# JS8 for Nets – Protocol

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TECHCON 2021   – February 27 2021

Shameless Plug for March 19 EXERCISE

- Whirlwind Boom 2021 – large scale exercise to train and increase **INTEROPERABILITY** ("rub shoulders") between
  - ARES® groups
  - Individual resource units (unaffiliated volunteers)
  - Florida Baptist Disaster Relief (NGO Agency)
  - Florida Div Emergency Management (Governmental Agency)
  - SHARES (Federal DHS backup communications Effort)
- 7 – 9 PM Friday Evening March 19

- Massive tornado volley crossing state of "Roflida" wrecks havoc

- Terrorist bombing in Johnsonville damages Internet

- Incident Action Plan & HSEEP Exercise Plan:

- https://qsl.net/nf4rc/FBDR/2021/2021WhirlwindBoomICS201.pdf

- https://qsl.net/nf4rc/FBDR/2021/2021WhirlwindBoomExercisePlan(Particpant).pdf

- See qsl.net/nf4rc for more information
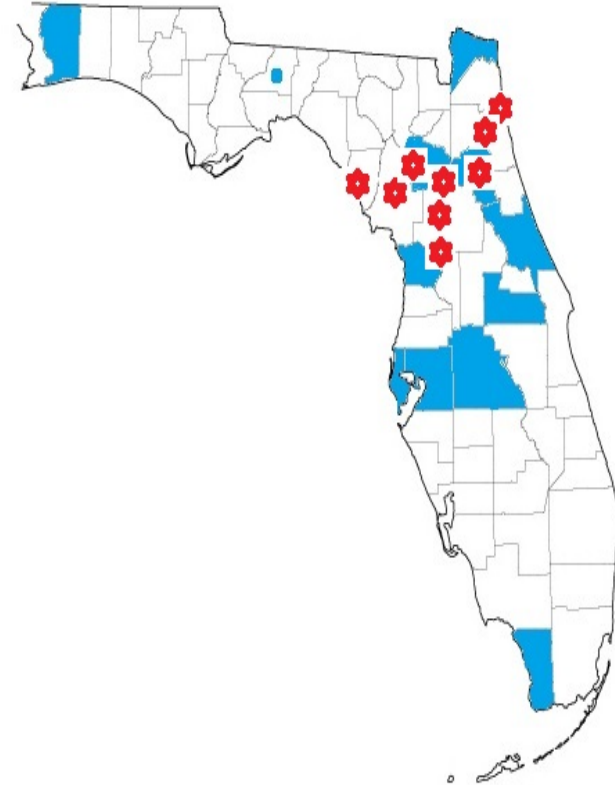
Shameless plug for Shelter Server!

- Significant upgrade, now can be installed on Buster operating system for Raspberry Pi 3BPlus or 4.

- Great way to make large amounts of official information available to shelter or POD arrivals.
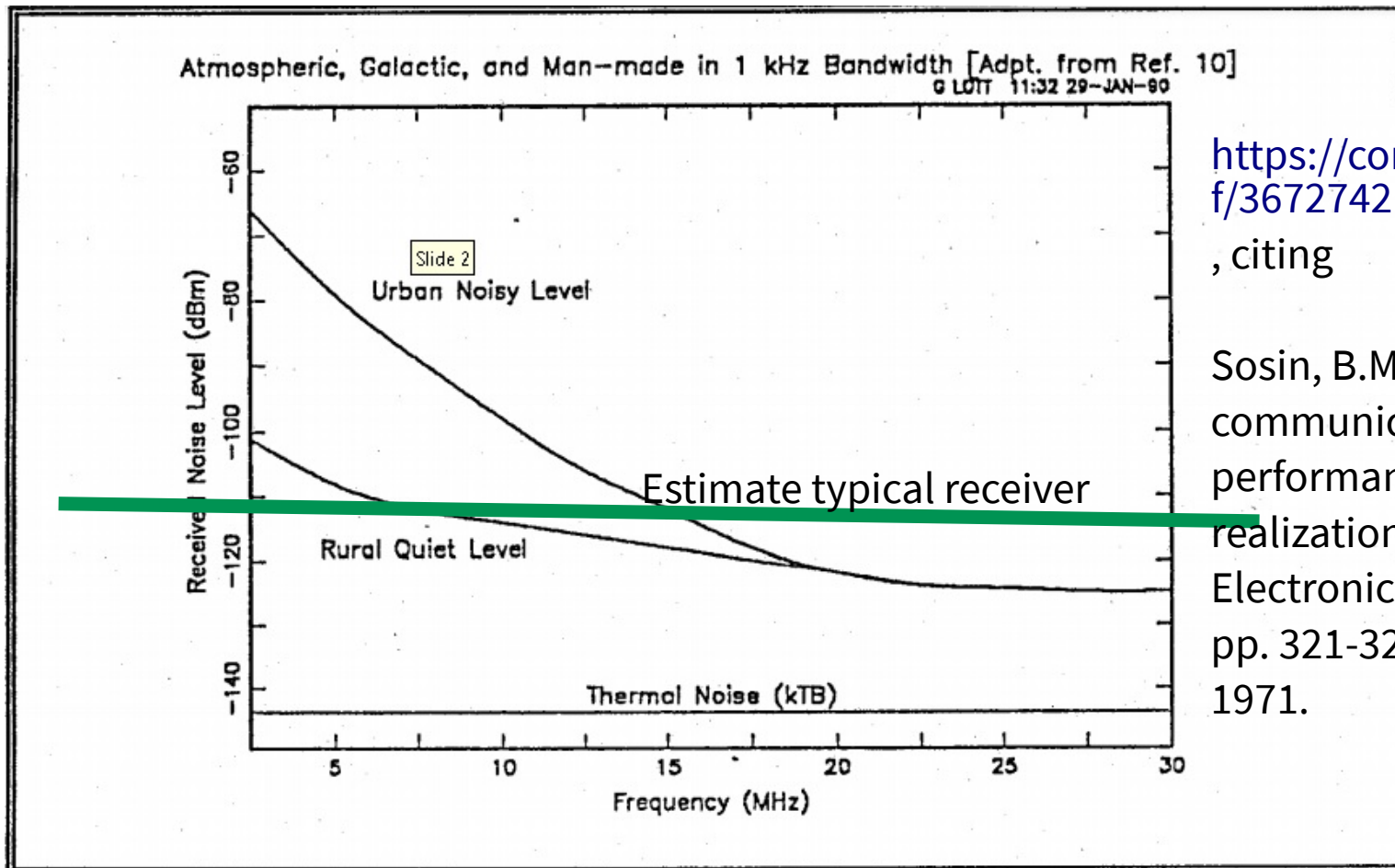

Only needs a cheap home wifi router and a raspberry pi!

