



285 TechConnect Radio Club - NAØTC

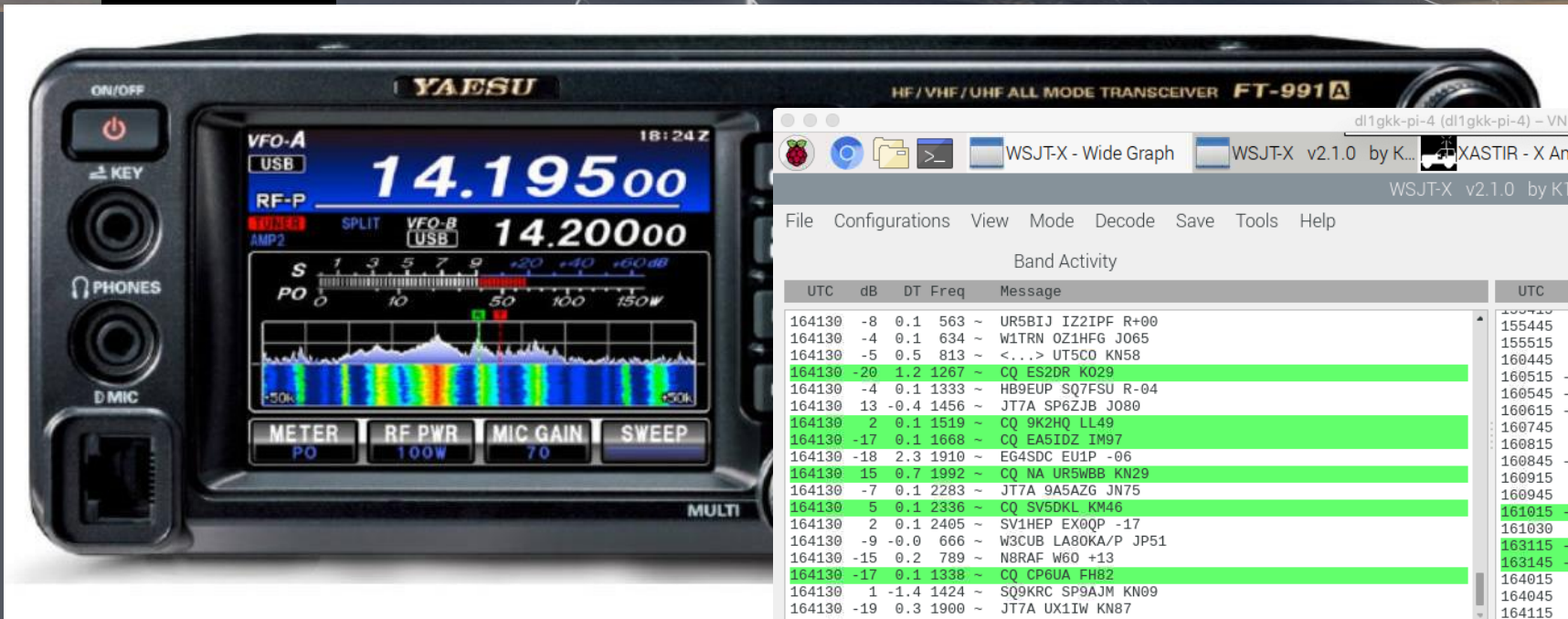
The Magic Behind FT8

June 3, 2023

Tony Montoya KØMCW



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WSJT-X v2.1.0 by K1JT

File Configurations View Mode Decode Save Tools Help

Band Activity

UTC	dB	DT	Freq	Message
164130	-8	0.1	563	~ UR5BIJ IZ2IPF R+00
164130	-4	0.1	634	~ W1TRN OZ1HFG J065
164130	-5	0.5	813	~ <...> UT5CO KN58
164130	-20	1.2	1267	~ CQ ES2DR K029
164130	-4	0.1	1333	~ HB9EUP SQ7FSU R-04
164130	13	-0.4	1456	~ JT7A SP6ZJB J080
164130	2	0.1	1519	~ CQ 9K2HQ LL49
164130	-17	0.1	1668	~ CQ EA5IDZ IM97
164130	-18	2.3	1910	~ EG4SDC EU1P -06
164130	15	0.7	1992	~ CQ NA UR5WBB KN29
164130	-7	0.1	2283	~ JT7A 9A5AZG JN75
164130	5	0.1	2336	~ CQ SV5DKL KM46
164130	2	0.1	2405	~ SV1HEP EX0QP -17
164130	-9	-0.0	666	~ W3CUB LA80KA/P JP51
164130	-15	0.2	789	~ N8RAF W60 +13
164130	-17	0.1	1338	~ CQ CP6UA FH82
164130	1	-1.4	1424	~ SQ9KRC SP9AJM KN09
164130	-19	0.3	1900	~ JT7A UX11W KN87

Rx Frequency

UTC	dB	DT	Freq	Message
155445	11	0.5	1844	~ ZS6NL SP9FV0 JN99
155515	7	0.5	1844	~ ZS6NL SP9FV0 JN99
160445	-8	1.0	1850	~ EA6ET SQ7RO K002
160515	-11	1.0	1850	~ EA6ET SQ7RO K002
160545	-14	1.0	1850	~ EA6ET SQ7RO K002
160615	-13	1.0	1850	~ EA6ET SQ7RO K002
160745	-6	0.1	1851	~ R3BV CT2JMA RR73
160815	-4	0.1	1851	~ R3BV CT2JMA RR73
160845	-10	0.1	1851	~ R3BV CT2JMA RR73
160915	-8	0.1	1851	~ R3BV CT2JMA RR73
160945	-9	0.1	1851	~ R3BV CT2JMA RR73
161015	-10	0.1	1851	~ CQ CT2JMA IM59
161030	0	0.3	1851	~ CT2JMA SP9BGL J090
163115	-10	0.1	1859	~ CQ UA9TK L091
163145	-10	0.1	1859	~ CQ UA9TK L091
164015	6	0.3	1844	~ EX0QP RA30X K090
164045	9	0.3	1844	~ EX0QP RA30X K090
164115	6	1.5	1844	~ EX0QP RA30X K090

