

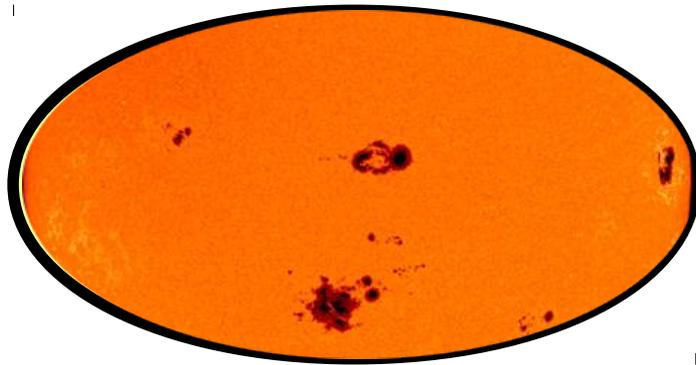
The FT8 Revolution

Mike Hasselbeck
WB2FKO

SARA Hamfest
20 October 2018



FT8 is revolutionizing how amateur radio operators work DX



**HF DX is possible
even at the solar minimum**

WHAT THIS PRESENTATION IS ABOUT:

How and why FT8 was designed

Why FT8 works so well for weak signal communications

WHAT THIS PRESENTATION IS **NOT** ABOUT:

How to setup a station for digital operation

How to operate effectively with FT8 (yes, there is a learning curve)

Related software: FT8 Call, JTDX, JTHF, JT Alert, etc

Picking a fight with ops who prefer traditional modes



Wide variety of digital modes in amateur radio

PSK31

RTTY

CLOVER

QPSK31

PACKET

MFSK16

AMTOR

THOR

OLIVIA

PACTOR

HELLSCHREIBER

WSJT-X

Choice strongly depends on what we are trying to do

PSK31 is popular: Keyboard-to-Keyboard Communication in Real-Time

Phase-shift keying at 31 baud (bits per second)

PC + sound card

Five bit code (baudot). Equivalent to ~ 60 wpm cw

Primarily on HF

The screenshot shows the fldigi software interface for a PSK31 QSO. The window title is "fldigi - AA6E". The interface includes a menu bar (File, Op Mode, Configure, View, Help), a status bar (RSID, TUNE), and a main display area. The main display area shows the frequency "14070.000" in a large yellow box. Below this, there are fields for QSO Freq (14071.661), On (2017), Call, Name, In, Out, and Notes. The mode is set to USB. The QTH field is empty. The main display area shows a text window with the following text: "RTX: Yaesu LT 847 abt. 75tyu", "a", "lBTU Nh ta pfm", "IW2HUS DE N4TDO", "Txn for Info using FT450 with short vertical Antenna Your signal is good copy Tnx", "QSO and good DX My report pls Best 73 to U and good DX 73 IW2HUS DE N4TDO SK", "ot u 4TDO de IWGx your equipment working fine, solid copy e ae for BK31 qso.", "I hop te 'e yot agn on screen.", "Best 73 & DX.", "N4TD.& o1". Below the text window is a control panel with buttons for CQ, ANS, QSO, KN, SK, Me/QTH, QTH, Brag, Tx, Rx, and a volume knob. The control panel also shows a frequency scale from 14070.5 to 14072.5. Below the control panel is a waterfall display showing the signal spectrum. The waterfall display shows a signal at 14071.661. The waterfall display also shows a frequency scale from 14070.5 to 14072.5. Below the waterfall display is a control panel with buttons for WF, -22, 49, x1, NORM, 1661, QSY, Store, Lk, Rv, T/R, and a volume knob. The control panel also shows the mode "BPSK31", the signal-to-noise ratio "s/n 20 dB", and the intermodulation distortion "imd -31 dB". The control panel also shows buttons for AFC and SQL.

Working DX: Want that new grid or country in the log!

Usually don't have the luxury or even desire to chat

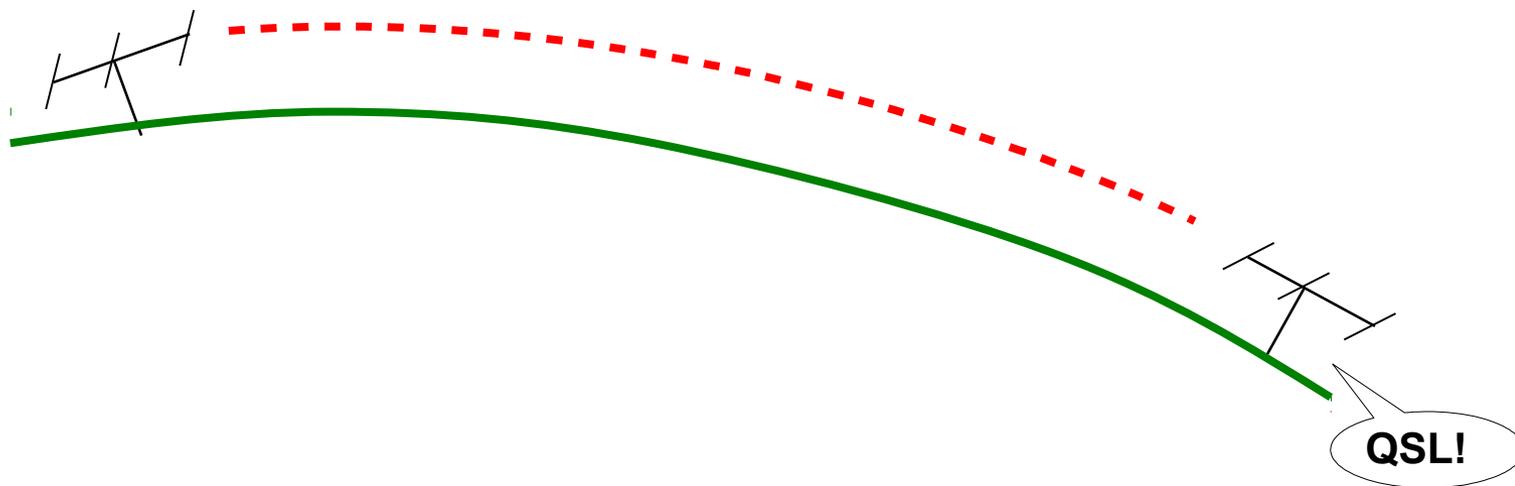
Success if we just exchange callsigns and a report



