

A Pragmatic Introduction to FT8

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Agenda

- Objective
- FT8 Background
- What is digital communications?
- Why has FT8 become so popular?
- A FT8 QSO
- A little technical nitty gritty
- Operating
- What is needed to get on FT8
- Almost effortless FT8
- Recent FT8 features
- Q&A

“People's reaction to FT8 the first time they see it is very dramatic. They either love it or hate it. If they love it, they will always love it. If they don't, they may learn to appreciate it, but it will never become part of their soul.”

From the movie Pretty YL

Objective

- Provide a basic understanding of FT8 operation and technology.
- No evangelism.

Fast Fourier Transformation (FFT)

$$\begin{aligned} X_{k+\frac{N}{2}} &= \sum_{m=0}^{N/2-1} x_{2m} e^{-\frac{2\pi i}{N/2} m(k+\frac{N}{2})} + e^{-\frac{2\pi i}{N} (k+\frac{N}{2})} \sum_{m=0}^{N/2-1} x_{2m+1} e^{-\frac{2\pi i}{N/2} m(k+\frac{N}{2})} \\ &= \sum_{m=0}^{N/2-1} x_{2m} e^{-\frac{2\pi i}{N/2} mk} e^{-2\pi mi} + e^{-\frac{2\pi i}{N} k} e^{-\pi i} \sum_{m=0}^{N/2-1} x_{2m+1} e^{-\frac{2\pi i}{N/2} mk} e^{-2\pi mi} \\ &= \sum_{m=0}^{N/2-1} x_{2m} e^{-\frac{2\pi i}{N/2} mk} - e^{-\frac{2\pi i}{N} k} \sum_{m=0}^{N/2-1} x_{2m+1} e^{-\frac{2\pi i}{N/2} mk} \\ &= E_k - e^{-\frac{2\pi i}{N} k} O_k \end{aligned}$$

FT8 background

- One of several protocols included in WSJT-X software.
- Originally written by Joe Taylor K1JT, is now open source, and development is done by a small team lead by Joe.
- Protocols for weak signal communications (WS)
- EME, propagation studies, meteor scatter

What is digital communications?

- Binary representation of data (zeroes and ones)
- Simple to Complex Modulation
 - Frequency shift
 - Amplitude
 - Phase
- Narrow bandwidth
- Error Correction

Bit Per Second versus Baud per Second

The **bit** rate is the number of **bits** transmitted per second, whereas, the **baud** rate is the number of signal units transmitted per second and one signal unit is able to represent one or more **bits**.

Therefore, **baud** rate is always less than or equal to the **bit** rate but never greater.

Why has FT8 become so popular?

- Faster than prior modes (JT9)
- Weak signal QSOs
- Low transmit power
- Compromised antennas
- It's different
- Relatively easy to get going with guidance....
- Another mode to set self goals (DXCC, WAC, WAS etc.)

FT8 QSO

- Ham radio SMS
- Fixed format
- Exchange of calls, grid square, and signal reports
- ***Automated*** process
- Automatic resending

FT8 QSO

Remote	Local
CQ W2ZQ FN20	
	W2ZQ K2VPX FN20
K2VPX W2ZQ -1	
	W2ZQ K2VPX R-8
K2VPX W2ZQ RR73	
	W2ZQ K2VPX 73

	TXC	QD	PT	Power	Rx Frequency
da	200245	-3	0.2	1194 ~	ZS1SBW AF7EL DM33
dor	200245	-6	0.0	1194 ~	ZS1SBW K1HZ FM13
A.	200300	9	0.1	1194 ~	KD2DC ZS1SBW -15
A.	200245	13	0.2	1442 ~	CQ K1JT FN20
.	200315	11	0.2	1443 ~	W6NEV K1JT -10
s	200330	-17	0.1	1437 ~	CQ VE1JS FN64
.	200345	11	0.2	1443 ~	W6NEV K1JT RR73
.	200401	Tx		1442 ~	K1JT W2ZQ FN20
ela	200415	8	0.2	1443 ~	W2ZQ K1JT +04
	200430	Tx		1442 ~	K1JT W2ZQ R+08
	200445	12	0.2	1443 ~	W2ZQ K1JT RRR
	200500	Tx		1442 ~	K1JT W2ZQ 73
	200515	12	0.2	1443 ~	HI GUYS 73
Rico					
Rico					