Overview –

1. WHY is this useful?

2. How FT8/JS8 actually work their magic

3. How this can be leveraged for dramatically increased NET communication ability

4. (Optional Additional)   How to get them working on YOUR station

5. Questions and/or Demo

1. WHY is this useful? FT8/JS8 Overview

Atmospheric, Galactic, and Man–made in 1 kHz Bandwidth [Adpt. from Ref. 10]
G LOTT 11:32 29–JAN–90

Slide 2
Urban Noisy Level

Estimate typical receiver

Rural Quiet Level

Thermal Noise (kTB)

Figure 2.6 - Average Expected HF Noise Levels for Central Latitudes

https://core.ac.uk/download/pdf/36727421.pdf
, citing

Sosin, B.M., "H.F. communication receiver performance requirements and realization," The Radio and Electronic Engineer, v. 41, n. 7, pp. 321-329, Jul 1971.

Locations

More volunteers live

- – in restricted HOA's or Apartments

- - next to solar powered neighbors

- - with their own solar power systems!

- - with many many wall warts, televisions, LED lights, and other noise sources.
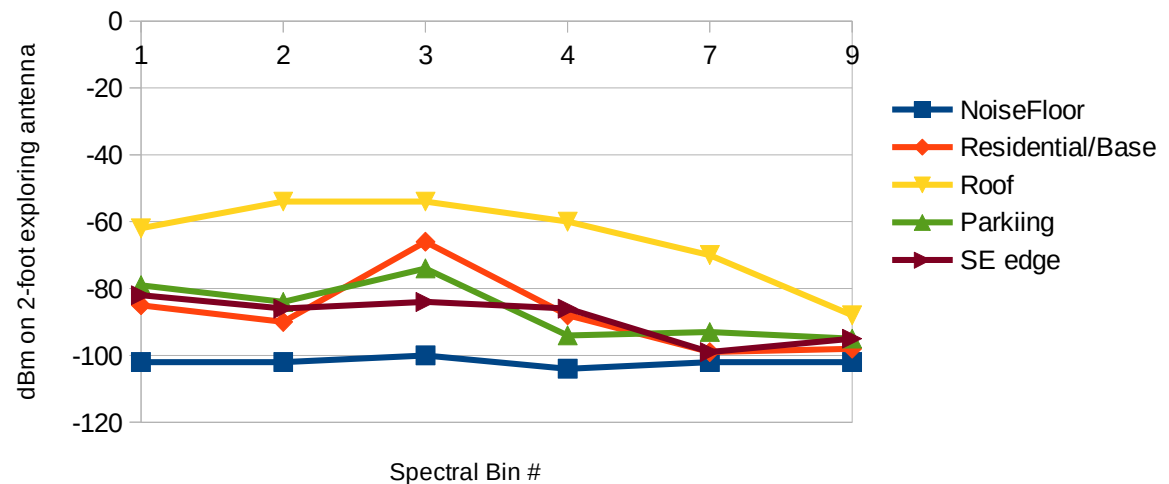
Hardened Installations

Most important comms nodes

Most in need of backups

Most likely to have IN HOUSE QRM GENERATORS

1,000 times stronger than signals we need to hear!

Noise @ Different Locations, by Frequency

Peak Spectral Energy Observed in 1.65 MHz-wide Bins

- NoiseFloor
- Residential/Base
- Roof
- Parkiing
- SE edge

y-axis: dBm on 2-foot exploring antenna

x-axis: Spectral Bin #

The Mother of Invention...

2 decades of work!! WSJT software....

FT8:   June 29, 2017 – RECENT!

Joe Taylor, currently age 79

Nobel Laureate (Physics)

Discovered: Russell Alan Hulse of a "new type of pulsar, a discovery that has opened up new possibilities for the study of gravitation."

Advanced modulation software began almost 2 decades ago: Joe Taylor, K1JT, "WSJT: New Software for VHF Meteor-Scatter Communication," QST, Dec. 2001, pp. 36-41.

Original release 2001

Multiple revisions since then

Things added...and taken away!

FSK441 (2001) – intended to allow meteor scatter VHF QSO

JT65 (2003) intended for mounbounce and troposcatter

JS8 is built on their work:
Full QSO, Open souce extension

Jordan Sherer – relatively new ham, IT guru, lives in apartment in Atlanta, adopted the modulations of FT8 and provided a few layers of networking on top to make it a bit more like old-fashioned PACKET

– Approx Aug 28 2018 ("FT8Call")

– free text real contacts – not "canned"

– able to address groups of callsigns (like subnets)

– – able to ask other stations to "do certain things"

   – ask for signal reports

   - relay information

Background: SOUNDCARD MODES

Leverage the special processing of "soundcards" to do audio processing and

- create the sounds that need to go into the microphone input

- recognize the sounds that come out of the speaker

EXAMPLES INCLUDE

RTTY, PSK31, MFSK(multiple) JT9, JT65, Olivia, Thor, AX.25 APRS and a ton of others

FASTEST GROWTH IN AMATEUR RADIO – soundcard modes

Unexpected Usage – HF!

Incredible LOW SIGNAL detection

Typical SSB/FM transmission needs signal>noise by factor of 4-10 (6-10 dB SNR)

These soundcard modes, when referenced to the "audio bandwidth" (2500 Hz) can pick out signals that woud be 10 or 20 dB BELOW the aggregate noise on that 2500 Hz bandwidth.

More sensitive than CW and yet narrower!

HOW?

Noise is often "white" – evenly distributed.

As you increase your bandpass, the noise increases by the square root of the increase in bandwidth.

If you zero in on a tiny tiny segment of the audio bandpass – you can THROW AWAY a ton of the noise that the voice operator is having to put up with – gives you immense advantage.

Same thing was done for YEARS by CW operators using telephone toroids to construct very narrow filters and give them an advantage. (built one myself)

REDUNDANCY

JT65, FT8 FT4 –

Scatter the information throughout the message so that bits and pieces of it are present in more than one place – and you can often successfully recover the intended message when part of the TRANSMISSION was missed.

Time Synchronization

JT65, FT8 FT4

Adds ability to determine what was really heard.

Means messages either "pass" or "fail" – little in between.

NOT LIKE PSK OR VOICE OR CW.

FT-8   June 29 2017

"Franke-Taylor design, 8-FSK modulation"

8-FSK means eight different audio tones, different frequencies.

RTTY is an FSK with 2 tones

Packet is an FSK with 2 tones

RTTY / Packet can send a 1 or 0 by choosing which tone to send.

8-FSK has choice of 8 tones, so can send 3bits simultaneously

Within 3 frames (9 bits) has sent enough to send an ascii character.

FT8 rapidly grew…at least among DX'ers

CLUB LOG is a group that appears primarily interested in DX.

They published data on the modes used for QSO's in 2017.

Dramatic rise in FT8

"breathed new life"

Even in the sunspot lows!!

