FT8 / FT4 / JS8

Gordon Gibby KX4Z Gainesville Amateur Radio Society Feb 16

With many thanks to slides from Anthony Luscre K8ZT!! Fantastic set of slides at

https://docs.google.com/presentation/d/e/2PACX-1vQwN09KY-awo4jUJWPewJNT0EnzkciXYXq6C5RAArYFrnTAeofNy1jtlWSYOo1k7wbP1oAK6o4iGoec/pub?start=false&loop=false&delayms=3000&slide=id.g994ab22d2d_0_0

CONGRATULATIONS to 2 local hams!!

Brett Wallace NH2KW and (now retired!) Col. Huckstep W4JIR have both completed all the RACES / local deployment training requirements for the BADGING process of Alachua County!!

Hooray for Brett & David!!

https://qsl.net/nf4rc/2021/Welcome-ARESRequirements2020.pdf

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

What We Will Learn Here –

1. Overview of the fastest growing part of ham radio today
2. How FT8/JS8 actually work their magic
3. How to get them working on YOUR station
4. Live Demos (fingers crossed!)

1. FT8/JS8 Overview

Where did FT8 come from?

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."

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

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.

Fantastic Open Source Project (GPL 3)

Major Co-Contributors:

Steve Franke K9AN

Bill Somerville G4WJS

Joe K1JT “You (or anyone else) are more than welcome to submit patches or larger revisions of our code to implement features you’d like to see.”

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

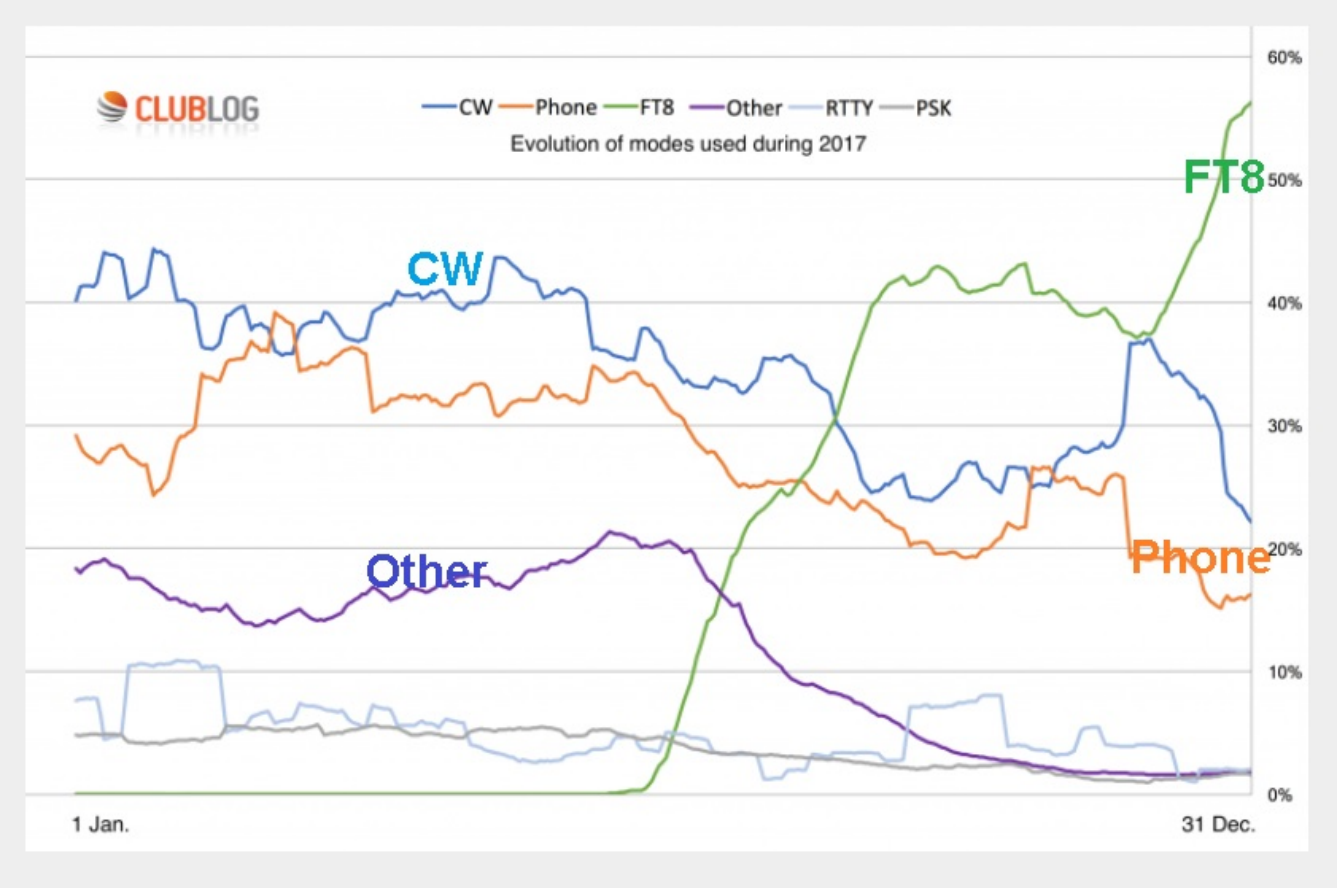
CLUB LOG is a group that appears primarily interested in DX.

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

Dramatic rise in FT8

"breathed new life"

Even in the sunspot lows!!



Typical decoding thresholds (2500 Hz comparison)