WSJT-X: Digital protocol for minimum communication on marginal paths

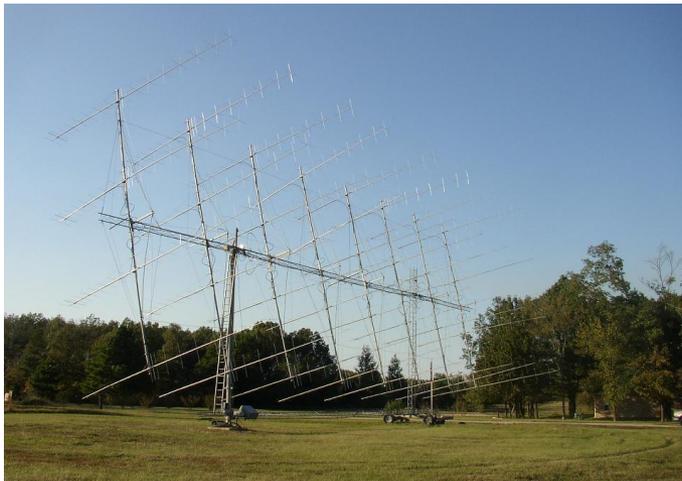
Fundamental Design Premise:

Exchange only enough information for a *minimum* QSO



FT8 is a sub-mode of WSJT-X

Derived from JT65



FT8: Franke-Taylor Design, 8-tone FSK

Introduced for Alpha-testing 30 June 2017

Design motivated by 6m Es:

Short duration, weak but steady openings

15 second sequences \Rightarrow 4x faster QSOs than JT65

4–6 dB less sensitive than JT65



Steve Franke, K9AN



Joe Taylor, K1JT

Foundational work for JT65 & FT8: Compact messages

QSO messages can be very efficiently coded

CALLSIGN1 CALLSIGN2 GRID



Tom Clark, K3IO



Phil Karn, KA9Q

JT65/FT8 messages are generally not free-form

Greatly reduces the amount of data required

Defines a 72/75 bit message protocol

JT65/FT8 messages are generally not free-form

Greatly reduces the amount of data required

Defines a 72/75 bit message protocol

KG5FHU WB2FKO DM65

This message can be coded into 71 digital bits

Compare: 209 bits in Morse Code (1 dit = 1 bit)

Why are compact messages useful?

1) Make data packets very small

– *OR* –

2) **Add other, very useful data to message**

FORWARD ERROR CORRECTION:

The crucial enhancement CW does not have

Modern technology:

Modems

Hard drives

CDs

DVDs

Blue-Ray

Digital TV

Satellites

Deep-space probes

QR codes for phones

Amateur radio:

D-Star

DMR

Fusion

QPSK31

MFSK16

Olivia

WSJT

What is Forward Error Correction?

EXAMPLE:

Simple 4 character alphabet without FEC

A: 00

B: 01

C: 10

D: 11

Each character represented
by **2 data bits**

A: 00

B: 01

C: 10

D: 11

Transmit an 8 character string:

C B D A B C A C

Requires 16 data bits:

10 01 11 00 01 10 00 10

A: 00

B: 01

C: 10

D: 11

Transmit an 8 character string:

C B D A B C A C

Requires 16 data bits:

10 01 11 00 01 10 00 10

Communication channels often have noise

A: 00

B: 01

C: 10

D: 11

Transmit an 8 character string:

C B D A B C A C

Requires 16 data bits:

10 01 11 00 01 10 00 10

Some bits may be incorrectly received

2 of 16 bits incorrect:

10 01 11 00 00 00 00 10

Decoded message:

C B D A A A C

Correct reception requires
100% transmission throughput

C B D A B C A C

87.5% transmission throughput garbles
some of the message

C B D A A A C

*Can message be correctly received
with < 100% throughput?*

Solution 1: Send message multiple times

Three transmissions: 48 bits with 87.5% throughput
2 of 16 bits in each TX incorrect

TX1: 10 01 11 00 00 00 00 10

Decoded message:

C B D A A A C

TX2: 10 01 10 00 11 10 00 10

Decoded message:

C B C A D C A C

TX3: 00 01 11 00 01 10 00 11

Decoded message:

A B D A B C A D

Solution 1: Send message multiple times

Three transmissions: 48 bits with 87.5% throughput
2 of 16 bits in each TX incorrect

TX1: 10 01 11 00 00 00 00 10

Decoded message:

C B D A **A** A C

TX2: 10 01 10 00 11 10 00 10

Decoded message:

C B **C** A **D** C A C

TX3: 00 01 11 00 01 10 00 11

Decoded message:

A B D A **B** C A **D**

5th character ambiguity: **A, D, B ?**

Solution 2: Send bits multiple times

1 data bit, 2 redundancy bits: 48 bits total:

111 000 000 111 111 111 000 000 000 111 111 000 000 000 111 000

**Interpretation of
received data**

000 = **0**; No error

111 = **1**; No error

011 = **1**; Corrected

101 = **1**; Corrected

001 = **0**; Corrected

Triple modular redundancy

Solution 3: Hamming code words

Invented in 1950 at Bell Labs

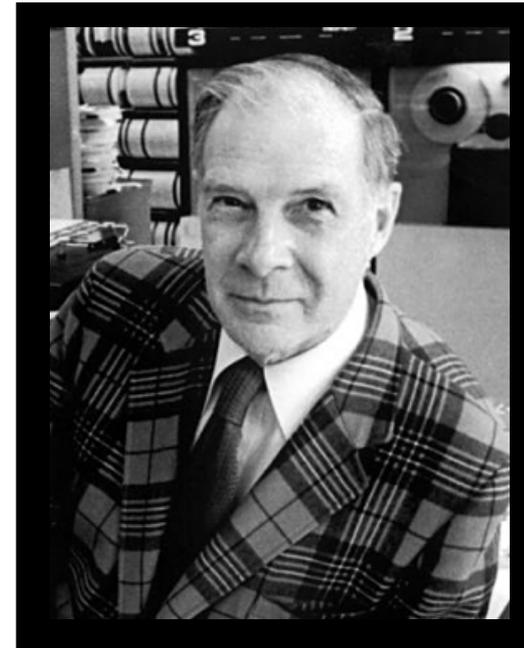
Simple example: **2 data bits**, **3 parity bits**

A: 00**0**1**0**

B: 11**0**0**1**

C: 1**0**1**1**0

D: 11**1**0**1**



Richard Hamming

Each character represented by
5 bits instead of 2 bits

Transmit same 8 character string *only once*:

C B D A B C A C

Requires **40 data bits** instead of 48 (or 16):

