Introduction to D-STAR Digital Voice

Roland Kraatz, W9HPX

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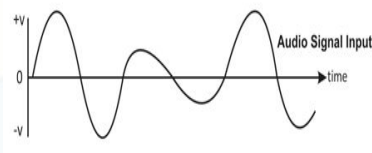
ARRL/TAPR Digital Communications Conference

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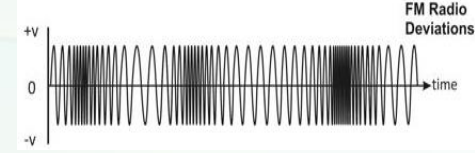Radio Group
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Topics

- How digital voice differs from FM
- Technical comparison of DV modes
- ICOM's D-STAR hardware evolution
- Networking
- Reflectors
- How to program the repeater memories
- Using DR mode features
- Questions

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How do FM & Digital Voice Differ?

FM transmit

MIC → [Audio Signal Input waveform] → Modulator → [FM Radio Deviations waveform]

How do FM & Digital Voice Differ?

FM transmit

MIC | Audio Signal Input | **Modulator** | FM Radio Deviations

Digital Voice transmit

MIC | Audio Signal Input | **Vocoder** | 1 1 1 0 1 0 1 1 1 0 1 0 0 | **Modulator**

AMBE by Digital
Voice Systems, Inc.

D-STAR – GMSK
DMR – 4FSK
Fusion – C4FM

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How do FM & Digital Voice Differ?

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Digital Voice transmit

MIC → Audio Signal Input → Vocoder → 1 1 1 0 1 0 1 1 1 0 1 0 0 → Modulator

AMBE by Digital Voice Systems, Inc.

D-STAR – GMSK
DMR – 4FSK
Fusion – C4FM

Digital Voice receive

Demodulator → 1 1 1 0 1 0 1 1 1 0 1 0 0 → Vocoder → Audio Signal Input → SPK

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Tech Spec Comparison

	D-STAR	DMR	Fusion	M17
Vocoder	AMBE+	AMBE+2	AMBE+2	Codec 2
Modulation	GMSK	4FSK	C4FM	4FSK
Multiplex Method	FDMA	TDMA	FDMA	FDMA
Transmission Rate	4.8 kbps	4.8 kbps x 2	9.6 kbps	9.6 kbps
Bandwidth	6.25 kHz	12.5 kHz	12.5 kHz	9 kHz
Channels supported	1	2	1	1
Standard Developer	JARL	ETSI	Yaesu	M17 Team

AMBE = Advanced Multi-Band Excitation (patented Digital Voice Systems, Inc.)
Codec 2 = Codec 2 developed by David Rowe, VK5DGR, (LGPL license)
GMSK = Gaussian Minimum Shift Keying
4FSK = 4-level Frequency Shift Keying
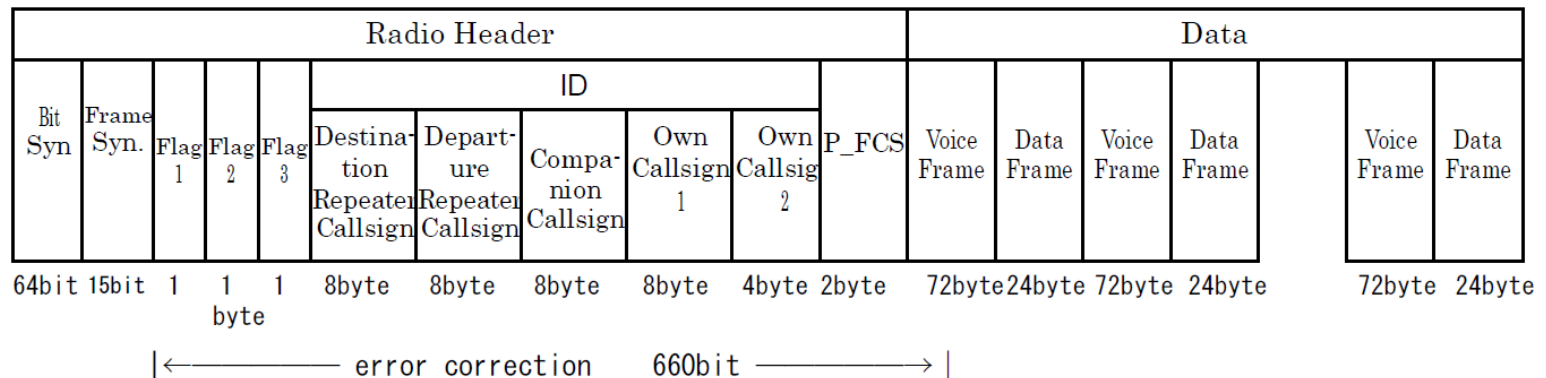C4FM = Continuous 4-level Frequency Modulation
FDMA = Frequency Division Multiple Access
TDMA = Time Division Multiple Access

