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?

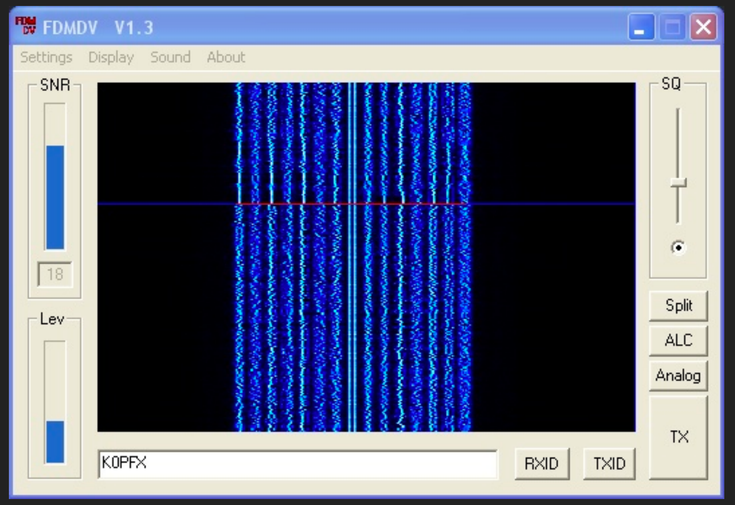
- AOR digital voice modems
  - Limited hardware availability (“made to order”)
  - Significantly expensive even when new

# 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

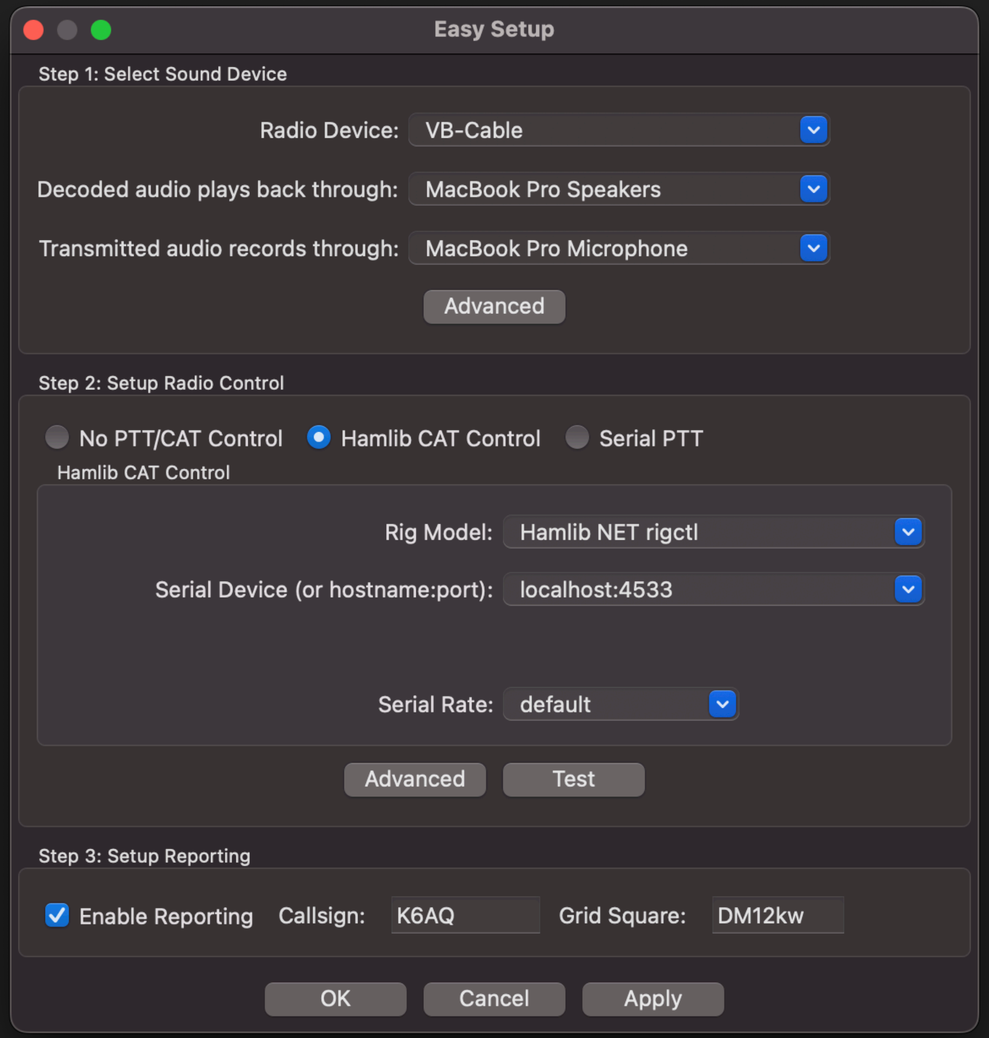
- FreeDV client application
  - Available at https://freedv.org/
  - Binaries for Windows (32/64 bit) as well as Mac (Intel/ARM)
  - Source code on GitHub
- Requires two sound cards to transmit
  - One of them is likely the same one you use for other digital modes