CQ only Log QSO Menus

20m 14,074 000 Tx even/1st

 Hold Tx Freq

 Auto Seq Call 1st

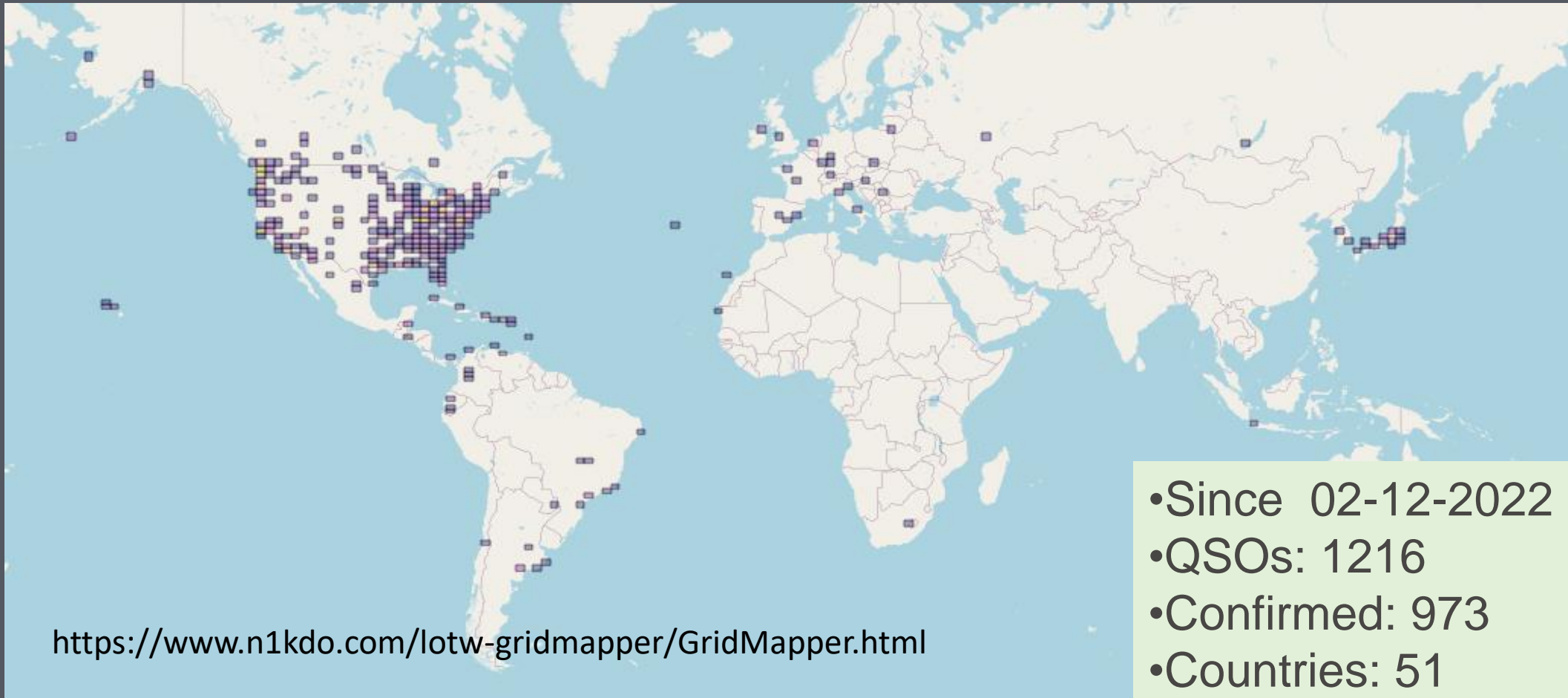
 Az: 87 2423 km

 Next Now
 Tx 1
 Tx 2
 Tx 3
 Tx 4
 Tx 5
 Tx 6

Receiving FT8 8/15 WD:0m

285

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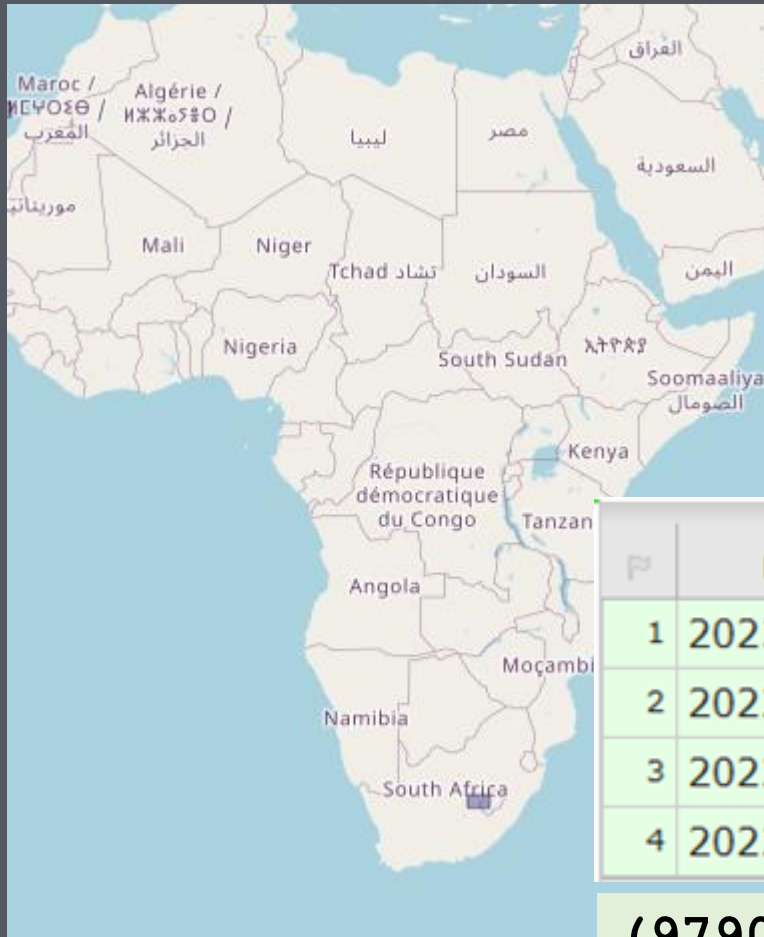


<https://www.n1kdo.com/lotw-gridmapper/GridMapper.html>

- Since 02-12-2022
- QSOs: 1216
- Confirmed: 973
- Countries: 51
- Mostly FT8 and FT4



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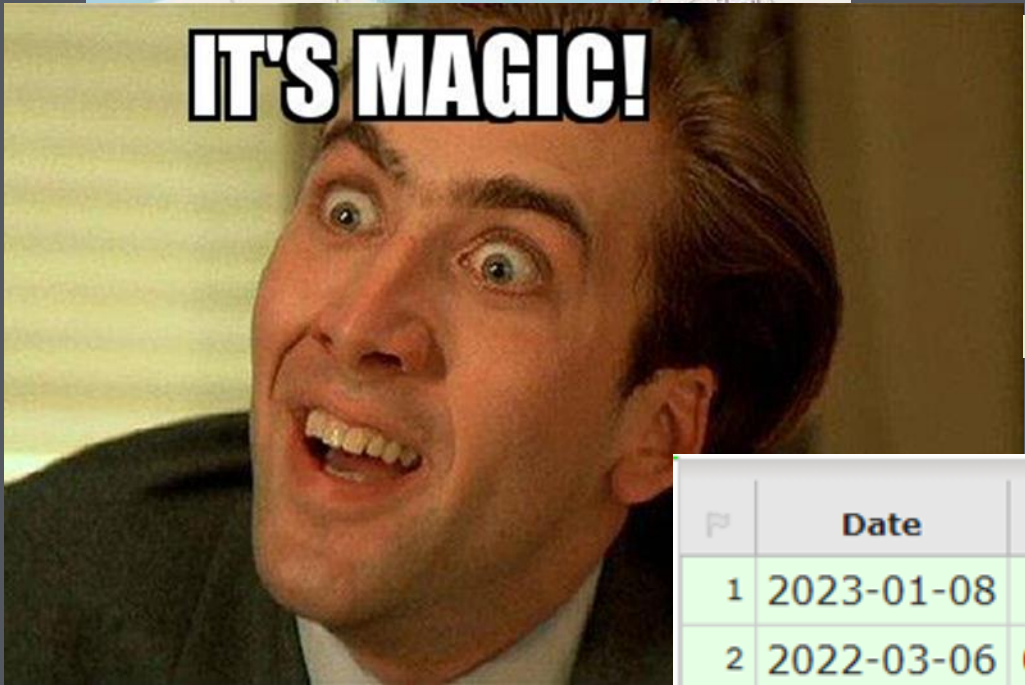
- First FT8 QSO 02-12-2022
- QTH DM79jo
- FT991a
- 75W
- 20m half wave dipole

P	Date	Time	RX Call	TX Freque...	RX Mode	RX Grid	RX	RX Country
1	2023-01-08	17:12	ZS4JAN	28.076	FT8	KG30bv		South Africa
2	2022-03-06	01:39	ZS6AF	14.075	FT8	KG54		South Africa
3	2022-02-25	04:34	ZS6AF	14.075	FT8	KG54		South Africa
4	2022-02-24	22:41	ZS6AF	14.075	FT8	KG54		South Africa