JT65 -24 dB

FT8 - 20 dB

FT4 - 18 dB

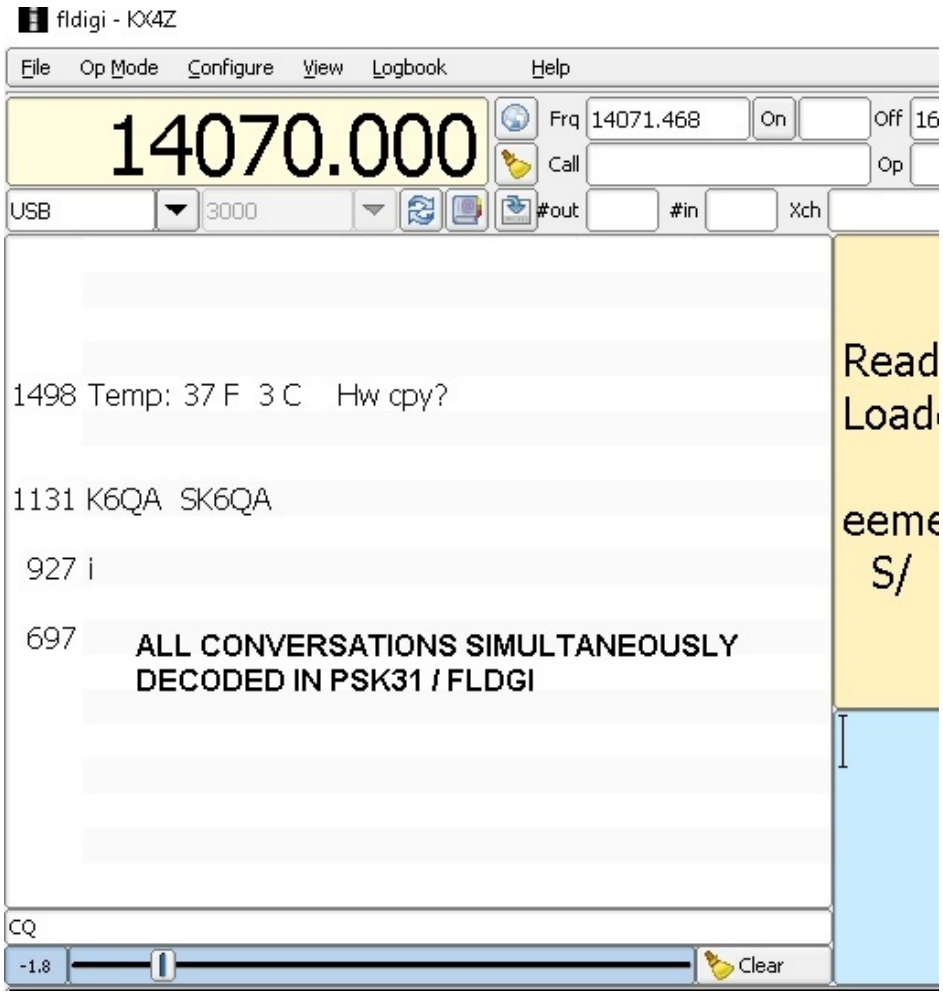
CW - 15 dB

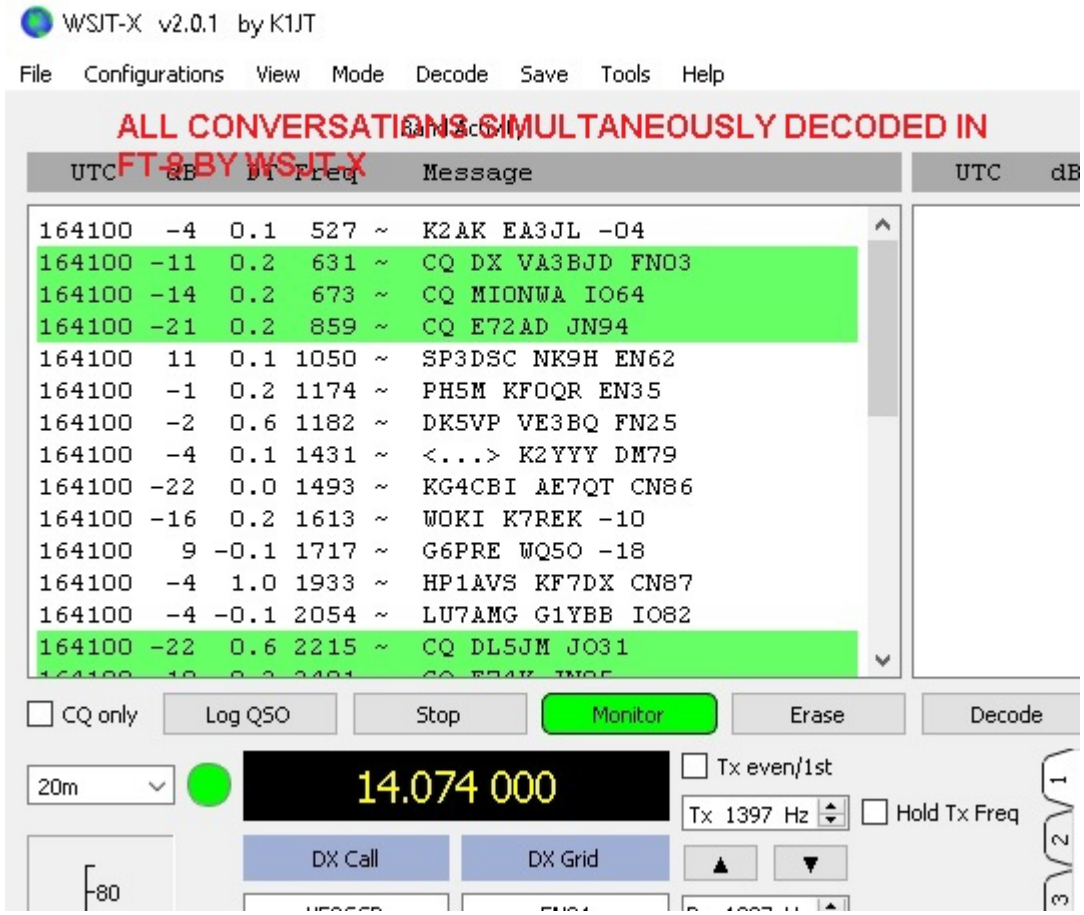
Noise = 0 dB

SSB = 10 dB

HUGE ADVANTAGE!!

Multi-Decoding Advantages





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

Intriguing New Opportunities

APRIS –

JS8 Receiver stations gated to the Internet allow APRS-type sending of GPS information, text messaging, and email messages from radio….

With independent receiver stations!

KM4ACK youtube explanation:

https://www.youtube.com/watch?v=qP-stm_UF4A&feature=youtu.be

https://www.youtube.com/watch?v=i5f2H96HIZQ

Python interface:

http://m0iax.com/2019/09/25/aprs-message-app-for-js8call/

APRS-IS

Automatic Packet Reporting System – Internet Service

http://aprs-is.net/

Watering Holes on bands

FT8 is so popular that the easiest way to discover if a band is open is to go their “slot” on a band and see what you hear….

3.574

7.074

10.136

14.074

18.100

21.074

24.915

Frequencies are stored in the application;
No need to memorize these

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.

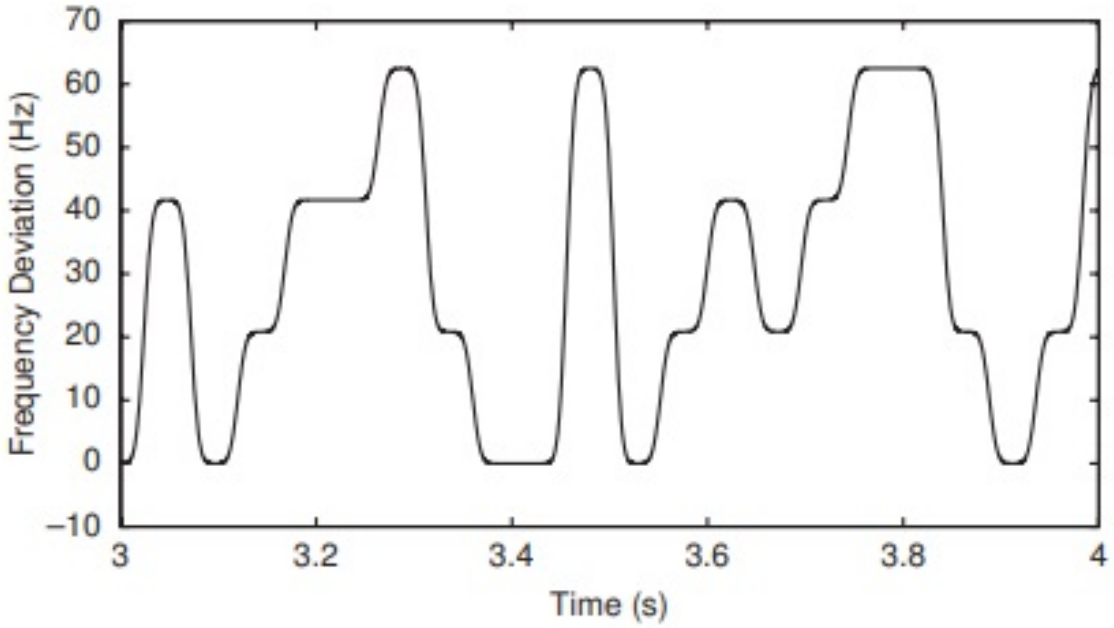
To help synchronization of detector, TONE PATTERNS known as "Costas Arrays" are transmitted at beginning, middle and end: following sequence of tones:

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

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.