# 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



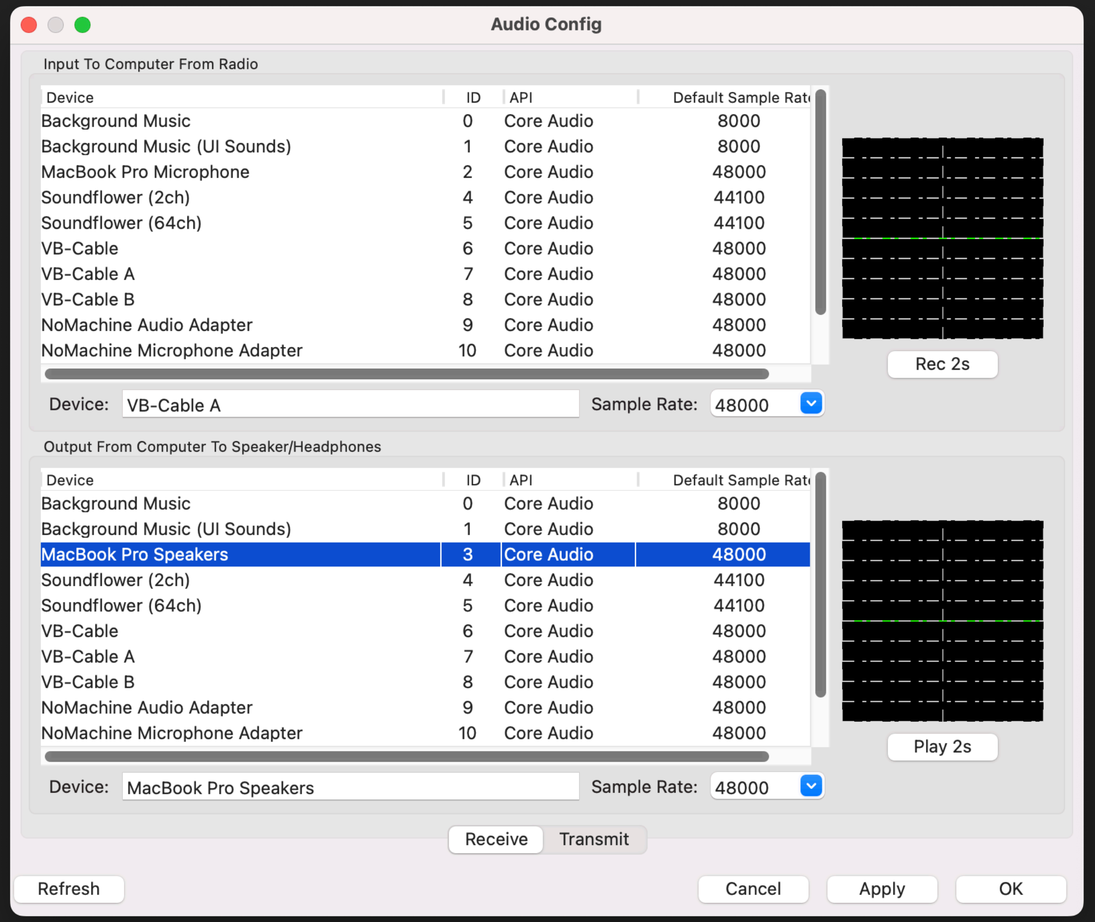
# ADVANCED SETUP

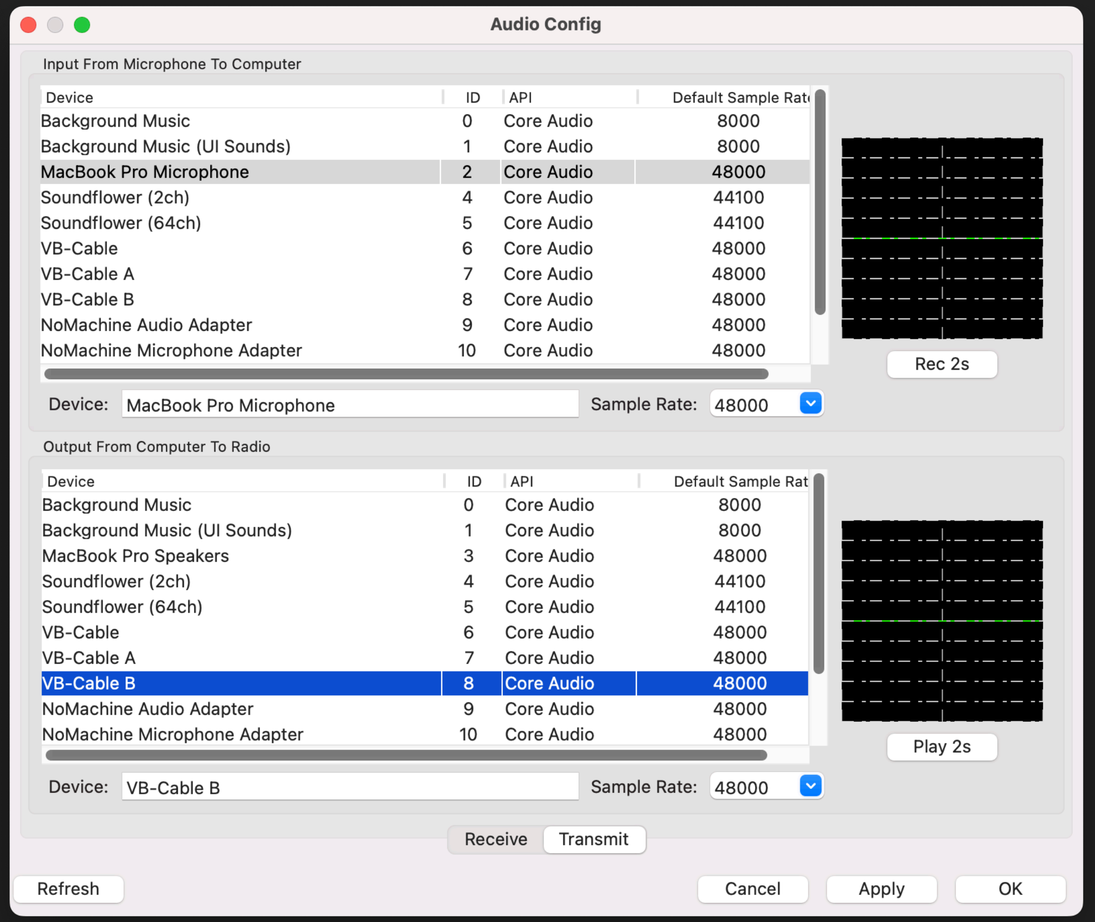
- Still possible (and required depending on setup)
  - Example: SDR radios using multiple virtual audio cables
- Minimum setup: sound card configuration
- Additional optional setup:
  - CAT control/serial PTT (if not using a VOX based digital interface)
  - PSK Reporter reporting