(9790 miles), bearing 82.5 degrees



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- First FT8 QSO 02-12-2022
- QTH DM79jo
- FT991a
- 75W
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3	2022-02-25	04:34	ZS6AF	14.075	FT8	KG54		South Africa
4	2022-02-24	22:41	ZS6AF	14.075	FT8	KG54		South Africa

(9790 miles), bearing 82.5 degrees



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WSJT-X v2.5.4 by K1JT, G4WJS, K9AN, and IV3NWW

File Configurations View Mode Decode Save Tools Help

- Open Ctrl+O
- Open next in directory
- Decode remaining files in directory Shift+F6
- Delete all *.wav & *.c2 files in SaveDir
- Erase ALL.TXT
- Erase wsjtx_log adi
- Erase WSPR hashtable
- Reset Cabrillo log ...
- Export Cabrillo log ...
- Open log directory
- Settings...
- Exit

224230	-16	-0.5	2718	~	5T5PA	WA6HBR
224230	-17	-0.6	1594	~	KOMCW	ZS6AF R
224230	-14	-0.4	1503	~	KC9VFO	W5BOE
224230	7	0.1	2381	~	WX6B	KN6NJU C
224230	6	-0.5	1879	~	EA8CVR	N4ZUK
224230	5	-0.5	2422	~	HC2EP	WA9FZB
224230	0	-0.5	1721	~	WA7CHF	N4YYV
224230	0	-0.6	2098	~	VE8CK	W9QB EN
224230	0	-0.5	1914	~	N8ERV	KK7BHY
224230	-3	-0.7	2071	~	CQ	N8THJ EM89
224230	1	-0.3	1795	~	LW8DOZ	W2RR R
224230	-6	-0.4	1812	~	WA2HIP	KN4MBF

CQ only

Tx ever

Open File

« WSJT-X » save

Organize New folder

Name	#	Title
220224_224000		
220224_224030		
220224_224100		
220224_224130		
220224_224200		
220224_224230		
220224_224300		
220224_224315		
220224_224330		
220224_224345		
220224_224400		
220224_224415		
220224_224430		
220224_224445		
220224_224500		

File name: 220224_224230 WSJT Files (*.wav)

Decode
Step 1 –
Save 15 sec .wav file



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WSJT-X v2.5.4 by K1JT, G4WJS, K9AN, and IV3NWV

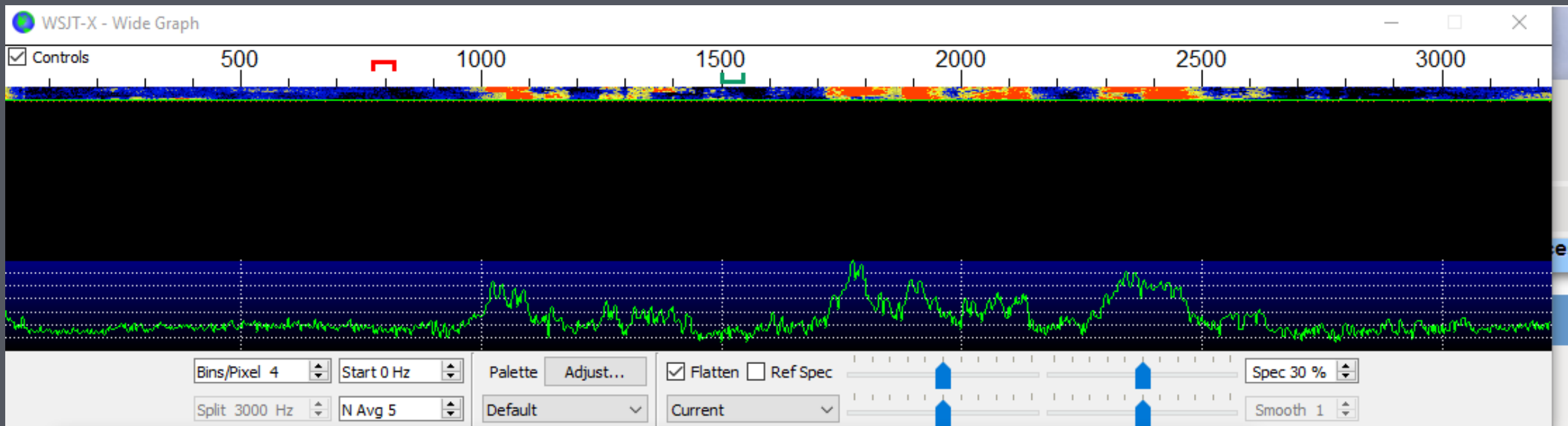
File Configurations View Mode Decode Save Tools Help

Band Activity					Rx Frequency				
UTC	dB	DT	Freq	Message	UTC	dB	DT	Freq	Message
224230	14	-0.5	1057	~ CQ SD KA8VHF EN34 U.S.A.	224230	-17	-0.6	1594	~ KOMCW ZS6AF RR73
224230	18	-0.6	1760	~ VK5WU WB0TAX -18	224230	-14	-0.4	1503	~ KC9VFO W5BOE R+02
224230	6	-0.5	2043	~ CQ MD N3GSD FM29 U.S.A.					
224230	-2	-0.5	1135	~ HK1REB VE3DCG FN03					
224230	-3	-0.5	1307	~ CQ KK6MYO DM79 U.S.A.					
224230	-5	-0.5	1248	~ K5VYT KW4IG R-11					
224230	3	-0.5	2289	~ W5LST K4CPZ EL89					
224230	-10	0.1	2544	~ K9CPA YV1GIY -15					
224230	-9	-0.9	1466	~ K2CDP KF4AQO EM83					
224230	-10	-0.0	2595	~ KF5YNN KG7WPQ R-04					
224230	-3	-0.5	1996	~ WA6OVP K7MAW RR73					
224230	13	-0.5	2415	~ KV4OP N2JQI FN12					
224230	10	-0.4	1884	~ AC2SB AE5B +05					
224230	2	-0.4	2099	~ W5LST WA7VFQ DN16					
224230	-16	-0.5	2718	~ 5T5PA WA6HBR EM10					
224230	-17	-0.6	1594	~ KOMCW ZS6AF RR73					
224230	-14	-0.4	1503	~ KC9VFO W5BOE R+02					
224230	7	0.1	2381	~ WX6B KN6NJU CM87					
224230	6	-0.5	1879	~ EA8CVR N4ZUK R-24					
224230	5	-0.5	2422	~ HC2EP WA9FZB EN61					
224230	0	-0.5	1721	~ WA7CHF N4YYV -20					
224230	0	-0.6	2098	~ VE8CK W9QB EN51					
224230	0	-0.5	1914	~ N8ERV KK7BHY RRR					
224230	-3	-0.7	2071	~ CQ N8THJ EM89 U.S.A.					
224230	1	-0.3	1795	~ LW8DOZ W2RK R-13					
224230	-6	-0.4	1812	~ WA2HIP KN4MBF R-11					

CQ only Log QSO Stop Monitor Erase Decode Enable Tx Halt Tx Tune Menus



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WSJT-X v2.5.4 by K1JT, G4WJS, K9AN, and IV3NWW