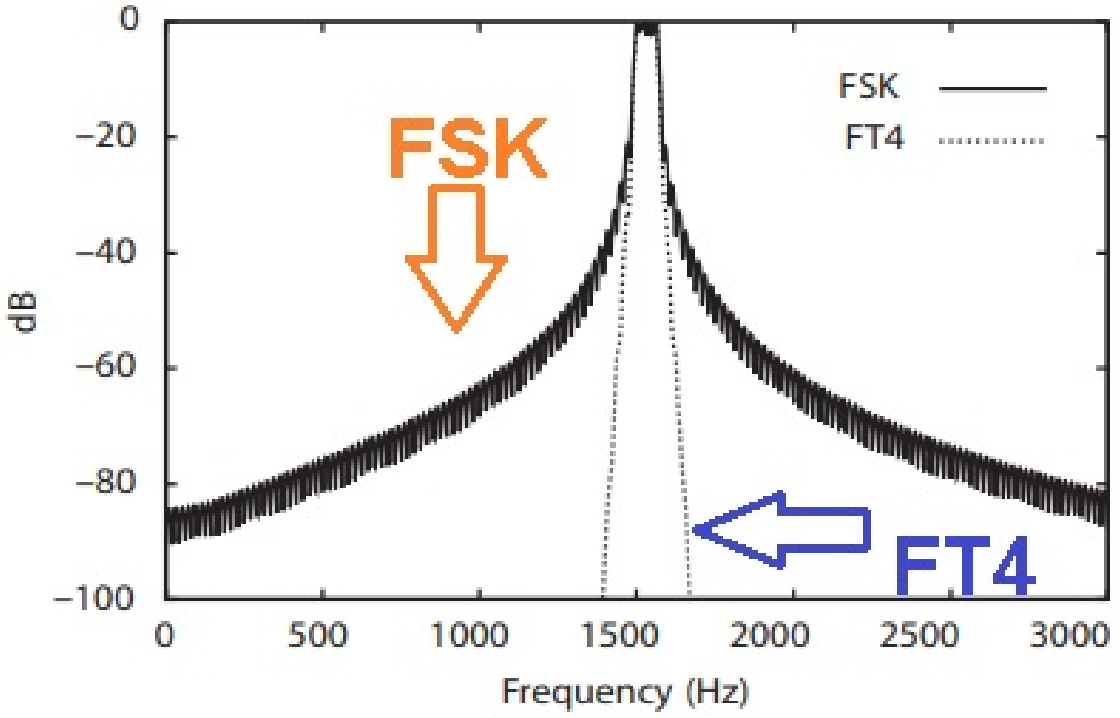


Figure 3 — Average spectrum of an FT4 signal (GFSK, BT=1.0: dotted line) and the spectrum of an otherwise equivalent standard FSK waveform (solid line).

3. GETTING IT TO WORK AT YOUR STATION

3 Systems to Make Work

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

Manual tuning works FINE!

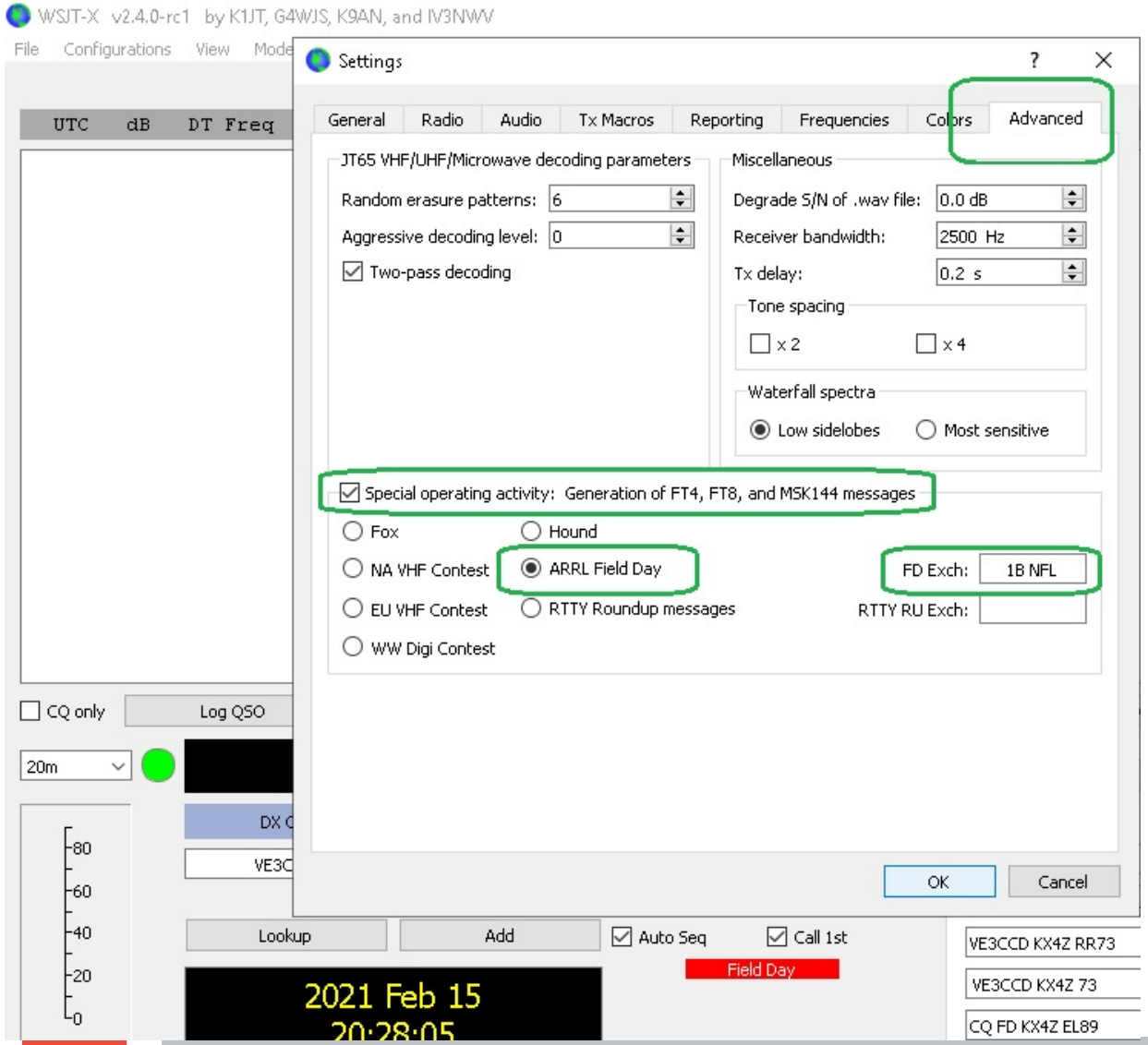
Online manual:

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!

Regular vs Field Day FT8 or FT4



Change to a Field Day Exchange

With an intermediate application (JTAlert) you can have WSJT-X logging all the way into N3FJP Field Day Log Read more here:

https://www.kevinhooke.com/2019/05/27/configuring-wsjt-x-to-log-to-n3fpj-for-arrl-field-day-part-1/#:~:text=WSJT-X doesn't log directly to N3FJP (it does,Server API from Settings %2F Application Programming Interface%3A

GOT TO BE ONE OF THE EASIEST WAYS FOR GARS TO RACK UP FIELD DAY CONTACTS!!

