FT8

DESIGN, SETUP AND OPERATION

CLALLAM COUNTY AMATEUR RADIO CLUB

MAY 9, 2018

BILL PETERSON – K7WWP

FT8 DESIGN

AUTHORS

- Joe Taylor – K1JT
  - Professor of Physica (Emeritus) – Princeton University
  - Nobel Prize winner for measuring with great accuracy the energy loss of a binary star system due to gravitational waves (supporting Einstein's theory of gravitational waves)
  - Inventor of many "JT" digital modes for weak signal contacts
- Steven Franke – K9AN
  - Professor of Electrical and Computer Engineering – University of Illinois

DESIGN CRITERIA

- "FT8" stands for "Franke and Taylor, 8-FSK modulation“
- FT8 is a “slow” mode
- Designed to make contacts with weak signals where signal fading is a significant factor
- “Intended” for low power, but people often use high power
  - To get through bad conditions
  - Just because they have a very large amp

DESIGN CRITERIA (CONTINUED)

- A “replacement” for JT65
- Faster Contacts: 15-second T/R sequences – QSO’s 4X faster
- Provides 50% or better decoding probability down to -20 dB
- Designed to have high assurance of accurate message content
  - If we can decode it we’re 100% sure it is right
  - No retransmissions

SENSITIVITY (WEAK-SIGNAL S/N LIMITS)

Mode		(B=2500 Hz)
SSB		~ +10 dB
MSK144		-8 dB
CW “ear and brain”		-15 dB
FT8		-21 dB
JT4		-23 dB
JT65		-25 dB
JT9		-29 dB
QRA64		-27 dB
WSPR		-31 dB

QSO CONVERSATION

Station - A

- CQ CallSign GridLocation
- CallSign-B CallSign-A Signal Report
- CallSign-B CallSign-A RRR

Station - B

- CallSign-A CallSign-B GridLocation
- CallSign-A CallSign-B R+Signal Report
- CallSign-A CallSign-B 73

QSO CONVERSATION (EXAMPLE)

	Message from Station-A	Message from Station-B
#K1ABC calls CQ	CQ K1ABC FN4	
#G0XYZ answers		K1ABC G0XYZ IO91
#K1ABC sends report	G0XYZ K1ABC –19	
#G0XYZ sends R+report		K1ABC G0XYZ R-22
#K1ABC sends RRR	G0XYZ K1ABC RRR	
#G0XYZ sends 73		K1ABC G0XYZ 73

DESIGN SPECIFICATIONS (CONTINUED)
SUCCESSFUL TRANSMISSIONS

- No Re-Transmissions
- Uses robust forward error correction

DESIGN SPECIFICATIONS

FORWARD ERROR CORRECTION

What is parity

Simple parity:

- Message = (0 1 1 0) Parity = 0: I transmit (0 1 1 0 0)

- If I Receive (0 1 1 0 0) then the Parity (5^{th} bit) is correct for the message (bits 1-4)
- If I Receive (0 0 1 0 0) then the Parity (5^{th} bit) does not match the message parity (bits 1-4)

- So I know in the second example, the message & parity shows an incorrect transmission

DESIGN SPECIFICATIONS (CONTINUED)
FORWARD ERROR CORRECTION

Simple Forward Error Correction

- (0 1 1 0) Parity = 0
- (0 1 1 1) Parity = 1
- (1 0 0 0) Parity = 1
- (1 1 1 1) Parity = 0
- [0 1 1 0] ← Parity of Columns

DESIGN SPECIFICATIONS (CONTINUED)
FORWARD ERROR CORRECTION

- (0 1 1 0) Parity = 0
- (0 1 **0** 1) Parity = 1 ← This parity is wrong
- (1 0 0 0) Parity = 1
- (1 1 1 1) Parity = 0
- [0 1 1 0] ← Parity of Columns (Parity of Column 3 is Wrong)

- So we know the intersection of the row and column is wrong and we can correct it.

DESIGN SPECIFICATIONS (CONTINUED)
FORWARD ERROR CORRECTION

- Previous example of FEC was simplistic
- Steven Franke brought State of the Art communications technology to FT8.
  - FEC uses Low Density Parity Check Codes
    - Developed in 1963, but not used as it required extensive computing power to code.
    - Rediscovered in 1996, and became the best code by 2003
- Joe Taylor did not use LDPC until FT8
  - We learn as we went along.
  - Learning and improving low signal messaging is part of the fun.

DESIGN SPECIFICATIONS (CONTINUED)

- The message block:
  - Message Content – 75 bits
    - Crammed callsigns, grid, etc into 72 bits. Used one bit for “Free Form Messages”
  - Cyclic Redundancy Check – 12 bits
- LDPC – 87 bits

DESIGN SPECIFICATIONS (CONTINUED)

- Decoding LDPC calculates the probability of each bit
- Add to that probabilities of expected message content to assist decoding
  - CQ, Your Call Sign, other Known Call signs, etc.
- Once decoded, if the CRC checks to the message content, you're essentially 100% sure it's right
- A second pass of the signal is made, subtracting out the first decoded signals in order to pickup weaker signals that have been covered up
- Successful reception of the message content is critical to the mode's

WSJT-X DESIGN

- WSJT – Weak Signal Joe Taylor
- Started in 2001
  - Low Signal VHF DX
  - Meteor Scatter
  - Moon-Bounce
- WSPR (Weak Signal Propagation Reporter) added in 2008

WSJT-X DESIGN (CONTINUED)

- WSJT-X – Experimental or Extended “Fork-Code” of WSJT
- WSJT-X now replaces WSJT
- Runs on all platforms – Windows, Linux, and OS X
- Uses Python, C++, and Fortran – Using the best tool for the specific task
- Rig Control for nearly all modern radios
- Reports to PSKReporter