CLUBLOG — CW — Phone — FT8 — Other — RTTY — PSK
Evolution of modes used during 2017
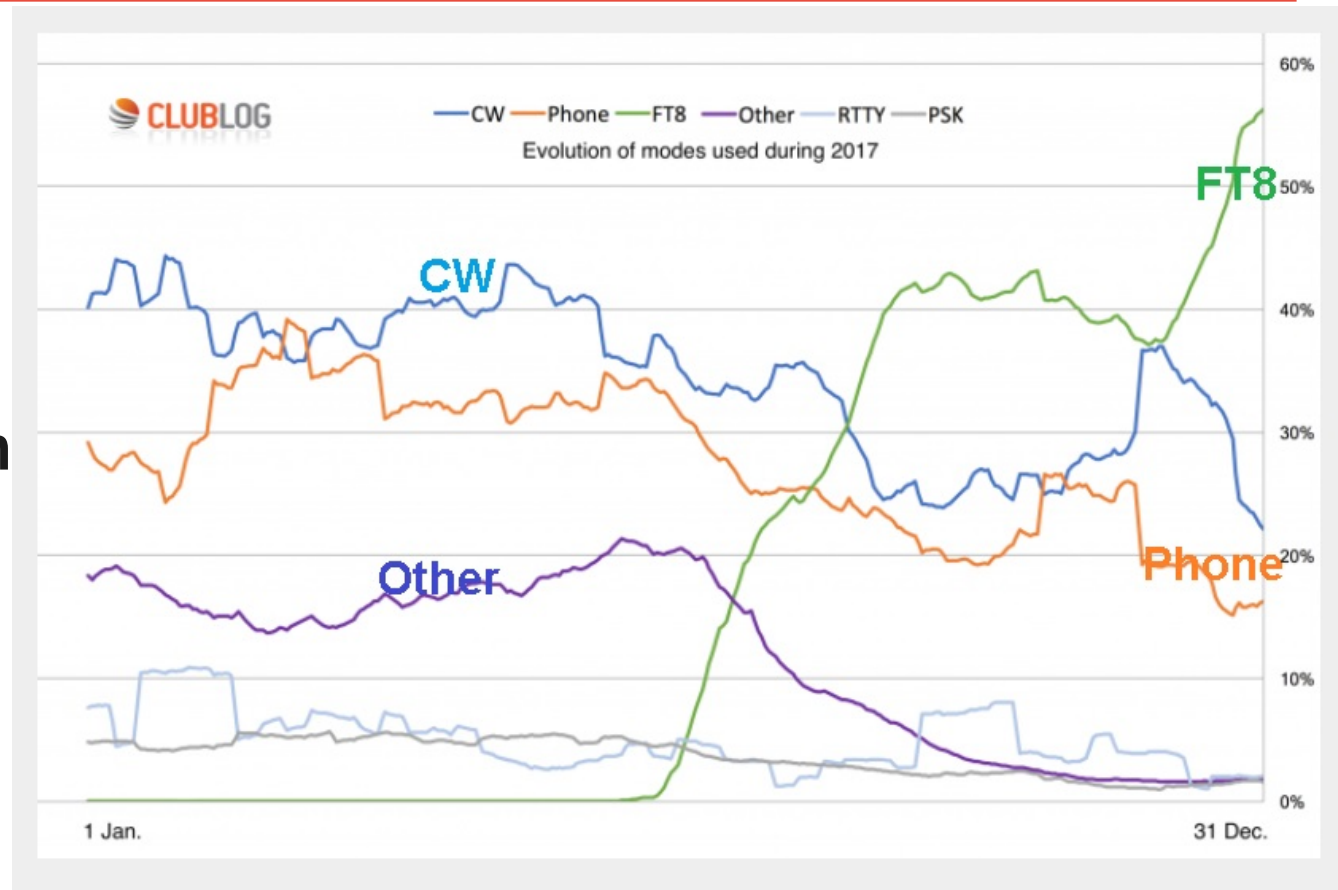
Typical decoding thresholds (2500 Hz comparison)

JT65   -24 dB

FT8   - 20 dB

FT4   - 18 dB

CW   - 15 dB

Noise = 0 dB

……..   Compared to legacy SSB =   10 dB

HUGE ADVANTAGE!!

Multi-Decoding Advantages

FT8 / JS8 – no need to go to THEIR FREQUENCY to hold a QSO!!

2. HOW IT WORKS

What's the narrowest CW filter you're willing to use?

If you go below about 300 Hz the CW is "mushy" and most people have trouble or don't like copying it.

JS8 is NARROWER THAN CW – at only 50 Hz for real.

When you click in a narrower filter, have you noticed the noise decreases?

That's because "white noise" is uniformly spread across the spectrum. When you cut reception to a narrower slice, YOU GET LESS NOISE.

JS8/FT8 are made to be detected using their native width (50Hz) and thus enjoy tremendous S/N ratio advantages.

Truth In Advertising

SSB (voice) is the basic "gold standard" used for Signal to Noise detection capability of newer modulations. As Heil pointed out, the 2200Hz sounds of voice are very important for readability:

SSB requires a bandwidth of about 2500 Hz. Lots of noise!

All other modes' sensitivity is typically reported based on 2500 Hz comparable voice bandwidth (giving them a considerable "head start") because they DON'T USE that entire bandwidth!

But it does make al the reports directly comparable.

Very tough to copy SSB voice is SNR (2500Hz) is < 10dB S/N

Link:
https://physics.princeton.edu/pulsar/k1jt/FT4_FT8_QEX.pdf

Defined message length = 77 bits

FT8, FT4, MSK144

3 bits declare which of 8 message types are encoded (ranging from free text, Dxpedition, Field Day, to EU VHF

Each message type has a defined set of included fields, 74 bits.

There are
23 different
fields
defined.

Table 2 - Assigned purposes for the bit fields listed in Table 1. Numbers in the tags indicate the number of bits in that field.

Tag	Information conveyed
c1	First callsign is CQ; h12 is ignored
c28	Standard callsign, CQ, DE, QRZ, or 22-bit hash
c58	Nonstandard callsign, up to 11 characters
f71	Free text, up to 13 characters
g15	4-character grid, Report, RRR, RR73, 73, or blank
g25	6-character grid
h1	Hashed callsign is the second callsign
h10	Hashed callsign, 10 bits
h12	Hashed callsign, 12 bits
h22	Hashed callsign, 22 bits
k3	Field Day Class: A, B, ... F
n4	Number of transmitters: 1-16, 17-32
p1	Callsign suffix /P
r1	Callsign suffix /R
r2	RRR, RR73, 73, or blank
r3	Report: 2-9, displayed as 529 – 599 or 52 - 59
R1	R
r5	Report: -30 to +32, even numbers only
s11	Serial number (0-2047)
s13	Serial Number (0-7999) or State/Province
S7	ARRL/RAC Section
t1	TU;
t71	Telemetry data, up to 18 hexadecimal digits

First the digital magic

- Source-encoded message (74 bits+3bit message type) is 0-extended to 82 bits

- Then Cyclic Redundancy Check (14 bits) appended to get to 91 bits

- Then 83 bits of redundancy [huge redundancy!!!] added to get to 174-bit codeword

- Custom-designed redundancy grid, also includes verification that the signal is valid. Not perfect = nothing!

