



# **DX FT8**

## A QUEST FOR DEVELOPING A PORTABLE SDR GUI BASED HF TRANSCEIVER

**Presented at Ham Radio 2025  
Friedrichshafen, GERMANY**

By:

**Charles(Charley) Hill W5BAA**

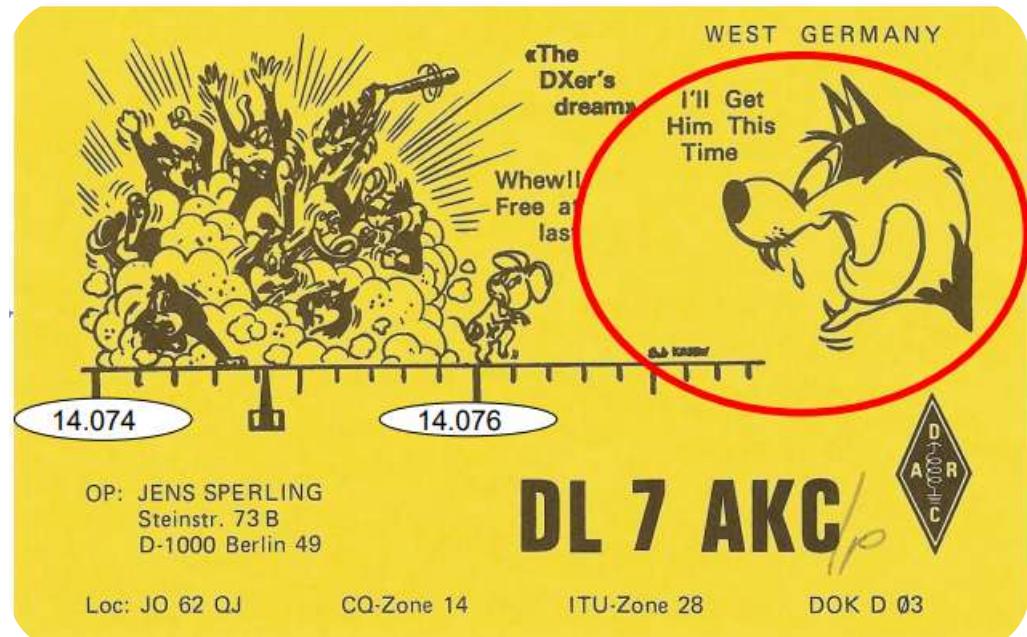
**Barbaros(Barb)Asuroglu WB2CBA**

[https://github.com/WB2CBA/DX-FT8-FT8-MULTIBAND-  
TABLET-TRANSCEIVER](https://github.com/WB2CBA/DX-FT8-FT8-MULTIBAND-TABLET-TRANSCEIVER)

## WHY FT8?

### It Has Grown Into A Free For All Scrum

- FT8 is Quite Popular
- FT8 is easy to operate
- Most Operators Are Well Behaved
- Most On Air Traffic Is Automated
- When Calling CQ Both Even & Odd Slots Are Used



# AGENDA

- What is DX FT8?
- Design Objectives
- Alternatives
- Project Design Evolution
- Hardware
- Firmware
- Operating
- FT8 Traffic Handling