# SOUND CARD CONFIGURATION

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

# EXAMPLE AUDIO CONFIGURATION

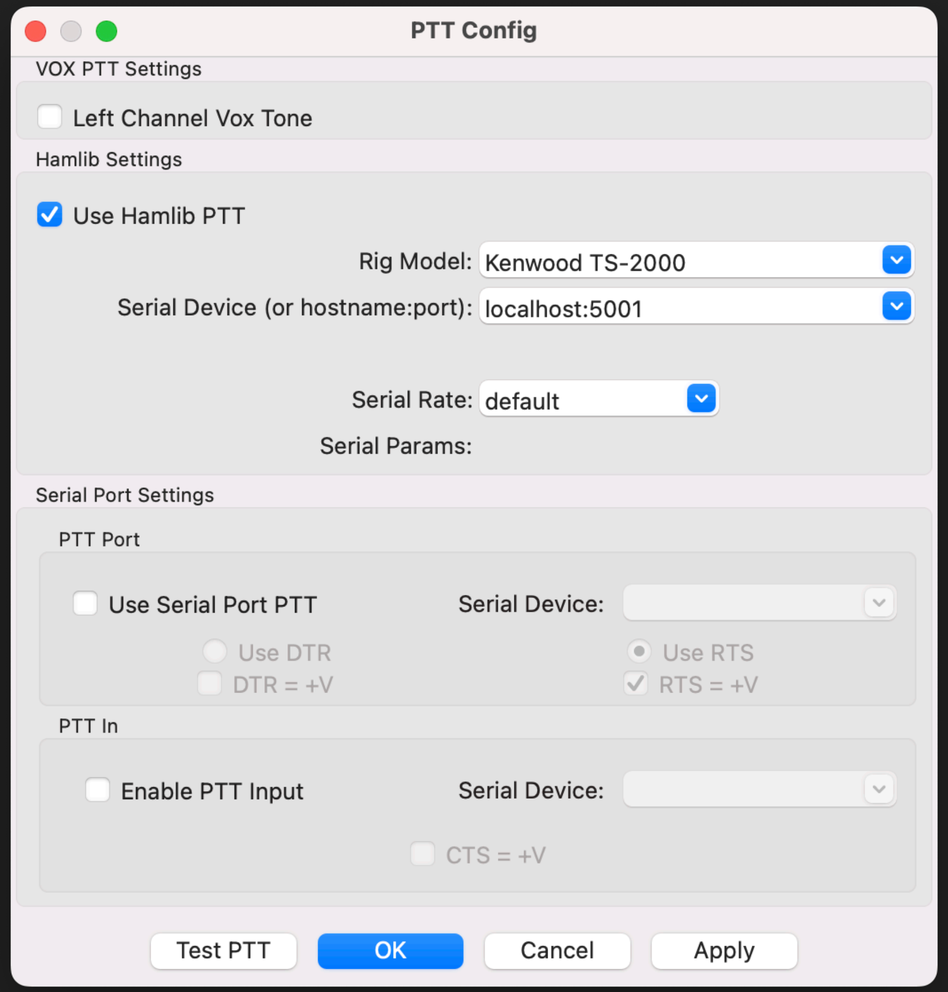


# CAT/PTT CONTROL

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

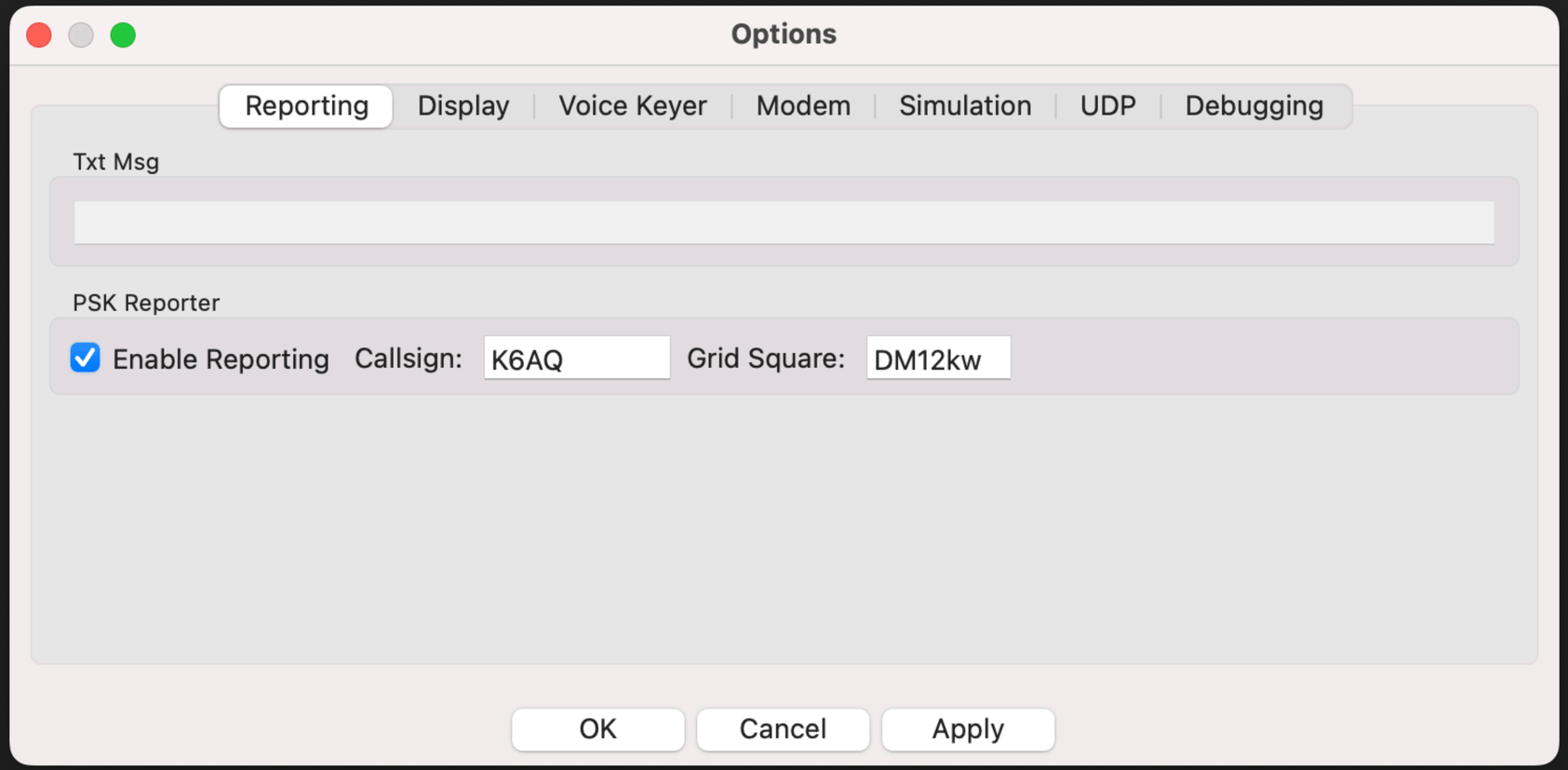