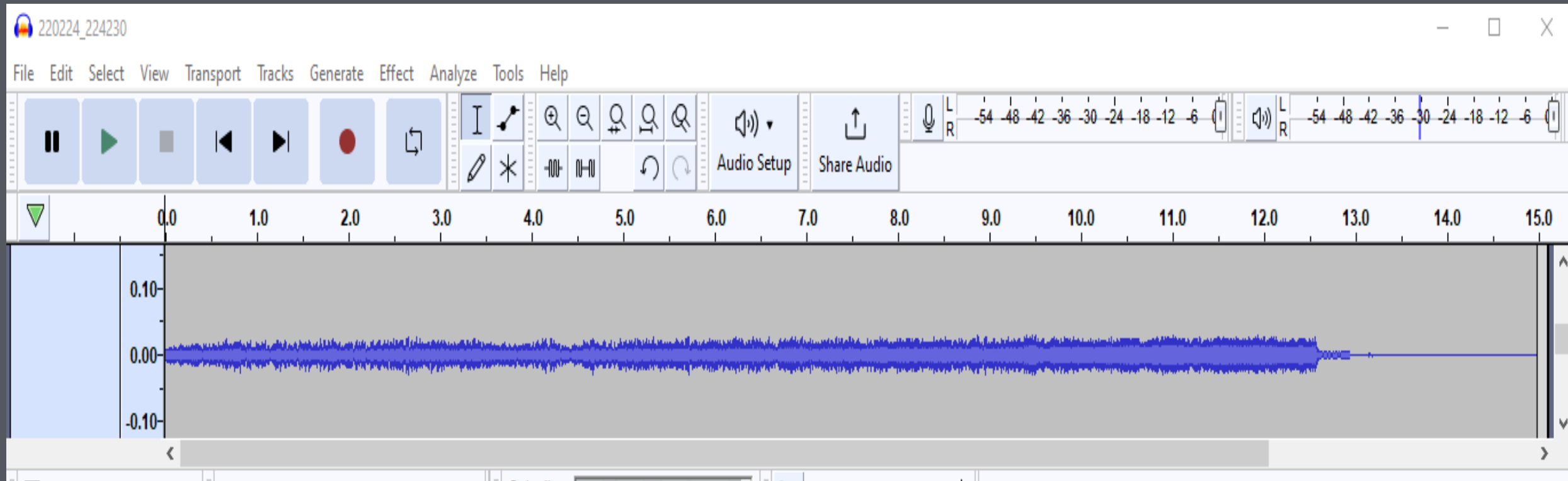
File Configurations View Mode Decode Save Tools Help

Band Activity					Rx Frequency				
UTC	dB	DT	Freq	Message	UTC	dB	DT	Freq	Message
224230	14	-0.5	1057	~ CQ SD KA8VHF EN34 U.S.A.	224230	-17	-0.6	1594	~ KOMCW ZS6AF RR73
224230	18	-0.6	1760	~ VK5WU WB0TAX -18	224230	-14	-0.4	1503	~ KC9VFO W5BOE R+02
224230	6	-0.5	2043	~ CO MD N3GSD FM29 U.S.A.					

Country	Operator Name
South Africa	Johan Visagie
Canada	Charles R. Smith
United States	Alan L Homan
Costa Rica	Federación Mexicana



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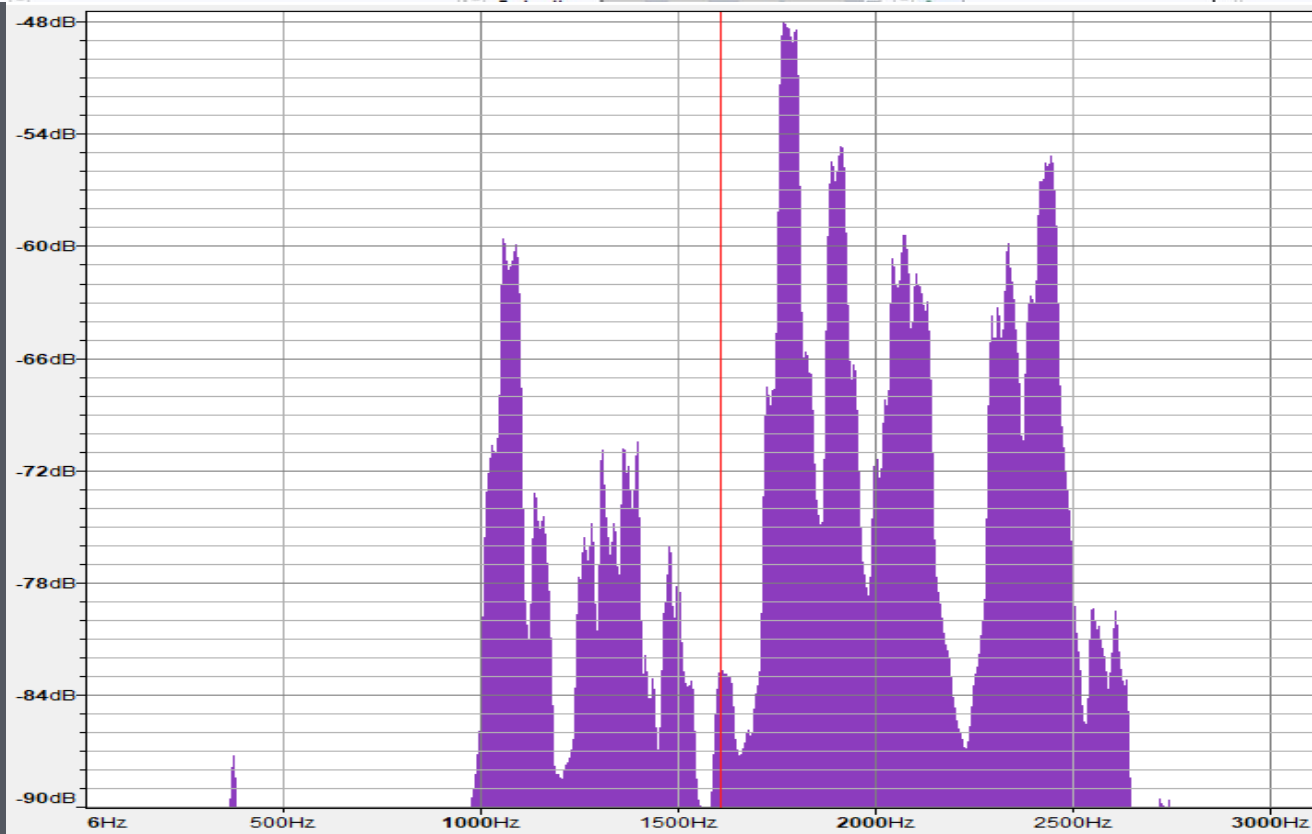
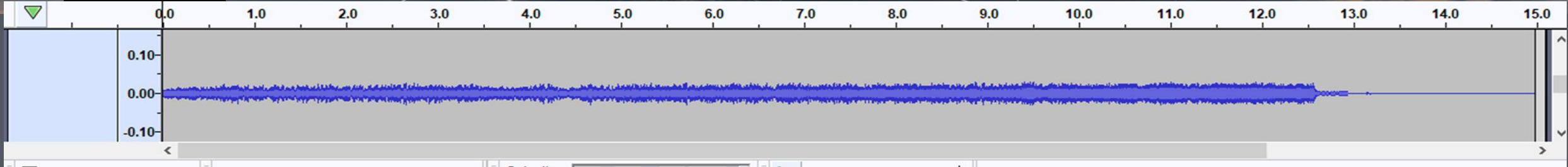