FT8 SETUP

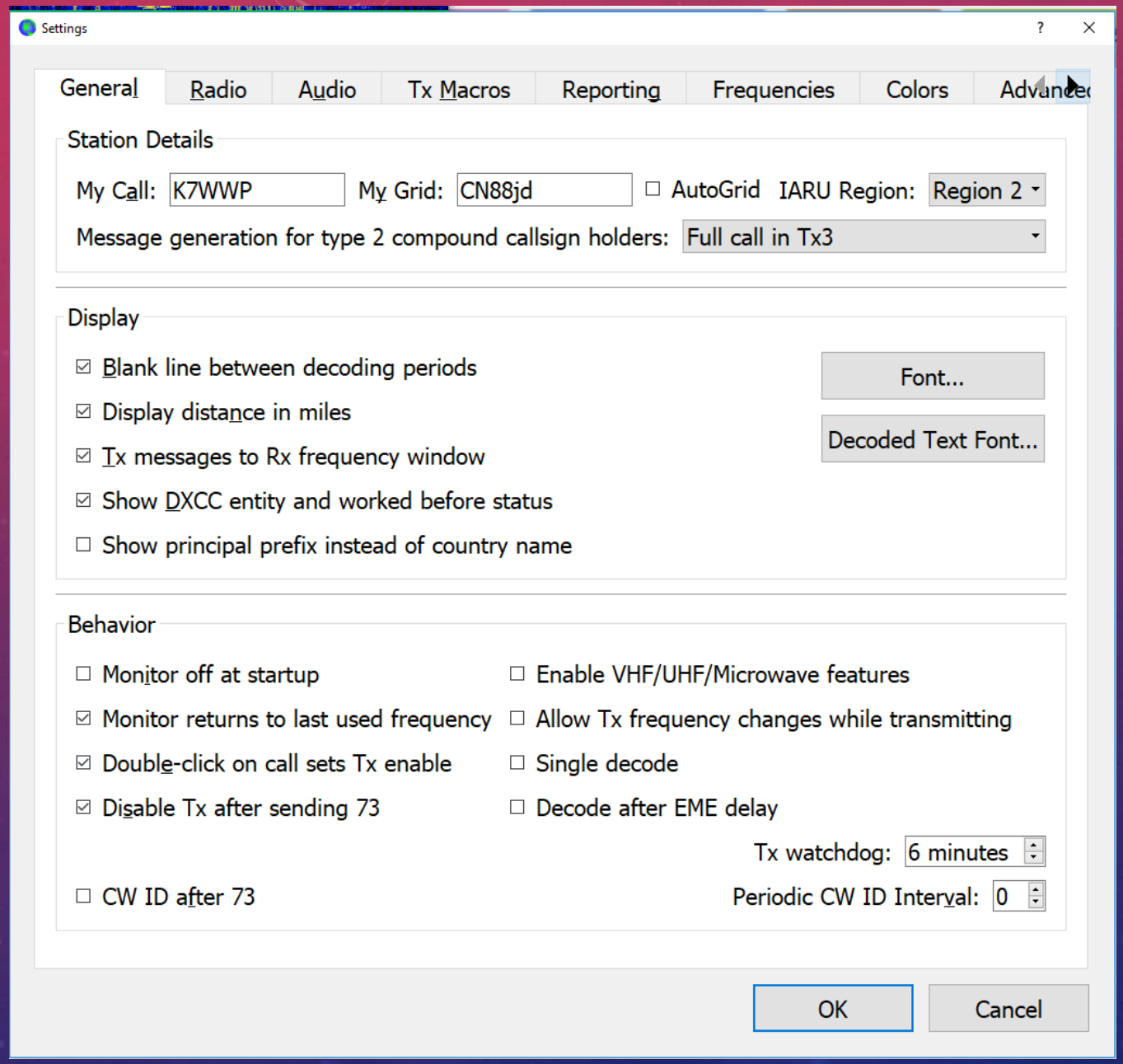
WSJT-X INSTALLATION AND SETUP

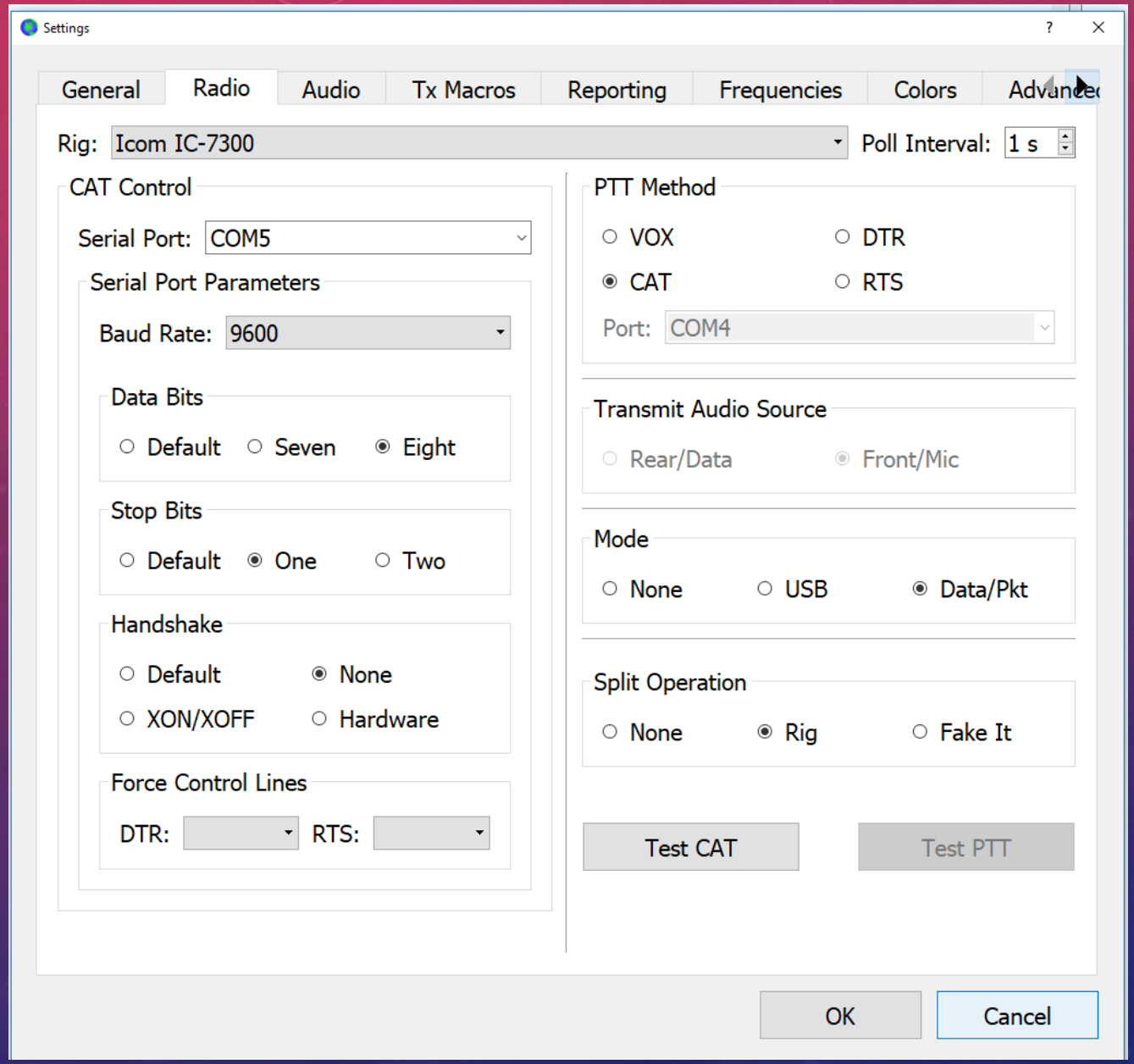
DOWNLOAD AND INSTALL WSJT-X

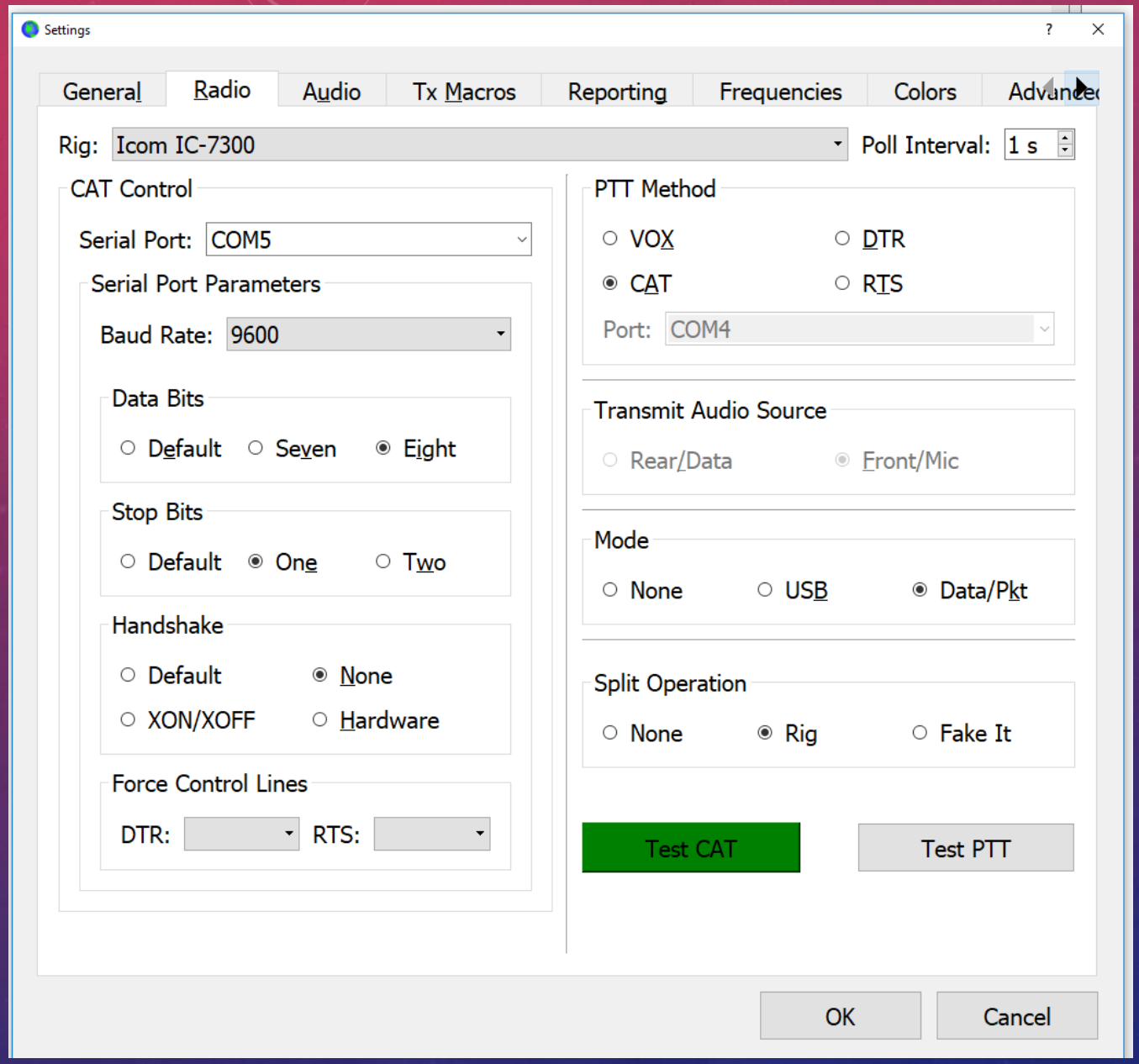
- Download from https://physics.princeton.edu/pulsar/k1jt/wsjtx.html
- Run Installation Process

CONFIGURE RADIO

- Setup Station Details (General Tab)
  - Call-Sign
  - Grid
- Setup Rig Control (Radio Tab)
  - Select Radio in list
  - Setup Communications parameters
  - Test CAT

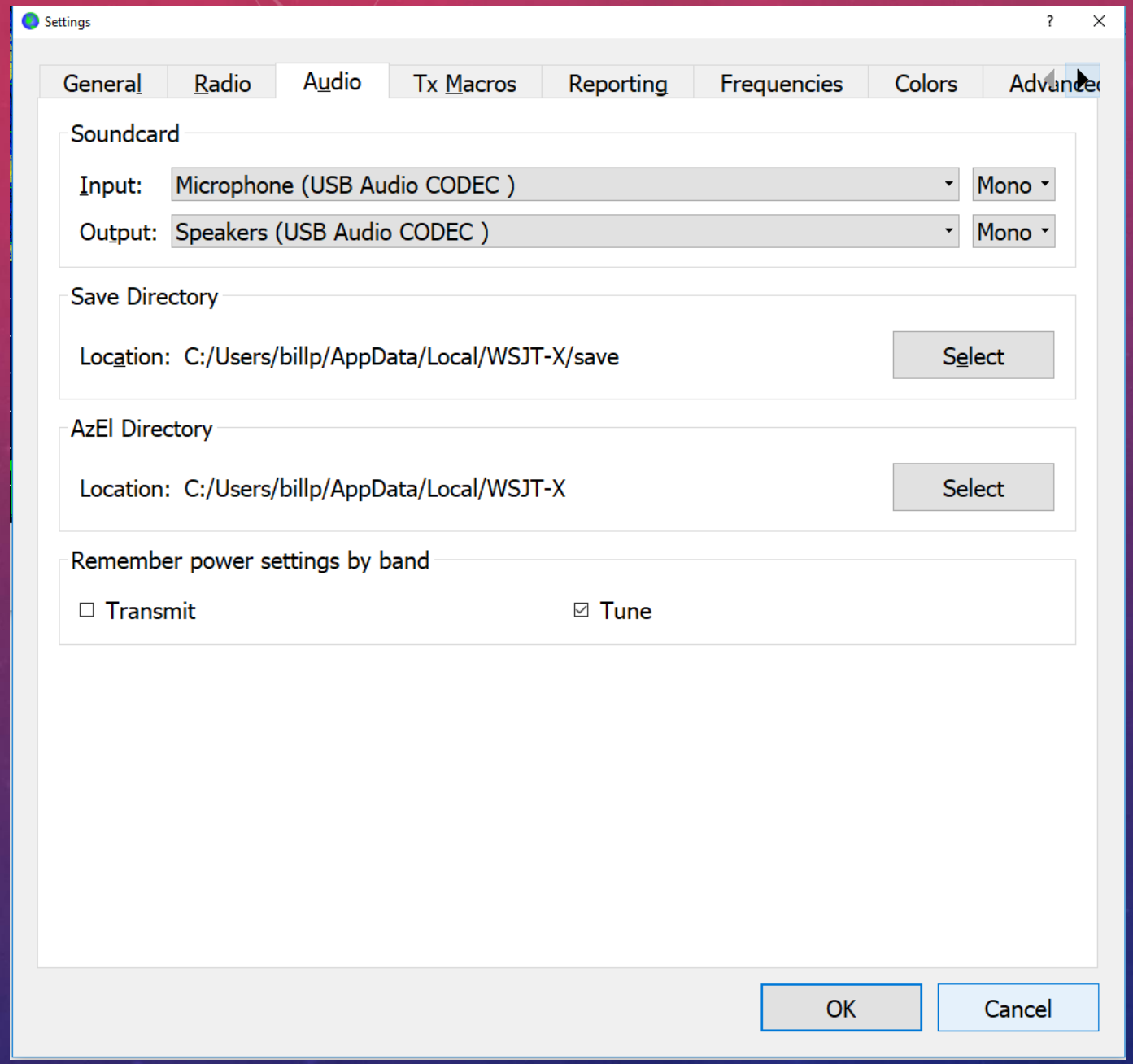

Settings
General
Radio
Audio
Tx Macros
Reporting
Frequencies
Colors
Station Details
My Call: K7WWP
My Grid: CN88jd
AutoGrid
IARU Region: Region 2
Message generation for type 2 compound callsign holders: Full call in Tx3
Display
Blank line between decoding periods
Display distance in miles
Tx messages to Rx frequency window
Show DXCC entity and worked before status
Show principal prefix instead of country name
Font...
Decoded Text Font...
Behavior
Monitor off at startup
Monitor returns to last used frequency
Double-click on call sets Tx enable
Disable Tx after sending 73
CW ID after 73
Enable VHF/UHF/Microwave features
Allow Tx frequency changes while transmitting
Single decode
Decode after EME delay
Tx watchdog: 6 minutes
Periodic CW ID Interval: 0
OK
Cancel