10110 11001 11101 00010 11001 10110 00010 10110

Assume 87.5% throughput: 5 bits are incorrect

Transmitted signal:

10110 11001 11101 00010 11001 10110 00010 10110

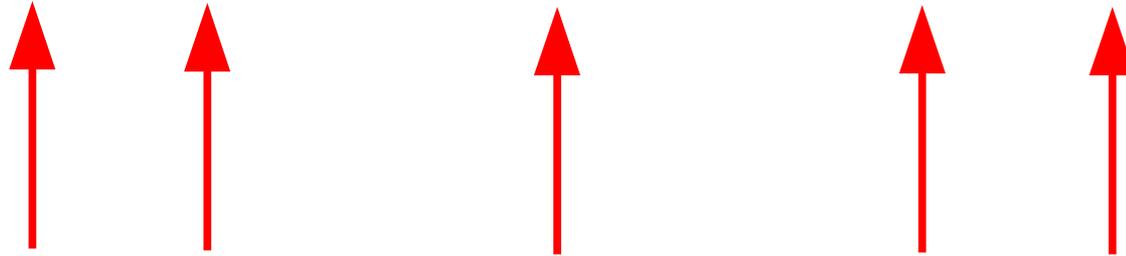
Received signal:

10110 11000 01101 00010 11011 10110 00000 10111

What happens at the receiver?

10110 11000 01101 00010 11011 10110 00000 10111

C ? ? A ? C ? ?

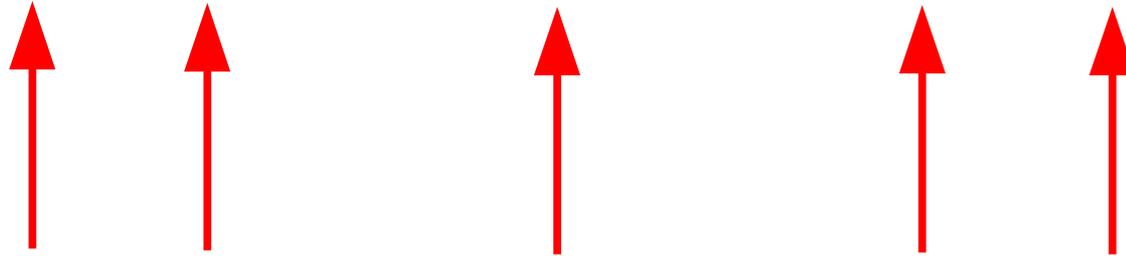


**Five characters are not recognized
Not in the codeword dictionary!**

What happens at the receiver?

10110 11000 01101 00010 11011 10110 00000 10111

C ? ? A ? C ? ?



That's worse than
with no FEC !



What happens at the receiver?

10110 11000 01101 00010 11011 10110 00000 10111
C ? ? A ? C ? ?

Not really worse. Now we know there are errors and could ask transmitter to re-send.



What happens at the receiver?

10110 11000 01101 00010 11011 10110 00000 10111
C ? ? A ? C ? ?

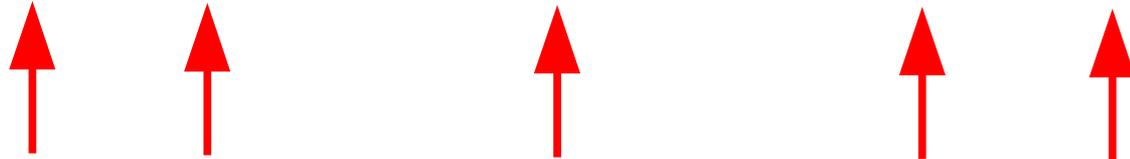
The 16-bit message gave only 2 false decodes *BUT* the receiver didn't know it!



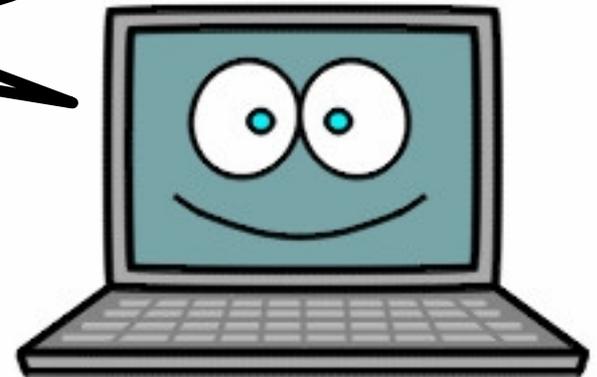
What happens at the receiver?

10110 11000 01101 00010 11011 10110 00000 10111

C ? ? A ? C ? ?



Let the FEC algorithm try to figure out what isn't initially recognized

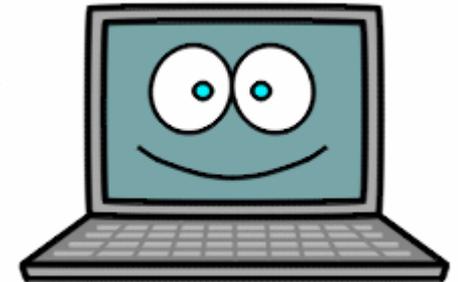


2nd received character: 11000

Compare it to our dictionary or code book

A:	00010	XX0X0	3 bits wrong
B:	11001	1100X	1 bit wrong
C:	10110	1XXX0	3 bits wrong
D:	11101	11X0X	2 bits wrong

It's probably a B



3rd received character: 01101

Compare it to our dictionary

A:	00010	0XXXXX	4 bits wrong
B:	11001	X1X01	2 bits wrong
C:	10110	XX1XX	4 bits wrong
D:	11101	X1101	1 bit wrong

It's probably a D



5th received character: 11011

Compare it to our dictionary

A:	00010	XX01X	3 bits wrong
B:	11001	110X1	1 bit wrong
C:	10110	1XX1X	3 bits wrong
D:	11101	11XX1	2 bits wrong

It's probably a B



7th received character: 00000

Compare it to our dictionary

A:	00010	000X0	1 bit wrong
B:	11001	XX00X	3 bits wrong
C:	10110	X0XX0	3 bits wrong
D:	11101	XXX0X	4 bits wrong

It's probably an A



8th received character: 10111

Compare it to our dictionary

A:	00010	X0X1X	3 bits wrong
B:	11001	1XXX1	3 bits wrong
C:	10110	1011X	1 bit wrong
D:	11101	1X1X1	2 bits wrong

It's probably a C



Transmitted message:

10110 11001 11101 00010 11001 10110 00010 10110

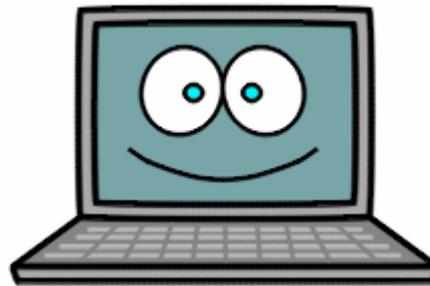
C B D A B C A C:

Received message, no FEC

C ? ? A ? C ? ?