A little technical nitty gritty

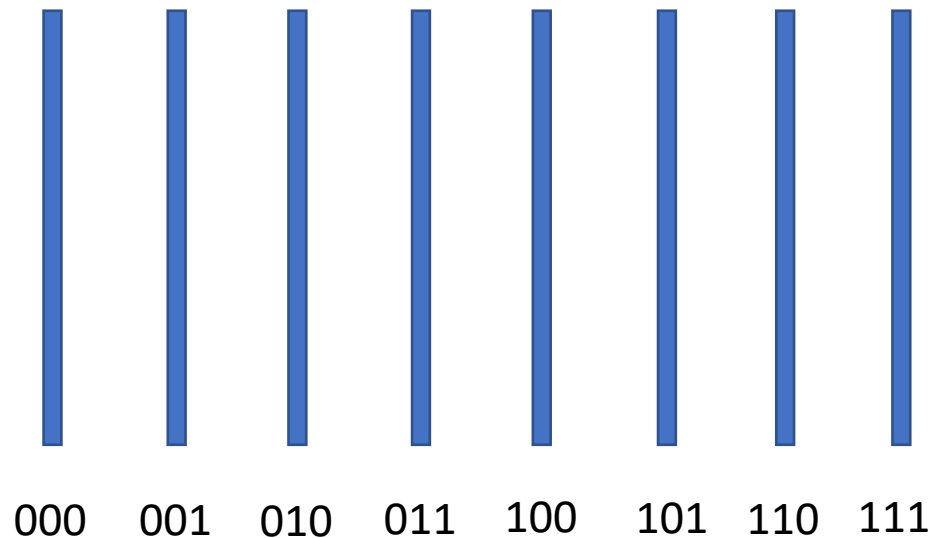
- ***15 Second timeslots (Synchronized/Accurate clock necessary)***
- FSK-8 modulation / audio tones
- 5.86 Hz tone spacing
- 6.25 baud
- 50 Hz bandwidth
- 12.6 Seconds Tx
- 77 bit message (Payload)
- Forward error detection/correction
- Domain encoding (message format, call signs)

A little technical nitty gritty - 2

- During reception, sampling from audio card is copied to disk
- At end of Tx time of timeslot data is decoded using Fast Fourier Transform (FFT) to extract multiple signals
- Decoded message can then be subtract from sample data allowing for decoding of additional signals. Multiple stations on same "frequency"

Frequency Shift keying (FSK)

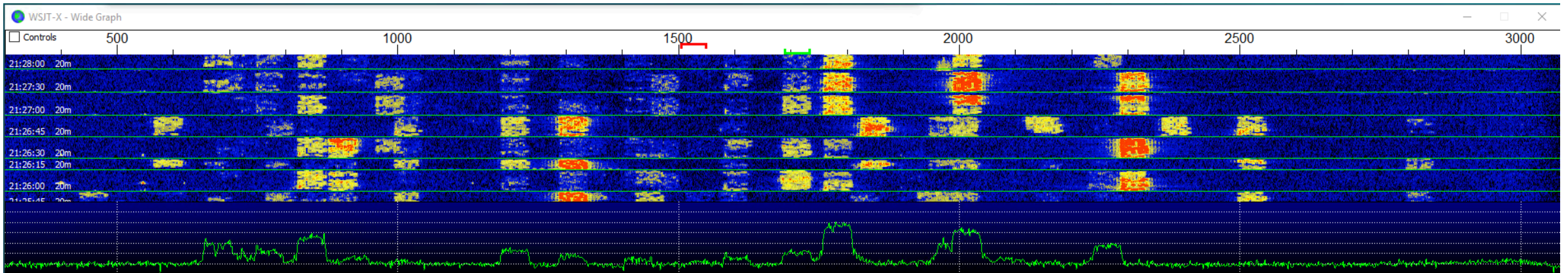
- Information is transferred by changing of frequency
- RTTY(FSK-2) – Mark/Space – Zero/One- 850 Hz shift (2125 / 1275)
- FT8 (FSK-8)



One baud is three bits

How can everyone use the same frequency?

- Signal mixing – Sum and difference of signals
- $1\text{KZ} \rightarrow 14.074 = 14.073(\text{LSB}) + 14.074(\text{Carrier}) + 14.074(\text{USB})$
- Suppress LSB and carrier (Single Sideband)
- FSK Modulate around USB frequency (50hz bandwidth)