Now the RF Layer

8-tone, continuous phase, frequency shift keying (tones are 6.25 Hz apart)

Since each tone could be one of 8 choices, a single tone conveys 8 bits of data.

Three successive message BITS are grouped together through a table (known as a Gray Code) to determine which tone will be transmitted [selected to minimize frequency changes to minimize effects of Doppler shift]

FT4 uses a 4-tone system.

To help time-synchronization of detector, TONE PATTERNS known as "Costas Arrays" are transmitted at beginning, middle and end: following sequence of tones:

3, 1, 4, 0, 6, 5, 2

Allows fantastic time sync.

The message initiation and ending are amplitude shaped (avoids a "click"); in between the amplitude is CONSTANT to reduce intermodulation distortion (IMD) in non linear amplification.

The tones are generated with changing frequencies, but NO CHANGE in phase.

The changes in frequencies are not ABRUPT, rather they are shaped, in order to reduce side lobes.
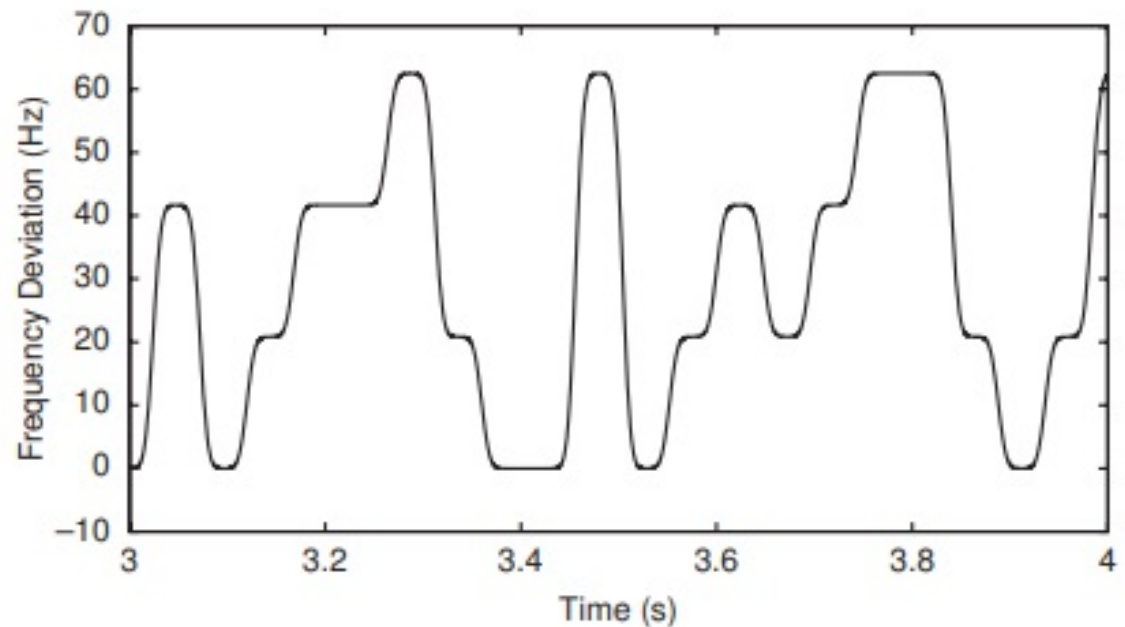
Result is a very narrow spectrum compared with normal frequency shift keying (e.g. RTTY).

40 FT8 QSO's can simultaneously exist in a 2kHz slice of spectrum.
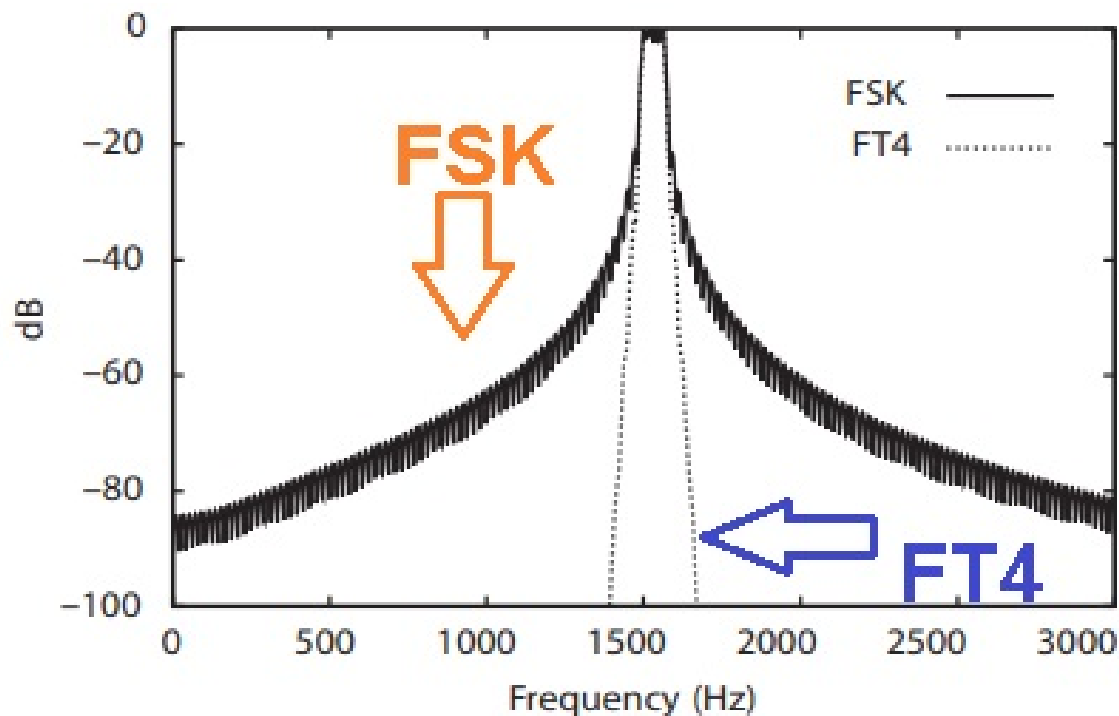
And regularly DO.

Figure 3 — Average spectrum of an FT4 signal (GFSK, BT=1.0: dotted line) and the spectrum of an otherwise equivalent standard FSK waveform (solid line).