Audacity 3.3.2



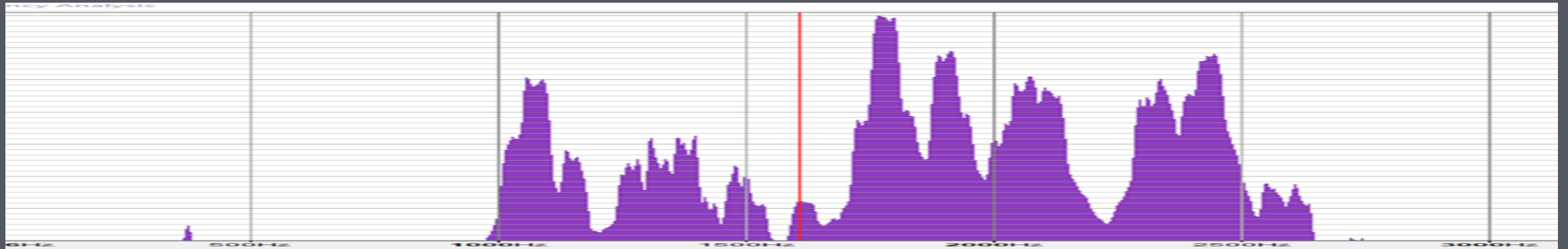
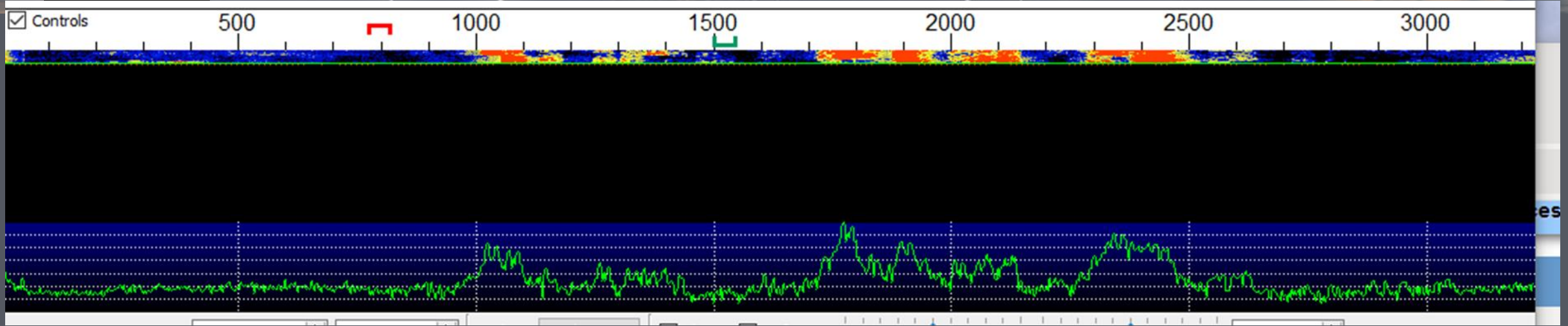


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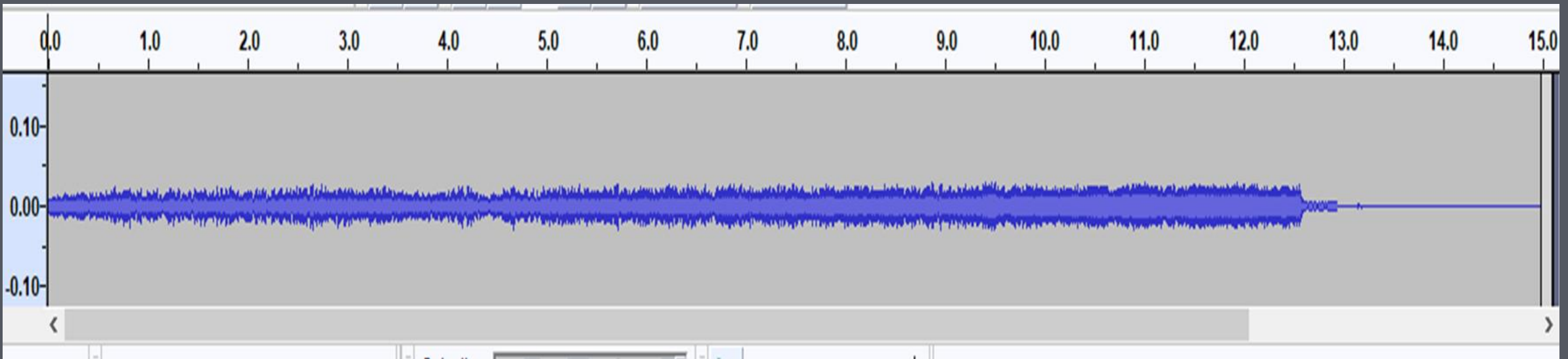


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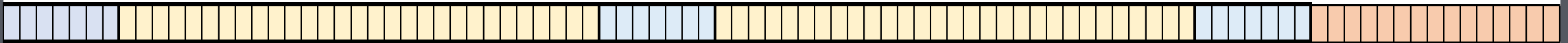




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0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78



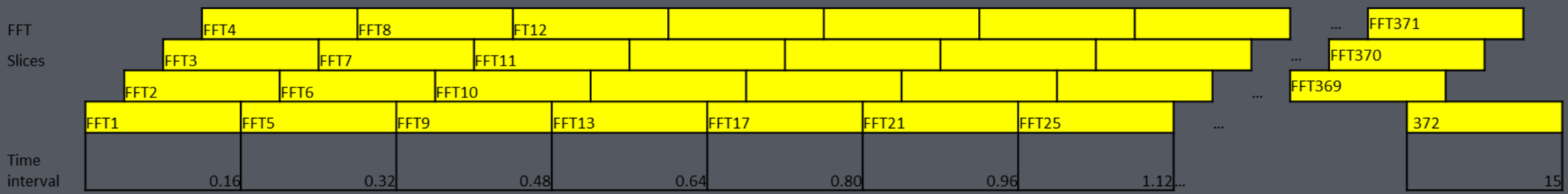
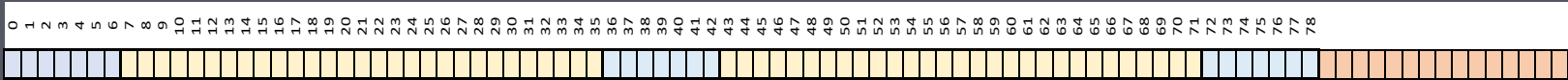
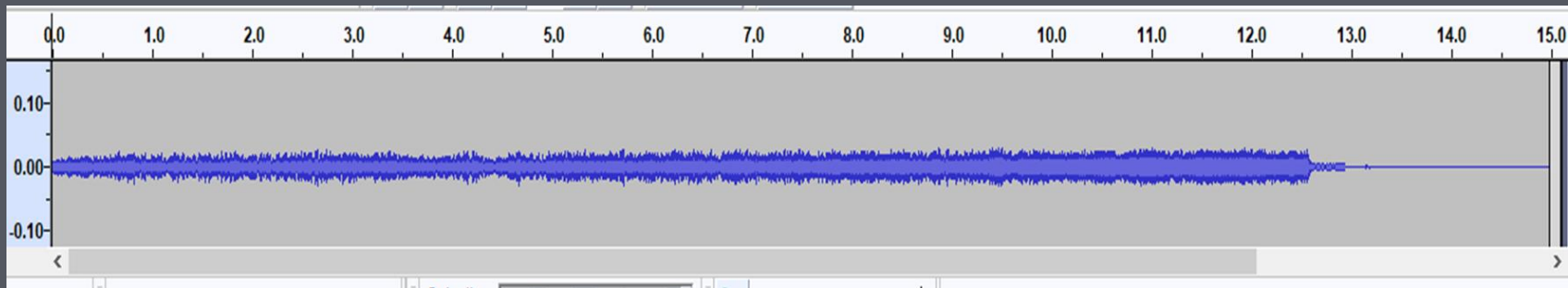
7sync 29 data 7sync 29 data 7 sync unused

Multiple messages with multiple RX carrier frequencies, each containing
79 symbols, .16 sec long = 12.64 second message