TUNE

USB-D

FIL1

SD

19:44

TX

VFO A 1

S/Po 1 5 9

14.074.00

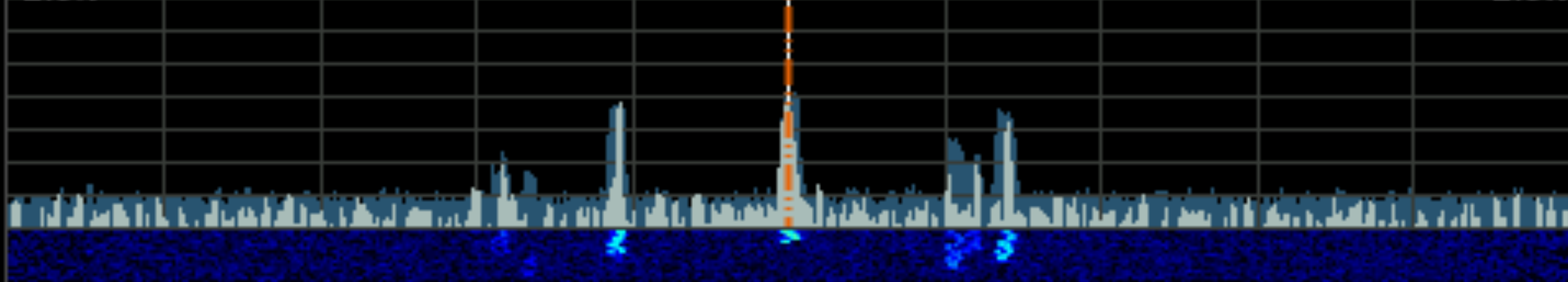
R T HOLD

SPECTRUM SCOPE

CENTER

Grid 0.5k/10dB

-2.5k +2.5k



-2.0

-1.5

-1.0

-0.5

0

+0.5

+1.0

+1.5

+2.0

< 1 >

SPAN

HOLD

CENT/FIX

EXPD/SET

Software

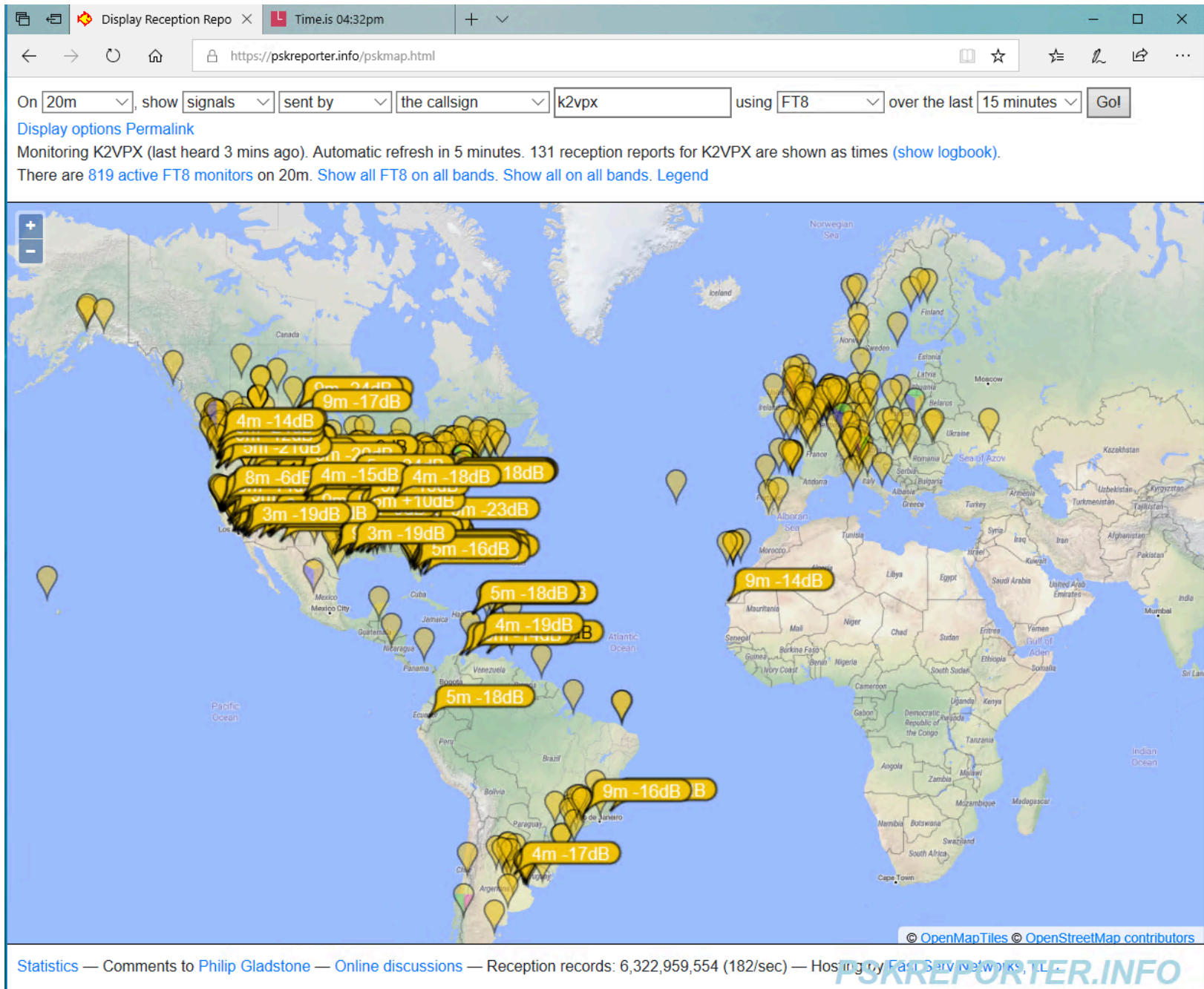
- WSJT-X
- <https://physics.princeton.edu/pulsar/k1jt/wsidx.html>
- FT8, JT4, JT9, JT65, QRA64, ISCAT, MSK144, and WSPR
- Free

Hello... Can anyone hear me?

- CQ CQ CQ.....Silence.....
- Has this ever happened to you?

PSK Reporter

- Check box on WSJT-X
- Participating stations send received call signs with signal report to PSK Reporter server.
- You can go to PSK Report website and see who has heard you