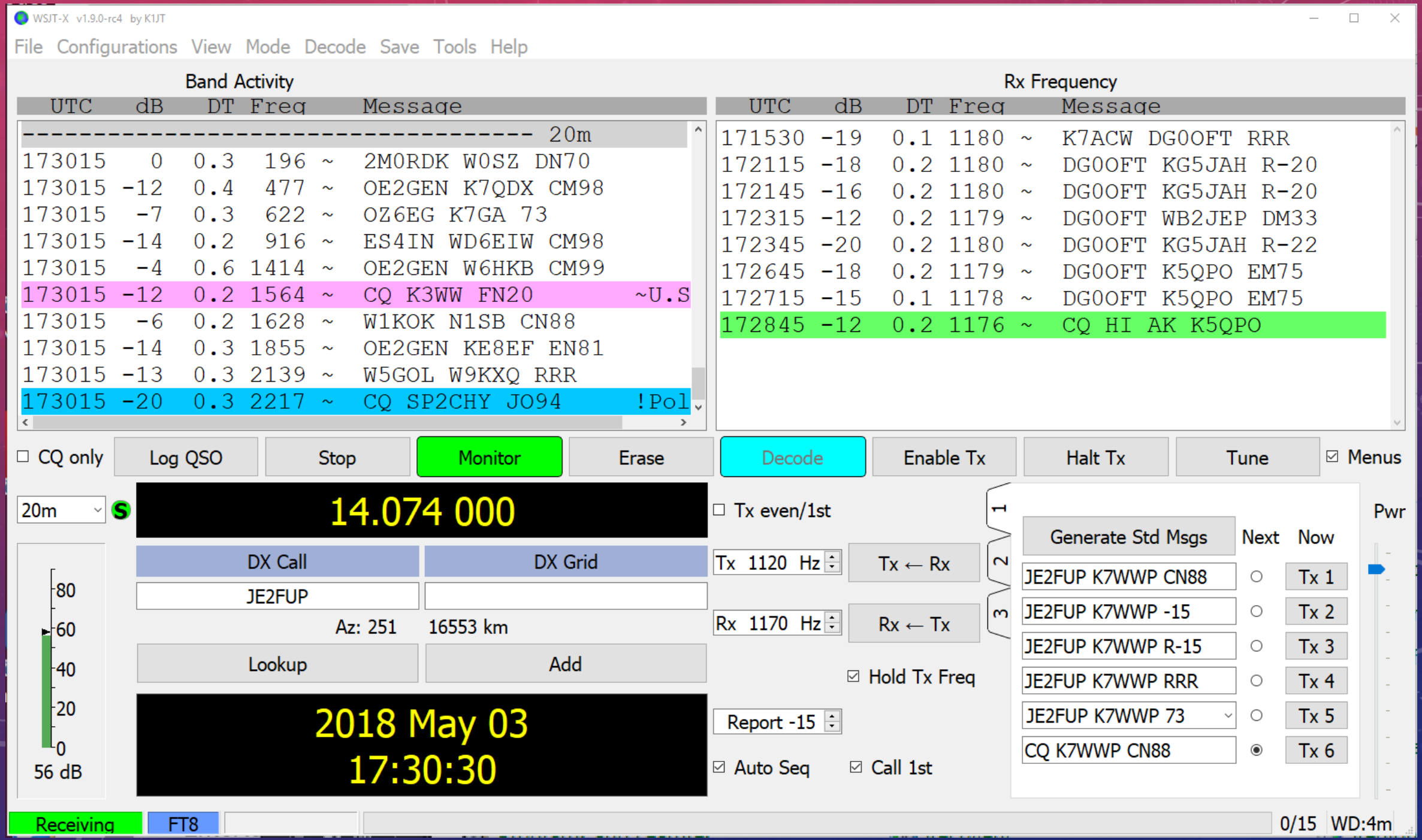

Settings
General
Radio
Audio
Tx Macros
Reporting
Frequencies
Colors
Rig: Icom IC-7300
Poll Interval: 1 s
CAT Control
Serial Port: COM5
Serial Port Parameters
Baud Rate: 9600
Data Bits
Default
Seven
Eight
Stop Bits
Default
One
Two
Handshake
Default
None
XON/XOFF
Hardware
Force Control Lines
DTR:
RTS:
PTT Method
VOX
DTR
CAT
RTS
Port: COM4
Transmit Audio Source
Rear/Data
Front/Mic
Mode
None
USB
Data/Pkt
Split Operation
None
Rig
Fake It
Test CAT
Test PTT
OK
Cancel

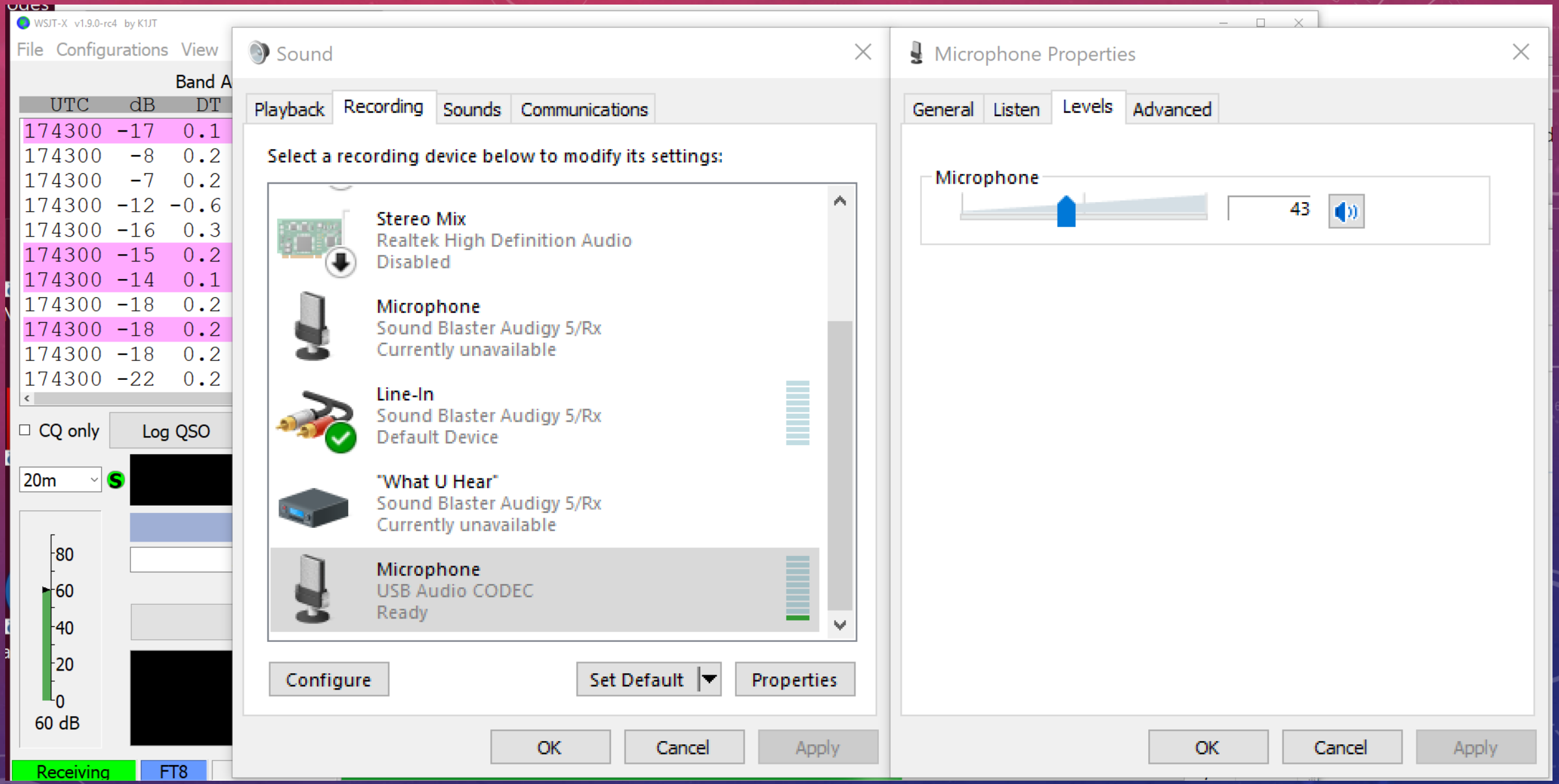

Settings
General
Radio
Audio
Tx Macros
Reporting
Frequencies
Colors
Rig: Icom IC-7300
Poll Interval: 1 s
CAT Control
Serial Port: COM5
Serial Port Parameters
Baud Rate: 9600
Data Bits
Default
Seven
Eight
Stop Bits
Default
One
Two
Handshake
Default
None
XON/XOFF
Hardware
Force Control Lines
DTR:
RTS:
PTT Method
VOX
DTR
CAT
RTS
Port: COM4
Transmit Audio Source
Rear/Data
Front/Mic
Mode
None
USB
Data/Pkt
Split Operation
None
Rig
Fake It
Test CAT
Test PTT
OK
Cancel