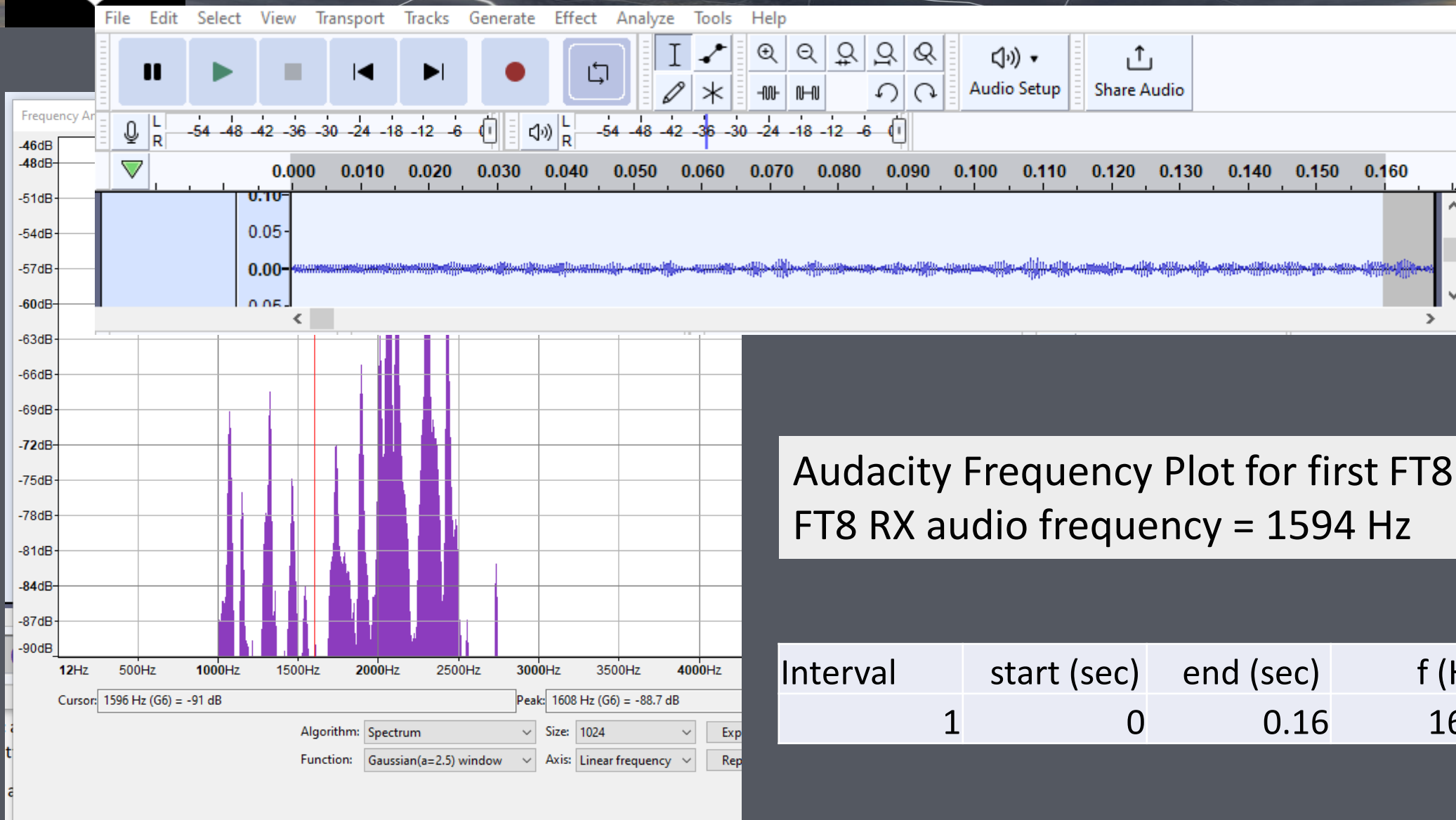
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Decode Step 2 –
Calculate 372 overlapping
FFTs, .16 sec each





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Audacity Frequency Plot for first FT8 interval
FT8 RX audio frequency = 1594 Hz

Interval	start (sec)	end (sec)	f (Hz)
1	0	0.16	1608.



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Interval	start (sec)	end (sec)	f (Hz)	0.16
1	0	0.16	1608	3
2	0.16	0.32	1604	1
3	0.32	0.48	1618	4
4	0.48	0.64	1555	0
5	0.64	0.8	1619	5
6	0.8	0.96	1620	6
7	0.96	1.12	1605	2

Decode Step 3 –
Scan the spectrum for each
FFT interval for sequences
matching the sync array.

Using Audacity
Rank order peak
frequencies for first 7
intervals

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

7 symbol FT8 sync array
7X7 Costas Array [3,1,4,0,6,5,2]



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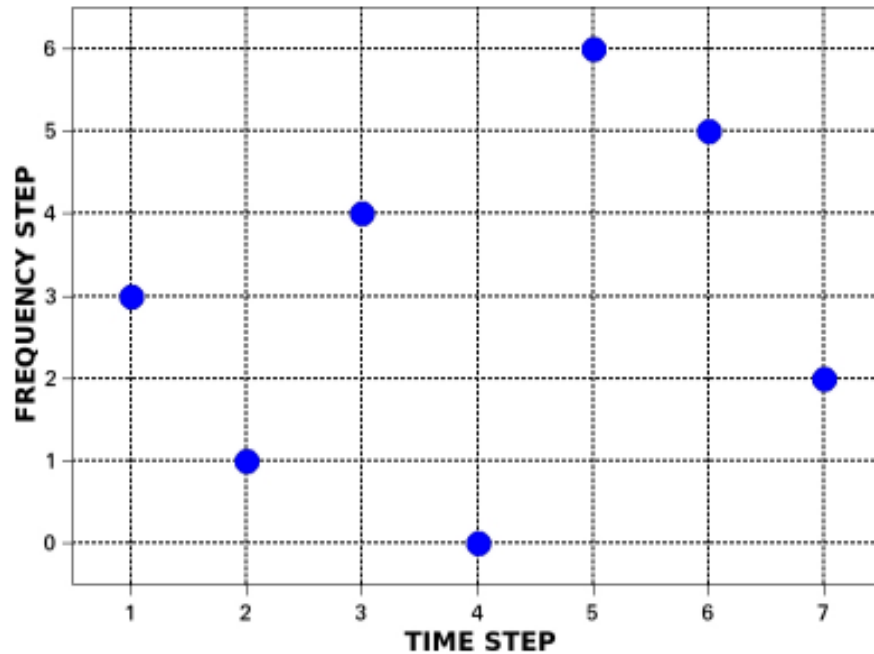
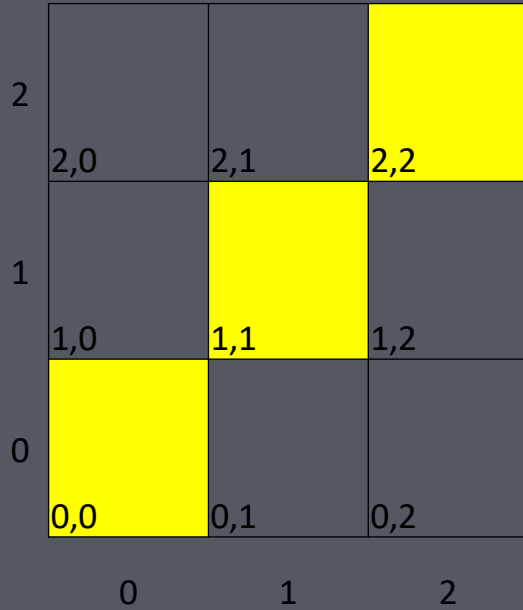


Figure 5: 7x7 Costas Array used in FT8 v2. The time and frequency steps are 160 ms and 6.25 Hz, respectively.