Only D-STAR is narrow enough to use on HF

Digital Voice Packet Structure

- Digital voice is transmitted in packets with a header and a payload as described in the JARL specifications at https://www.jarl.com/d-star/shogen.pdf

Radio Header											Data						
					ID												
Bit Syn	Frame Syn.	Flag 1	Flag 2	Flag 3	Destination Repeater Callsign	Departure Repeater Callsign	Companion Callsign	Own Callsign 1	Own Callsig 2	P_FCS	Voice Frame	Data Frame	Voice Frame	Data Frame		Voice Frame	Data Frame
64bit	15bit	1	1 byte	1	8byte	8byte	8byte	8byte	4byte	2byte	72byte	24byte	72byte	24byte		72byte	24byte

|←——— error correction   660bit ———→|

- The digital data packet has a different payload.
- The header has four 8-byte ASCII callsign fields that provide ID and signal destination information.

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Four Header Callsign Fields

- R1: Destination (receiving) repeater callsign including module. Ex. KI4WXS C (8 bytes)

- R2: Departure (forwarding) repeater callsign where to send the packets. Ex. KI4WXS G (8 bytes)

- UR: Companion callsign directs the receiving station to do certain things   CQCQCQ means calling anyone. (8 bytes)

- MY – Own callsign. Your callsign / 4 added characters. (8 & 4 bytes)

CALL SIGN
UR: CQCQCQ
R1: KI4WXS C
R2: KI4WXS G
MY: W9HPX   /ID52

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ICOM's Early D-STAR Radios

- ICOM began releasing D-STAR radios in 2004 beginning with the IC-2200H mobile.

- The ID-1 released in late 2004 was the first 1.2 GHz mobile radio with 128 kbps digital data (DD) capability through an RJ-45 jack.

- Single band HTs with DV capability were released in 2005 and the IC-91AD dual band in 2006.

- These all needed an optional board to do D-STAR.

- Users had to manually program repeaters into memories using either software or front panel entry.

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ICOM's D-STAR Features

- Talk radio to radio (simplex) with FM or DV.

- Talk on a local DV repeater in DV mode.

- Talk on a local DV repeater to another DV repeater anywhere. This is called talking between zones.

- Talk on a local DV repeater to a specific ham without knowing where he is located. This is called callsign routing.

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Why Network a Repeater?

- Repeaters are very quiet without users.

- Connectivity brings more users to the repeater and increases the coverage area.

- Wide area nets become possible.

- Giving users control gives them choices, but some repeater owners prefer to limit control.

- Access Points (hotspots) give the user full control.

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The Creation of Reflectors

- US hams wanted to use D-STAR differently than JARL's original plan.

- Robin Cutshaw, AA4RC, in Atlanta wrote D-Plus, an add-on to ICOM's repeater software that allows multiple D-STAR repeaters to be linked together.

- The software duplicates the data stream and resends it (reflects) to all the other linked repeaters.

- D-Plus is therefore known as a reflector system.

- ICOM has embraced this and incorporated it in the design of their later D-STAR radios.

Reflector – What is it?

- Reflectors are not unique to D-STAR?
- Other DV modes also use them, but they are named differently:
  - D-STAR calls them Reflectors
  - DMR calls them Talk Groups
  - WIRES-X – Yaesu calls them Rooms
- Hams have created many reflector systems:
  - D-STAR – REF, XRF, DCS, XLX
  - DMR – IPSC (Motorola), IPMSC (Hytera), PCS, BrandMeister (DMR+), TGIF (DMR+)
  - Fusion – WIRES-X Rooms, YSF reflectors, FCS reflectors

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ICOM 2ⁿᵈ Gen D-STAR Radios

- These radios still required a separate D-STAR board.