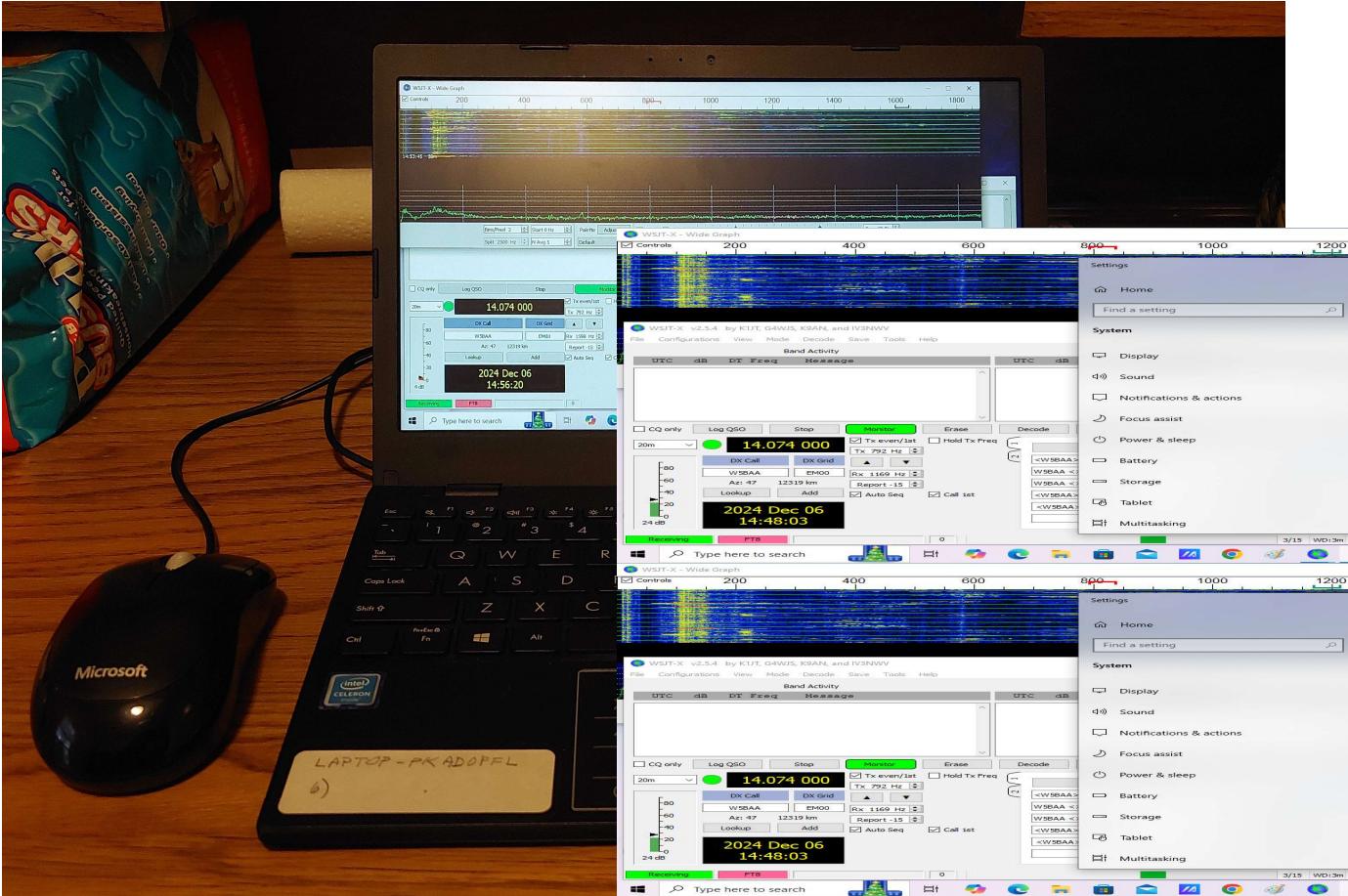


## DX FT8 PROJECT DESIGN OBJECTIVES

- Small Size, Self Contained with Internal Battery
- Powered and Charged From 5 Volt standard USB Phone Wall Charger or 12V DC External Power source
- No Mouse or Keyboard Required. Touchscreen Operation
- Ultimate Portability for Backpacking, SOTA or POTA Operations
- RF PA can withstand Severe SWR Conditions and Accidents such as no antenna or antenna shorts
- Flexibility on Calls, such as SOTA/POTA FREE TEXTS, i.e. CQ EU, CQ DX etc.
- Airport Security friendly Compact HF Transceiver System for travels