SETUP AUDIO AND AUDIO LEVELS

- Input (Signal from radio) input to “mic” on computer
- Adjust green “Receive signal strength” on lower left side of main WSJT-X screen
  - Should be near zero with the radio off
  - Should be about 30 dB in quiet band
    - Adjust “mic” volume on computer and/or radio interface volume output
  - Should be 40 dB – 70 dB in band with signal activity

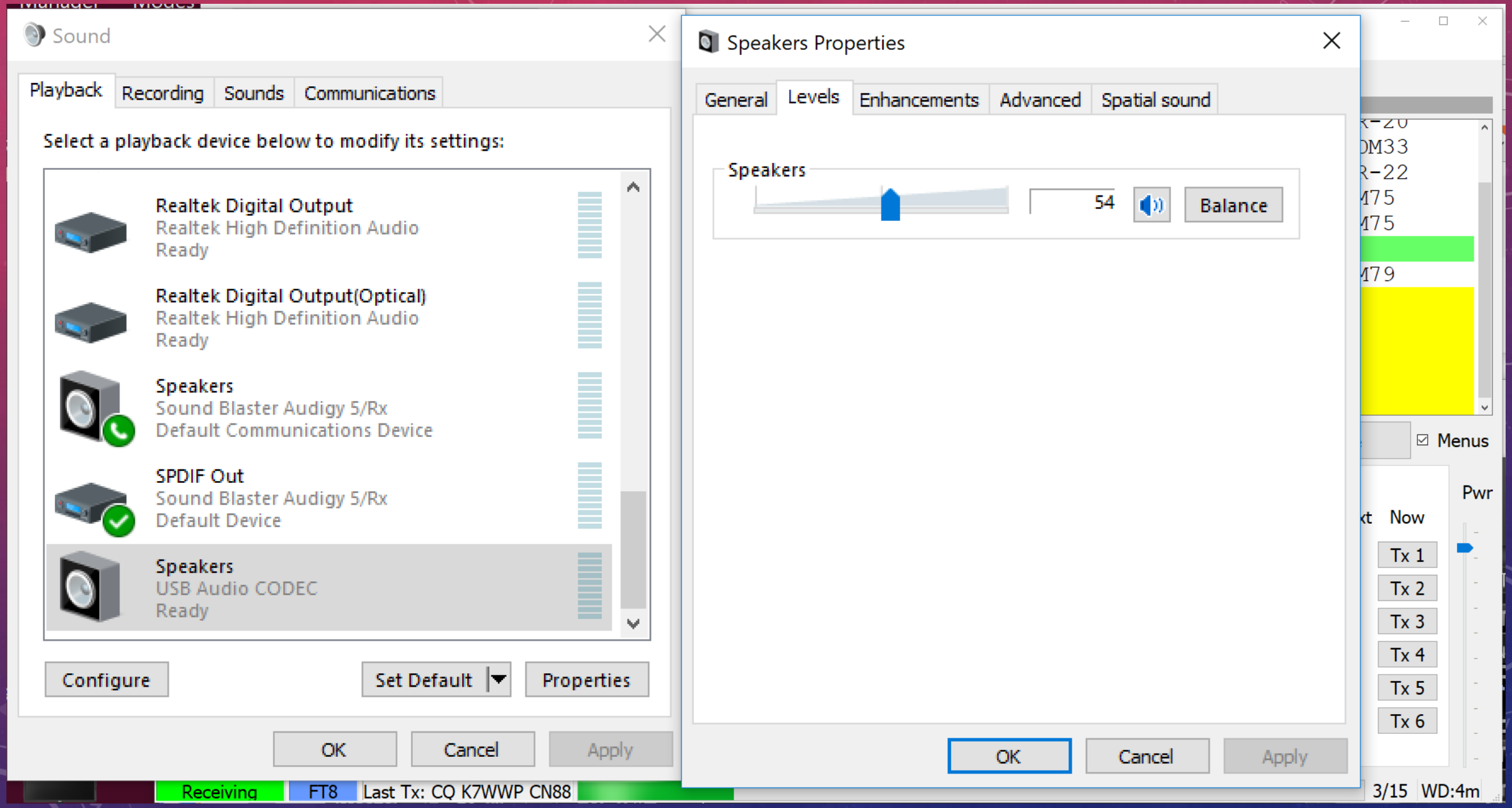

Settings
General
Radio
Audio
Tx Macros
Reporting
Frequencies
Colors
Soundcard
Input:
Microphone (USB Audio CODEC)
Mono
Output:
Speakers (USB Audio CODEC)
Mono
Save Directory
Location: C:/Users/billp/AppData/Local/WSJT-X/save
Select
AzEl Directory
Location: C:/Users/billp/AppData/Local/WSJT-X
Select
Remember power settings by band
Transmit
Tune
OK
Cancel


WSJT-X v1.9.0-rc4 by K1JT
File Configurations View Mode Decode Save Tools Help
Band Activity
UTC dB DT Freq Message
---------- 20m
173015 0 0.3 196 ~ 2M0RDK W0SZ DN70
173015 -12 0.4 477 ~ OE2GEN K7QDX CM98
173015 -7 0.3 622 ~ OZ6EG K7GA 73
173015 -14 0.2 916 ~ ES4IN WD6EIW CM98
173015 -4 0.6 1414 ~ OE2GEN W6HKB CM99
173015 -12 0.2 1564 ~ CQ K3WW FN20 ~U.S
173015 -6 0.2 1628 ~ W1KOK N1SB CN88
173015 -14 0.3 1855 ~ OE2GEN KE8EF EN81
173015 -13 0.3 2139 ~ W5GOL W9KXQ RRR
173015 -20 0.3 2217 ~ CQ SP2CHY JO94 !Pol
Rx Frequency
UTC dB DT Freq Message
171530 -19 0.1 1180 ~ K7ACW DG0OFT RRR
172115 -18 0.2 1180 ~ DG0OFT KG5JAH R-20
172145 -16 0.2 1180 ~ DG0OFT KG5JAH R-20
172315 -12 0.2 1179 ~ DG0OFT WB2JEP DM33
172345 -20 0.2 1180 ~ DG0OFT KG5JAH R-22
172645 -18 0.2 1179 ~ DG0OFT K5QPO EM75
172715 -15 0.1 1178 ~ DG0OFT K5QPO EM75
172845 -12 0.2 1176 ~ CQ HI AK K5QPO
CQ only
Log QSO
Stop
Monitor
Erase
Decode
Enable Tx
Halt Tx
Tune
Menus
20m
14.074 000
Tx even/1st
DX Call
DX Grid
JE2FUP
Az: 251
16553 km
Lookup
Add
Tx 1120 Hz
Rx 1170 Hz
Tx ← Rx
Rx ← Tx
Hold Tx Freq
Report -15
Auto Seq
Call 1st
2018 May 03
17:30:30
80
60
40
20
0
56 dB
1
2
3
Generate Std Msgs
Next
Now
JE2FUP K7WWP CN88
JE2FUP K7WWP -15
JE2FUP K7WWP R-15
JE2FUP K7WWP RRR
JE2FUP K7WWP 73
CQ K7WWP CN88
Tx 1
Tx 2
Tx 3
Tx 4
Tx 5
Tx 6
Pwr
Receiving
FT8
0/15
WD:4m


WSJT-X v1.9.0-rc4 by K1JT
File Configurations View
Band A
UTC dB DT
174300 -17 0.1
174300 -8 0.2
174300 -7 0.2
174300 -12 -0.6
174300 -16 0.3
174300 -15 0.2
174300 -14 0.1
174300 -18 0.2
174300 -18 0.2
174300 -18 0.2
174300 -22 0.2
CQ only
Log QSO
20m
80
60
40
20
0
60 dB
Receiving
FT8
Sound
Playback
Recording
Sounds
Communications
Select a recording device below to modify its settings:
Stereo Mix
Realtek High Definition Audio
Disabled
Microphone
Sound Blaster Audigy 5/Rx
Currently unavailable
Line-In
Sound Blaster Audigy 5/Rx
Default Device
"What U Hear"
Sound Blaster Audigy 5/Rx
Currently unavailable
Microphone
USB Audio CODEC
Ready
Configure
Set Default
Properties
OK
Cancel
Apply
Microphone Properties
General
Listen
Levels
Advanced
Microphone
43
OK
Cancel
Apply

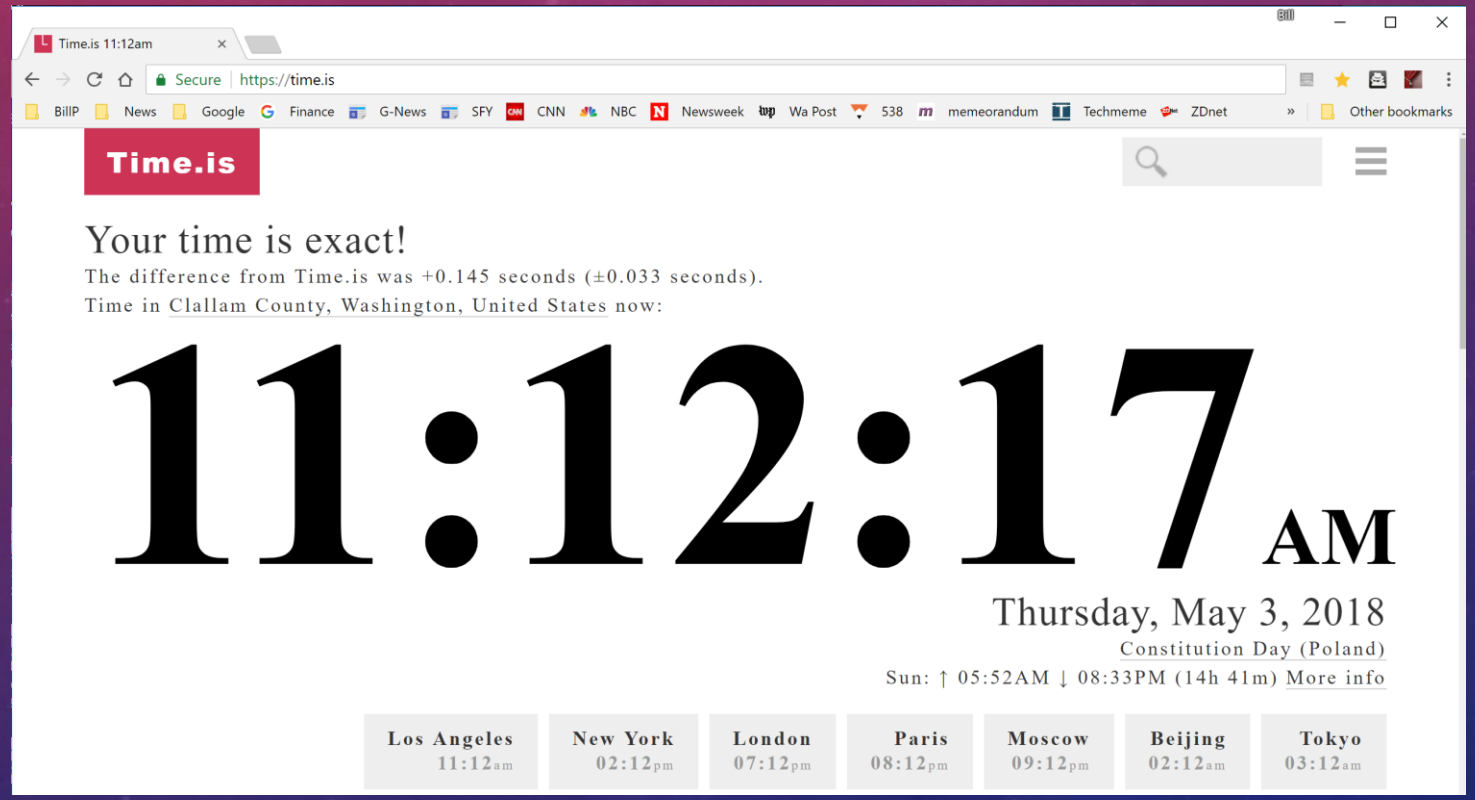
SETUP AUDIO AND AUDIO LEVELS (CONTINUED)