After FEC decoding

C B D A B C A C



Perfect decode even with **12.5% data loss**

**This FEC scheme won't work
if we lose more than 1 bit per character**

EXAMPLE: First two characters won't decode

10000 00110 11101 00010 11001 10110 00010 10110

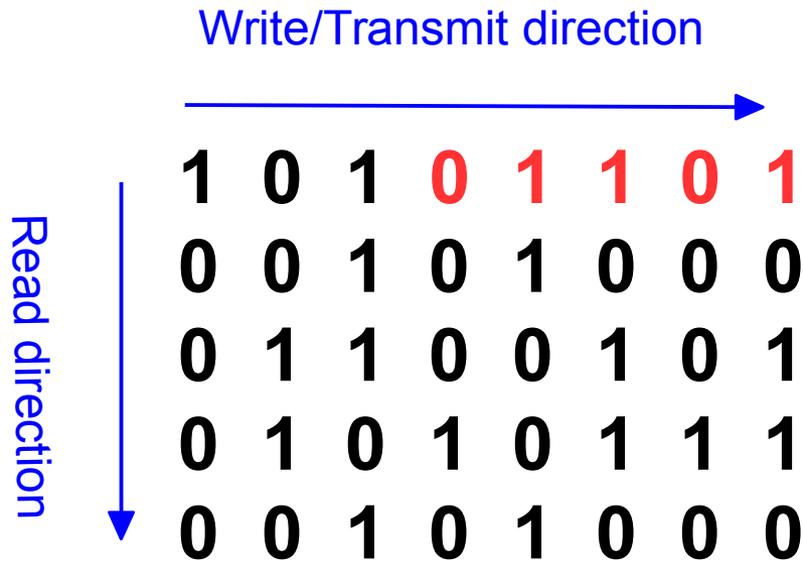
Solution 1: Ask transmitter to re-send

Solution 2: Add more parity bits*

* as determined by the Shannon Limit

Solution 3: Design decoder to arrange data to be **read as columns** instead of rows

100**00** **001**10 11101 00010 11001 10110 00010 10110



FORWARD ERROR CORRECTION in FT8

Each **75 bit** message is augmented with
+ **87 Forward Error Correction bits** (Low Density Parity Check)
+ **12 Cyclical Redundancy Check bits**
= **174 bits total**

50% of the message length is for FEC
using LDPC



Dr Robert Gallager
Inventor of the LDPC
in 1960

HOW **TONES** GENERATE A **DIGITAL MESSAGE**

Alphabet

A: 00

B: 01

C: 10

D: 11

8 FSK TONES

tone 0: 000

tone 1: 001

tone 2: 010

tone 3: 011

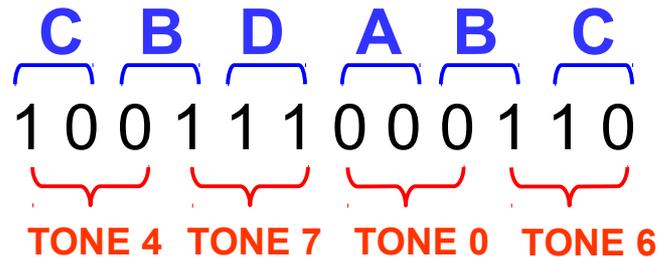
tone 4: 100

tone 5: 101

tone 6: 110

tone 7: 111

Example: 12-bit message



CBDABC is sent as a
tone sequence: 4,7,0,6

FT8 TONES GENERATE A DIGITAL MESSAGE

174 bits per FT8 message*

÷ **3 bits** per **TONE**

= **58 TONES SENT** per FT8 message

***174 bits** = 75 data + 87 FEC + 12 CRC

TIME SYNCHRONIZATION

PSK31 and other digital modes can be sent and decoded randomly

WSJT modes gain additional sensitivity by requiring tight time-synch of the stations