# WHAT IS THE ALTERNATIVE?



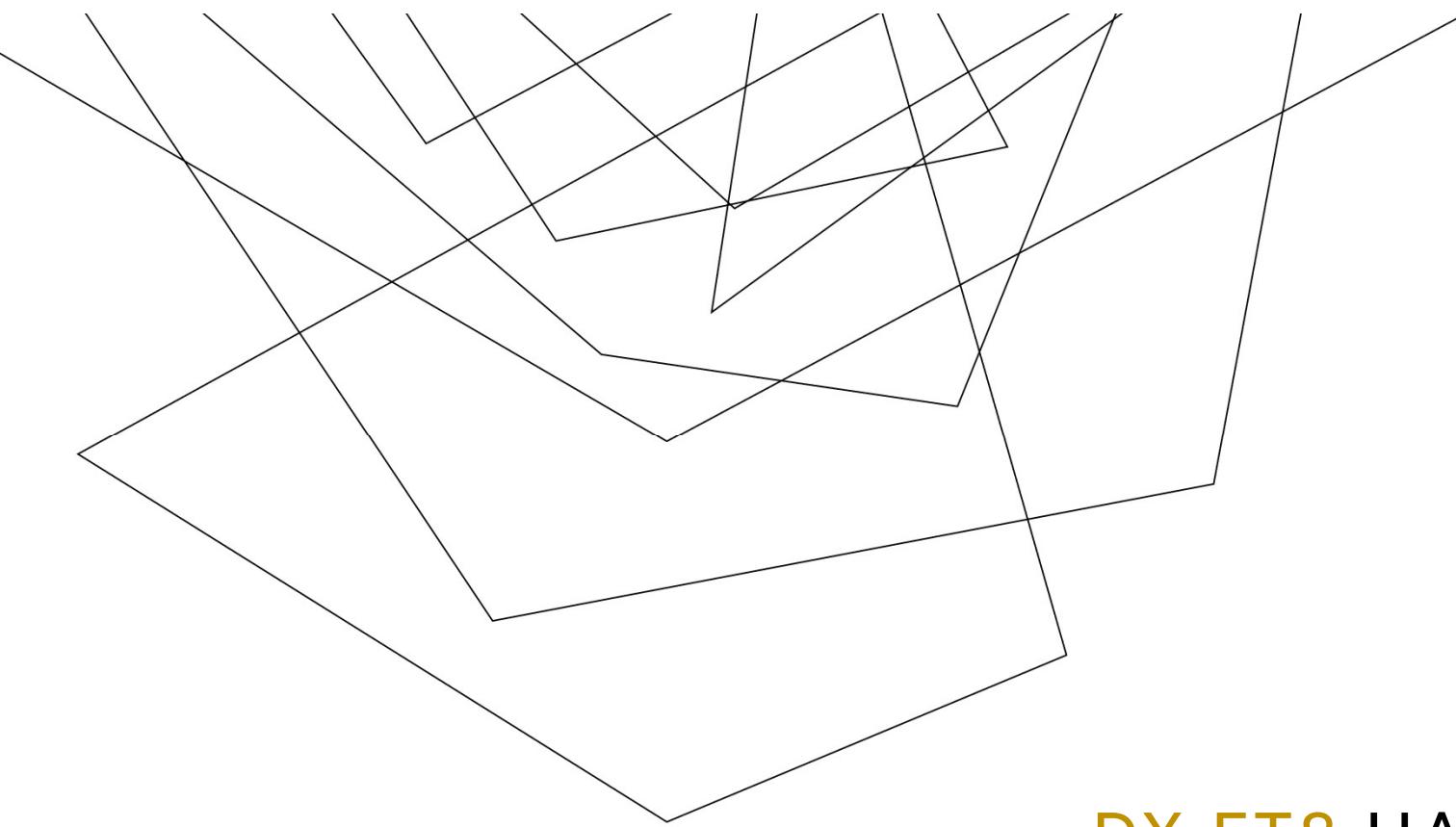
- Laptop With:
- 13 Inch Display
- Keyboard
- Mouse
- 1.10 GHz Clock Speed
- 3.83 GB RAM
- Lot's Of Cables
- Audio Interface
- Serial Interface

## DX FT8 PROJECT DESIGN EVOLUTION

Charley's interest In DSP SDR Projects Started in 2010 With SDR2GO and Collaboration With Kees- K5BCQ & Milt W8NUE

In 2022 Barb watched a YouTube video of Charley's Teensy 3.6 Version and fell in love with it. Charley and Barb started their collaboration Interfacing Barb's DX Boards to Charley's Firmware