- Output (Signal to Radio) Output from computer
- Adjust “Pwr” pointer on lower right hand side of WSJT-X screen
  - Adjust “Pwr” and/or radio interface volume input
    - Adjust to minimal radio ALC (Audio Level Compression) level
    - Adjust high enough to drive radio to “desired” power output
      - No higher or signal compression and/or distortion will occur


Sound
Playback
Recording
Sounds
Communications
Select a playback device below to modify its settings:
Realtek Digital Output
Realtek High Definition Audio
Ready
Realtek Digital Output(Optical)
Realtek High Definition Audio
Ready
Speakers
Sound Blaster Audigy 5/Rx
Default Communications Device
SPDIF Out
Sound Blaster Audigy 5/Rx
Default Device
Speakers
USB Audio CODEC
Ready
Configure
Set Default
Properties
OK
Cancel
Apply
Speakers Properties
General
Levels
Enhancements
Advanced
Spatial sound
Speakers
54
Balance
OK
Cancel
Apply
Menus
Pwr
Now
Tx 1
Tx 2
Tx 3
Tx 4
Tx 5
Tx 6
Receiving
FT8
Last Tx: CQ K7WWP CN88
3/15
WD:4m

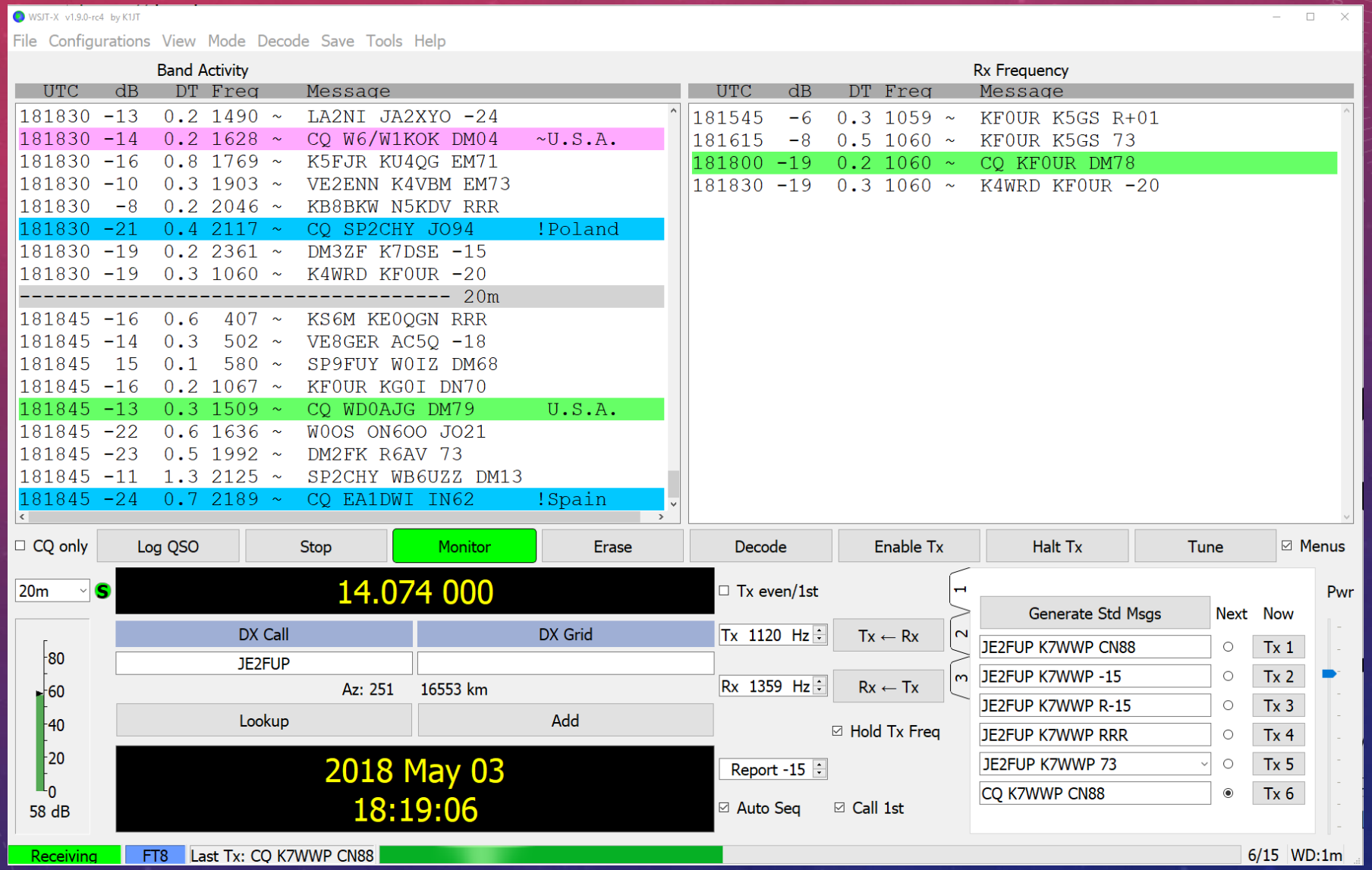
OTHER GENERAL SETUP OPTIONS

- Validate system time to coordinate your receive/transmit windows with other stations