3. Leveraging these Advantages for NET

Background on SHARES nets

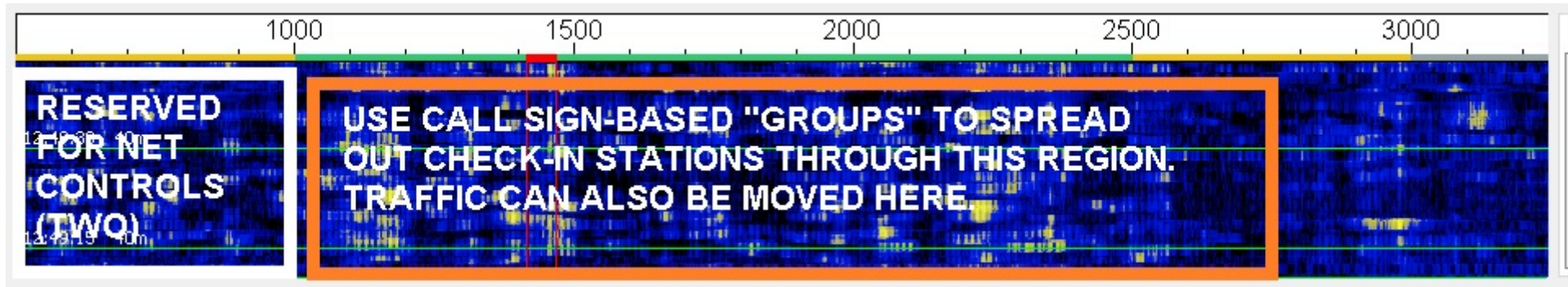**Very wide geographical areas –**

Higher frequencies (lower D layer losses) → skip zones

Lower frequencies bring greater losses

Voice and digital both allowed on same frequency (no need for A/ B vfo or qsy)

Frequency Division of Participants

SSB PASSBAND ALLOTMENT:

FREQUENCY DIVISION – Different areas for net controls and participants allow everyone to hear NCS (and backup!) while NCS can hear all check-in stations in a requested group simultaneously.

Overview of Time Sequence

TIME	ACTION	Comment
45 seconds	Net announce / solicit Emergency / Priority	NCS in lower frequencies
30 Seconds	Listen for Emerg/Priority	
30 Seconds	Callup Group 1 (10-20 stns)	
15-45 Seconds	Group 1 Replies	Participants higher freq Longer check-in to list traffic
	(Repeat for additional groups)	
?? 30 sec	Compile list	McDonald software does this automatically.
60 seconds	Primary sends list of checked in stations	Secondary & participants observe
30 seconds	Any missed stations reply	
30 seconds	Conclusion from Primary	

Multiple ways to de-conflict participants

Have "groups" based on callsign or geographic characteristic #1

Have self-selected frequency bins based on callsign characteristic #2

With each callup able to take 10-20 stations.

McDonald built software that captures ALL checkins!

Moving Traffic

Approx 1.5 kHz available at any time (net control discretion) for traffic movement.   NCS is in protected space 500Hz-1kHz

MANY Possible techniques:

JS8 - slow & narrow

PSK31 – typing speed, but not error correction (narrow)

Broadcast modes with FEC

Winlink 500 Hz modes (ARDOP, VARA) – full error correction

300 Baud AX.25

HAM voice nets adding these layers would need two frequencies (A/B VFO)

Easy to accommodate multiple narrow techniques on one passband.

Older radios (without soundcards) have an advantage : any software can begin TX AUDIO and signalink will happily key the PTT

Newer radios (soundcards) often have single-program-connecting drivers!   [find some trick with the monitor?]

4. How to get it working?

Get it Working: RADIO CONNECTIONS SIDE

3 Systems to Make Work

Even a vacuum tube radio will work fine for FT8 and JS8!

Manual tuning works FINE!

Online manual:

https://physics.princeton.edu/pulsar/K1JT/wsjtx-doc/wsjtx-main-2.3.0-rc3_en.html

1. Audio, both receive and transmit (speaker and mic)

2. Push to Talk

3. Frequency control / measurement

Lets take them one at a time!

Step 1) GETTING AUDIO CONNECTED

This has gotten much simpler.   Basically all you are doing is selecting from among the various playback and recording devices on your computer.

Typically, the one for amateur radio will have a giveaway name that either shows it is a "CODEC" or that it is plugged into a USB port….

Next several slides demonstrate very similar in almost every software you're likely to use…

Getting AUDIO connected
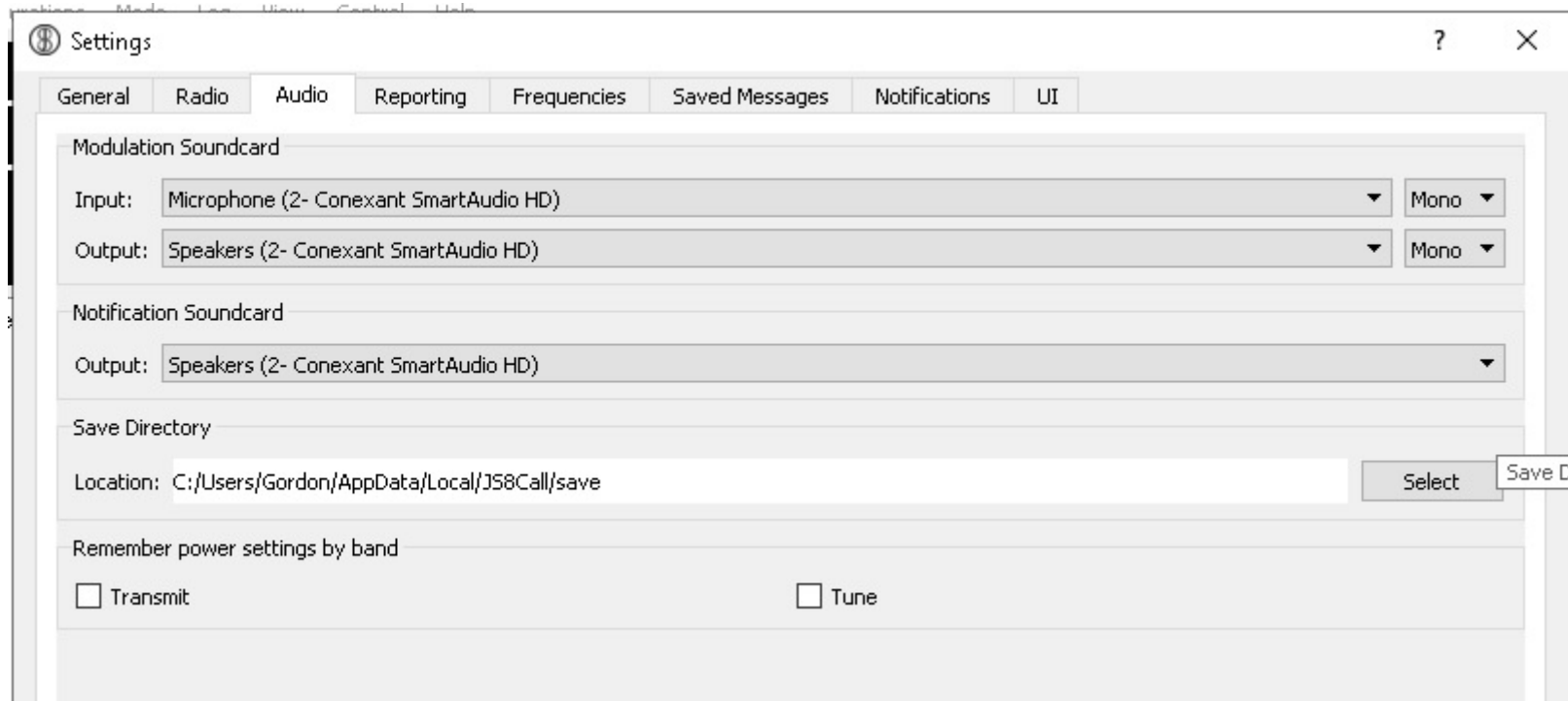
Relatively standardized in all applications (WINLINK, WSJT-X, FLDGI, JS8 – drop down menu of possible sound devices.