Lock the 2 computers to a reference clock



TIME SYNCHRONIZATION

Computer Internet synch only gets in the ballpark

JT65 decoder requires an accuracy ≤ 0.03 seconds

FT8 decoder requires an accuracy ≤ 0.02 seconds

The message supplies its own synch signal

TIME SYNCHRONIZATION IN FT8

An FT8 message has 79 time intervals

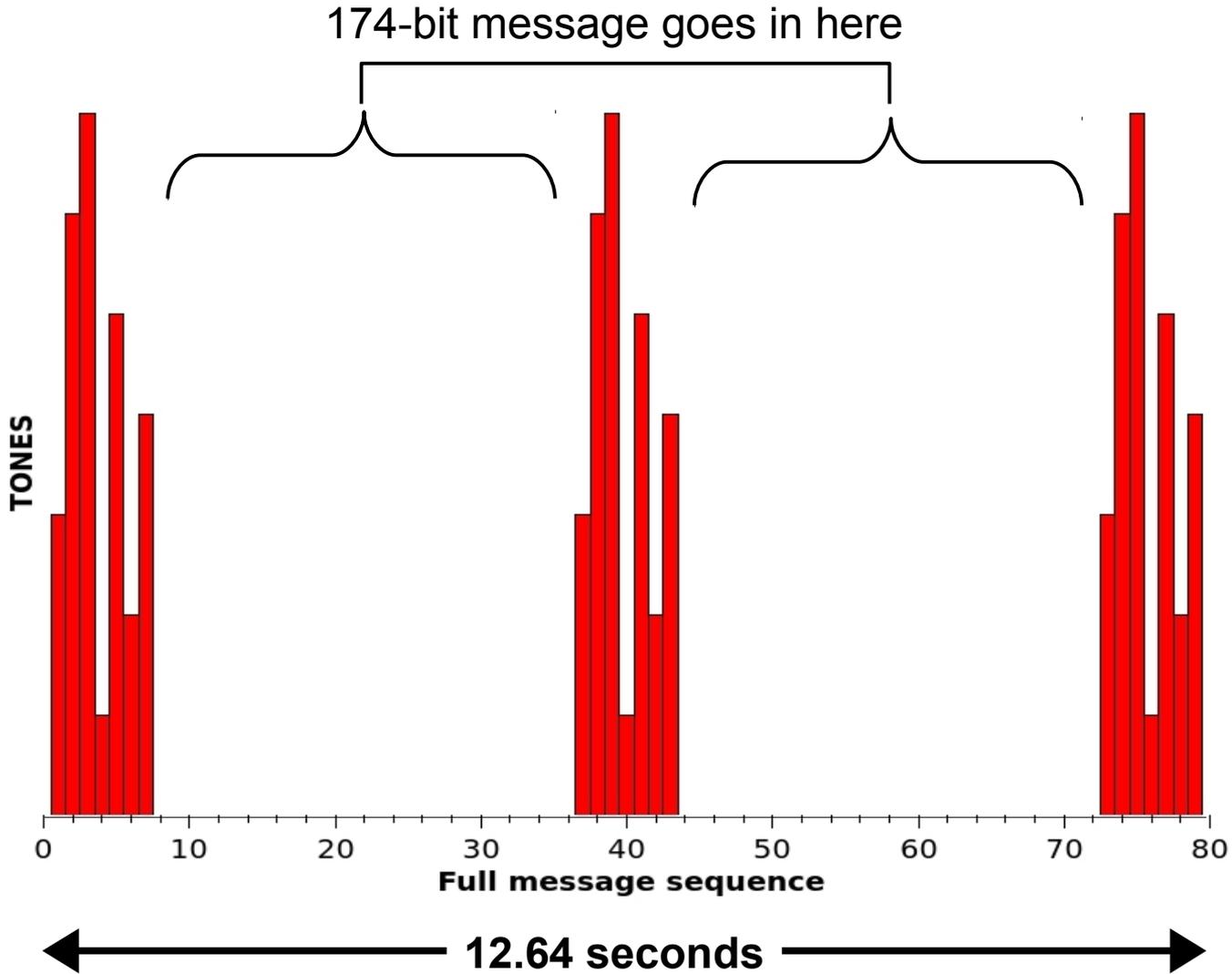
Each interval is 0.16 seconds

Total message duration: 12.64 seconds

58 intervals allotted for the message + FEC + CRC

21 intervals allotted for **SYNCH TONES**

7 tone sequence* at start, middle, and end of transmission



* 7x7 Costas Array: 7 frequencies x 7 time steps

WHAT THE HECK IS A
COSTAS ARRAY ???

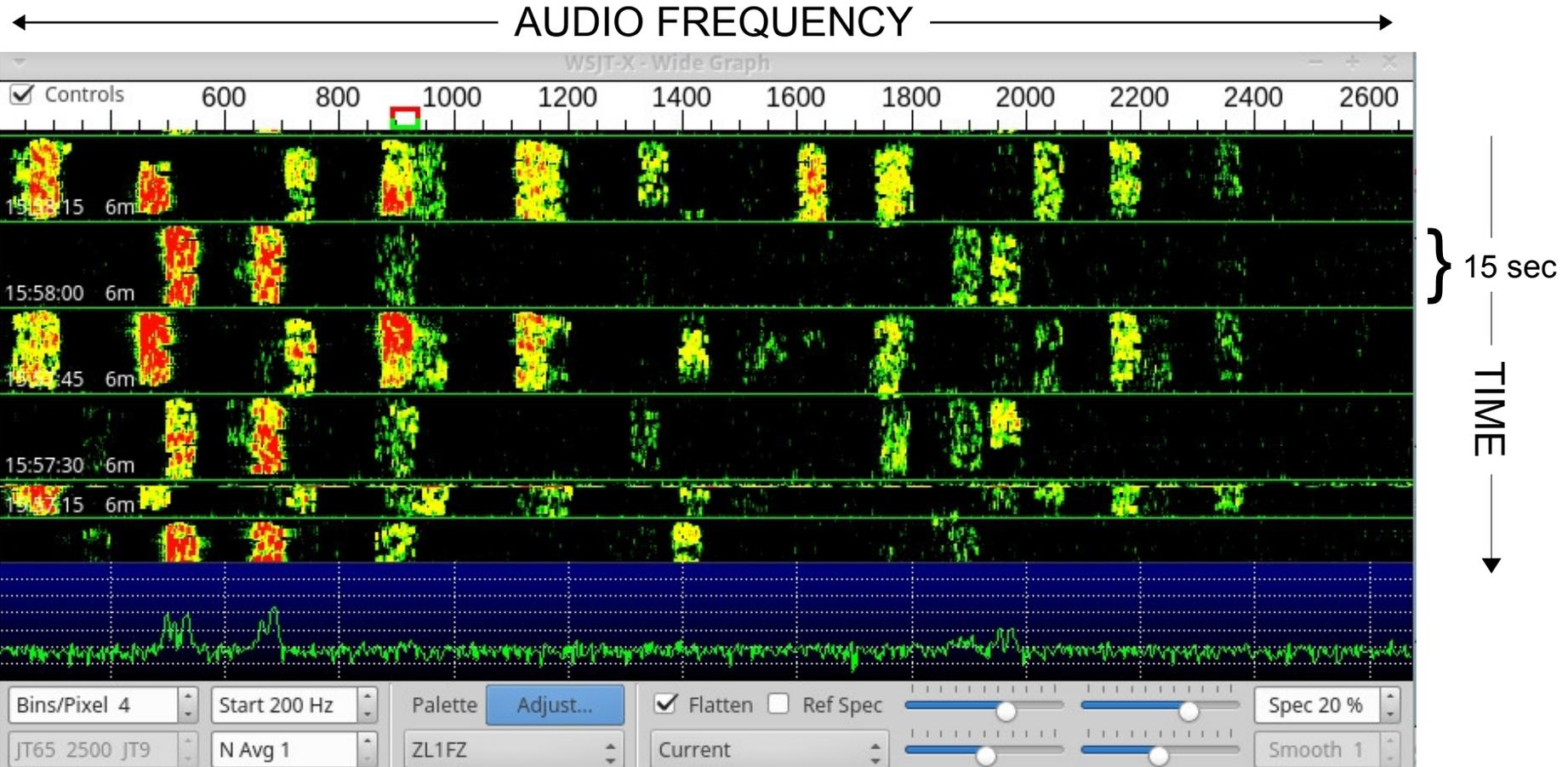
AND WHY SHOULD
I CARE ABOUT IT?