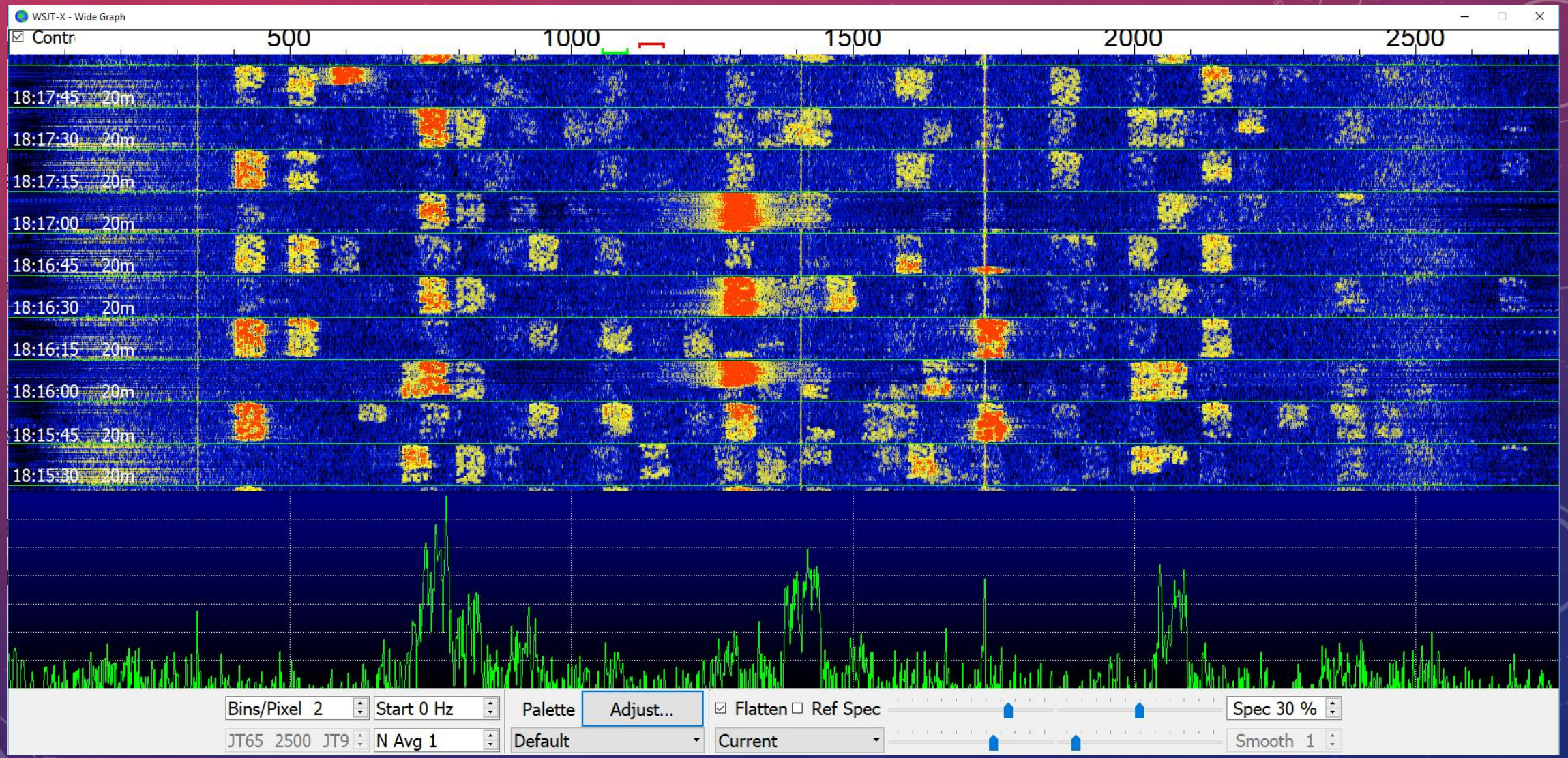


FT8 OPERATION

THE MAIN SCREEN



THE WATERFALL



Display Reception Report

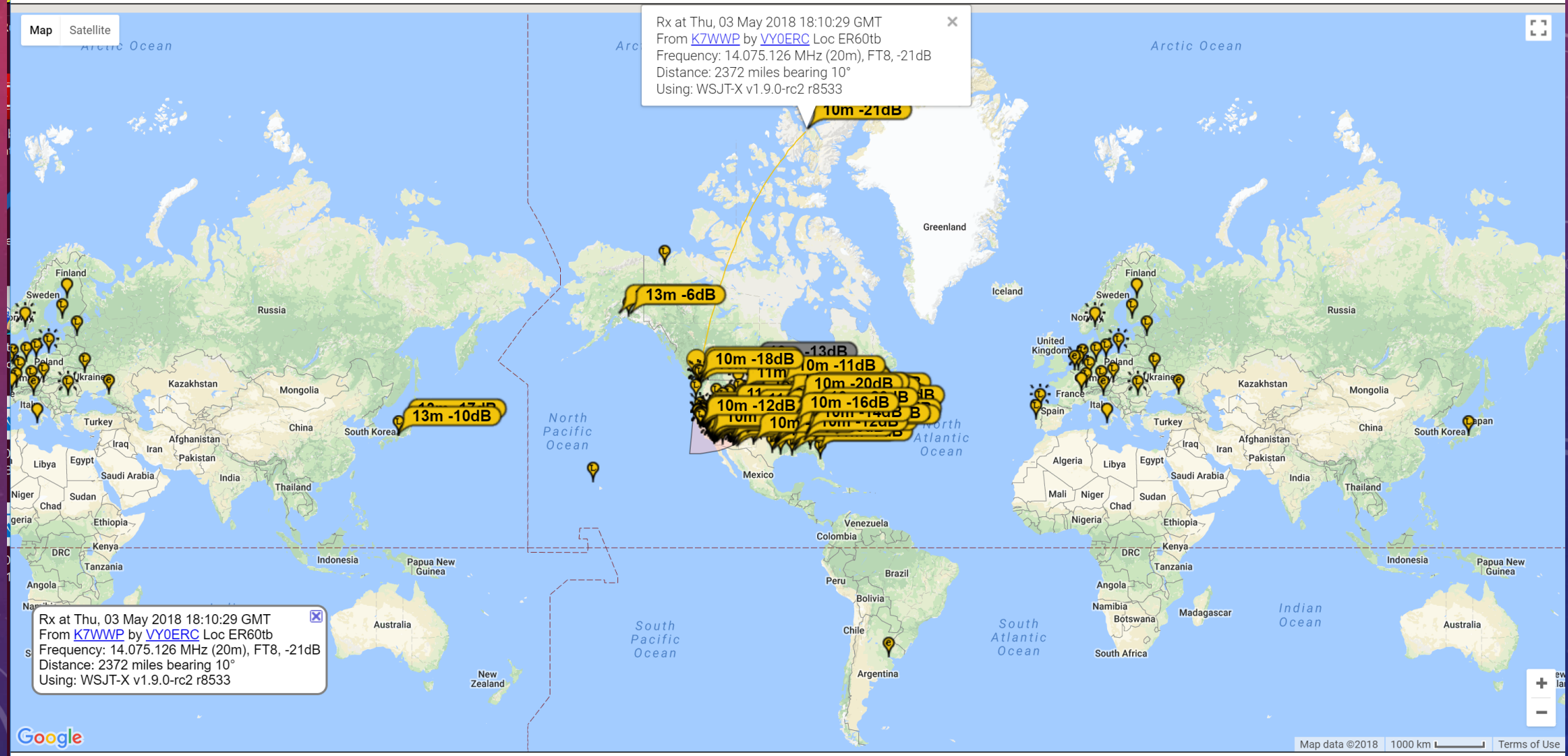
Secure | https://pskreporter.info/pskmap.html

BillP | News | Google | Finance | G-News | SFY | CNN | NBC | Newsweek | Wa Post | 538 | memeorandum | Techmeme | ZDnet | 9to5G | 9to5Toys | Other bookmarks

On all bands, show signals, sent/rcvd by the callsign k7wwp using FT8 over the last 6 hours Go! Display options

Monitoring K7WWP (last heard 10 mins ago). Automatic refresh in 4 minutes. Small markers are the 178 transmitters (show logbook) heard (distance chart) at K7WWP (340 reports, 24 countries last 24 hours; 1253 reports, 24 countries last week).

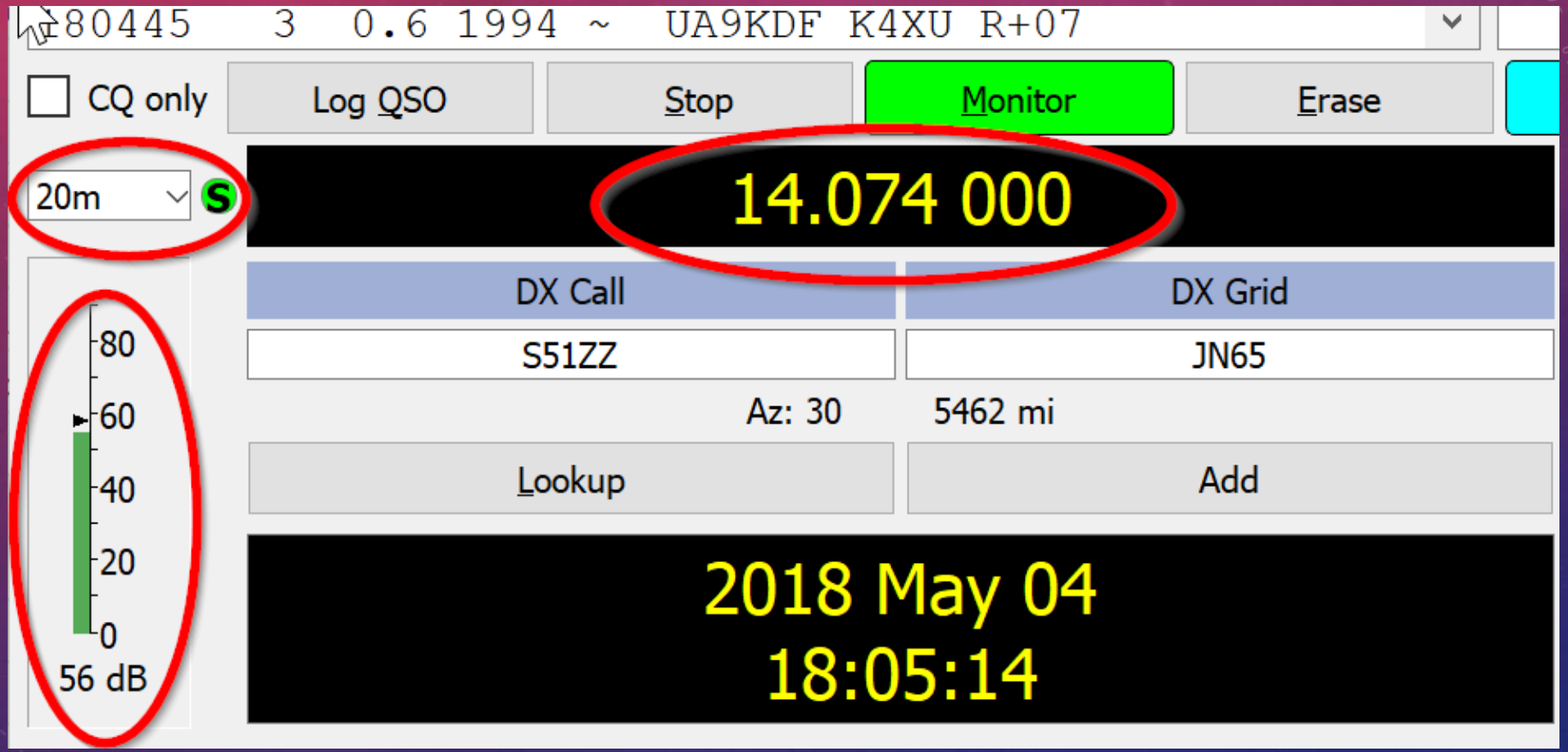
There are 2757 active FT8 monitors: 1131 on 20m, 391 on 40m, 359 on 30m, 283 on 6m, 263 on 17m, 92 on 80m, 74 on 15m, 46 on 2m, 44 on 10m, 35 on 60m, 24 on unknown, 7 on 12m, 5 on 160m, 2 on 4m, 1 on 70cm. Show all on all bands. Legend



System statistics. Comments, problems etc to Philip Gladstone. Online discussion of problems/issues. Reception records: 3,393,686,397