WSJT-X v2.0.0 by K1JT

File Configurations View Mode Decode Save Tools Help

Band Activity

UTC	dB	DT	Freq	Message
----- 20m -----				
164715	0	-0.2	930 ~	CQ AG5PC EM12 U.S.A.
164715	-13	-0.3	1418 ~	CQ K9ZW EN64 U.S.A.
----- 20m -----				
164745	-11	-0.1	976 ~	CQ KI0E DN13 U.S.A.
164745	-16	-0.2	1329 ~	CQ PD7RF JO22 Netherlands
164745	-14	-0.3	1418 ~	KM4UJI K9ZW +01
164745	4	-0.1	2087 ~	MONPT K1YTG CM87
164745	-11	-0.2	2328 ~	DG00BU AF7NX R-11
164745	3	-0.2	2519 ~	CQ DX K6MKF U.S.A.
164745	-10	-0.2	2572 ~	CQ SM3PHM JP82 Sweden
164745	-20	-0.3	2750 ~	N4ZJW F5MXQ -11
164745	-9	-0.2	2052 ~	CQ W5SWG EM13 U.S.A.
----- 20m -----				
164800	6	-1.1	1988 ~	RA2FB AB0P EM38
----- 20m -----				
164815	-8	-0.1	673 ~	F5POE WA0LIF EN35
164815	-10	-0.2	976 ~	CQ KI0E DN13 U.S.A.
164815	-13	-0.2	1329 ~	KK6BJU PD7RF -16
164815	-4	-0.1	2087 ~	MONPT K1YTG CM87
164815	-9	-0.2	2328 ~	DG00BU AF7NX R-11
164815	1	-0.1	2519 ~	CQ DX K6MKF U.S.A.
164815	7	-0.2	2610 ~	DK3PZ N6JV RR73
164815	-9	-0.2	2047 ~	OM3DX W7WM DM79
164815	-9	-0.2	2572 ~	CQ SM3PHM JP82 Sweden
----- 20m -----				
164830	13	-1.1	1133 ~	9A7DA AB0P EM38
164830	0	-0.2	1857 ~	IK2TDM KE8FT 73
164830	-5	-0.1	1081 ~	GM4FDM W2GS EM42
----- 20m -----				
164845	-19	-0.2	614 ~	CQ EU W7CCY CN96 U.S.A.
164845	-14	-0.1	673 ~	F5POE WA0LIF EN35
164845	-4	-0.3	813 ~	KOPLQ KI6QDH -14
164845	-2	-0.2	929 ~	VA6QAS AG5PC -16
164845	-12	-0.2	976 ~	CQ KI0E DN13 U.S.A.
164845	6	-0.1	1970 ~	OM3DX W5LRU -18
164845	-8	-0.2	2328 ~	DG00BU AF7NX R-11
164845	4	-0.1	2519 ~	OK1ASG K6MKF -12
164845	3	-0.2	2609 ~	DM2DMI N6JV -21
164845	-16	-0.5	2749 ~	N4ZJW F5MXQ -11
164845	-8	-0.2	2266 ~	DG00BU K6BS DM13
164845	-9	-0.2	2572 ~	W1AST SM3PHM +10

Rx Frequency

UTC	dB	DT	Freq	Message
164415	-12	-0.2	1193 ~	CQ EA5OL IM99 Spain
164432	Tx		1193 ~	EA5OL K2VPX FN20
164445	-16	-0.2	1192 ~	CQ EA5OL IM99 Spain
164500	Tx		1193 ~	EA5OL K2VPX FN20
164530	Tx		1193 ~	EA5OL K2VPX FN20
164545	-3	-0.2	1198 ~	OK1AW K1YTG CM87
164600	Tx		1193 ~	EA5OL K2VPX FN20

☐ CQ only

Log QSO

Stop

Monitor

Erase

Decode

Enable Tx

Halt Tx

Tune

☒ Menus

20m

76 dB

80

60

40

20

0

14.073 750

TX even/1st

Tx 1193 Hz

▲ ▼

Hold Tx Freq

Rx 1482 Hz

▲ ▼

Report -12

▲ ▼

DX Call

EA5OL

DX Grid

IM99

Az: 65

3802 mi

Lookup

Add

2019 Feb 26

16:49:04

☒ Auto Seq

☒ Call 1st

Generate Std Msgs

Next

Now

EA5OL K2VPX FN20

☒

Tx 1

EA5OL K2VPX -12

☐

Tx 2

EA5OL K2VPX R-12

☐

Tx 3

EA5OL K2VPX RR73

☐

Tx 4

EA5OL K2VPX 73

☐

Tx 5

CQ K2VPX FN20

☐

Tx 6

Pwr

76 dB

Receiving

FT8

Last Tx: EA5OL K2VPX FN20

4/15

WD:6m

UTC	dB	DT	Freq	Message	
-----				20m	^
-----				20m	
164715	0	-0.2	930 ~	CQ AG5PC EM12	U.S.A.
164715	-13	-0.3	1418 ~	CQ K9ZW EN64	U.S.A.
-----				20m	
-----				20m	
164745	-11	-0.1	976 ~	CQ KI0E DN13	U.S.A.
164745	-16	-0.2	1329 ~	CQ PD7RF JO22	Netherlands
164745	-14	-0.3	1418 ~	KM4UJI K9ZW +01	
164745	4	-0.1	2087 ~	M0NPT K1YTG CM87	
164745	-11	-0.2	2328 ~	DG00BU AF7NX R-11	
164745	3	-0.2	2519 ~	CQ DX K6MKF	U.S.A.
164745	-10	-0.2	2572 ~	CQ SM3PHM JP82	Sweden
164745	-20	-0.3	2750 ~	N4ZJW F5MXQ -11	
164745	-9	-0.2	2052 ~	CQ W5SWG EM13	U.S.A.
-----				20m	
164800	6	-1.1	1988 ~	RA2FB AB0P EM38	
-----				20m	
164815	-8	-0.1	673 ~	F5POE WA0LIF EN35	
164815	-10	-0.2	976 ~	CQ KI0E DN13	U.S.A.
164815	-13	-0.2	1329 ~	KK6BJU PD7RF -16	
164815	-4	-0.1	2087 ~	M0NPT K1YTG CM87	
164815	-9	-0.2	2328 ~	DG00BU AF7NX R-11	
164815	1	-0.1	2519 ~	CQ DX K6MKF	U.S.A.
164815	7	-0.2	2610 ~	DK3PZ N6JV RR73	
164815	-9	-0.2	2047 ~	OM3DX W7WM DM79	
164815	-9	-0.2	2572 ~	CQ SM3PHM JP82	Sweden
-----				20m	