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…

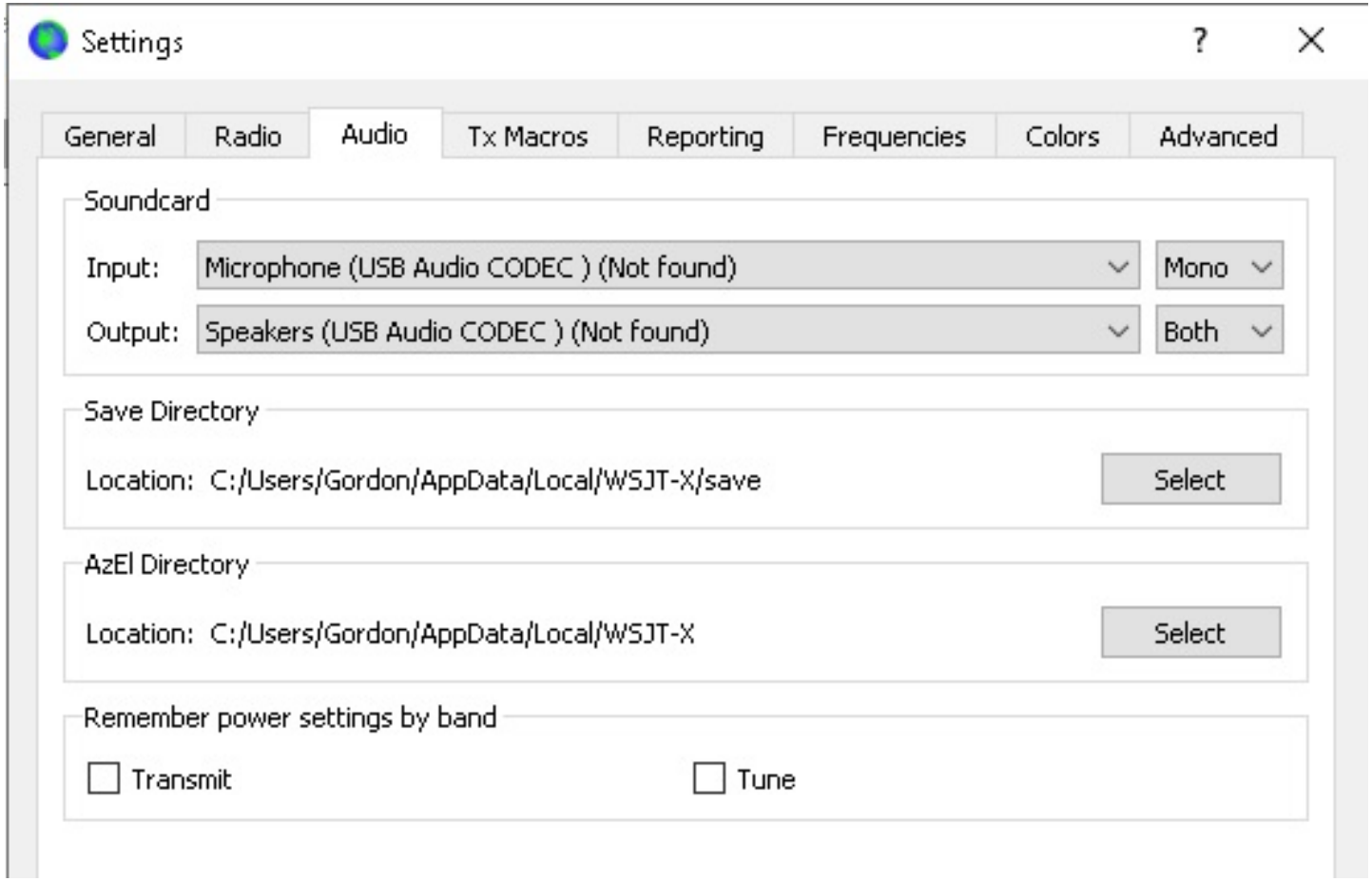
Getting AUDIO connected

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.