Choose something with "USB" or "CODEC" in the name.

STEP 2) PUSH TO TALK

- Physically, this is connecting a terminal to GROUND, that activates the transmitter and stops the receiver.

- Human reflexes not fast enough to do this for digital modes, so mic button isn't a good solution.

- TWO MAJOR WAYS

(1, Easiest!!)   Soundcard devices such as SIGNLINK or our local homebrew boards detect incoming audio on the "transmit line" and use a transistor or relay to close the Push To Talk

(2, Newest) Fancy new radios use CAT control to do this. ("Computer Aided Tuning")

Older Rig: Signalink

"VOX" – very similar to voice-operated push-to-talk from voice radio.

BE CERTAIN to set that Delay knob to the absolu minimum.

Older Rig: Signalink & Similar

<u>USB cable to the computer</u> – pick the "soundcard"

<u>RJ45 cable to the RADIO</u> (receive audio, mic signal, ground, push-to-talk) – every rig is different, so they came up an overly complicated way for you to set jumpers AND purchase custom cables for each rig.   Locally, we set all jumpers identically and then construct or purchase certain custom cables. Much simpler.

Big Advantage: *Signalink doesn't care which application generated the audio.   You can run FT8, JS8, FLDGI software SIMULTANEOUSLY and just click on the one you want to use at any given instant.*

Older Rig: Use "VOX" Setting – EASY on JS8

Rig isn't important.
Vacuum tube or 7300
all the same with an
external signalink!

No CAT control
needed.
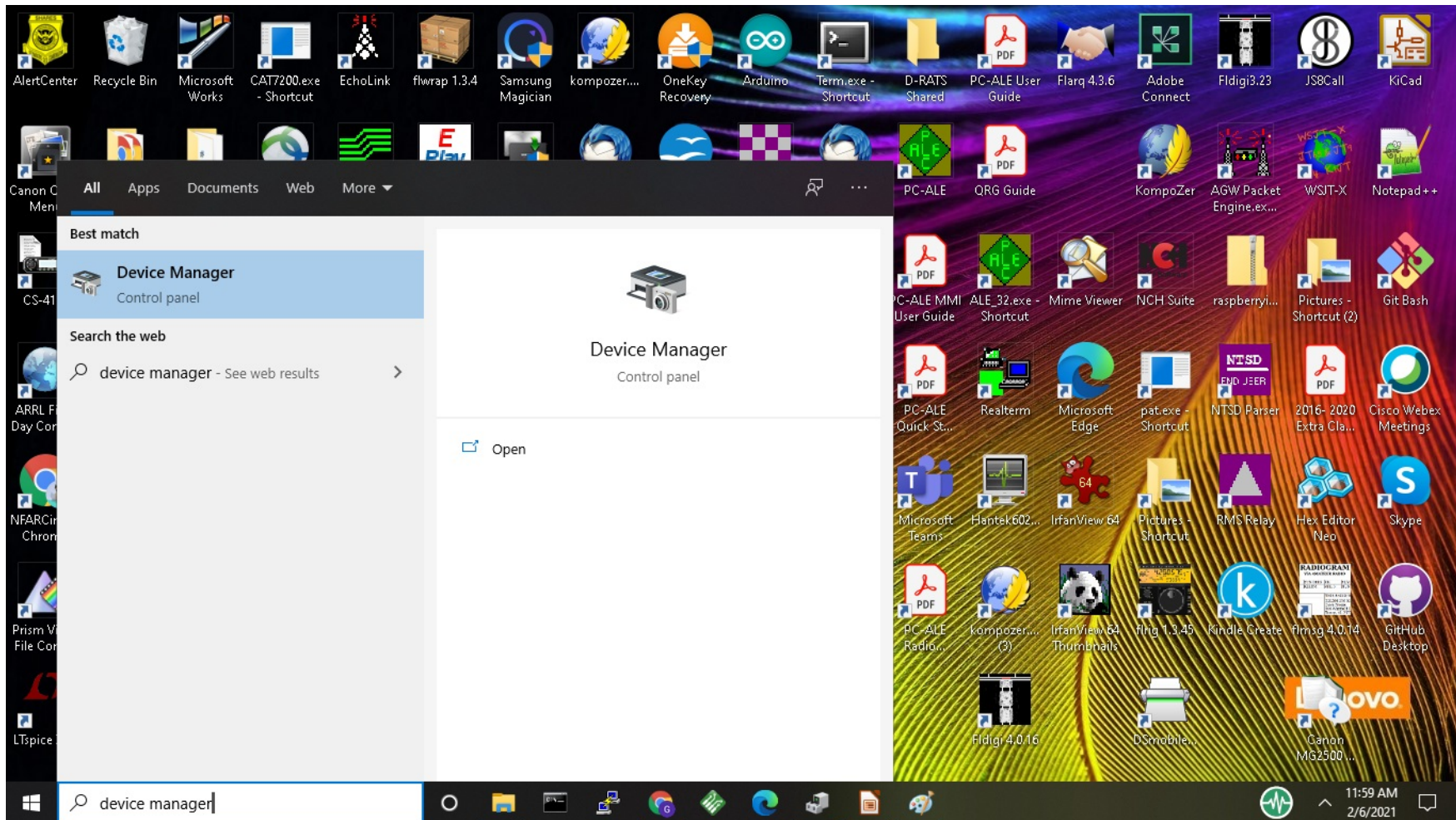Just select "VOX" for
PTT
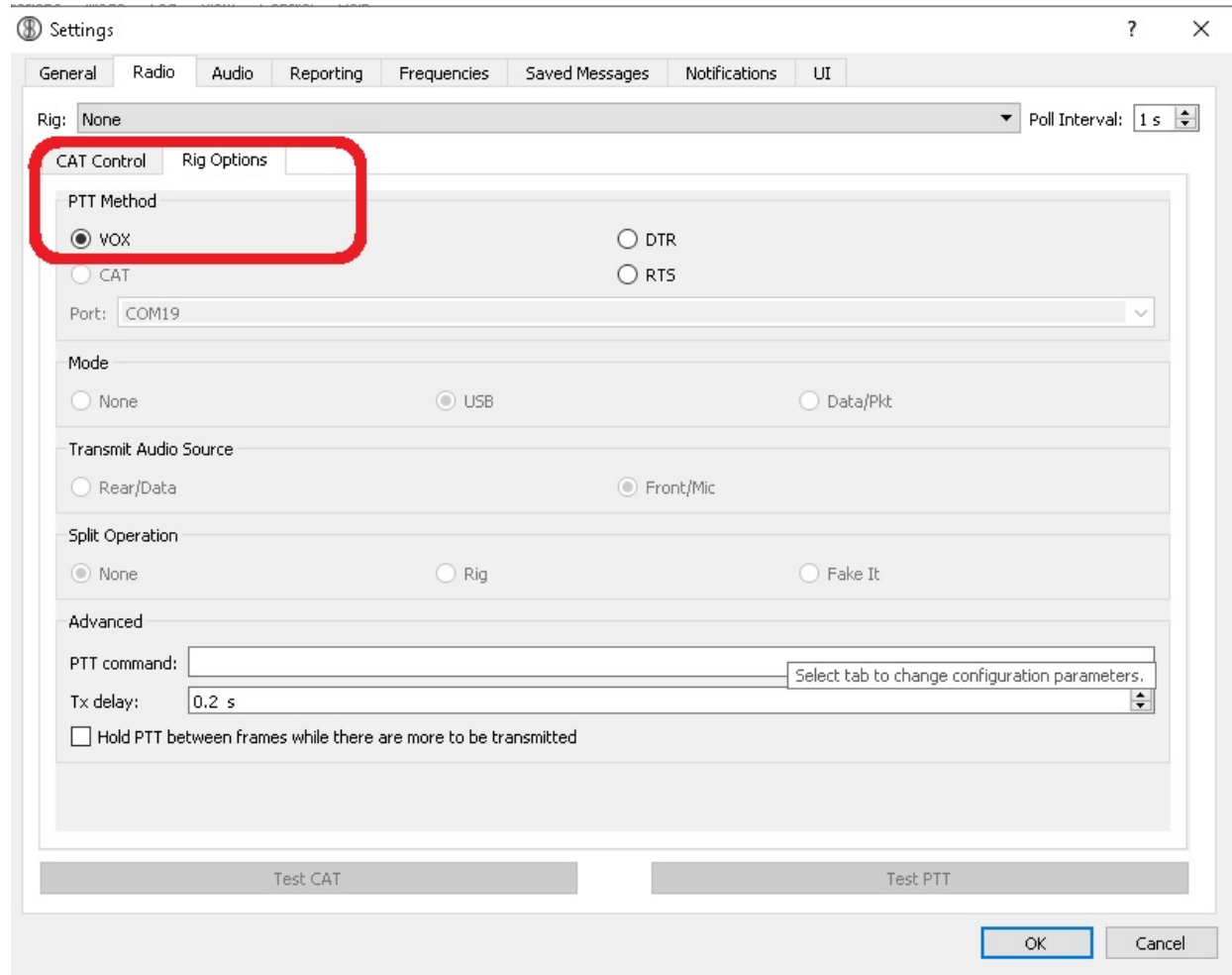
VOX is great for modes that always the same amplitude

