

MOONEER SALEM K6AQ

FREEDV DIGITAL VOICE

ABOUT ME

- ▶ Been licensed since the early 2000s
 - ▶ KG6AOV was my original callsign
- ▶ Currently a software developer at a medical device company
 - ▶ Primarily C/C++ with some C# and Python thrown in
- ▶ Do open source development in my spare time
 - ▶ FreeDV being the biggest so far

WHAT IS DIGITAL VOICE?

- ▶ A method of modulating a digitized voice signal for transmission
 - ▶ Analog voice is fed in via an A/D converter (e.g. sound card)
 - ▶ Software modulates the digital audio into a form that can be transmitted with a radio
 - ▶ Process is done in reverse for receive

BENEFITS OF DIGITAL VOICE

- ▶ Less bandwidth than a similar analog signal
 - ▶ FM is ~15KHz for comparison
 - ▶ Many digital voice modes cut this in half or potentially more
- ▶ Potentially better resilience as the signal gets weaker
 - ▶ Digitization of received signal inherently adds some noise immunity
 - ▶ Forward error correction can potentially fix significant issues

DISADVANTAGES OF DIGITAL VOICE

- ▶ “Digital cliff” effect limits ability to pull signal out of the noise
 - ▶ Analog TV vs. ATSC digital TV during DTV transition
- ▶ More difficult to implement compared to traditional modes
 - ▶ Transceiver circuits readily available for traditional modes
 - ▶ Potentially no need to include a microcontroller or other computer control

DOES AMATEUR RADIO USE IT TODAY?

- ▶ D-Star first developed in 2001
 - ▶ Started being supported in Icom radios in 2004
 - ▶ ...and a few non-Icom radios too!
- ▶ 4800 bps GMSK data stream in 6.25 KHz bandwidth
 - ▶ 3600 bps for voice (incl. FEC)
 - ▶ 1200 bps for additional data

DOES AMATEUR RADIO USE IT TODAY?

- ▶ Yaesu System Fusion is another common digital voice mode
 - ▶ Continuous 4-Level Frequency Modulation (C4FM)
 - ▶ 12.5 KHz bandwidth, 9600 bps max bitrate
 - ▶ Forward Error Correction also used

DOES AMATEUR RADIO USE IT TODAY?

- ▶ Amateur radio has adapted existing DV modes as well
 - ▶ Examples: DMR, P25, NXDN
 - ▶ DMR in particular is similar to D-STAR and Fusion
- ▶ Demonstrates strong demand for this part of the hobby
 - ▶ DMR has 232,500 unique radio IDs (as of January 2023)
 - ▶ Large interest in new M17 mode too

WHY NOT AS MUCH USED ON HF?

- ▶ HF in general is a big ask for most
 - ▶ Typically requires General or Extra (with limited exemptions)
 - ▶ Requires more/costlier hardware (e.g. HF radio)
 - ▶ HOA, landlord, etc. restrictions may limit your on-air presence
- ▶ Subject to whatever RFI producing electronics your neighbors have
 - ▶ Many of course can still make it work

WHY NOT AS MUCH USED ON HF?

- ▶ The existing modes use far more bandwidth than is standard
 - ▶ Typical SSB voice signal is ~3KHz for comparison
 - ▶ Approximately as wide as AM at best (e.g. 6.25 KHz for D-STAR)
 - ▶ Limits the locations on the bands where it can be used

WHY NOT AS MUCH USED ON HF?

- ▶ VHF/UHF+ propagation is significantly different than HF
 - ▶ Slow/fast fading (sometimes selectively)
 - ▶ Available bands depend on the sunspot cycle/time of day
 - ▶ Geomagnetic storms can shut off HF entirely

WHY NOT AS MUCH USED ON HF?

- ▶ The existing modes have patent issues
 - ▶ AMBE codec as used in DMR and Fusion expires in 2028 (!)
 - ▶ D-Star is now okay, however
- ▶ Developing a legal product results in increased costs
 - ▶ Such costs may be prohibitive for many

WHAT IS AVAILABLE ON HF?

- ▶ D-Star is capable of being used on HF
 - ▶ The only legacy VHF/UHF+ DV mode that can be
 - ▶ Requires an HF-capable Icom radio—a significant expense!
 - ▶ 6KHz bandwidth means limits on where it can be used

WHAT IS AVAILABLE ON HF?

- ▶ AOR digital voice modems
 - ▶ Limited hardware availability (“made to order”)
 - ▶ Significantly expensive even when new



 Free Shipping!