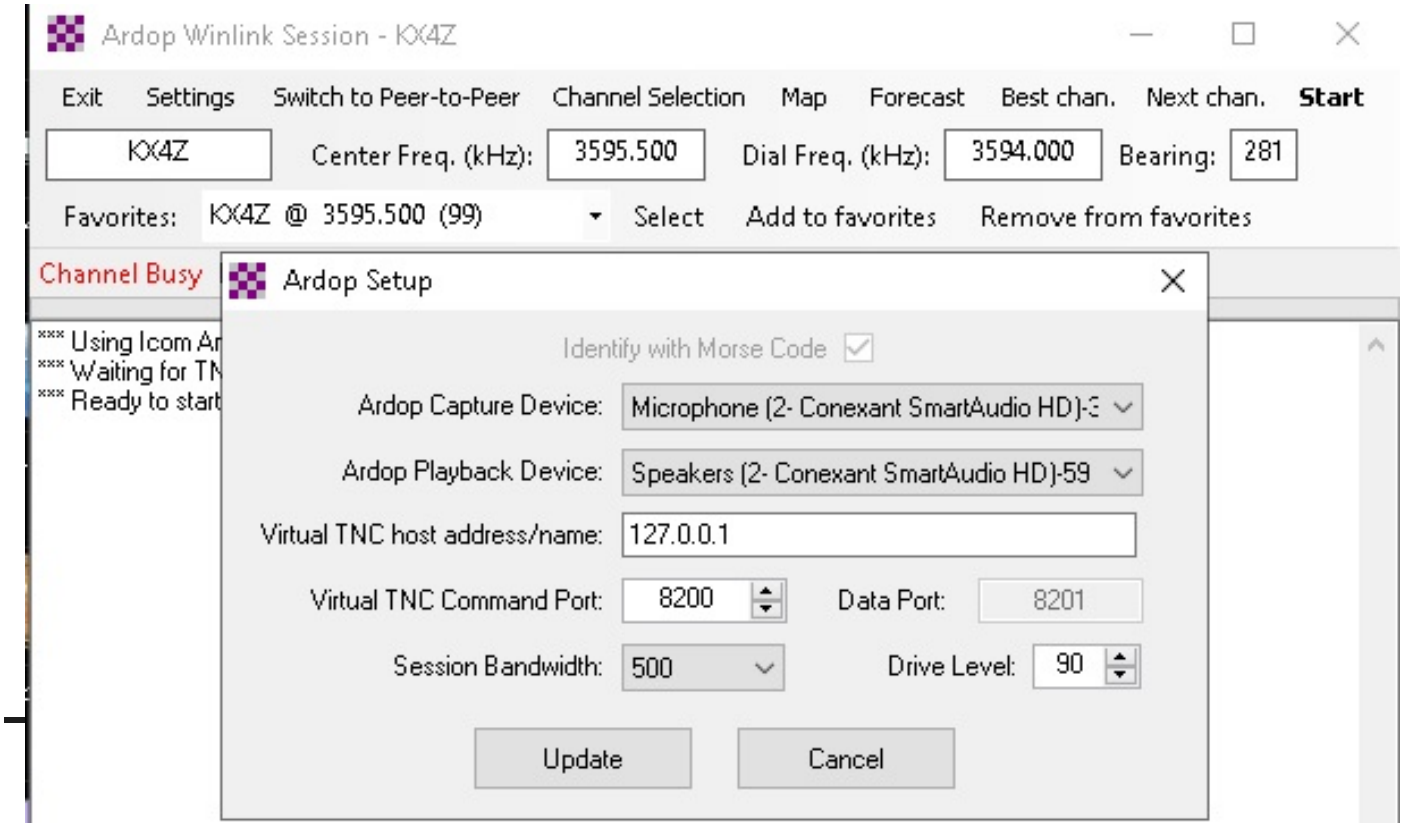
Getting Soundcard Connected WSJT-x

Identical to JS-8

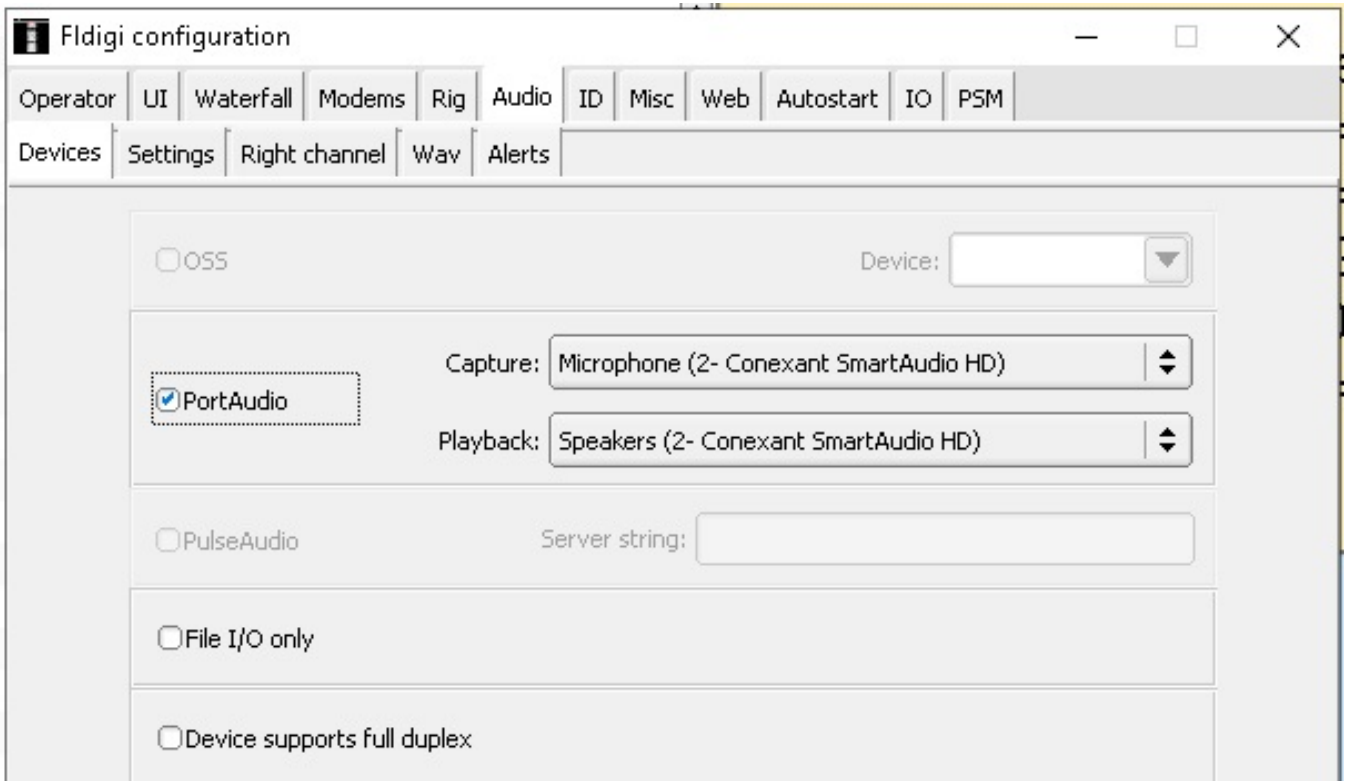


Soundcard Selection – WINLINK

Winlink very similar – done for each "mode"



Soundcard Selection - FLDGI

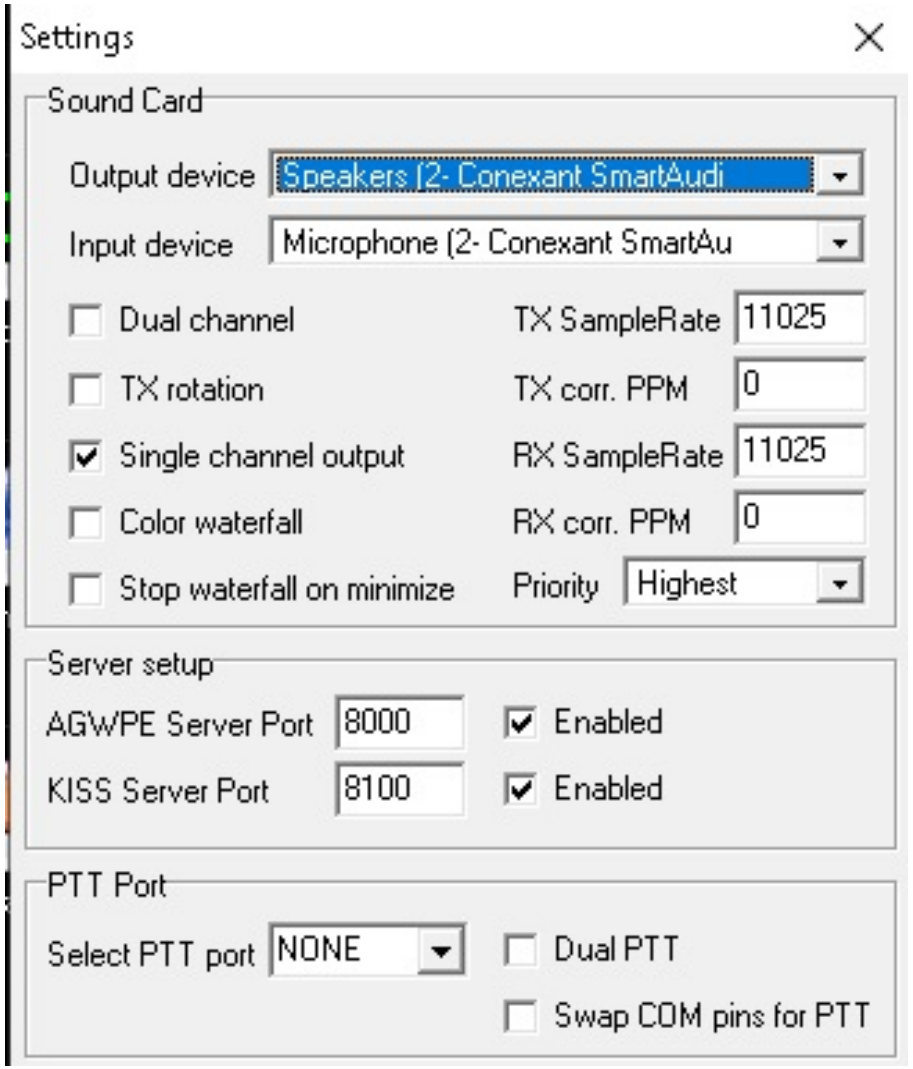


FLDGI gathers ALL its configuration settings into a massive tabbed dialog. Choose "Audio" and "devices", click "port audio" and select your sound cards..

Packet TNC “soundmodem.exe” (from UZ7HO)

UZ7HO wrote this free software to allow soundcards to do Packet (AX.25)

Selecting the soundcard is the same but you have to pick “single channel output” and set some tcp/ip ports. The rest we leave along.



STEP 2) PUSH TO TALK

2.

- 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")

Signalink

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

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

Signalink & Similar

USB cable to the computer – pick the "soundcard"

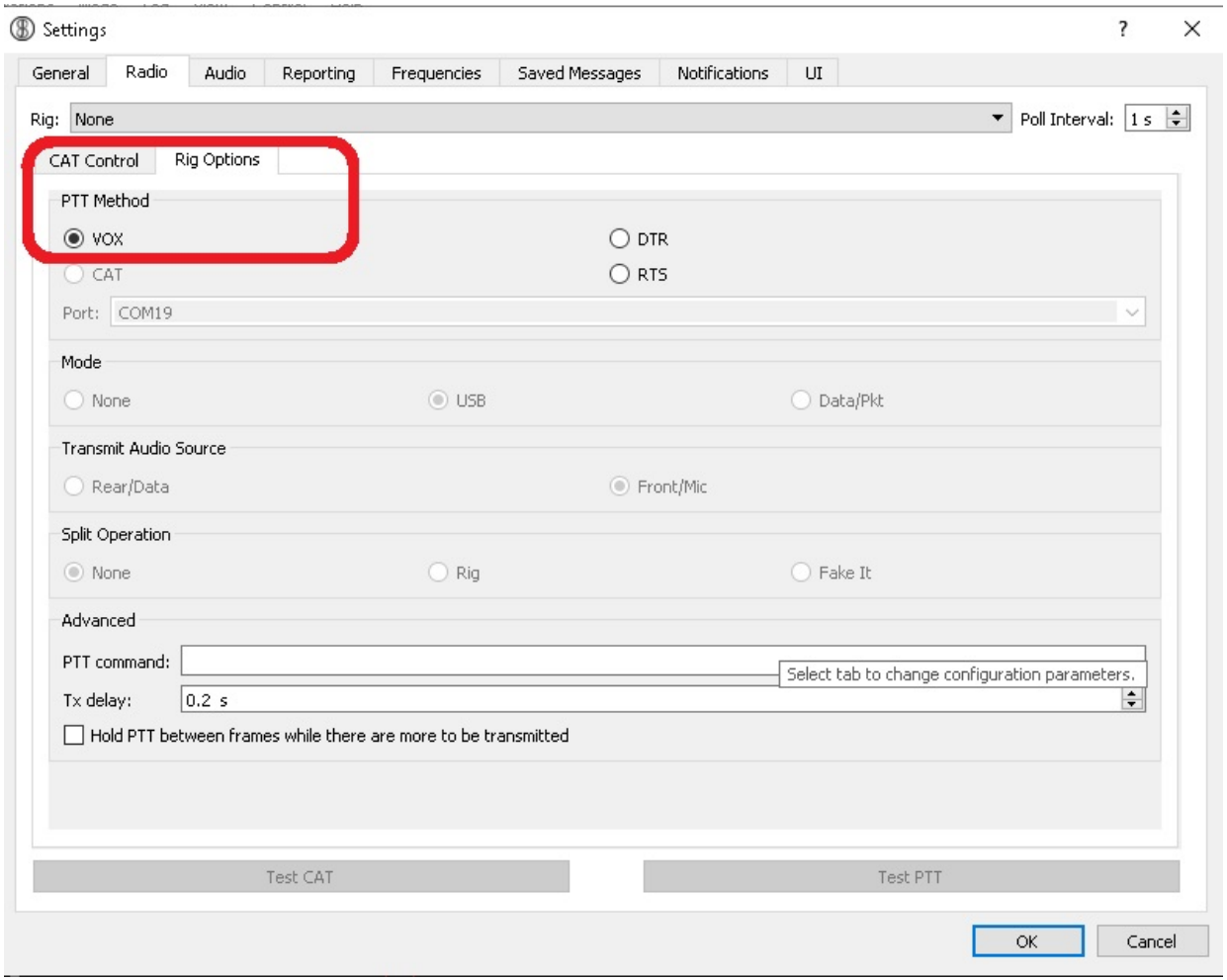
RJ45 cable to the RADIO (receive audio, mic signal, ground, push-to-talk) – every rig is different, so they came up an overly complicated way for you to set jumpers AND purchase custom cables for each rig. Locally, we set all jumpers identically and then construct or purchase certain custom cables. Much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