- HT's
  - IC-92AD (2008) – GPS capable with a special speaker mic.
  - IC-80AD (2009)

- Mobile's
  - IC-2820H (2008) – GPS capable, diversity receive capable
  - ID-880H (2009)

- Base Station
  - IC-9100 (2011) – HF through 1.2 GHz (opt.) all mode radio

ICOM 3rd Gen D-STAR Radios

- ICOM introduced DSP built-in vocoder, SD card, QSO recording, DR mode (GPS near repeater search.)

- HT's
  - ID-31 (2013) – UHF only, internal GPS, SD card slot.
  - ID-51AD (2013) – Internal GPS, SD card slot.

- Mobile's
  - ID-5100A (2014) – Internal GPS, SD card slot, touch screen, Bluetooth.
  - ID-4100A (2017) - Internal GPS, SD card slot, Bluetooth.

- Base Station/Mobile
  - IC-7100 (2013) – HF through 450 MHz all mode radio, GPS support with 3rd party GPS receiver.

Current D-STAR Radios

- DR Mode, GPS, and SD card slots are now found in all ICOM's current radios.

- ICOM added Picture Mode, Spectrum Scope/ Waterfall, Terminal and Access Point Modes

- HT
  - ID-52A (2019) – Color screen, improved RX audio, Bluetooth.

- Portable
  - IC-705 (2020) – QRP, all mode HF through 450 MHz, battery operation, color touch screen, spectrum scope, Bluetooth.

- Base Station
  - IC-9700 (2019) - VHF/UHF/1.2G software defined radio, color touch screen, spectrum scope, Digital Data capability.

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Future D-STAR Radio

- Current ICOM D-STAR radio technology is mature, but there are new horizons

- Base Station

  - IC-905 (not yet released) –
    VHF/UHF/SHF all mode transceiver -
    144, 440, 1200, 2400, 5600 MHz,
    10 GHz (optional)

RF Module ▲

Controller ▲

DR Mode Features

- Makes most efficient use of available memories.

- Easy to update repeater frequencies, both FM and DV.

- Easy to find nearest repeaters, FM or DV or both.

- Easy to dial UR commands to the repeater to:
  - Link to a reflector.
  - Unlink from a reflector.
  - Find out what the repeater is linked to.
  - Echo test your TX audio.
  - Call sign route to someone.
  - Select a local call or a gateway call (Use reflector).

- Newest ICOM radios have 2500 Repeater Memories to fill. ICOM ships the radio with a Repeater List.

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Repeater Memory Programming

- How do you program all those memories?

- Go to www.dstarinfo.com
  - Click on Downloads / Repeater List Downloads for DR Mode Radios
  - Enter your geographic location
  - Click Lookup Location
  - Select your radio model
  - Select number of Empty Repeater Slots (I do 3 or 4)
  - Select percent FM (I do 70%-80%)
  - Click Download

- You will now have a .csv file on your PC which can be viewed and edited with Excel if desired.

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Repeater Memory Programming

- Insert your SD card into your PC (adaptor if used). SD card must have been formatted in your radio.

- Copy the .csv file(s) from your PC to the SD card placing it into the Csv/RptList folder.

- Put the SD card back into the radio.

  - Press Menu.
  - navigate to Set /SD Card /Import/Export /Import /Repeater List /<file name> /Import file /YES
  - When complete, power cycle the radio.

- You have now programmed 2,500 DV and FM repeaters into your radio.

Your Callsign (UR) Memories

- There are up to 300 UR memories in D-STAR radios.

- They hold the commands you will send to the repeater to do Linking, Unlinking, Echo Test, Callsign Routing, etc.

- These must be programmed by you to meet your needs.

- Each memory holds a name and a command.