UTC	dB	DT	Freq	Message	
164415	-12	-0.2	1193 ~	CQ EA5OL IM99	Spain
164432	Tx		1193 ~	EA5OL K2VPX FN20	
164445	-16	-0.2	1192 ~	CQ EA5OL IM99	Spain
164500	Tx		1193 ~	EA5OL K2VPX FN20	
164530	Tx		1193 ~	EA5OL K2VPX FN20	
164545	-3	-0.2	1198 ~	OK1AW K1YTG CM87	
164600	Tx		1193 ~	EA5OL K2VPX FN20	

WSJT-X v2.0.0 by K1JT

File Configurations View Mode Decode Save Tools Help

Band Activity

UTC	dB	DT	Freq	Message
----- 20m				
212630	1	0.5	825 ~	CQ AC5V EM12 U.S.A.
212630	-21	1.1	1517 ~	CQ N3ITT FN20 U.S.A.
212630	-8	-0.1	1583 ~	CQ W1KE EL09 U.S.A.
212630	-7	-0.4	1762 ~	CQ YV5ZV FK60 Venezuela
212630	13	-0.1	2290 ~	CQ K5XOM EM20 U.S.A.
----- 20m				
212645	-2	0.2	569 ~	CQ KE0A00 DN98 U.S.A.
212645	-5	0.2	996 ~	CQ K0JV DN84 U.S.A.
212645	8	0.2	1291 ~	CQ N7XG CN84 U.S.A.
212645	3	0.3	2500 ~	CQ KG7V CN77 U.S.A.
212645	-7	-0.5	1992 ~	CQ PY7ZZ HI21 Brazil
----- 20m				
212700	-13	0.1	749 ~	CQ KR7DX DM22 U.S.A.
212700	-15	-0.1	1583 ~	CQ W1KE EL09 U.S.A.
212700	7	-0.2	2290 ~	CQ K5XOM EM20 U.S.A.
212700	-16	0.2	722 ~	CQ WC7S DN71 U.S.A.
212700	-13	1.5	1407 ~	CQ PY4LH GG68 Brazil
----- 20m				
212730	-8	0.1	749 ~	CQ KR7DX DM22 U.S.A.
212730	-11	-0.1	1584 ~	CQ W1KE EL09 U.S.A.
212730	7	-0.1	2290 ~	CQ K5XOM EM20 U.S.A.
----- 20m				
212800	-14	-0.1	1585 ~	CQ W1KE EL09 U.S.A.
----- 20m				
212830	-5	0.2	2243 ~	CQ PJ2MAN FK52 Curacao
212830	-4	0.1	1774 ~	CQ N4LDF EL95 U.S.A.
----- 20m				
212900	-10	0.2	1187 ~	CQ W7CD CN87 U.S.A.
212900	5	0.1	1773 ~	CQ N4LDF EL95 U.S.A.
212900	-9	0.3	2229 ~	CQ HK4FZ FJ26 Colombia
----- 20m				
212915	-10	0.1	767 ~	CQ KA4JON EM84 U.S.A.
212915	-4	0.2	995 ~	CQ K0JV DN84 U.S.A.
212915	5	0.2	2500 ~	CQ KG7V CN77 U.S.A.
----- 20m				
212930	-17	0.2	997 ~	CQ HI3MFR FK49 Dominican Rep.
212930	-10	0.3	1187 ~	CQ W7CD CN87 U.S.A.
212930	-7	0.2	2228 ~	CQ HK4FZ FJ26 Colombia
212930	-9	0.5	825 ~	CQ AC5V EM12 U.S.A.
212930	-2	0.1	1772 ~	CQ N4LDF EL95 U.S.A.
212930	-13	0.8	2220 ~	CQ PY4LH GG68 Brazil