Use “VOX” Setting – EASY on JS8/FT8U

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

No CAT control needed.
Just select “VOX” for PTT



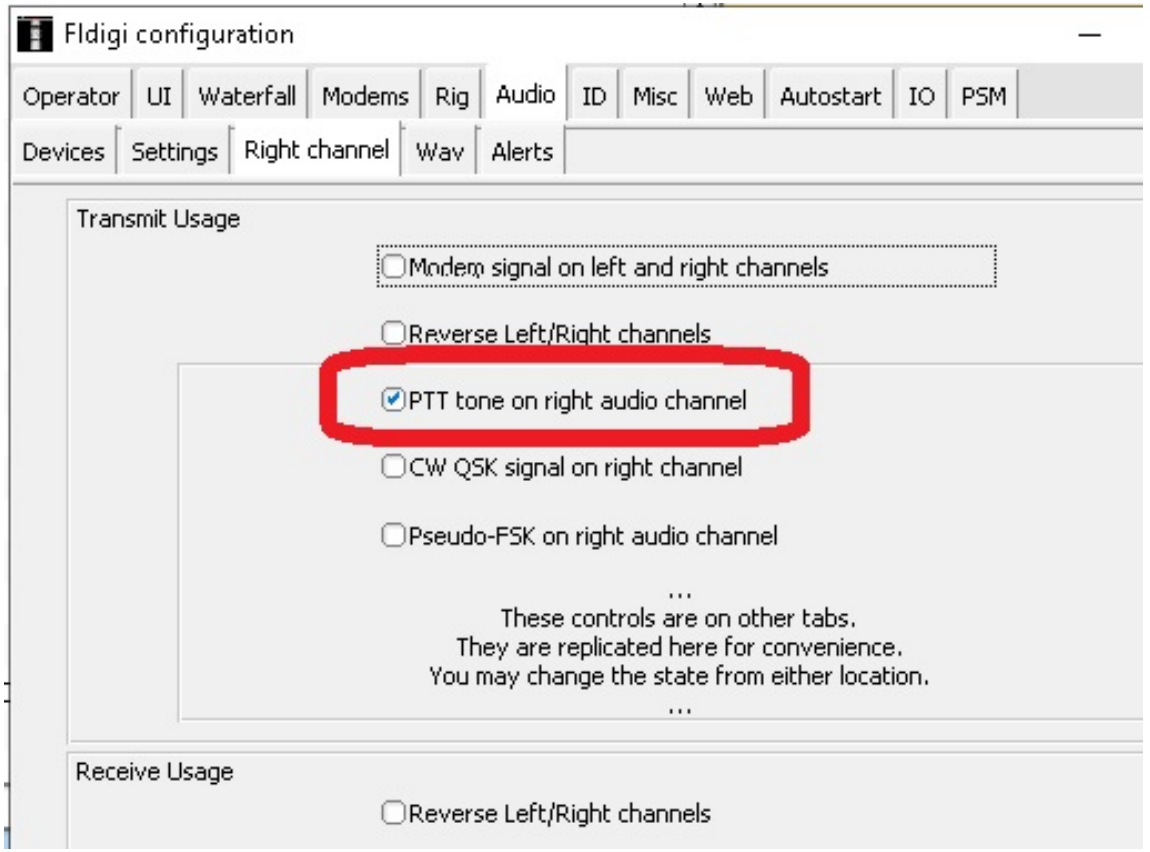
VOX is great for modes that always the same amplitude

- 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.



STEP 3) Controlling Frequency

Completely Optional. 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…

FT8 is at 3.574, 7.074, 14.074 (and jam packed)

JS8 is at 3.578, 7.078, 14.078 (and more rare)

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/

Nice thing about CAT!

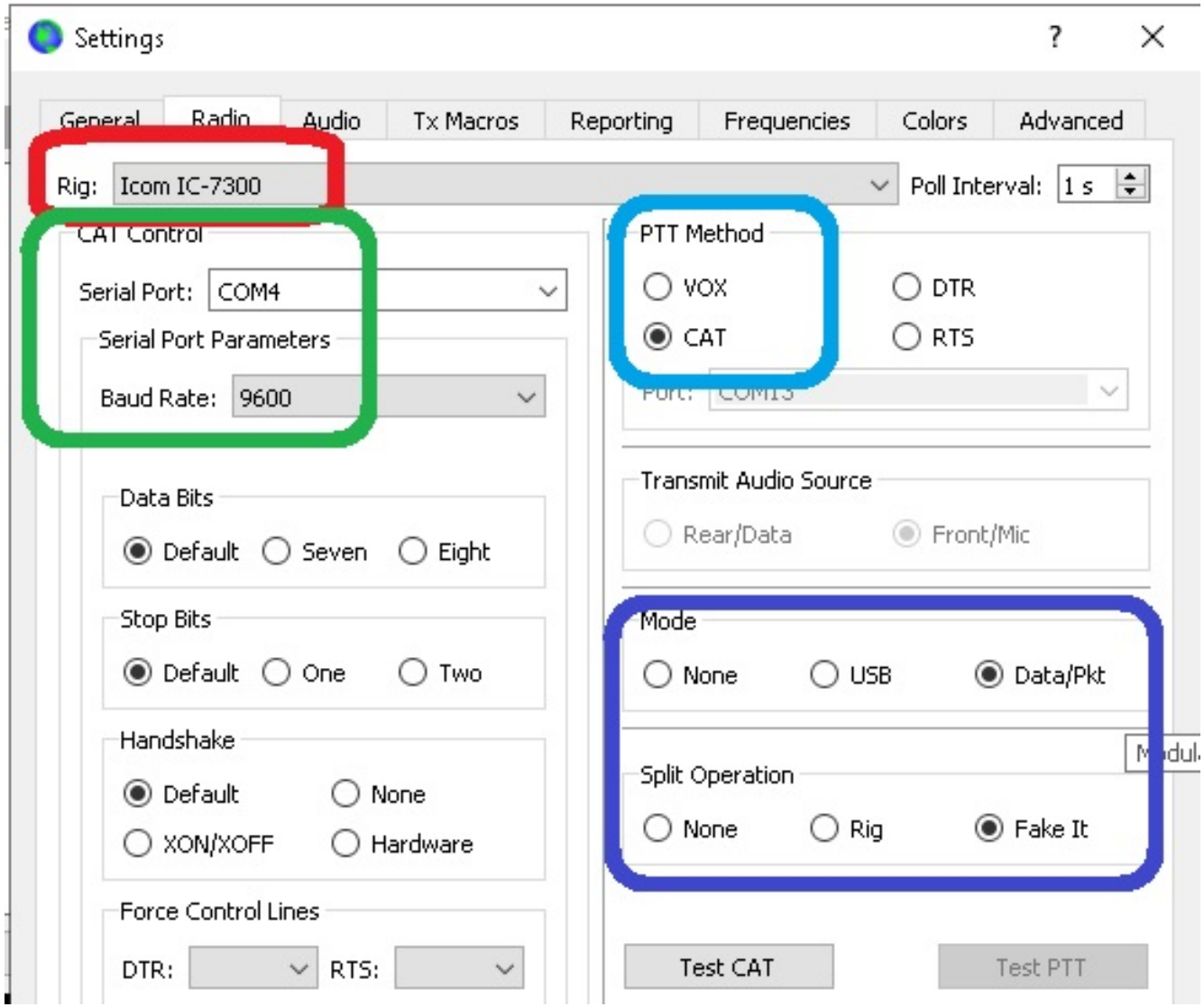
If you can get the CAT to work….it can do Almost Everything on ONE USB Computer Cable