- Works great for RTTY

- All the FSK modes, including FT8/ JS8

- Not so good for PSK modes or ARDOP that may vary in amplitude

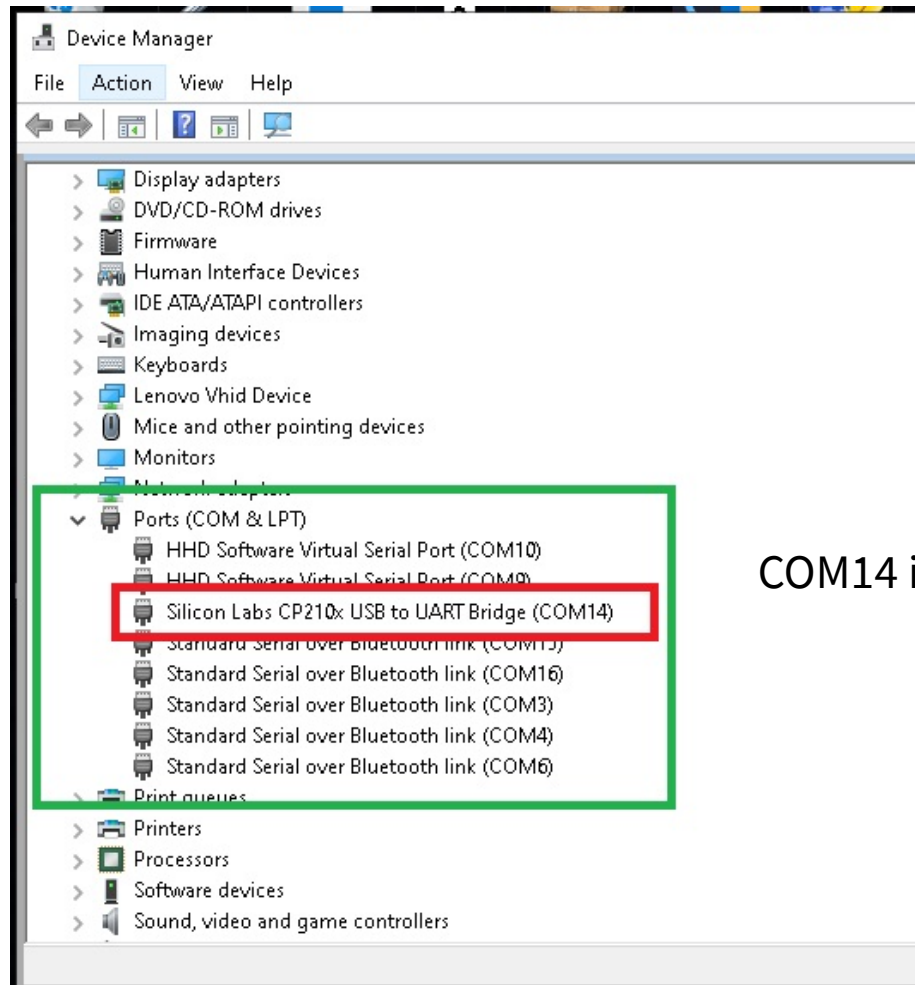- FLDGI has a nice solution – Transmitted audio is on L chan; solid tone is sent on RIGHT Chan – Signalink looks at Right channel for VOX control.