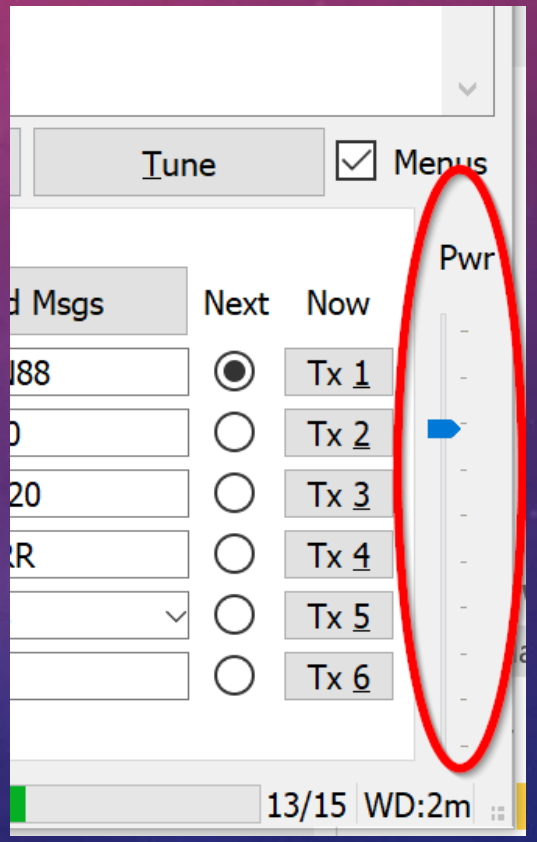
PSKREPORTER.INFO

MAIN SCREEN – BAND, FREQ, LEVEL



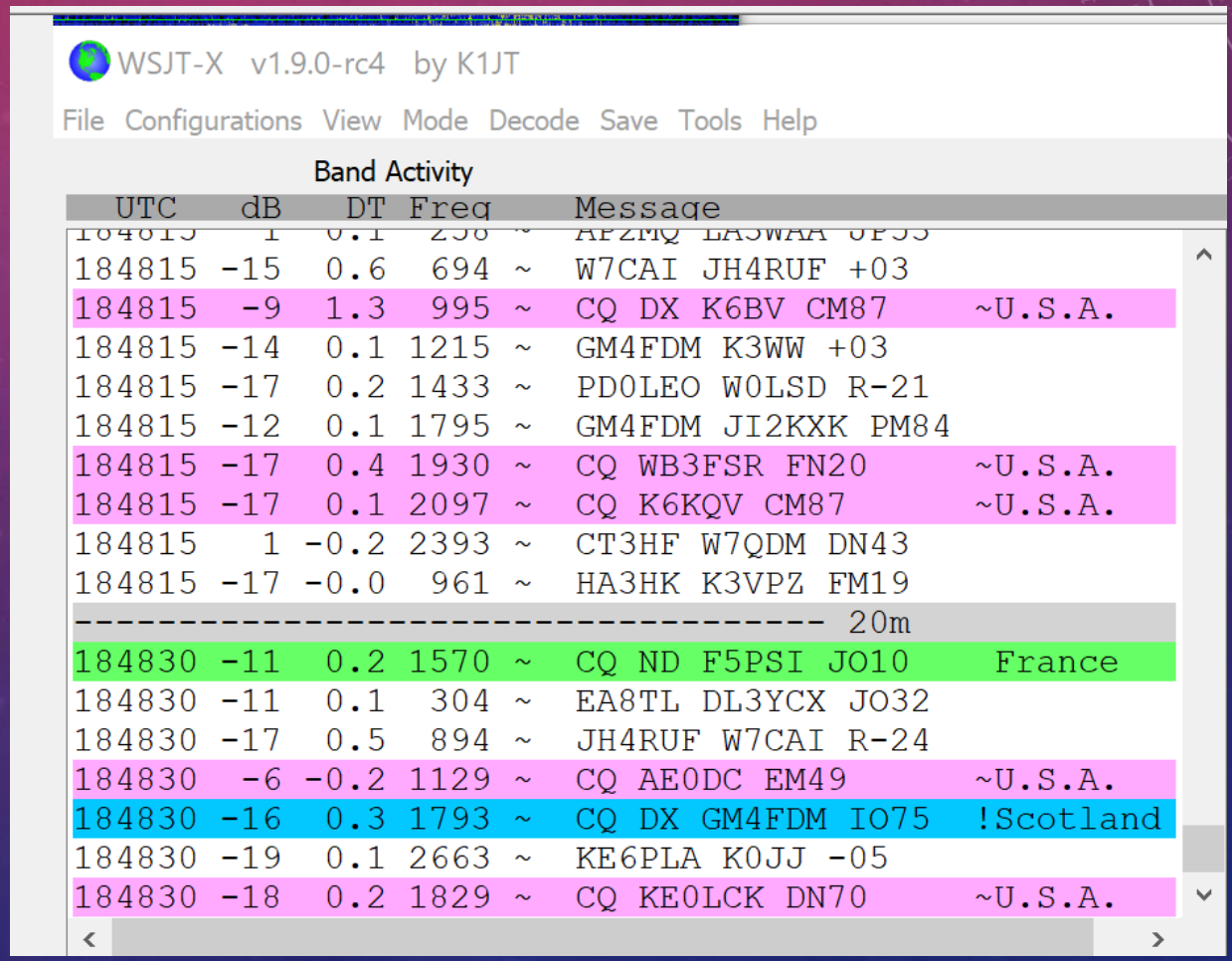
MAIN SCREEN – PWR

- Controls audio level that drives signal amplitude



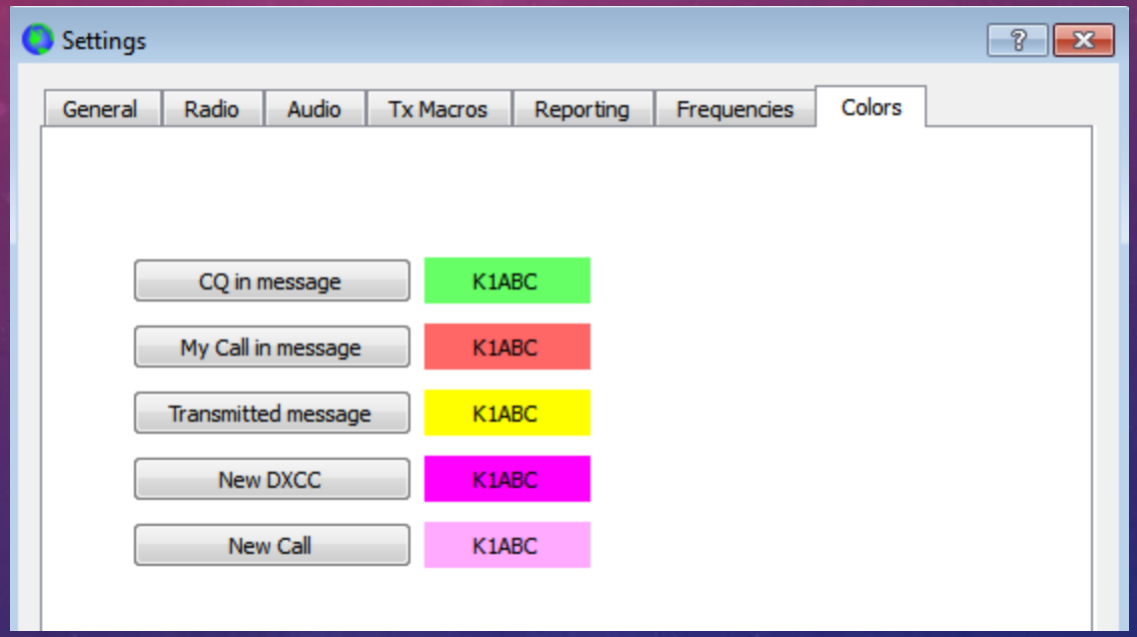
MAIN SCREEN – BAND ACTIVITY

- Entire 2.5 K audio band
- UTC – Time
- dB – Signal Strength
- DT – Delta Time
- Freq
- Message
- “Blank” Line
- Color
  - Green – Worked this station
  - Pink – New Station
  - Blue – New DXCC (Country)
  - White – Non of the above



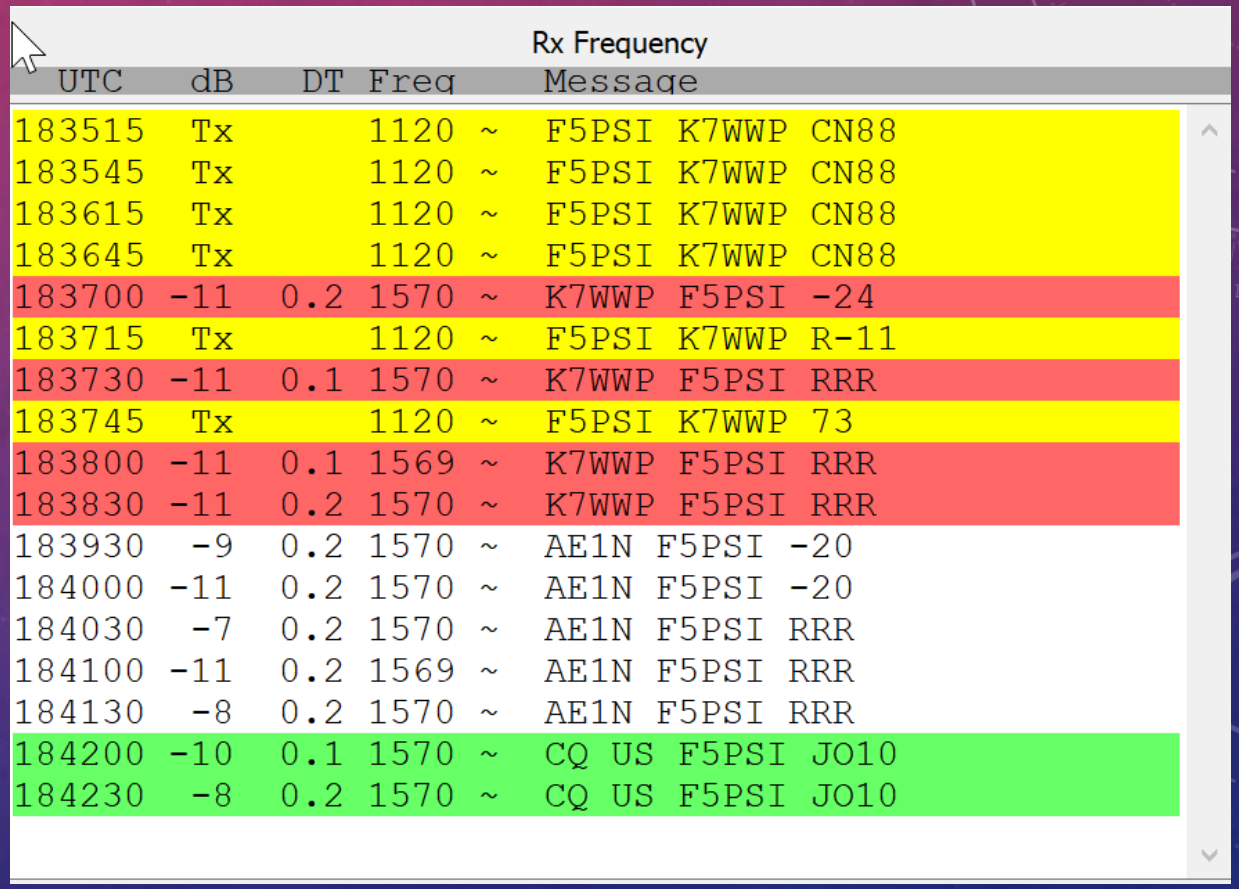
MAIN SCREEN – MESSAGE COLOR

- I’ve changed my “New DXCC” to blue because it is easier to differentiate from “New Call on some monitors.



