site
145 and 447 MHz MotoTRBO
- 50 watt Repeaters on
- 1400 VA UPS
- Kohler 14 KW Auto-start Generator
MMDVM Amateur Repeater Controller
Amateur DMR Growth by # Repeaters
Amateur DMR Growth by # Radio IDs
Some DMR Web Sites
(check out the links at these web sites)

- [http://www.dmr-marc.net/](http://www.dmr-marc.net/) (great general info)
- [http://groups.yahoo.com/group/MOTOTRBO/](http://groups.yahoo.com/group/MOTOTRBO/) (need to join the group to access some links)
- [http://brandmeister.network](http://brandmeister.network) (Brandmeister)
- [http://trbo.org](http://trbo.org) (Independent Digital Network)
- [http://hose.brandmeister.network](http://hose.brandmeister.network) (Listen In)
DMR: A NEW MODE FOR AMATEUR DIGITAL RADIO

- Spectrum Efficient!
- Supported by multiple manufacturers!
- Longer Battery Life!
- Resilient Networks (no internet needed)
- To learn more http://dmr-marc.net
Questions?

- Contact Kai Chen, k2trw@arrl.net
- Registration http://dmr-marc.net/contact.html
  - Reserve your DMR Identification Number
  - For your next DMR radio
    - KB Cubed LLC sales@kbcubed.com
    - Authorized Connect Systems Value Added Reseller
    - Barbara KD2JCK 201-660-5051
Acknowledgement

- Thanks to Bill NE1B for key slides
- Thanks to DMR-MARC for starting network
- Thanks to NJ-TRBO Bob KC2CWT
- Thanks to the many amateur radio infrastructure operators whom have put in much of their time, money and effort into making DMR possible for radio (terminal) users
- THANK YOU FOR YOUR TIME AND ATTENTION