Newer Radio:
Find The USB Codec or USB to UART bridge
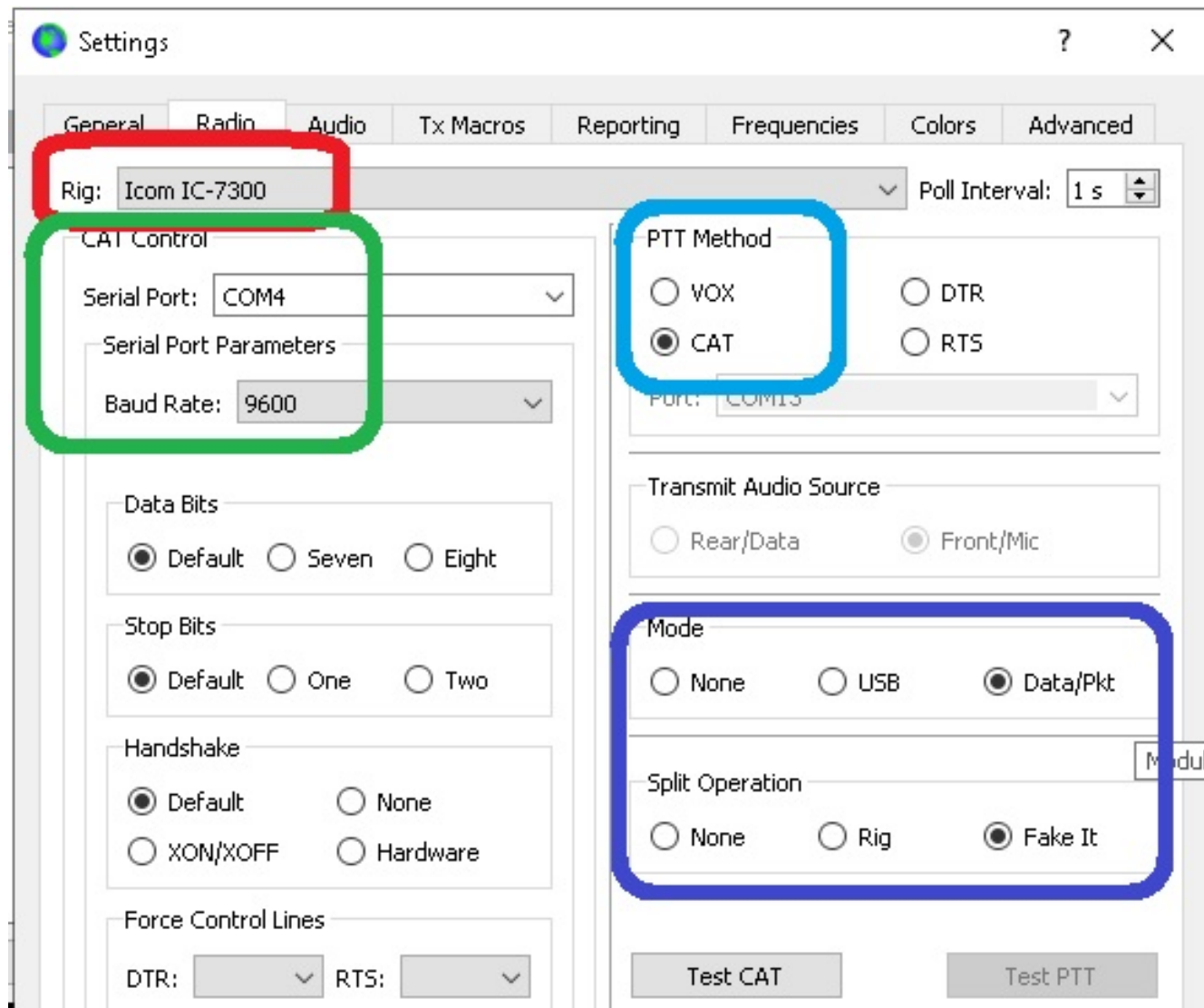

COM14 in this example of an Icom7300

"split" techniques work to keep your modulating audio between 1500-2500 so IMD products are disadvantaged. Nice! But not show-stoppers

STEP 3) Controlling Frequency

Completely Optional.

Older or Newer Radio: You can always tune your radio to the desired watering hole manually. Everybody fits in the same bandpass!! Set freq ONCE, you're done!

Most newer modes are using UPPER Sideband. A few modes don't care…

Newer Radio: CAT Computer Aided Tuning

Completely non-standardized.

Earlier ICOM radios used an open-collector connection cable that LOOKs like a programming cable.   User must select the "COM PORT" and set baud rate.   (Device Manager helps find the port)

ICOM 7300-genre uses a specific software DRIVER

RIGS: 7100, 7200 7300 7410 7600 7610 7850 7851 9100 9700 R8600

Google it or: https://www.icomjapan.com/support/firmware_driver/1974/

Newer Radio: Nice thing about CAT!

If you can get the CAT to work….it can do Almost Everything on ONE USB Computer Cable

PUSH TO TALK

FREQUENCY CONTROL

MODE SELECTION (USB-D [uppersideband digital] on 7300 can be set to take commands from the USB [computer cable] input)

Get it Working: TIMING

Windows outta da box isn't good enough!]

Easiest way is to google Dimension4 and load it from Thinking Man Software.

http://www.thinkman.com/dimension4/

Time Synchronized in Disaster

5. DEMOS or QUESTIONS

Draws

1. If you are low power – this is for you!

2. If limited antenna – this is for you!

ANTENNA HELP:

https://qsl.net/nf4rc/2021/BeginnersCorner-Antennas.pdf

https://qsl.net/nf4rc/2021/MostDifficultAntennaForm.pdf

https://qsl.net/nf4rc/2019/BalunArticle.pdf

https://qsl.net/nf4rc/2019/InstructionsEFHW.pdf

JS8 Beginnings

Click where you want your TX signal (red) – pick a clear spot!

Click the signal you want to converse with – only they show up in your conversation box

Order your received box by most convenient – probably most recent at top??

JS8 Fancy Tricks

- Enable most of the "auto" stuff – heartbeat, etc

- Then find out who can hear you! (Heart beat)

- If you have a group you can address them (Callsign Groups)

- Fancy storage of messages [beyond this talk]

- APRS-IS (new to me)

JS8 Keys

Even if you don't have CAT, you don't have to be on their frequency.

Split: Rig (VFO A/B) vs. Fake It (CAT) – reduces IMDs

Ya gotta pick something to say!! (not like FT8)

Type just a bit – and immediately hit SEND and then just finish what you're wanting to say – when it hits the end it adds ending character.

… = missed a frame

Get comfy with the canned tx lines

The End

This slide set is available online at
https://qsl.net/nf4rc/2021/JS8FT8Talk.pdf