# EXAMPLE PTT CONFIGURATION



# REPORTING

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

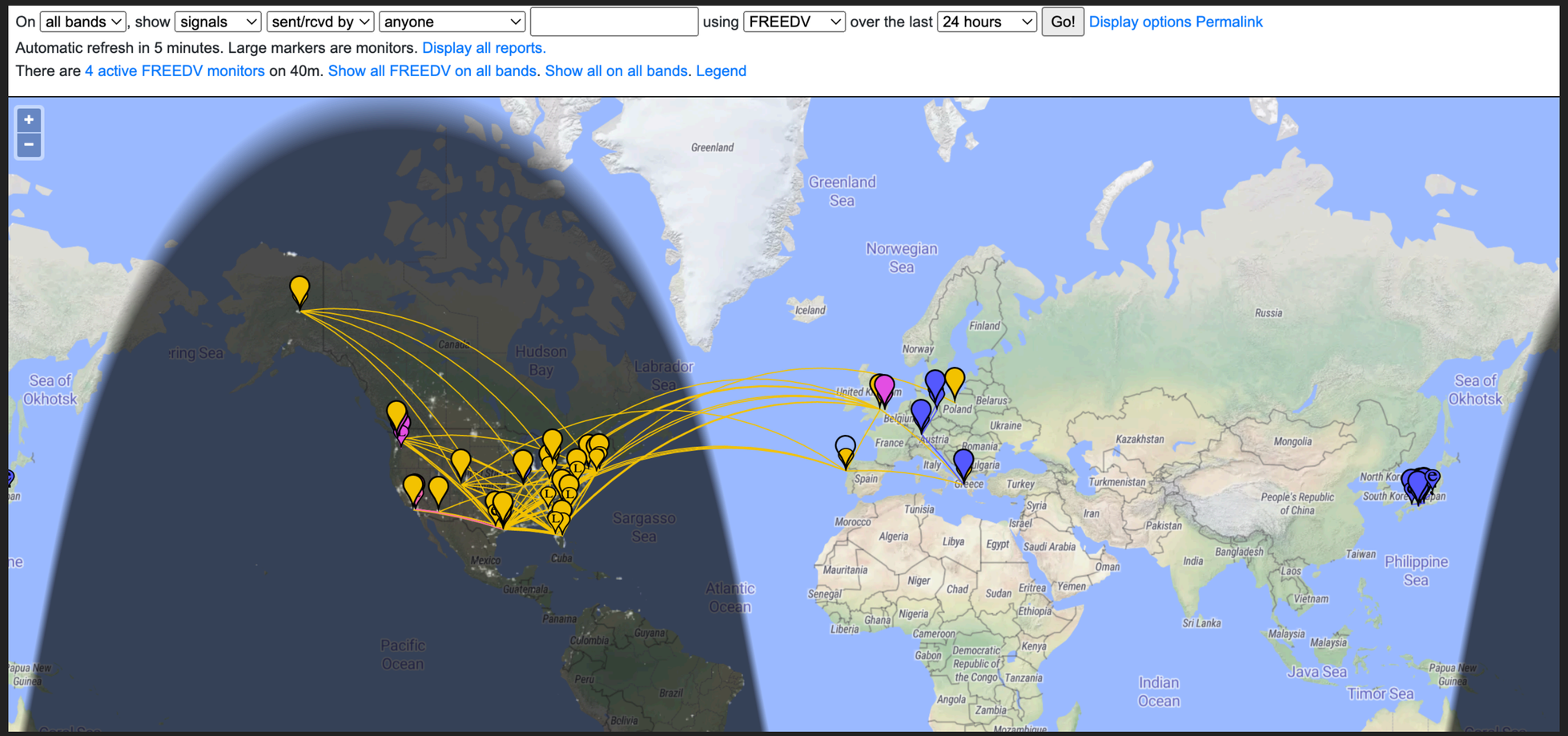
# PSK REPORTER EXAMPLE



# 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



# 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
qso-finder
Find people on the air to chat with here! 14.236 MHz is also...
Events
announcements
rules
TEXT CHANNELS
general
qso-finder
moderator-only
VOICE CHANNELS
General
OTHER NETWORKS
freedv-irc
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
K0PFX (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
K0SHD (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