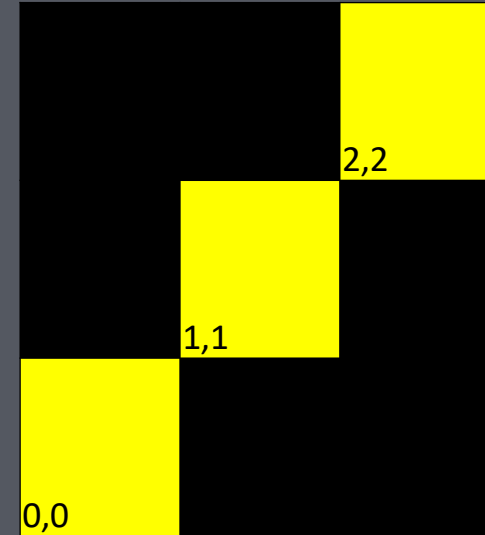
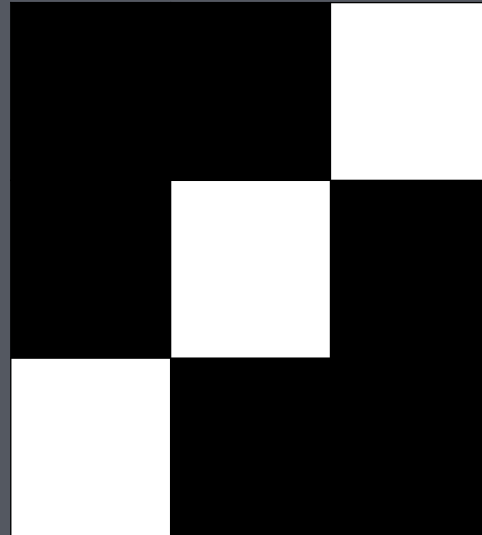
7X7 FT8 Costas Array [3,1,4,0,6,5,2]



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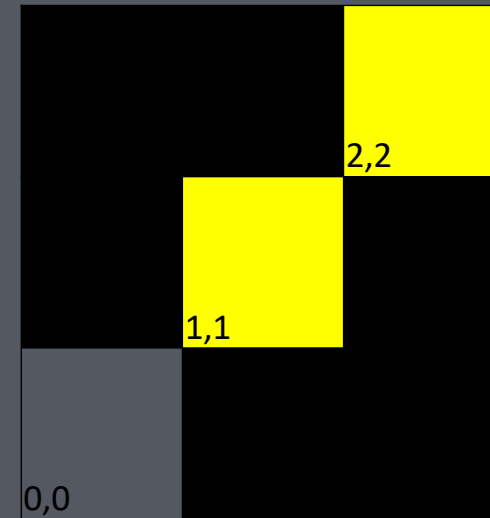
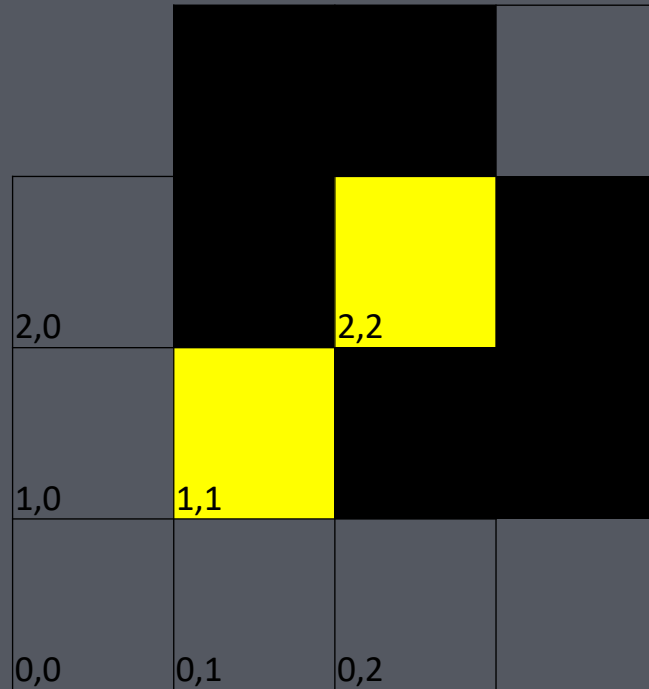


Shorthand = 0,1,2 array





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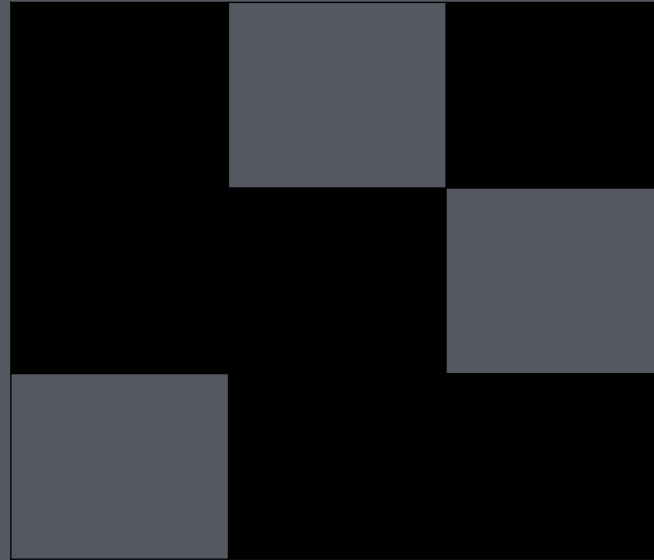


For weak signal, ambiguous with two sync solutions



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2,0	2,1	2,2
1,0	1,1	1,2
0,0	0,1	0,2



Shorthand = 0,2,1 array



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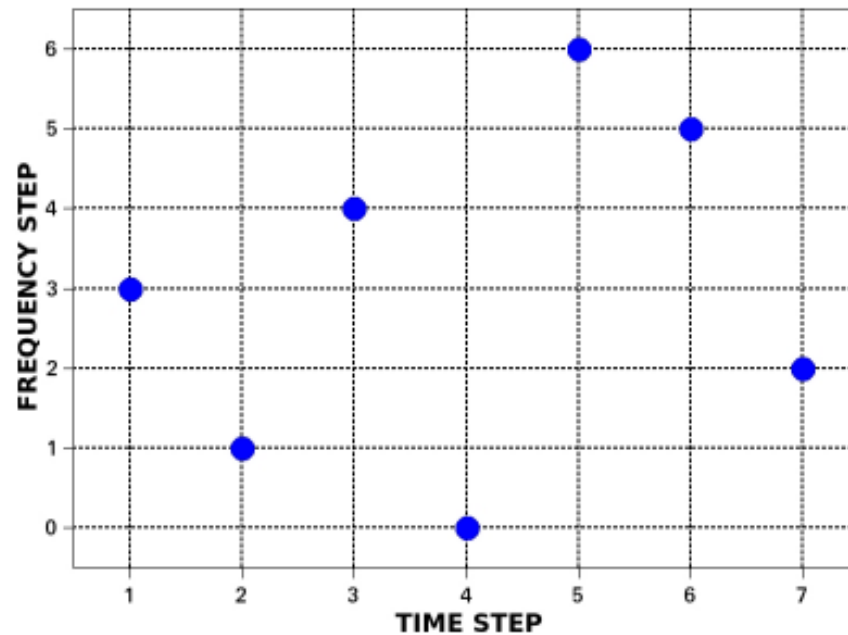


Figure 5: 7x7 Costas Array used in FT8 v2. The time and frequency steps are 160 ms and 6.25 Hz, respectively.