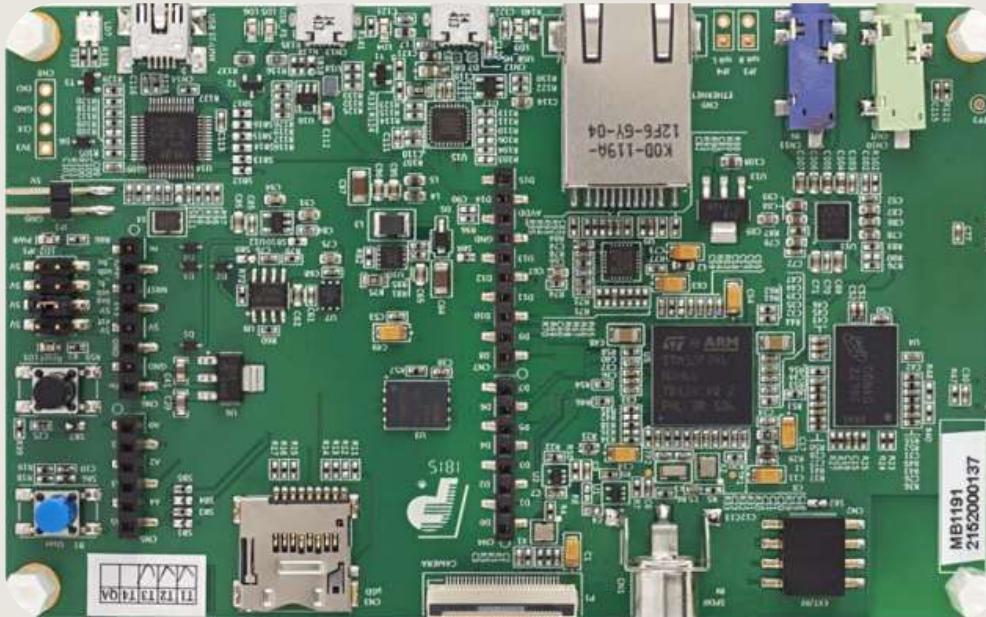
**DX FT8 HARDWARE**

## DX FT8 HARDWARE ELEMENTS

- The Brains – STM32F746  
DISCOVERY BOARD
- An RF BOARD for MULTIBAND  
QRPP Operations
- Inner workings and Secrets of  
DX FT8