AOR USA ARD9800

Digital Voice and Image Interface with Hand Mic and Cables

Special Order Item!*

HRO Discount Price: \$789.95*

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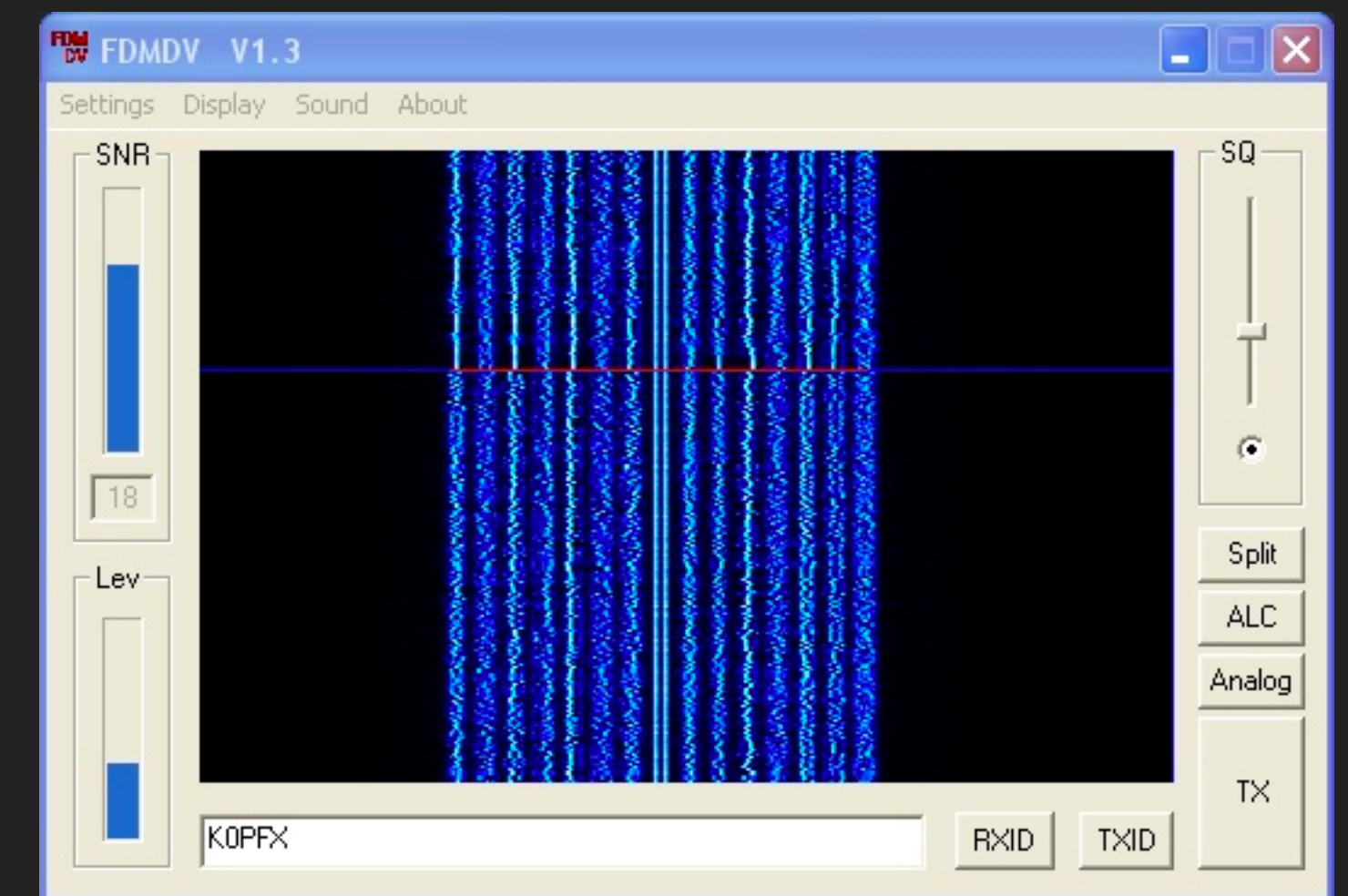
 Add To Wish List

WHAT DOES FREEDV PROVIDE?