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)

WSJT-x Icom 7300 CAT setup (JS8 the same)



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

Crawl Before You Walk: Get Reception First

In order to RECEIVE all we need is 2 things:

(1) time-sync and

(2) audio connection to the CODEC (in the soundcard)

– More modern rig with built in soundcard – driver

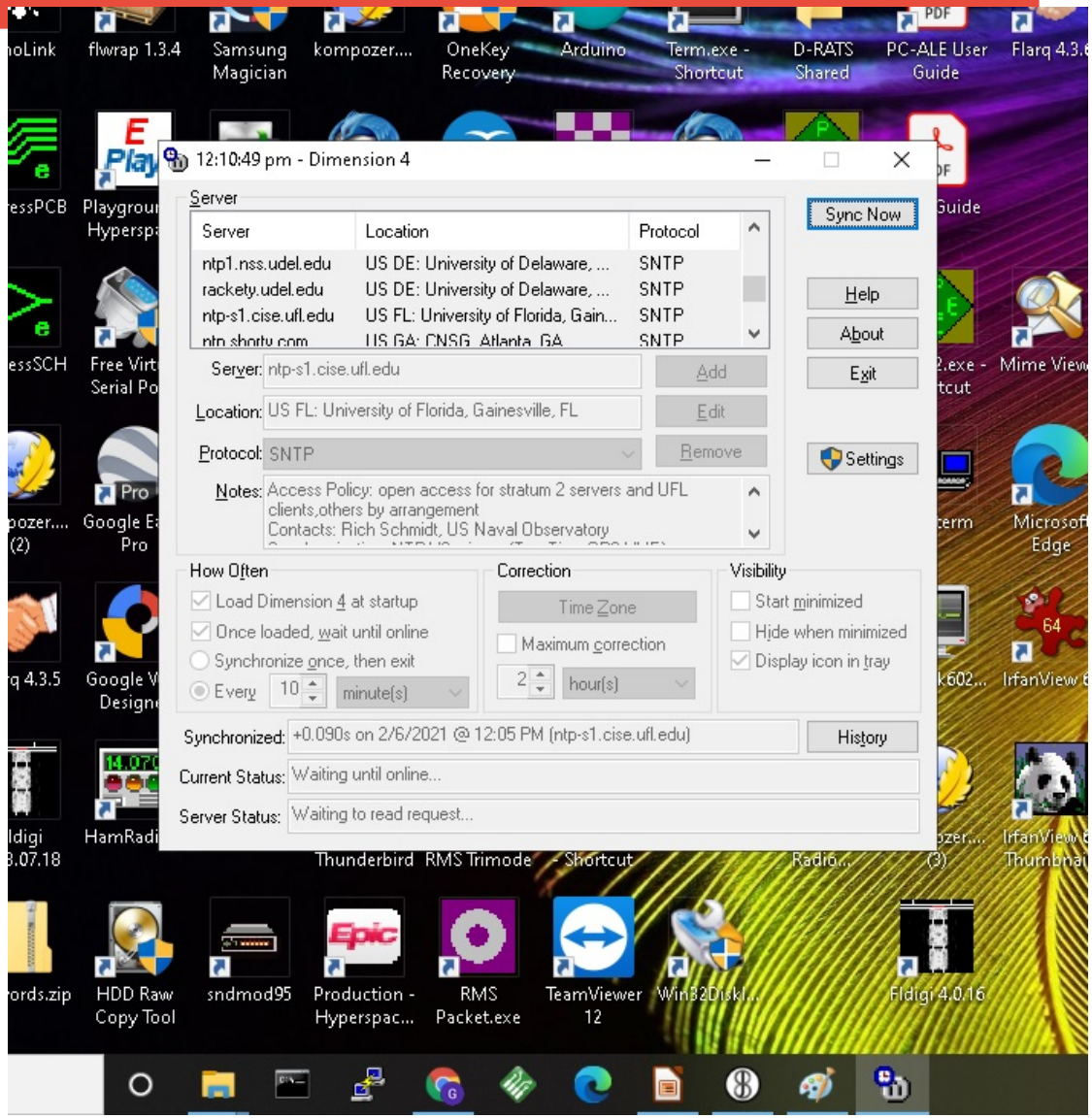
– Older rig (even Heathkit) – use Signalink or similar

(1) GETTING TIME SYNCHRONIZED

Windows outta da box isn't good enough!]

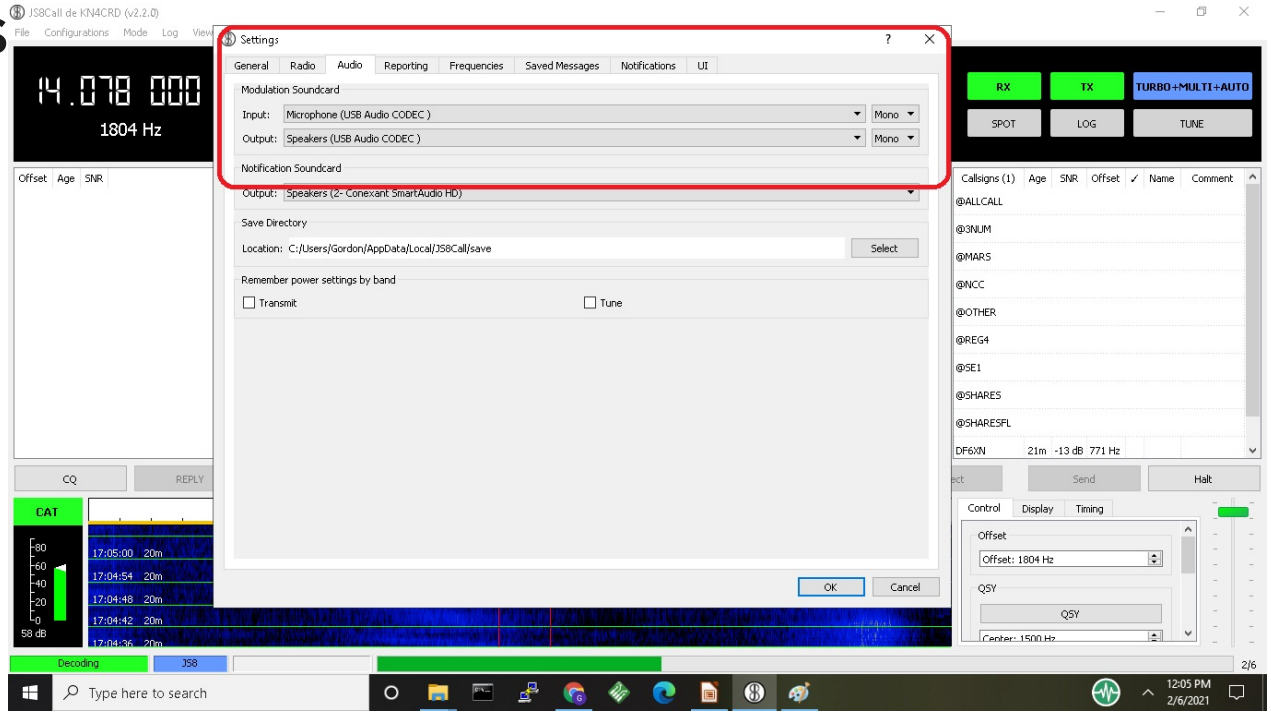
Easiest way is to google Dimension4 and load it from Thinking Man Software.