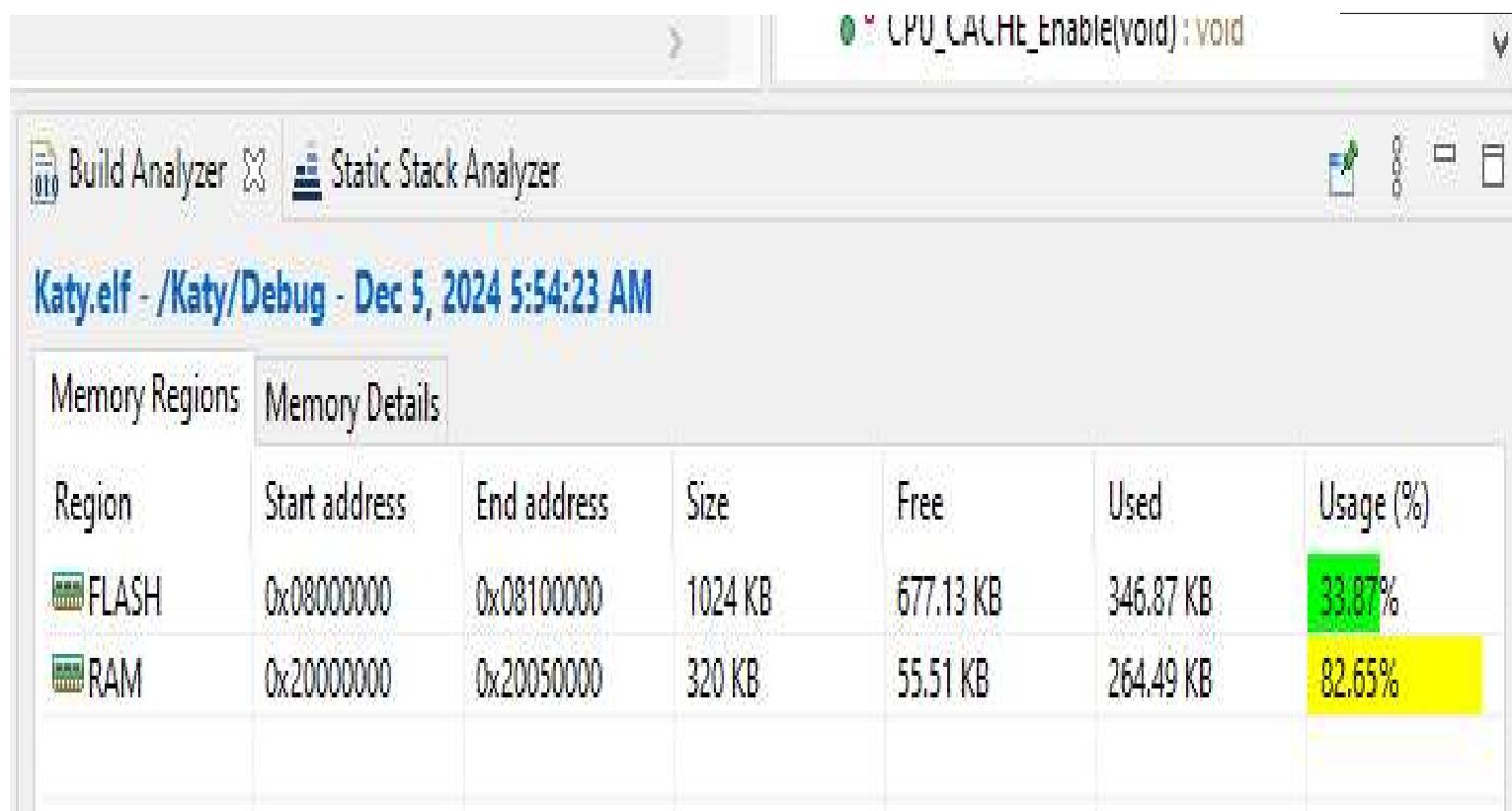


## STM32F746 DISCOVERY BOARD KEY FEATURES

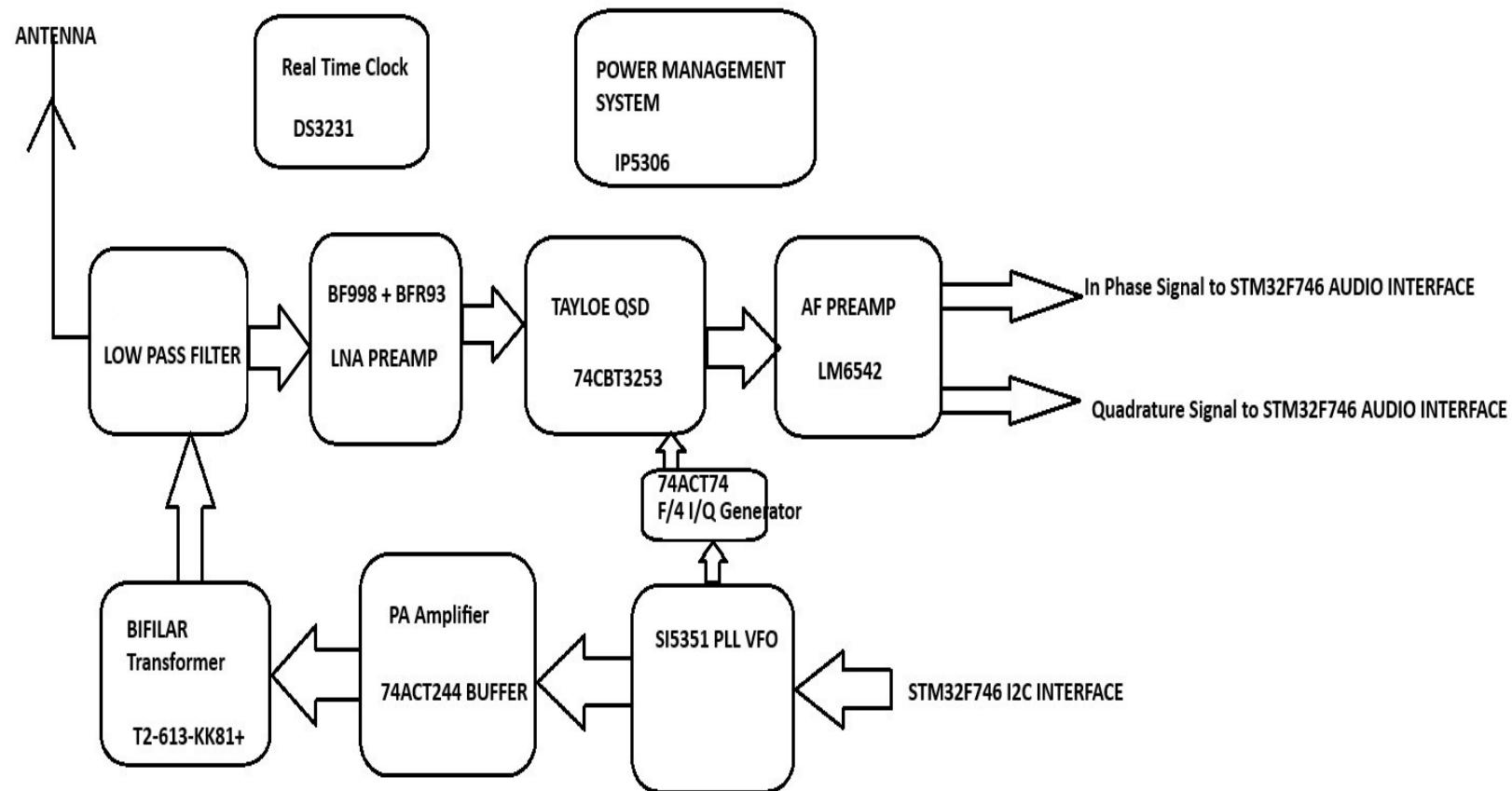


- Quad-SPI Flash memory (1024 KB Accessible)
- SDRAM (320KB Accessible)
- 48 Kbps I/Q Codec With Line In and Line Out Audio
- I2C Peripheral Interface
- Color display, **4.3-inch LCD-TFT** (resolution: 480x272), capacitive touch
- 1082 CoreMark /462 DMIPS Performance
- 180 MHz Clock Speed
- Affordable < \$60 And In Stock