- ▶ Digital voice modes optimized for HF band conditions
 - ▶ 1 to 1.5KHz bandwidth and can handle fading, etc.
- ▶ A way to use digital voice with your existing radios
 - ▶ If you're already using FT8, you can use FreeDV
- ▶ Most importantly: open source and non patent encumbered

HISTORY

- ▶ Was originally a program called FDMDV
 - ▶ In use during the 2000s
 - ▶ Codec based on commercial products
 - ▶ Licensing issues prevented further development with the codec



HISTORY

- ▶ David Rowe (VK5DGR) implemented Codec2
 - ▶ Open source digital voice library for radio use
 - ▶ Implemented in what is now FreeDV
 - ▶ Licensed under LGPL 2.1
- ▶ 1600 mode initially implemented
 - ▶ 700E is the most recent stable mode (2020)

HISTORY

- ▶ Significant additional development kicked off 2020-21
 - ▶ “Multiple RX” support
 - ▶ PSK Reporter integration
 - ▶ Usability enhancements/bug fixes
 - ▶ 700E mode

HISTORY

- ▶ Qualitative testing performed to determine performance
 - ▶ Transmitted analog signal followed by FreeDV signal
 - ▶ Both used the same peak power levels
 - ▶ Automated transmission and recording of received signals
- ▶ See August 2021 QSO Today talk "Making The Most of Your Station With HF Digital Voice" for more

FREEDV NOW PART OF SOFTWARE FREEDOM CONSERVANCY

- ▶ Benefits to community
 - ▶ 501(c)3 organization for tax-deductible donations
 - ▶ Gained ability to obtain grant funds for future development (for example, from ARDC)
 - ▶ More formal project structure to better direct development
 - ▶ Better support open source hardware/software in general
- ▶ More info and donations at <https://sfconservancy.org/>

MODES AVAILABLE

- ▶ Several modes to choose from based on current band conditions
 - ▶ Commonly used: 700D/E, 1600, 2020
 - ▶ All modes use some form of QPSK modulation
- ▶ 700D uses the least bandwidth (~1KHz)
 - ▶ Can operate down to -2 dB SNR
 - ▶ Best for those with compromised stations/low power

700D EXAMPLE

MODES AVAILABLE

- ▶ 700E is optimized for fast fading
 - ▶ 1.5KHz bandwidth
 - ▶ Can operate down to 1 dB SNR
 - ▶ Best for NVIS paths (~several hundred miles)

700E EXAMPLE

MODES AVAILABLE

- ▶ 1600 is the original FreeDV mode
 - ▶ ~1.1KHz bandwidth, 4dB minimum SNR
 - ▶ Constant pilot carrier in the center of the signal
 - ▶ Previously used for satellite contacts

1600 EXAMPLE

MODES AVAILABLE

- ▶ 2020 is the highest quality
 - ▶ 1.6KHz bandwidth
 - ▶ Requires a bit more SNR than the others (2dB)
 - ▶ Sounds great if band conditions are good

2020 EXAMPLE

IS IT LEGAL?

- ▶ Disclaimer: I am not a lawyer! Please seek expert legal advice.
 - ▶ This will also vary for operation outside of the US
- ▶ The ARRL considers digital voice as having designator J2E
 - ▶ J = SSB, 2 = single channel with digital information , E = telephony
- ▶ See "Practical HF Digital Voice", May/June 2000 QEX

IS IT LEGAL?

- ▶ J2E is considered a “phone” emission per §97.3(5)(c)
 - ▶ §97.305(c) thus governs where DV can be used on HF
 - ▶ 60 meters is not allowed (§97.307(f)(14)(i) limits phone to J3E)
- ▶ The standard FCC rules/“considerate operator” practices apply as always
 - ▶ ID every 10 minutes, only as much power as needed, etc.

WHERE CAN IT BE USED

- ▶ Standard conventions match analog voice
 - ▶ USB > 10MHz, LSB < 10MHz
- ▶ Most activity is on 14.236 MHz +/- QRM
 - ▶ 7.177 MHz, 28.330 MHz also common

USING FREEDV

GETTING ON THE AIR

- ▶ FreeDV client application
 - ▶ Available at <https://freedv.org/>
 - ▶ Binaries for Windows (32/64 bit) as well as Mac (Intel/ARM)
 - ▶ Source code on GitHub
- ▶ Requires two sound cards to transmit
 - ▶ One of them is likely the same one you use for other digital modes

GETTING ON THE AIR

- ▶ SM1000 handheld microphone
 - ▶ US\$205 as of October 2021
 - ▶ Supports 700D/E as well as 1600
- ▶ Only need RJ45<->Radio + power
 - ▶ Good for portable use
- ▶ Unfortunately sold out due to chip shortage



EASY SETUP

- ▶ A new startup screen to streamline FreeDV setup
- ▶ Single radio audio device (e.g. one plugged in via USB)
- ▶ Supports CAT control and serial PTT configuration
- ▶ "Test" button keys radio and emits a constant carrier

The screenshot shows the 'Easy Setup' window for FreeDV, which is divided into three main sections:

- Step 1: Select Sound Device**
 - Radio Device: VB-Cable
 - Decoded audio plays back through: MacBook Pro Speakers
 - Transmitted audio records through: MacBook Pro Microphone
 - Advanced button
- Step 2: Setup Radio Control**
 - Radio Control Options: ☐ No PTT/CAT Control, ☒ Hamlib CAT Control, ☐ Serial PTT
 - Hamlib CAT Control section:
 - Rig Model: Hamlib NET rigctl
 - Serial Device (or hostname:port): localhost:4533
 - Serial Rate: default
 - Advanced and Test buttons
- Step 3: Setup Reporting**
 - ☒ Enable Reporting
 - Callsign: K6AQ
 - Grid Square: DM12kw
 - OK, Cancel, and Apply buttons

ADVANCED SETUP

- ▶ Still possible (and required depending on setup)
 - ▶ Example: SDR radios using multiple virtual audio cables
- ▶ Minimum setup: sound card configuration
- ▶ Additional optional setup:
 - ▶ CAT control/serial PTT (if not using a VOX based digital interface)
 - ▶ PSK Reporter reporting

SOUND CARD CONFIGURATION

- ▶ Tools->Audio Options
 - ▶ Two tabs: Receive and Transmit
 - ▶ Typically audio devices are reversed on the Transmit tab

EXAMPLE AUDIO CONFIGURATION

Audio Config

Input To Computer From Radio

Device	ID	API	Default Sample Rate
Background Music	0	Core Audio	8000
Background Music (UI Sounds)	1	Core Audio	8000
MacBook Pro Microphone	2	Core Audio	48000
Soundflower (2ch)	4	Core Audio	44100
Soundflower (64ch)	5	Core Audio	44100
VB-Cable	6	Core Audio	48000
VB-Cable A	7	Core Audio	48000
VB-Cable B	8	Core Audio	48000
NoMachine Audio Adapter	9	Core Audio	48000
NoMachine Microphone Adapter	10	Core Audio	48000

Device: VB-Cable A Sample Rate: 48000

Rec 2s

Output From Computer To Speaker/Headphones

Device	ID	API	Default Sample Rate
Background Music	0	Core Audio	8000
Background Music (UI Sounds)	1	Core Audio	8000
MacBook Pro Speakers	3	Core Audio	48000
Soundflower (2ch)	4	Core Audio	44100
Soundflower (64ch)	5	Core Audio	44100
VB-Cable	6	Core Audio	48000
VB-Cable A	7	Core Audio	48000
VB-Cable B	8	Core Audio	48000
NoMachine Audio Adapter	9	Core Audio	48000
NoMachine Microphone Adapter	10	Core Audio	48000

Device: MacBook Pro Speakers Sample Rate: 48000

Play 2s

Receive

Transmit

Refresh

Cancel

Apply

OK

Audio Config

Input From Microphone To Computer

Device	ID	API	Default Sample Rate
Background Music	0	Core Audio	8000
Background Music (UI Sounds)	1	Core Audio	8000
MacBook Pro Microphone	2	Core Audio	48000
Soundflower (2ch)	4	Core Audio	44100
Soundflower (64ch)	5	Core Audio	44100
VB-Cable	6	Core Audio	48000
VB-Cable A	7	Core Audio	48000
VB-Cable B	8	Core Audio	48000
NoMachine Audio Adapter	9	Core Audio	48000
NoMachine Microphone Adapter	10	Core Audio	48000

Device: MacBook Pro Microphone Sample Rate: 48000

Rec 2s

Output From Computer To Radio

Device	ID	API	Default Sample Rate
Background Music	0	Core Audio	8000
Background Music (UI Sounds)	1	Core Audio	8000
MacBook Pro Speakers	3	Core Audio	48000
Soundflower (2ch)	4	Core Audio	44100
Soundflower (64ch)	5	Core Audio	44100
VB-Cable	6	Core Audio	48000
VB-Cable A	7	Core Audio	48000
VB-Cable B	8	Core Audio	48000
NoMachine Audio Adapter	9	Core Audio	48000
NoMachine Microphone Adapter	10	Core Audio	48000

Device: VB-Cable B Sample Rate: 48000

Play 2s

Receive

Transmit

Refresh

Cancel

Apply

OK

CAT/PTT CONTROL

- ▶ Tools->PTT Config
 - ▶ Supports all radios that Hamlib does
 - ▶ Can also use serial PTT if preferred

EXAMPLE PTT CONFIGURATION

PTT Config

VOX PTT Settings

☐

Left Channel Vox Tone

Hamlib Settings

☒

Use Hamlib PTT

Rig Model:

Kenwood TS-2000

Serial Device (or hostname:port):

localhost:5001

Serial Rate:

default

Serial Params:

Serial Port Settings

PTT Port

☐

Use Serial Port PTT

☐

Use DTR

☐DTR = +V

☒

Use RTS

☒RTS = +V

Serial Device:

PTT In

☐

Enable PTT Input

Serial Device:

☐

CTS = +V

Test PTT

OK

Cancel

Apply

REPORTING

- ▶ Tools->Options in the Reporting tab
 - ▶ PSK Reporter support: callsign and grid square
 - ▶ You can also transmit a free-form text field instead

PSK REPORTER EXAMPLE

Options

Reporting

Display

Voice Keyer

Modem

Simulation

UDP

Debugging

Txt Msg

PSK Reporter

☒ Enable Reporting

Callsign:

K6AQ

Grid Square:

DM12kw

OK

Cancel

Apply

HOW TO FIND CONTACTS

- ▶ FreeDV QSO Finder: <http://qso.freedv.org/>
 - ▶ Chatroom style interface with "current frequency" indicators
 - ▶ Coordinate with other users live
- ▶ PSK Reporter
 - ▶ Map based view of who can decode your signal

HOW TO FIND CONTACTS

On , show sent/rcvd by using over the last [Display options](#) [Permalink](#)

Automatic refresh in 5 minutes. Large markers are monitors. [Display all reports.](#)

There are [4 active FREEDV monitors](#) on 40m. [Show all FREEDV on all bands.](#) [Show all on all bands.](#) [Legend](#)

The map displays a network of signal paths (yellow lines) connecting various locations (pins). The locations are primarily concentrated in the North Atlantic, the Caribbean Sea, and Europe. The map includes labels for various countries and bodies of water. A legend in the top right corner indicates that large markers are monitors and that the map shows signals sent/rcvd by anyone using FREEDV over the last 24 hours. There are 4 active FREEDV monitors on 40m. Links are provided to show all FREEDV on all bands, show all on all bands, and a legend.

HOW TO FIND CONTACTS

- ▶ FreeDV Activity Day
 - ▶ Third weekend of every month (both Saturday and Sunday)
 - ▶ 12AM Pacific (0800Z) - 11:59PM Pacific (0759Z)
 - ▶ Not a contest! Just a time for people to get together on the air

DISCORD

- ▶ A chat service that enables troubleshooting and QSO coordination
- ▶ Go to <https://discord.gg/QrZDwy5n7K> to join (or scan QR code)



DISCORD

FreeDV HF Digital Voice

Events

announcements

rules

TEXT CHANNELS

general

qso-finder

moderator-only

VOICE CHANNELS

General

OTHER NETWORKS

freedv-irc

qso-finder

Find people on the air to chat with here! 14.236 MHz is also...

PSK Reporter BOT

Yesterday at 7:10 PM

JA4ECX (PM64VU11TQ) received JA3JHG (PM85AC) on 7200.000 KHz on 2023-01-17 03:06:07

PSK Reporter BOT

Yesterday at 11:30 PM

JA4ECX (PM64VU11TQ) received JA3JHG (PM85AC) on 7200.000 KHz on 2023-01-17 07:25:37

PSK Reporter BOT

Yesterday at 11:50 PM

JA4ECX (PM64VU11TQ) received JA3JHG (PM85AC) on 7200.000 KHz on 2023-01-17 07:46:15

January 17, 2023

PSK Reporter BOT

Today at 3:10 PM

KOPFX (EM48US) received K5WH (EL29fx) on 14236.000 KHz on 2023-01-17 23:07:08

WA6NUT (DM68wt39) received K5WH (EL29fx) on 14236.000 KHz on 2023-01-17 23:05:04

KOSHD (EN14kv08) received K5WH (EL29fx) on 14236.000 KHz on 2023-01-17 23:05:00

SPECIAL THANKS

- ▶ David Rowe VK5DGR - Maintainer of FreeDV/Codec2 and developer of the various FreeDV modes
- ▶ Walter Holmes K5WH - Rapid turnaround on testing for new FreeDV builds and general FreeDV advocacy
- ▶ Jose Donnari LU5DKI - Assisting with automated testing and also FreeDV advocacy
- ▶ ...and way more other people than can be listed here!

Q&A

THANK YOU!

- ▶ Contact me anytime with questions
 - ▶ Email: mooneer@gmail.com
 - ▶ Discord: tmiw#9019
 - ▶ Personal GitHub: <https://github.com/tmiw>