M.P. Hasselbeck,
WB2FKO
Synchronization
in FT8,
08 February 2019,
<http://laarc.weebly.com/uploads/7/3/2/9/73292865/ft8syncv8.pdf>

7x7 Costas Array Shorthand 3,1,4,0,6,5,2



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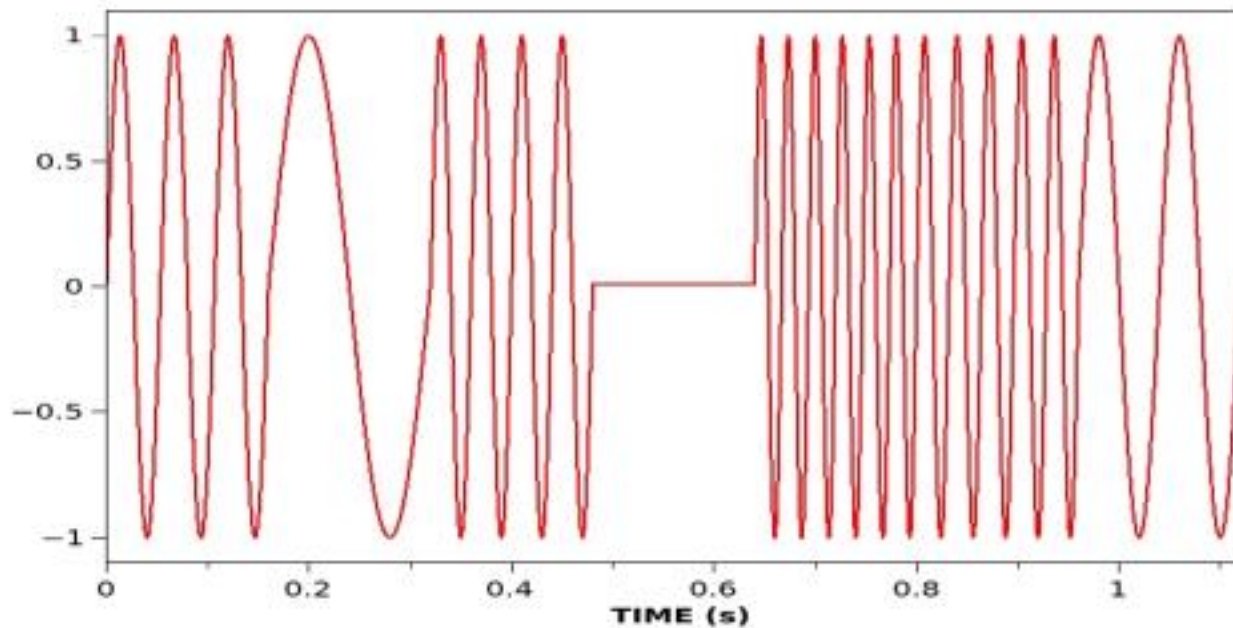


Figure 6: The 7x7 Costas Array generates a sequence of symbols at 6.25 Hz multiples. The audio carrier frequency f_c has been set to zero for clarity.

M.P. Hasselbeck,
WB2FKO
Synchronization
in FT8,
08 February 2019,
<http://laarc.weebly.com/uploads/7/3/2/9/73292865/ft8syncv8.pdf>

Time Domain

7x7 Costas Array Shorthand 3,1,4,0,6,5,2



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Using Audacity for first interval – [3,1,4,0,5,6,2]
Compare to 7x7 FT8 Costas array – [3,1,4,0,6,5,2]
Found 5 out of 7 synch tones for first interval (71%)
But frequency interval not a good match.

FT8 Decoder using three sets of [3,1,4,0,6,5,2] synch arrays.

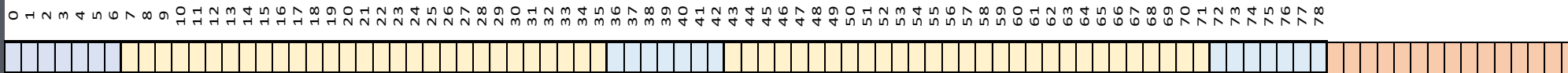
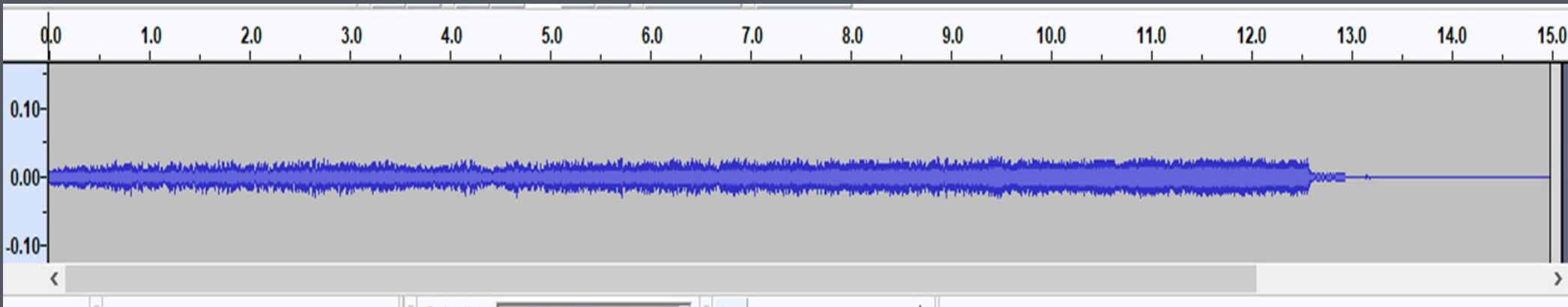
- 1 - Intervals 0-6
- 2 – Intervals 36-42
- 3 – Intervals 72-78

Decoder Step 4

Assume Time and frequency synchronization if 7 or more synch tones out of 21 are found (33%)



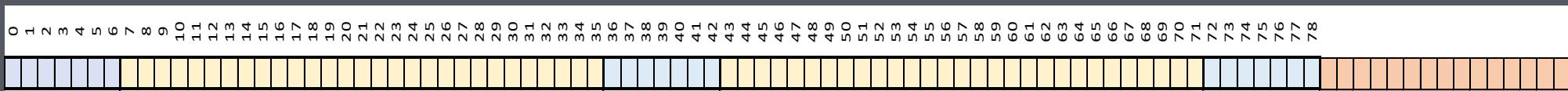
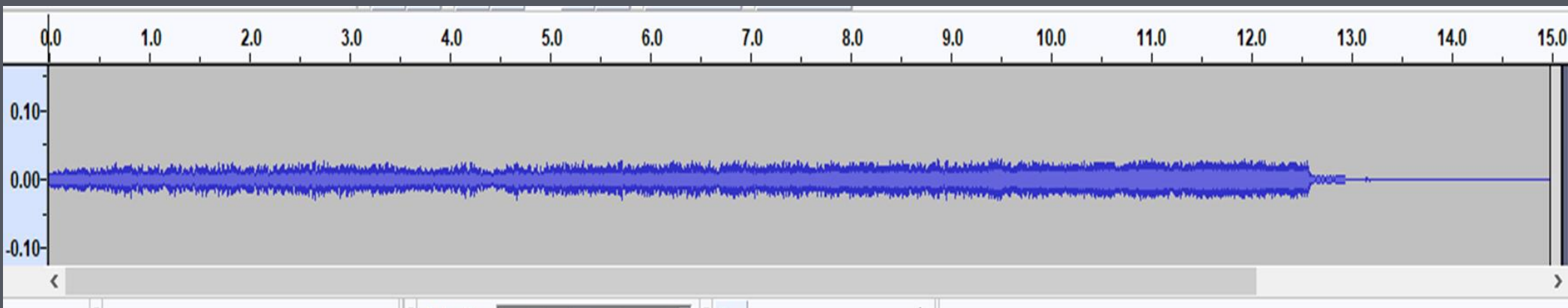
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Now that we have located and isolated our message in time and RX carrier frequency using the 21 costa array symbol intervals, we can identify the 58 other data symbols in our message and decode the QSO.



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KØMCW ZS6AF RR73

But that's for another day...



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