Overview of WSJT-X FT8*& FT8 Dxpedition Modes

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*Franke-Taylor 8-FSK

Much Material Borrowed from References [2-4]

INTRODUCTION FT8: Rapid Acceptance/Usage



2 Hour Mode Count 3/26/17 8:15 AM

Mode	Count
FT8	683329
CW	1790
JT65	1423
PSK31	683
MSK144	487
PSK63	241
SIM31	162
RTTY	96
3Т9	59
ROS	58
OPERA	20
PI4	9
SSB	6
T10	3
PSK125	2
FSK441	1
QPSK31	1
PSK	1

INTRODUCTION WSJT-X Software Package

- WSJT-X Overview
 - WSPR
 - Beacon Mode 2 Minute TX Segments
 - MSK144
 - Meteor Scatter 5, 10, 15, or 30 Second Segments
 - Offset Quadrature Shift Keying (OQSK)
 - JT65 (JT9/JT4)
 - 65 (9/4) Tones 1 Minute TX Segments
 - FT8
 - 8 Tones 15 Second Segments BW ≈ 50 Hz
- Highly Structured QSO's

WSJT-X Frequencies

Table 1 Conventional Dial Frequencies for FT8, JT65, JT9, and WSPR on the HF Bands								
Band (m)		Frequence	cies (MHz)					
	FT8	JT65	JT9	WSPR				
160	1.840	1.838	1.839	1.8366				
80	3.573	3.570	3.572	3.5686*				
40	7.074	7.076	7.078	7.0386				
30	10.136	10.138	10.140	10.1387				
20	14.074	14.076	14.078	14.0956				
17	18.100	18.102	18.104	18.1046				
15	21.074	21.076	21.078	21.0946				
12	24.915	24.917	24.919	24.9246				
10	28.074	28.076	28.078	28.1246				
6	50.313	50.310 [†]	50.312	50.293				
*Pending change from 3.5926, †Pending change from 50.276								

Subject to Change

[2] Joe Taylor, K1JT, Steve Franke, K9AN, and Bill Somerville, G4WJS, "Work the World with WSJT-X, Part 1: Operating Capabilities," *QST*, pp. 1-7, October 2017

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WSJT-X Mode Parameters

Table 1: Parameters of the Slow WSJT-X Protocols

Bandwidths (BW) are for the narrowest submodes. S/N threshold is referenced to a 2,500 Hz bandwidth at a 50% probability for decoding of an unfading signal.

Mode	FEC type (n,k)	q m	Modulation	Keying rate, baud	BW, Hz	Sync energy	TX duration, s	S/N threshold, dB
FT8	LDPC(174,87)	1 3	8-FSK	6.250	50.0	0.27	12.6	-20
JT4	C(206,72)	1 2	4-FSK	4.375	17.5	0.50	47.1	-23
JT9	C(206,72)	1 3#	9-FSK	1.736	15.6	0.19	49.0	-27
JT65	RS(63,12)	6 6#	65-FSK	2.692	177.6	0.50	46.8	-25
QRA64	QRA(63,12)	6 6	64-FSK	1.736	111.1	0.25	48.4	-26
WSPR	C(162,50)	1 2	4-FSK	1.465	5.9	0.50	110.6	-28

#Modulation includes one additional tone used for synchronization.

LDPC: Low Density Parity Check Code C: Convolutional Code

[3] Joe Taylor, K1JT, Steve Franke, K9AN, and Bill Somerville, G4WJS, "Work the World with WSJT-X, Part 2: Codes, Modes and Cooperative Software Development," *QST*, pp. 1-6, November 2017.

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FT8/JT Structured QSO's

40m 7.074 000 DX Call DX Grid B0 -60 -40 -40 -20 -0 -0 - - - - - - -	 ✓ Tx even/1st Tx 1605 Hz Tx ← Rx Rx + Tx Lock Tx=Rx N Report -15 ✓ Auto Seq Call 1st 	Generate Std Ms W3JX K4IQJ EM72 W3JX K4IQJ -15 W3JX K4IQJ R-15 W3JX K4IQJ RRR W3JX K4IQJ 73 CQ K4IQJ EM72	gs Next Now Pwr Tx 1 Tx 2 Tx 2 Tx 3 Tx 4 Tx 5 Tx 6
 Message 2 Call Signs Grid Square, sig Can construct y 13 Character Lie 	gnal report, RRR, 73, ef our own mit - Spaces Count!	C. Calling C CQ dB RRR KF4RWA K1JT FB SIG 73 GL	Tab 2 Q Answering CQ Grid R+dB 73 73 @ Gen msg Free msg