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



(2) Signalink or Built-in Soundcard

Simply find the USB CODEC, UART, or similar words in the software audio settings



That should be enough to DECODE signals

74 – typical FT8 signals

78 – typical JS8 (or possibly FT4) signals

Possible stop for a DEMO

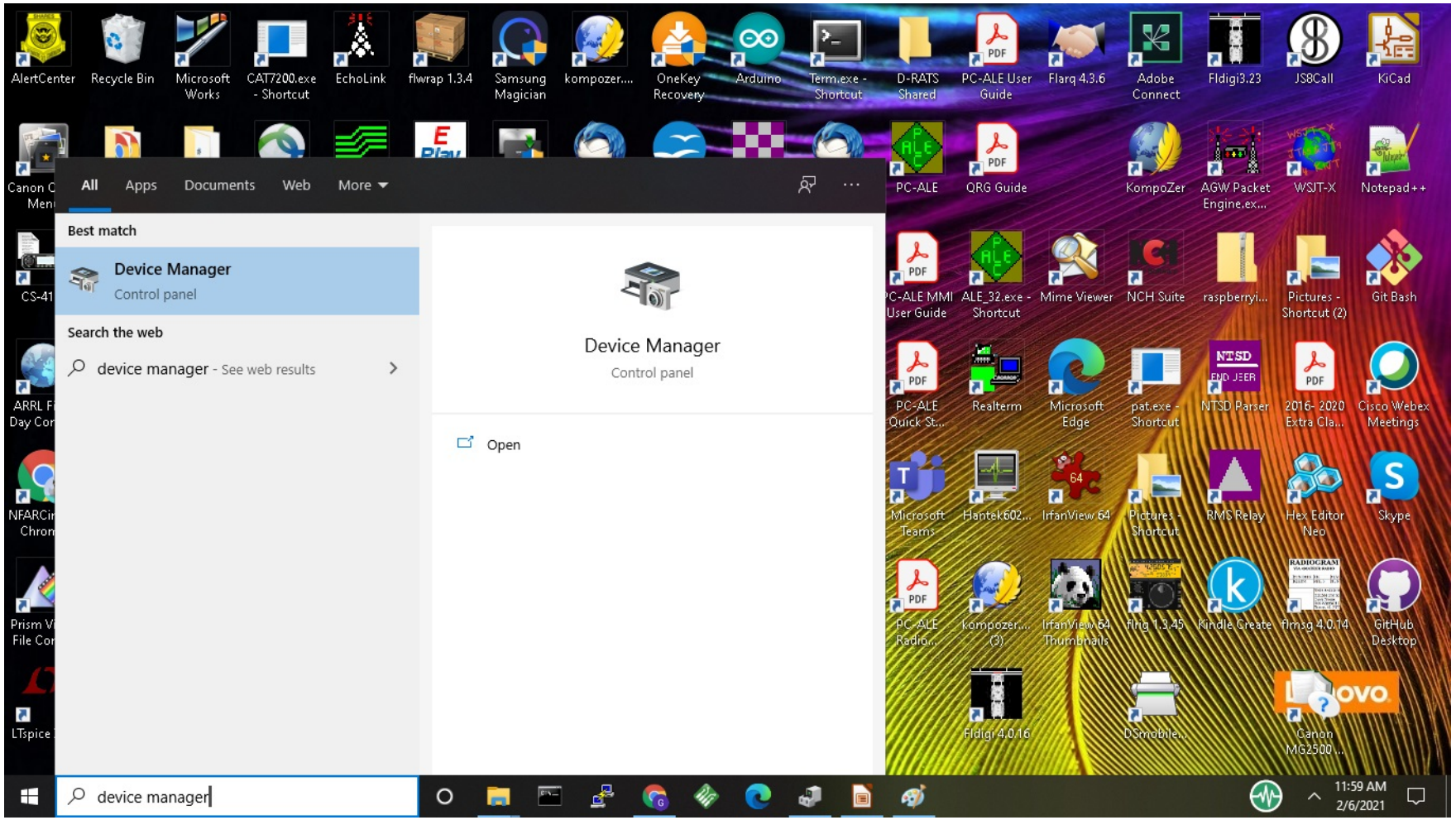
Getting TRANSMIT going

We already have the AUDIO connected.

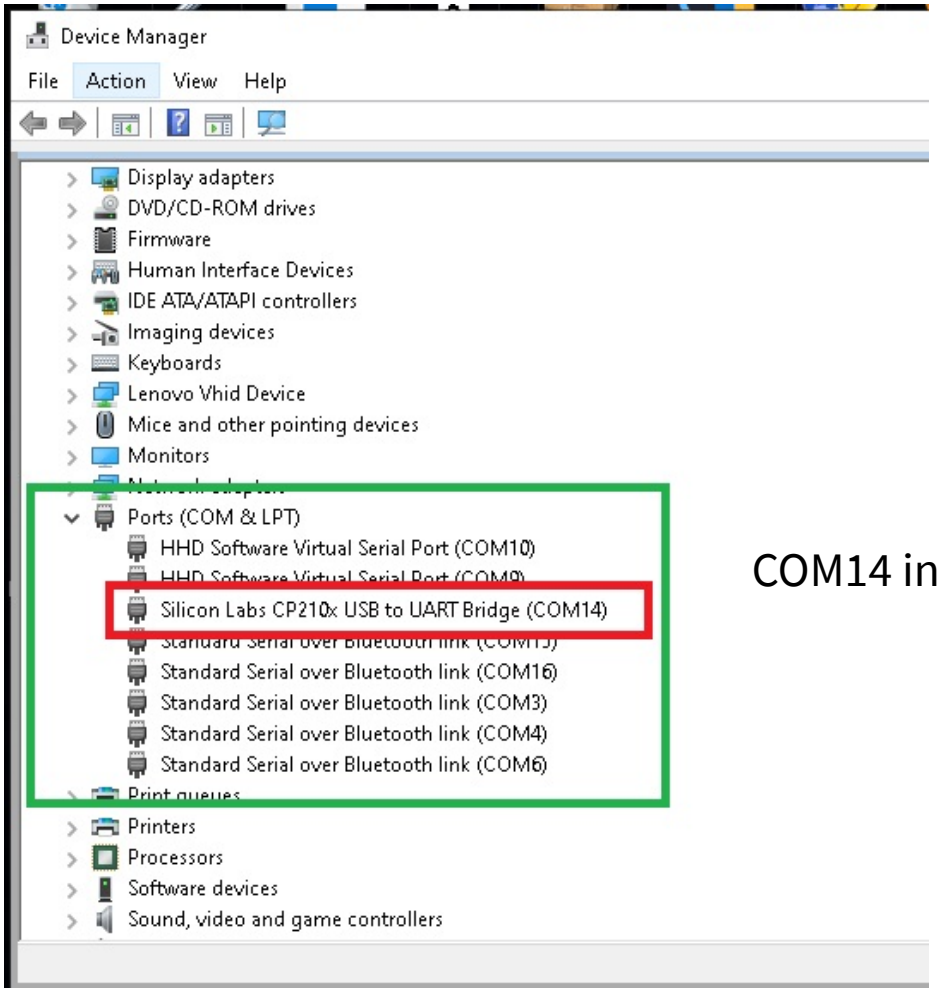
Getting Push To Talk (PTT) working

- Signalink to older rig: It will do the magic for us
- More Modern Rig – we have to get the CAT working

WINDOWS: Get Comfy with Device Manager



Find The USB Codec or USB to UART bridge



COM14 in this example of an Icom7300

4. DEMOS

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

FT8 Tricks

Put your TX in a clear spot! (red bracket)

Your RX can move all over – click the person you wish to connect to.

Most stuff is automatic

(Explain odd/even)

Shift-Click

The End

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