Dr John P Costas

A talk is in preparation for:
NEW MEXICO TECHFEST
February 2019, Albuquerque

FT8 WATERFALL DISPLAY



World Wide
VHF Contest
July 2018

VFO: 50.313 MHz

Upper sideband

50 Hz signals in ~2200 Hz receiver bandwidth

Simultaneous decodes of multiple signals in waterfall display

WSJT-X v1.9.1 by K1JT

File Configurations View Mode Decode Save Tools Help

Band Activity

UTC	dB	DT	Freq	Message
155815	-11	0.1	1326	~ CM2RSV W9RF EM57
155815	-2	-0.4	1607	~ CQ DX KZ4AK FM07
155815	-6	-1.2	1741	~ K9KON K4SOG R-15
155815	-10	-0.1	2016	~ KG7CW W4NH 73
155815	-8	0.3	2151	~ CQ DX N3MK FM27
155815	-17	0.4	2331	~ CQ DX K6EID EM73
155815	-12	0.1	233	~ KD0GFQ W4TM EM73
155815	-6	-0.0	1137	~ CQ KE5MIS EM53
155815	-12	0.1	1755	~ AB5J W4PH EM85

Rx Frequency

UTC	dB	DT	Freq	Message
55445	-15	0.1	1253	~ CQ K1TEO FN31
55515	-16	0.1	1253	~ CQ K1TEO FN31
55545	-19	0.2	1253	~ KI5EE K1TEO FN31
55545	-10	0.2	1114	~ CQ K1GG EM97
55615	-11	0.2	1115	~ KC5WX K1GG R+01
55645	-13	0.1	1114	~ KC5WX K1GG R+02
55700	-14	0.1	892	~ CQ NB3T EM97
55730	-12	0.1	891	~ WB0QLU NB3T -11
55800	-16	0.1	891	~ WB0QLU NB3T RRR

CQ only Log QSO Menus

6m **S** **50.313 300** Tx even/1st

Tx 892 Hz Tx ← Rx

Rx 892 Hz Rx ← Tx

Az: 77 1449 mi Hold Tx Freq

Report -14 Auto Seq Call 1st

NA VHF Contest

Generate Std Msgs

Next	Now	Pwr
NB3T WB2FKO DM65	<input checked="" type="radio"/>	Tx 1
NB3T WB2FKO -14	<input type="radio"/>	Tx 2
NB3T WB2FKO R-14	<input type="radio"/>	Tx 3
NB3T WB2FKO RRR	<input type="radio"/>	Tx 4
NB3T WB2FKO 73	<input type="radio"/>	Tx 5
CQ WB2FKO DM65	<input type="radio"/>	Tx 6

Receiving FT8 Last Tx: NB3T WB2FKO DM65 1/15 WD:29m

Relative strength of decoded signals

The screenshot shows the WSJT-X v1.9.1 interface. The 'Band Activity' window on the left and the 'Rx Frequency' window on the right display decoded signals. A red arrow points to the 'dB' column in the 'Band Activity' window, highlighting the relative strength of the signals.

UTC	dB	DT	Freq	Message
155815	-11	0.1	1326	~ CM2RSV W9RF EM57
155815	-2	-0.4	1607	~ CQ DX KZ4AK FM07
155815	-6	-1.2	1741	~ K9KON K4SOG R-15
155815	-10	-0.1	2016	~ KG7CW W4NH 73
155815	-8	0.3	2151	~ CQ DX N3MK FM27
155815	-17	0.4	2331	~ CQ DX K6EID EM73
155815	-12	0.1	233	~ KD0GFQ W4TM EM73
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UTC	dB	DT	Freq	Message
155445	-15	0.1	1253	~ CQ K1TEO FN31
155515	-16	0.1	1253	~ CQ K1TEO FN31
155545	-19	0.2	1253	~ KI5EE K1TEO FN31
155545	-10	0.2	1114	~ CQ K1GG EM97
155615	-11	0.2	1115	~ KC5WX K1GG R+01
155645	-13	0.1	1114	~ KC5WX K1GG R+02
155700	-14	0.1	892	~ CQ NB3T EM97
155730	-12	0.1	891	~ WB0QLU NB3T -11
155800	-16	0.1	891	~ WB0QLU NB3T RRR

Control panel details:

- Mode: 6m
- Frequency: 50.313 300
- TX/RX offset: 892 Hz
- DX Call: NB3T, DX Grid: EM97
- Distance: Az: 77, 1449 mi
- Report: -14
- Auto Seq: checked
- NA VHF Contest: unchecked

Message Queue:

- Generate Std Msgs
- NB3T WB2FKO DM65 (Tx 1)
- NB3T WB2FKO -14 (Tx 2)
- NB3T WB2FKO R-14 (Tx 3)
- NB3T WB2FKO RRR (Tx 4)
- NB3T WB2FKO 73 (Tx 5)
- CQ WB2FKO DM65 (Tx 6)

Status: Receiving, FT8, Last Tx: NB3T WB2FKO DM65, 1/15, WD:29m

Time offset between stations The FT8 decoder can correct up to ± 2.5 seconds

The screenshot shows the FT8 decoder software interface. At the top, a red arrow points from the title text to the 'Configurations' menu item. Below the menu bar, there are two main tables: 'Band Activity' on the left and 'Rx Frequency' on the right. Both tables have columns for UTC, dB, DT, Freq, and Message. The 'Band Activity' table shows several entries, with the one at DT -0.4 highlighted in green. The 'Rx Frequency' table shows a list of received stations, with the one at DT 0.1 highlighted in green. Below the tables are control buttons: 'CQ only', 'Log QSO', 'Stop', 'Monitor' (highlighted in green), 'Erase', 'Decode', 'Enable Tx', 'Halt Tx', 'Tune', and 'Menus'. The central control area displays the frequency '50.313 300' and a signal strength indicator 'S'. Below this are fields for 'DX Call' (NB3T) and 'DX Grid' (EM97), along with distance information 'Az: 77' and '1449 mi'. There are also buttons for 'Lookup' and 'Add'. A large digital display shows the date and time: '2018 Jul 22 15:58:31'. To the right of the central area is a 'Generate Std Msgs' section with a list of messages and buttons for 'Tx 1' through 'Tx 6'. The bottom status bar shows 'Receiving', 'FT8', 'Last Tx: NB3T WB2FKO DM65', '1/15', and 'WD:29m'.