Rx Frequency

UTC	dB	DT	Freq	Message
211900	1	0.1	2172 ~	PY7ZZ WA1RYQ 73
211915	13	0.2	1290 ~	CQ N7XG CN84 U.S.A.
211939	Tx		1290 ~	N7XG K2VPX FN20
211945	14	0.2	1290 ~	CQ N7XG CN84 U.S.A.
212000	Tx		1290 ~	N7XG K2VPX FN20
212030	Tx		1290 ~	N7XG K2VPX FN20
212102	Tx		1290 ~	N7XG K2VPX FN20
212130	-8	0.1	1291 ~	N7XG WA4M EL87
212145	12	0.2	1290 ~	N5AHM N7XG -11
212200	-5	0.3	1045 ~	CQ KR7DX DM22 U.S.A.
212219	Tx		1290 ~	KR7DX K2VPX FN20
212230	-5	0.3	1045 ~	N4BYY KR7DX -10
212315	Tx		1504 ~	CQ K2VPX FN20
212345	Tx		1504 ~	CQ K2VPX FN20
212400	1	0.1	1504 ~	K2VPX WA6NFJ CN85
212415	Tx		1504 ~	WA6NFJ K2VPX +01
212430	1	0.1	1504 ~	K2VPX WA6NFJ R-17
212445	Tx		1504 ~	WA6NFJ K2VPX RR73
212500	-2	0.1	1504 ~	K2VPX WA6NFJ 73
212500	-9	0.1	1689 ~	CQ PJ2LJG FK52 Curacao
212519	Tx		1689 ~	PJ2LJG K2VPX FN20
212530	4	0.5	1688 ~	W0DYD KA4DTL EL87
212545	Tx		1623 ~	PJ2LJG K2VPX FN20
212530	-7	0.1	1689 ~	W0KIT PJ2LJG -01
212600	2	0.4	1685 ~	W0DYD KA4DTL EL87
212615	Tx		1504 ~	PJ2LJG K2VPX FN20
212600	-4	-0.0	1689 ~	NN9T PJ2LJG +03
212630	-2	0.5	1688 ~	W0DYD KA4DTL EL87
212700	-4	0.1	1689 ~	NN9T PJ2LJG RR73
212715	Tx		1504 ~	PJ2LJG K2VPX FN20
212730	-10	0.1	1689 ~	K0AWU PJ2LJG -06
212745	Tx		1504 ~	PJ2LJG K2VPX FN20
212800	-11	0.1	1689 ~	K3RSJ PJ2LJG -10
212815	Tx		1504 ~	PJ2LJG K2VPX FN20
212830	-7	0.1	1689 ~	N0PSO PJ2LJG -07
212845	Tx		1504 ~	PJ2LJG K2VPX FN20
212930	-9	0.1	1689 ~	N0PSO PJ2LJG RR73

☒ CQ only

Log QSO

Stop

Monitor

Erase

Decode

Enable Tx

Halt Tx

Tune

☒ Menus

20m

S

14.074 000

DX Call

PJ2LJG

DX Grid

FK52

Az: 168 1962 mi

Lookup

Add

2019 Mar 04 21:29:55

☐ Tx even/1st

Tx 1504 Hz

☐ Hold Tx Freq

1

2

3

Generate Std Msgs

Next

Now

PJ2LJG K2VPX FN20

Tx 1

PJ2LJG K2VPX -09

Tx 2

PJ2LJG K2VPX R-09

Tx 3

PJ2LJG K2VPX RR73

Tx 4

PJ2LJG K2VPX 73

Tx 5

CQ K2VPX FN20

Tx 6

Receiving

FT8

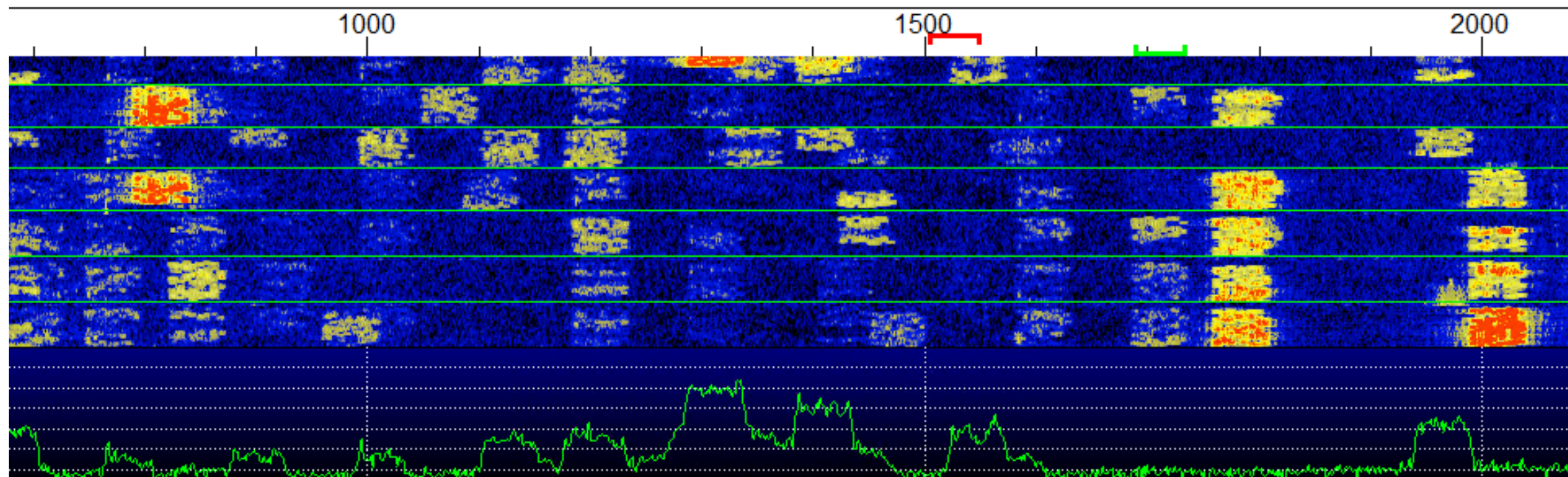
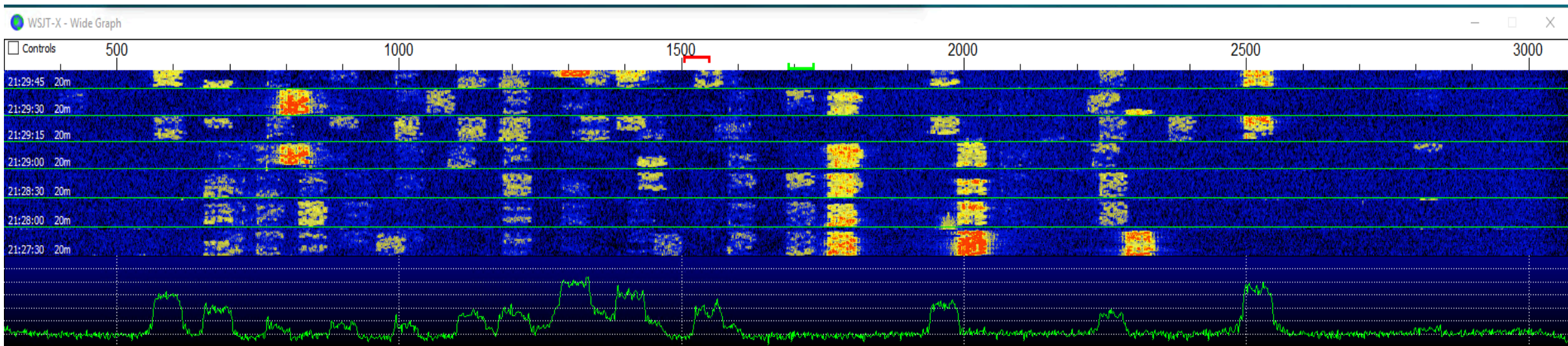
Last Tx: PJ2LJG K2VPX FN20