FT8 Technical Overview

- T/R Sequence length: 15 Sec
 - Message 12.6 sec
 - Decoding 2.4 Sec
- Message: 2 Call Signs, Grid Square, Control
- Message length: 75 bits + 12-bit CRC (87 Bits)
 - 28 bits/call sign, 15 bits for grid locator, 4 control bits
 - Message: 2 x 28 + 15 + 4 = 75
- Forward Error Correction (FEC)
 - LDPC^{*} (174,<u>87</u>)
- 8 Tones One/Symbol + Sychronization
 - Frequency Spacing: 6.25 Hz
 - BW ≈ 50 Hz
- Multidecoder
 - Decoding Threshold: -20 dB S/N
 - Finds & Decodes all FT8 Signals in the Passband
- Optional auto-sequencing/auto-reply to CQ

WSJT-X Coding & Decoding – High Complexity



- 1. Generate Message
- 2. Compress Message to k symbols of q bits/symbol
- 3. Add Error-Correcting Redundency to Produce a Codeword of n Symbols
- 4. Add Sync Pattern and Modulate onto Carrier
- 5. Transmit Modulated Waveform
- 6. Receive, Demodulate to Yield n Symbols Including Errors
- 7. Decode n Received Symbols to Recover k Error-Free Message Symbols
- 8. Decompress k Symbols to Recover Original Message
- 9. Deliver Message to User

[3] Joe Taylor, K1JT, Steve Franke, K9AN, and Bill Somerville, G4WJS,

"Work the World with WSJT-X, Part 2: Codes, Modes and Cooperative Software Development," *QST*, pp. 1-6, November 2017.

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LDPC (n,k)

Clock Synchronization Required in All Modes (FT8 Example)



- Transmission Starts 1 Second Into a Given Time Block
- Timing is Critical to Decoding!
- Be Sure Your Clock is Correct (Network Time)
- Receiver Calibration is Also Important



UTC	dB	DT	Freq	Drift	Call	Grid	dBm	km	
									20m
1558	-21	5.7	14.097073	0	MOTVV	1090	37	6929	
1558	-13	1.3	14.097080	-1	K52E	DM65	37	2008	
1558	-19	0.0	14.097086	0	2E0EV2	J001	37	7026	
1558	-10	-0.1	14.097099	-3	VE3CJE	EN76	23	1550	
1558	3	-0.2	14.097103	0	VE2GK	FN25	23	1698	
1558	-24	-0.1	14.097176	0	KE2GS	FN30	20	1423	
									20m
1600	-23	-0.1	14.097066	0	KE2GS	FN30	20	1423	
1600	-25	-0.1	14.097117	1	VECEXP	FN74	23	2216	
1600	-21	0.6	14.097120	0	F6KOP	JN18	23	7278	
1600	-27	-0.1	14.097135	0	DD1CC	J031	40	7413	
1600	-23	0.0	14.097146	1	EA6FG	JM19	17	7682	

"0" = 14.0956 MHz

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WSPR Transmissions in Progress (Spectrum)



EA2CYJ

K5ZE

KILC

N12KO

F5LHP

VEBSFE

IN82

D0065

7542

2842

FN14

JN25

47

37

27

23

23

37

7087

2008

1688

1688

1518

7549

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Decoded

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1432

1432

1432

1432

1432

1432

-23

-14

-8

-13

-17

-25

0.0

-0.4

-0.1

2.6

-0.1

0.2

14.097072

14.097081

14.097098

14.097156

14.097161

14.097168



Transmissions in Progress (Decoding)



MSK144 Receiving Meteor Scatter



Continuous Decoding

Banu Activity								
UTC	dB	Т	Freq		Message			
114030 114045 114045 114100 114100	10 3 7 -1 4	11.1 1.1 13.9 5.0 13.2	1504 1485 1488 1501 1487	10 10 10 10 10 10	CQ N5OSK EM25 CQ WA1EAZ FN42 CQ WA1EAZ FN42 CQ N5OSK EM25 CQ N5OSK EM25	$\begin{array}{cccccccccccccccccccccccccccccccccccc$		

FT8 QSO's on 40M Same Frequency (Half Duplex – "Simplex")



FT8 QSO's Same Frequency (Half Duplex – "Simplex")





FT8 QSO's on 40 M Same Frequency (Half Duplex – "Simplex")



"0" = 7.074 MHz

FT8 QSO's Working Split



Slots used = 6 Slots vacant = 6 Total slots = 12 Slot utilization = 50%

QSOs made = at least 1 (other stations can use the vacant slots, ideally DWF/split)

FT8 QSO's QRM Mess! Responders Not Split!