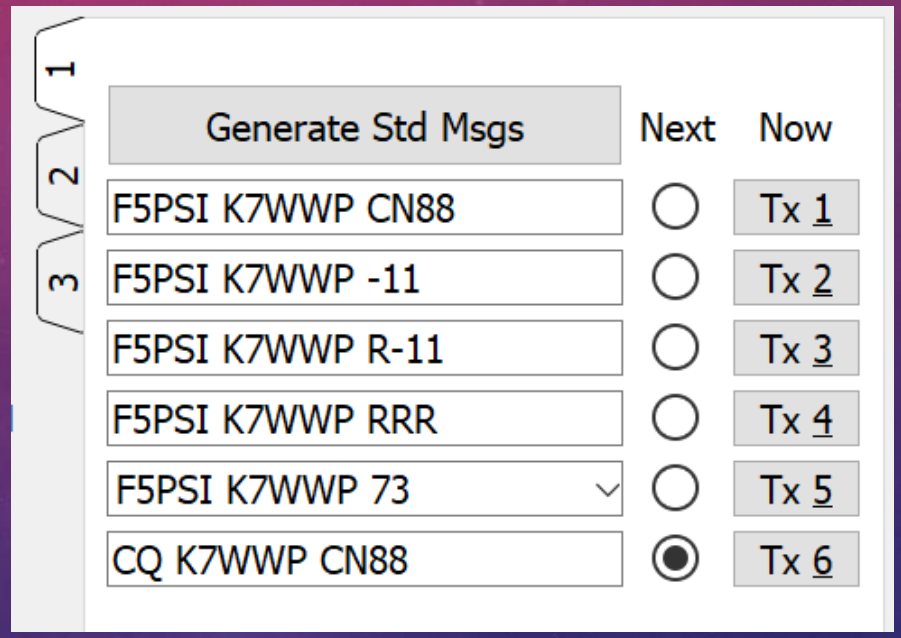
MAIN SCREEN – RECEIVE FREQUENCY

- This is the activity on your “receive” frequency
  - My transmissions on 1120
  - My Rx Frequency on 1570
- Colors
  - Yellow – My Transmission
  - Red – My Call-Sign in Message
  - Green – CQ in message
  - White – Non of the above



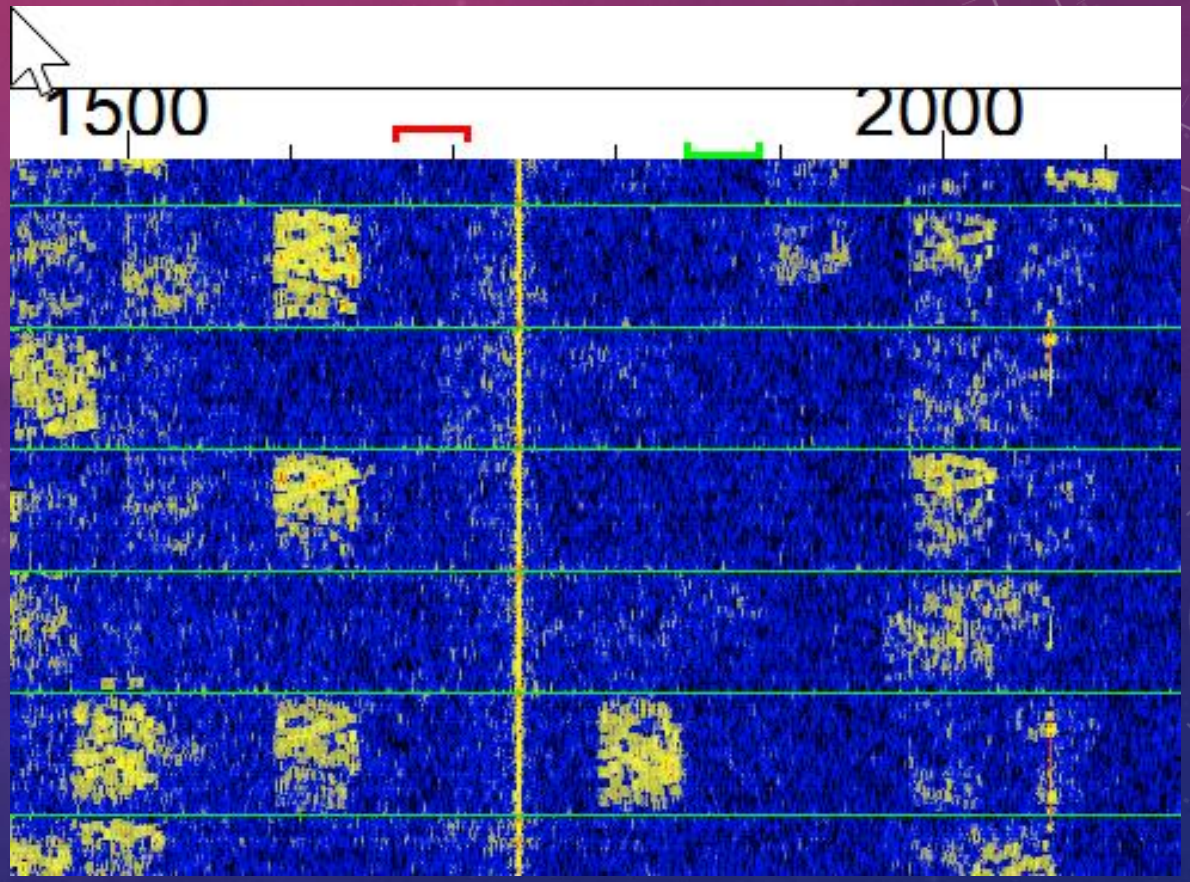
MAIN SCREEN – GENERATED STANDARD MESSAGES

- Setup when double-click on CQ
- Auto sequence through messages
- Can be manually selected
- Select #6 when you “CQ”



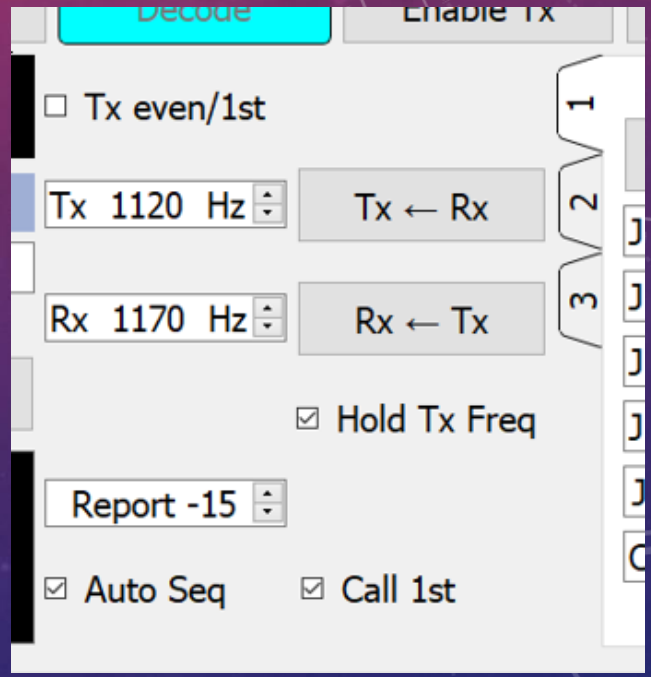
WATERFALL – SET RX AND FX

- Click on waterfall location to set Rx (green)
- Shift-Click on waterfall location to set Tx (red)
  - Select a quiet area, set Tx there and leave it.

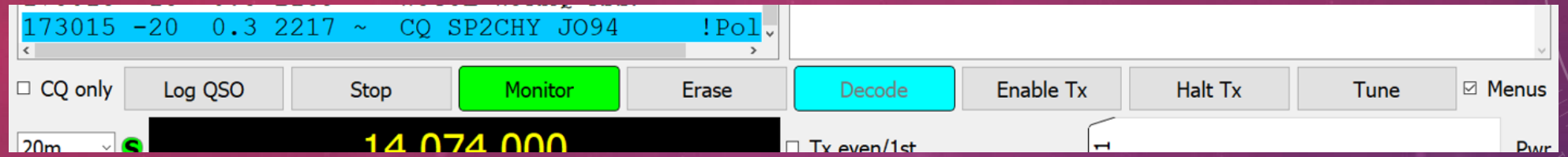


MAIN SCREEN – OTHER

- CQ Only – Only display CQ messages in Band Activy
- Tx Even/1st – Transmit in even time window, receive in odd time window.
- Only for you CQ'ing.
- Tx and Rx controls – ways to adjust Tx and Rx.
  - It's easiest to just click on the waterfall, or double-click on CQ to work a call
- Hold Tx Freq
- Report-nn – Lets you change the signal report that is automatically inserted
- Auto Seq – Enable auto message transmissions
- Call 1st – Call first responder to your CQ



MAIN SCREEN – BUTTON ROW



- Log QSO – Opens QSO dialog box
- Stop – Stops data acquisition. Freezes waterfall
- Monitor – Toggles Receive on / off
- Erase
  - Single Click – Erases Receive Frequency Activy
  - Double-Click – Erases Band Activity
- Decode – Tells program to decode most recent received activity. (Automatic
- Enable Tx – Enable your Tx for your time-slot. Disables Tx for next time slot
- Halt Tx- Immediately halts Tx
- Tune – Provides unmodulated tone so you can adjust your antenna tuner

WORK A CALLING STATION

- Set Transmit Frequency
- Double-click on CQ
  - Sets your Rx
  - Generates your standard messages
  - Turns on “Enable Tx”
  - Begins the Auto Sequence of standard messages
  - If message exchange is successful
    - Turns off “Enable Tx”
    - Opens QSO log dialog

CALL CQ

- Set Transmit Frequency
- Click on radio button on last generated Std Msg (CQ with your Call-Sign)
- Turn on “Enable Tx”

DX-PEDITION MODE

- Shorter QSO conversation
- Up to 5 QSO conversations simultaneously
- In last beta test, W7/KH7Z was able to log 174 QSO’s in 60 minutes

HELP! AND MORE INFORMATION

- The WSJT-X user manual and the “Hinson Tips” are very well written and provide a great deal of useful information. Read them.

FT8 LIVE DEMO

Q & A

REFENCE LINKS

- https://physics.princeton.edu/pulsar/k1jt/wsjtx-doc/wsjtx-main-1.8.0.html
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- https://www.physics.princeton.edu/pulsar/K1JT/FT8_Operating_Tips.pdf
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- https://wsjtx.net/home.html
-
- https://k4nab.org/wp-content/uploads/2018/01/FT8_Hinson_tips_for_HF_DXers.pdf
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- https://time.is