10/15 WD:6m

UTC	dB	DT	Freq	Message
----- 40m				
191300	0	0.1	1429 ~	CQ N8OYY EM98 U.S.A.

191330	3	0.1	1429 ~	CQ N8OYY EM98 U.S.A.
----- 40m				
191400	2	0.1	1409 ~	CQ N8OYY EM98 U.S.A.
----- 20m				
191545	-1	0.1	541 ~	CQ N5TJ EM13 U.S.A.
191545	-13	0.1	1534 ~	CQ NA EA7AQR IM76 Spain
191545	6	1.7	2075 ~	CQ YV5AAX FK60 Venezuela
----- 20m				
191600	-14	0.1	1275 ~	CQ WA4M EL87 U.S.A.
191600	-12	0.1	1916 ~	CQ WX6A CM97 U.S.A.
----- 20m				
191615	9	0.1	541 ~	CQ N5TJ EM13 U.S.A.
191615	-8	0.1	1534 ~	CQ NA EA7AQR IM76 Spain
191615	-2	0.1	1910 ~	CQ K0JV DN84 U.S.A.
191615	-7	0.4	2319 ~	CQ W7CXX DM37 U.S.A.
----- 20m				
191645	-8	0.1	1534 ~	CQ NA EA7AQR IM76 Spain
191645	2	0.1	541 ~	CQ N5TJ EM13 U.S.A.
191645	6	0.1	913 ~	CQ K9IG EM69 U.S.A.
191645	-1	0.1	1910 ~	CQ K0JV DN84 U.S.A.
191645	-1	0.4	2319 ~	CQ W7CXX DM37 U.S.A.
----- 20m				
191745	-4	0.0	913 ~	CQ K9IG EM69 U.S.A.
191745	-10	0.1	1204 ~	CQ KB9JJF/4 U.S.A.
191745	-7	0.0	1909 ~	CQ K0JV DN84 U.S.A.
----- 20m				

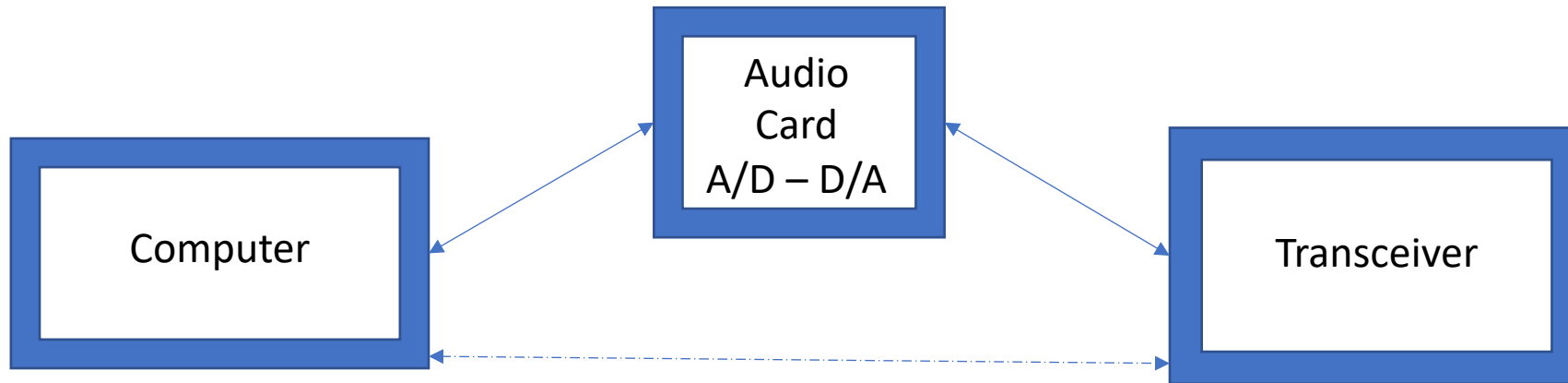
UTC	dB	DT	Freq	Message
191515	Tx		1503 ~	CQ K2VPX FN20
191615	-8	0.1	1534 ~	CQ NA EA7AQR IM76 Spain
191632	Tx		1534 ~	EA7AQR K2VPX FN20
191645	-8	0.1	1534 ~	CQ NA EA7AQR IM76 Spain
191700	Tx		1534 ~	EA7AQR K2VPX FN20
191730	Tx		1403 ~	EA7AQR K2VPX FN20
191800	Tx		1403 ~	EA7AQR K2VPX FN20