Slots used productively = 3 (or less) Slots blocked by QRM = 3 Slots vacant = 6 Total slots = 12 Slot utilization = up to 25% QSOs made = 0, possibly 1 if they are patient enough

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[4]

QSO – QRM on DX TX Freq. One Answering Station Split

DX Station Freq	Time slot	1500 Hz	Smart Caller
Station A transmits	1	Vacant	Above or Below
Several stations transmit, QRM	2	Station B transmits	
Station A transmits	3	Vacant	
Several stations transmit, QRM	4	Station B transmits	
Station A transmits	5	Vacant	
Several stations transmit, QRM	6	Station B transmits	
Slots used p Slots blocke Sl Tr Slot uti QSOs			

[4]

FT8 Dxpedition Mode QSO's in Progress



FT8 Dxpedition Mode K4IQJ QSO in Progress

	80	m		020230 2	0.2	308 ~ K4DET	RR73: KK4YWI <k9an> -05</k9an>			
020130 2 0.2 308 -	AB4SF RR73; K1J	T <k9an> -07</k9an>		020253 Tx		2210 - K9AN B	4IQJ EM72			
020130 2 0.2 368 -	N3XX RR73; K4DE	T <k9an> +00</k9an>		020300 2	0.2	308 ~ K5WE F	R73; K4IQJ <k9an> -06</k9an>			
020130 2 0.2 428 -	 AA4VV RR73; N1J. 	EZ <k9an> +03</k9an>		020315 Tx		733 - K9AN B	4IQJ R+05			
		M		020330 2	0.2	308 ~ WB9RAS	RR73; N1DG <k9an> -09</k9an>			_
020200 -1 0.2 308 -	 NIJT KR/3; KAIK NIJTZ BD73, K5W 	E CK9AND -04		020330 2	0.2	308 - K5DA B	RR/3; N3EL SN9AN2 T0/			
020200 2 0.2 428 -	- K4DET K9AN +00	E SKYRAN -04		020430 0	0.2	308 ~ K5PA F	R73: W05L <k9an> -09</k9an>			
020200 -1 0.2 1730 -	K9AN AE0AL EN35			-						
	80:	m		0						
020230 2 0.2 308 -	 K4DET RR73; KK4 	YWI <k9an> -05</k9an>								
020230 2 0.2 368 -	 KAIR RR73; WB9R KADET BD73; WB9R 	AS <k9an> -09</k9an>								
020230 -10 0.2 1730 -	K9AN AEOAL EN35	VA NAMANA TUS								
	80	m								
020300 2 0.2 308 -	 K5WE RR73; K4IQ 	J <k9an> -06</k9an>								
020300 1 0.2 368 -	KW4VA RR73; NOA	N <k9an> +00</k9an>								
020300 1 0.2 428 -	 K5WE RR73; K5PA 	<k9an> -17</k9an>								
020330 2 0.2 308	WB9RAS RR73 • N1	DG <k9an> -09</k9an>								
020330 2 0.2 368 -	NOAN RR73: KJ3N	<k9an> +05</k9an>								
020330 2 0.2 428 -	 K4IQJ RR73; K3E 	L <k9an> +07</k9an>								
	80	m								
020345 -12 0.3 693 -	K9AN N1DG R+00									
020345 -20 0.1 898 -	K9AN K5PA R+02 KH77 KB50D FM34									
020345 -6 -0.1 1189 -	K9AN K4SO FM18									
020345 -16 0.2 1259 -	K9AN K4VBM EM73									
020345 1 0.4 1366 -	K9AN W0IBM EN34									
020345 -5 0.4 1533 -	K9AN W8BAR EM95									
020345 -14 0.2 1608 -	 K9AN W3RJW FN20 									
	- K9AN W80M EM98									
020345 0 0 1 1033	ROAN ROAS PUED									
			_					_		
CQ only Log QS	O Stop	Monitor	Erase	Decode		Enable Tx	Halt Tx	Tune	N	/lenus
80m 🗸 🛑	3,585	000								Pwr
	0.000		Tx even/1st			Ge	nerate Std Msgs	Next	Now	
							inclute ora mogo	- HUAL		
			Tx 733 Hz 🗋	Tx ← Rx		KOANLKAIO			Tu 4	1.1
-	DX Call	DX Grid				K9AN K4IQ.	EIVI/2		TX 1	
00	DX Call	DX Onu	Dv 200 Hz A		_					-
-80			KX 308 HZ	KX ← TX		K9AN K4IQ.	1 +05		Tx 2	
-	K9AN	EN50								-
-60			Descel E	0	N	K9AN K4IQ.	J R+05		Tx 3	
2/27/19										

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- 2. Joe Taylor, K1JT, Steve Franke, K9AN, and Bill Somerville, G4WJS, "Work the World with WSJT-X, Part 1: Operating Capabilities," *QST*, pp. 1-7, October 2017
- 3. Joe Taylor, K1JT, Steve Franke, K9AN, and Bill Somerville, G4WJS, "Work the World with WSJT-X, Part 2: Codes, Modes and Cooperative Software Development," *QST*, pp. 1-6, November 2017. Note: There is a typo on Page 1, column 3: $Q = 2^{q}$.
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- 6. Joe Taylor, K1JT, "FT8 Dxpedition Mode Users Guide," February 20, 2018.

THANK YOU FOR YOUR ATTENTION

• QUESTIONS?

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