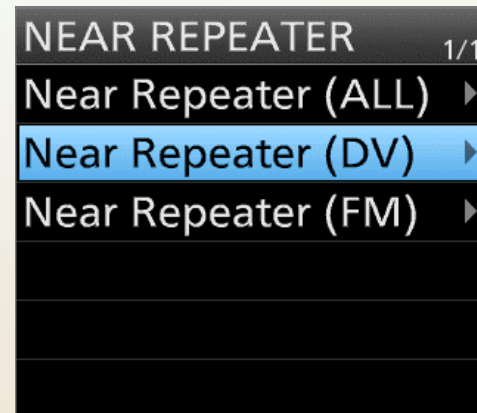| Your Call Sign	(Remain 288 memories)	
No.	Name	Call Sign
1	Use Reflector	CQCQCQ
2	Unlink REF	U
3	REF Status	I
4	Echo Test	E
5	link to REF001C	REF001CL
6	link to REF012A	REF012AL
7	link to REF030C	REF030CL
8	link to REF038A	REF038AL
9	link to REF038C	REF038CL
10	link to REF054C	REF054CL
11	link to XRF054C	XRF054CL
12	link to DCS054A	DCS054AL
New		

Using the DR Mode

- To enter the DR mode long press the DR button. You will see a screen like this:

- Scroll down to highlight the From part of the screen. Press the blue Enter button.

Using the DR Mode – Find Repeater

- You will be given this screen. Select Near Repeater and press Enter.

- You will be given a choice of ALL, DV, or FM. Select one and press Enter. If you have a good GPS position…

FROM SELECT 1/1
Repeater List ▶
Near Repeater ▶
TX History ▶

NEAR REPEATER 1/1
Near Repeater (ALL) ▶
Near Repeater (DV) ▶
Near Repeater (FM) ▶

Using the DR Mode – Find Repeater

- You will be given a repeater list sorted by closest first. It will see the direction and distance from you. Scroll for more repeaters.

- Select the one you want, and press Enter.

NEAR REPEATER (DV)   1/4
Indian Land Spot
Wingate
Charlotte
Charlotte
Gastonia
0.1mi   W9HPX B

NEAR REPEATER (DV)   2/4
Gastonia
Shelby
Shelby
ALBEMARLE
ALBEMARLE
32mi   KK4JDH B

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Using the DR Mode – Find Repeater

- You will be taken to the DR mode starting screen. Your radio is now ready to use the repeater.
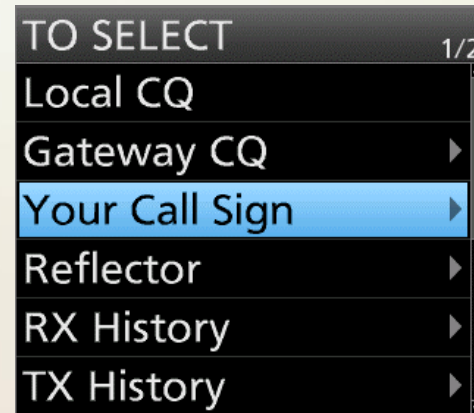
Using the DR Mode – UR Commands

- Select the TO part of the DR mode screen. Press Enter.

- Select the option you want from the menu. I select Your Call Sign because it contains my most used commands. Press Enter.

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Using the DR Mode – UR Commands

- You are now in the Your Call Sign memories. Select the command you want to use. Press Enter.

- You will be taken back to the DR mode starting screen.

- Your radio is ready to use.

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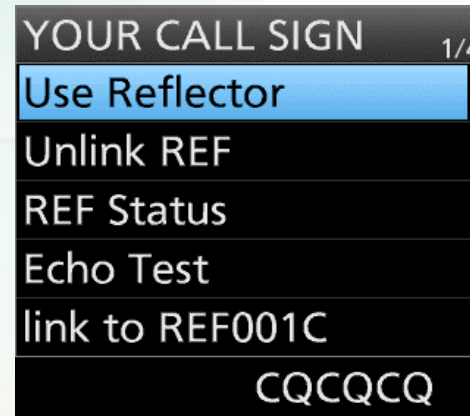
Using the DR Mode – UR Commands

- To access any of the commands in the Your Call Sign Memories rotate the dial to the one you want.

- With that command showing press PTT to send it to the repeater.

- Then turn the dial back to Use Repeater CQCQCQ to talk.

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Additional Information Sources

- http://www.charlottedstar.org/ – This is our web site. These slides will be posted on the site. https://groups.io/g/CharlotteDigitalRadio – This is our group. Please join to keep up with what we are doing. Post a message or a question.

- http://www.charlottedstar.org/D-STAR DR Mode.pdf – How to use DR mode.

- www.dstarinfo.com – download current repeater data (.csv file) to import into your compatible D-STAR radio.

- www.dstarusers.org – Official D-STAR repeater directory.

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D-STAR

THANKS FOR LISTENING

QUESTIONS?