What is needed to get on FT8

- SSB rig
- Antenna
- Computer
- Sound card (internal or external)
- WSJT-X Software

Equipment block diagram

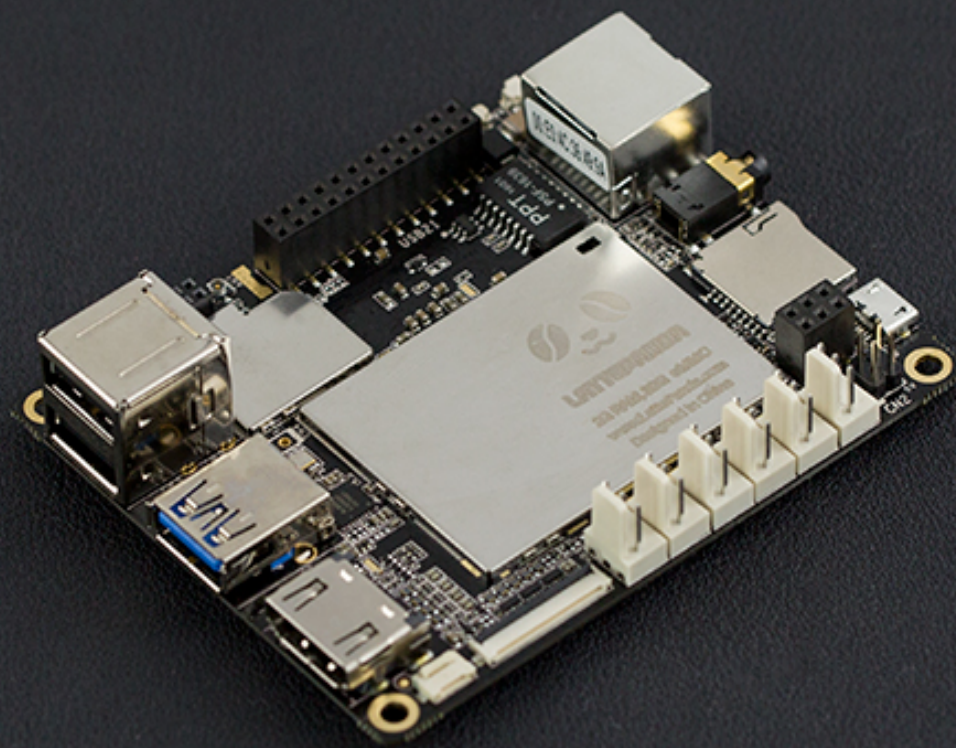


Computer to Rig Control
(Optional – Audio sweet spot)

- Windows, Mac OS, Linux
- PC, Raspberry PI, SBC
- Windows, Mac OS, Linux
- PC, Raspberry PI, SBC

K2VPX FT-8 Setup

- IC 7300 - USB audio and rig control (CI-V) – 30Watts
- Latte Panda SBC with Windows 10 Pro (\$150 + \$4)
- Attic Dipole for 20 meters
- Microsoft Remote Desktop Access
- ~ 40 DXCC counties and WAC
- ~700 contracts



Almost Effortless FT8

- Input to WSJT-X Through PC microphone
- Output to rig via PC speaker
- Web based SDR sites in lieu of receiver

Recent FT8 features

- Fox and Hound for DX
- Contest Formats
- JS8Call Alternative Software

Operational Hints

- Syncing PC clock
- Digital curtain
- Split frequency operation
- More power is not always the answer
- Turn off AGC
- Watch Tx and Rx levels
- Turn on split mode in WSJT-X software
- Use widest Rx filter
- Watch out for RF!

Pros and Cons ...

Pros	Cons
<ul style="list-style-type: none">• Good for weak signals e.g. marginal paths, QRP, stealth antennas, poor conditions• Efficient use of bandwidth: signals are just 50 Hz wide, and can often be decoded if they overlap with others• Minimal QSO information is passed reliably• FT8 DX Expeditions• Popular, with lots of HF activity	<ul style="list-style-type: none">• Mechanized, without the personal touch that comes from legacy-mode human-to-human contacts and conversation• Slow communication speed equivalent to about 5 wpm• Can seem complex and confusing for beginners• Problems with non-standard calls including CEPT travelers and special event calls• Popular, with lots of HF activity• Some grumpy old amateurs don't believe FT8 is real ham radio

Q&A