UTC	dB	DT	Freq	Message
155815	-11	0.1	1326	~ CM2RSV W9RF EM57
155815	-2	-0.4	1607	~ CQ DX KZ4AK FM07
155815	-6	-1.2	1741	~ K9KON K4SOG R-15
155815	-10	-0.1	2016	~ KG7CW W4NH 73
155815	-8	0.3	2151	~ CQ DX N3MK FM27
155815	-17	0.4	2331	~ CQ DX K6EID EM73
155815	-12	0.1	233	~ KD0GFQ W4TM EM73
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UTC	dB	DT	Freq	Message
155445	-15	0.1	1253	~ CQ K1TEO FN31
155515	-16	0.1	1253	~ CQ K1TEO FN31
155545	-19	0.2	1253	~ KI5EE K1TEO FN31
155545	-10	0.2	1114	~ CQ K1GG EM97
155615	-11	0.2	1115	~ KC5WX K1GG R+01
155645	-13	0.1	1114	~ KC5WX K1GG R+02
155700	-14	0.1	892	~ CQ NB3T EM97
155730	-12	0.1	891	~ WB0QLU NB3T -11
155800	-16	0.1	891	~ WB0QLU NB3T RRR

Audio baseline frequency

Each signal requires 50 Hz bandwidth



File Configurations View Mode Decode Save Tools Help

Band Activity

UTC	dB	DT	Freq	Message
155815	-11	0.1	1326	~ CM2RSV W9RF EM57
155815	-2	-0.4	1607	~ CQ DX KZ4AK FM07
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155815	-12	0.1	1755	~ AB5J W4PH EM85

Rx Frequency

UTC	dB	DT	Freq	Message
155445	-15	0.1	1253	~ CQ K1TEO FN31
155515	-16	0.1	1253	~ CQ K1TEO FN31
155545	-19	0.2	1253	~ KI5EE K1TEO FN31
155545	-10	0.2	1114	~ CQ K1GG EM97
155615	-11	0.2	1115	~ KC5WX K1GG R+01
155645	-13	0.1	1114	~ KC5WX K1GG R+02
155700	-14	0.1	892	~ CQ NB3T EM97
155730	-12	0.1	891	~ WB0QLU NB3T -11
155800	-16	0.1	891	~ WB0QLU NB3T RRR

CQ only Menus

6m **50.313 300** Tx even/1st

Tx 892 Hz Tx ← Rx

Rx 892 Hz Rx ← Tx

Az: 77 1449 mi Hold Tx Freq

Report -14 Auto Seq Call 1st

NA VHF Contest

Generate Std Msgs

Next	Now	Pwr
NB3T WB2FKO DM65	<input checked="" type="radio"/>	Tx 1
NB3T WB2FKO -14	<input type="radio"/>	Tx 2
NB3T WB2FKO R-14	<input type="radio"/>	Tx 3
NB3T WB2FKO RRR	<input type="radio"/>	Tx 4
NB3T WB2FKO 73	<input type="radio"/>	Tx 5
CQ WB2FKO DM65	<input type="radio"/>	Tx 6

Receiving FT8 Last Tx: NB3T WB2FKO DM65 1/15 WD:29m

Time between FT8 transmissions is ~ 2 seconds
Faster than most ops can react!
Most use the Auto Sequence feature to send next message

The screenshot displays the FT8 software interface. At the top, two message logs are visible. The left log shows a series of received messages, with several highlighted in green. The right log shows a sequence of transmitted messages, also with several highlighted in green. Below the logs is a control panel with various buttons and settings. A red circle highlights the 'Report -14' dropdown menu and the 'Auto Seq' checkbox, which is checked. The interface also shows a frequency display of 50.313 300, a signal strength indicator, and a date/time display of 2018 Jul 22 15:58:31. The status bar at the bottom indicates 'Receiving', 'FT8', and 'Last Tx: NB3T WB2FKO DM65'.

Time	Offset	SNR	Message
155815	-11	0.1	1326 ~ CM2RSV W9RF EM57
155815	-2	-0.4	1607 ~ CQ DX KZ4AK FM07
155815	-6	-1.2	1741 ~ K9KON K4SOG R-15
155815	-10	-0.1	2016 ~ KG7CW W4NH 73
155815	-8	0.3	2151 ~ CQ DX N3MK FM27
155815	-17	0.4	2331 ~ CQ DX K6EID EM73
155815	-12	0.1	233 ~ KD0GFQ W4TM EM73
155815	-6	-0.0	1137 ~ CQ KE5MIS EM53
155815	-12	0.1	1755 ~ AB5J W4PH EM85

Time	Offset	SNR	Message
155445	-15	0.1	1253 ~ CQ K1TEO FN31
155515	-16	0.1	1253 ~ CQ K1TEO FN31
155545	-19	0.2	1253 ~ KI5EE K1TEO FN31
155545	-10	0.2	1114 ~ CQ K1GG EM97
155615	-11	0.2	1115 ~ KC5WX K1GG R+01
155645	-13	0.1	1114 ~ KC5WX K1GG R+02
155700	-14	0.1	892 ~ CQ NB3T EM97
155730	-12	0.1	891 ~ WB0QLU NB3T -11
155800	-16	0.1	891 ~ WB0QLU NB3T RRR

Control Panel Settings:

- Buttons: CQ only, Log QSO, Stop, Monitor, Erase, Decode, Enable Tx, Halt Tx, Tune, Menus
- Frequency: 6m, 50.313 300
- TX/RX: Tx 892 Hz, Rx 892 Hz, Tx ← Rx, Rx ← Tx
- DX Call: NB3T, DX Grid: EM97
- Az: 77, 1449 mi
- Report: Report -14
- Auto Seq:
- Call 1st:
- NA VHF Contest:
- Generate Std Msgs: NB3T WB2FKO DM65, NB3T WB2FKO -14, NB3T WB2FKO R-14, NB3T WB2FKO RRR, NB3T WB2FKO 73, CQ WB2FKO DM65
- Next/Now: Tx 1, Tx 2, Tx 3, Tx 4, Tx 5, Tx 6

Status: Receiving, FT8, Last Tx: NB3T WB2FKO DM65, 1/15, WD:29m



**No need to
constantly fiddle
with VFO**



**30+ different stations
can be simultaneously decoded
in the receiver bandwidth**

**Decodes possible even when
signals partially overlap**

FT8 Frequencies

1.840	18.100
3.573	21.074
7.074	24.915
10.136	28.074
14.074	50.313

Hardware cost to get on the digital modes

\$



<

\$



[I assume everyone has a computer]

Why FT8 is better than CW for working DX



REASON 1:

FT8 is ~ 8 dB more sensitive than CW at 12 wpm

Communication possible with signals that are inaudible



REASON 2:

**False character decodes extremely unlikely:
FT8 is All-or-Nothing**

CW ops adept at filling-in missing characters



REASON 3:

Multiple streams of real-time decoded signals

Most CW ops can only reliably deal with one signal



REASON 4:

FT8 learning curve not as steep as CW

Many ops have poor or no CW skills

Chasing DX available to the hearing impaired

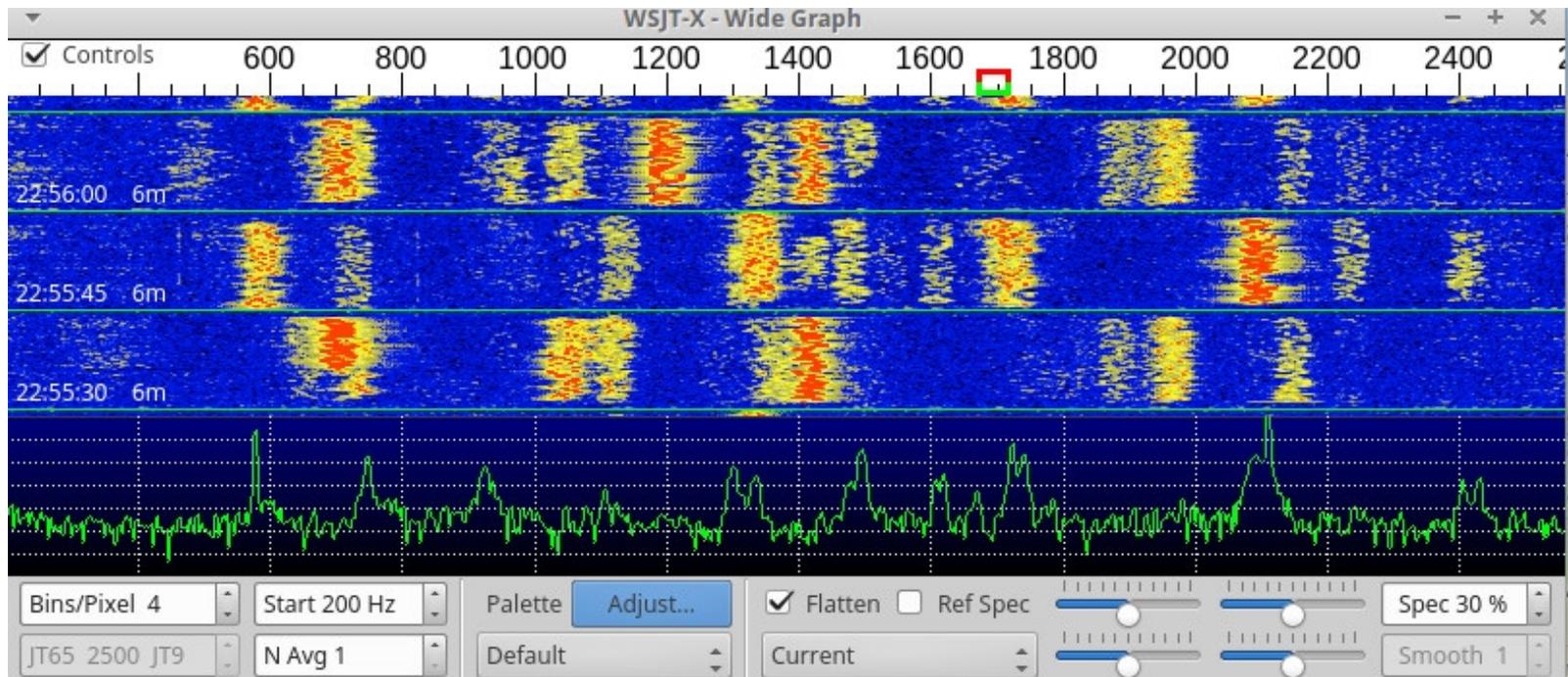


REASON 5:

QRM and congestion dramatically reduced

Many stations comfortably spread out over ~2500 Hz

A station picks out callers and works at discretion



REASON 5 (continued):

Two good CW ops can complete a QSO far faster than the minimum time for FT8: 45 seconds

...but they first have to find each other

...and they likely have to fight through QRM

Is FT8 more time-efficient in the aggregate?

REASON 5 (continued):

FT8 DXpedition Mode: Fox and Hounds

Many stations (Hounds) calling single, rare DX (Fox)

Pre-arranged frequency

Fox can work multiple hounds simultaneously

Run rates approaching 1000/hour on multiple bands



REASON 5 (continued):

AA7A and other experienced DXers provided guidance for Fox-Hound development

1) FT8 likely to displace RTTY in HF digital contests

2) FT8 will be preferred mode on future DXpeditions



Ned Stearns, AA7A

Major update of WSJT-X was released on 17 October 2018

Data payload size increase from 75 to 77 bits in FT8 and MSK144

Accommodates VHF contest rover suffix: /R

Auto-sequencing between contest and non-contest stations

Field Day contest exchanges (example: 2B NM)

ARRL RTTY Roundup contest exchanges (599)

75 and 77 bit format are not compatible

Alerts for new DXCC, new grid, etc

~ 1 dB more sensitivity

**“If a computer decodes it,
it's not real ham radio!”**



PROTESTING AGAINST NEW TECHNOLOGY - THE EARLY DAYS

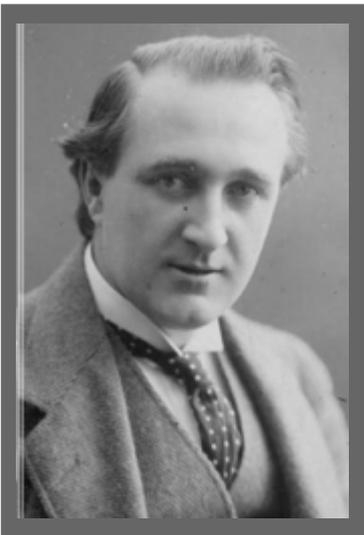
**“If a computer decodes it,
it's not real ham radio!”**

To each his own.

**Considerable skill required
to use FT8 effectively.**

Get better with practice.





**“It's difficult to make predictions,
especially about the future.”**

– Robert S. Petersen

FT8 or something like it is here to stay

DXers and Contesters will do one of the following:

- 1) Stick with traditional modes**
- 2) Move entirely to digital**
- 3) Use a combination of analog and digital to best advantage**