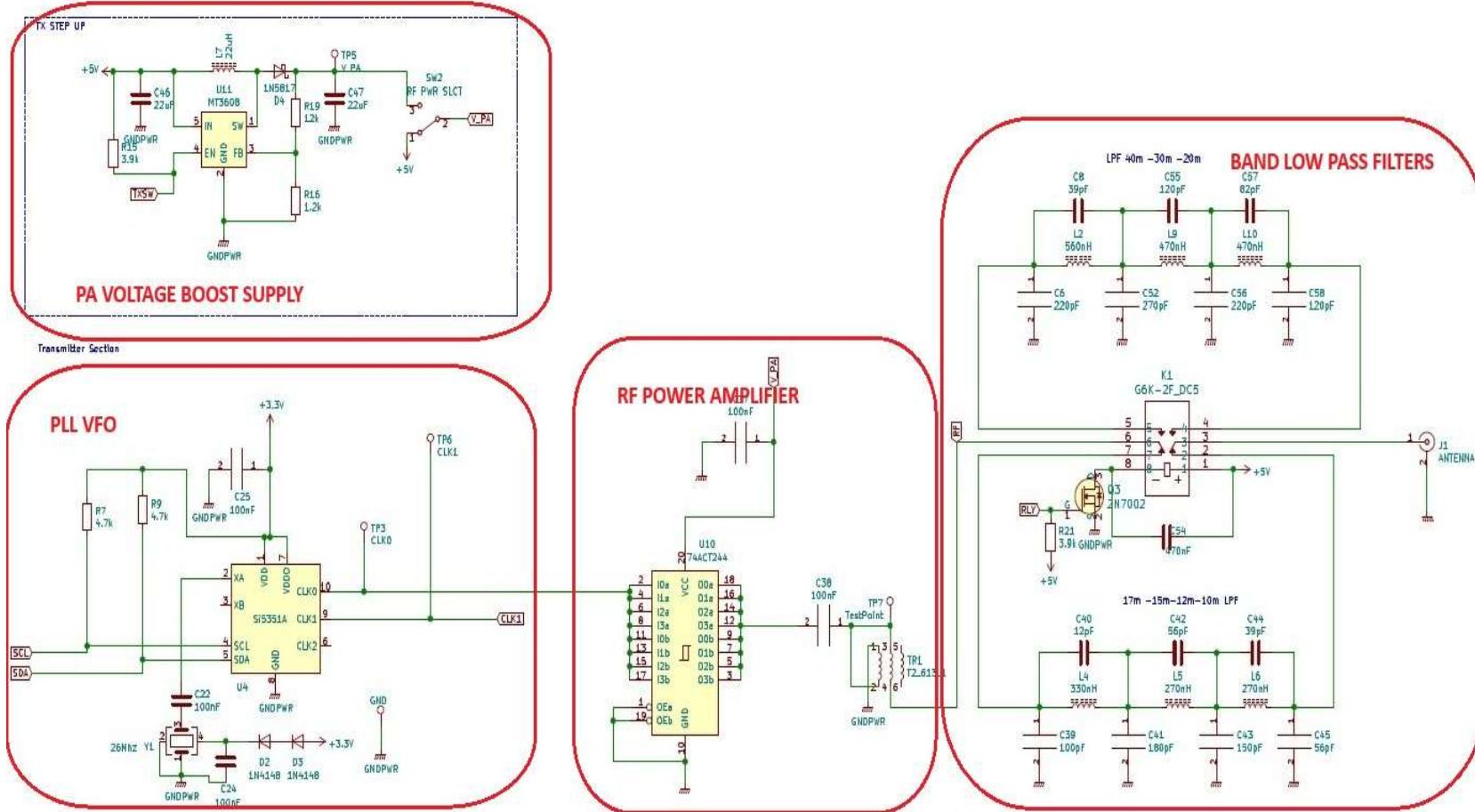
## DX FT8 APPLICATION MEMORY USAGE



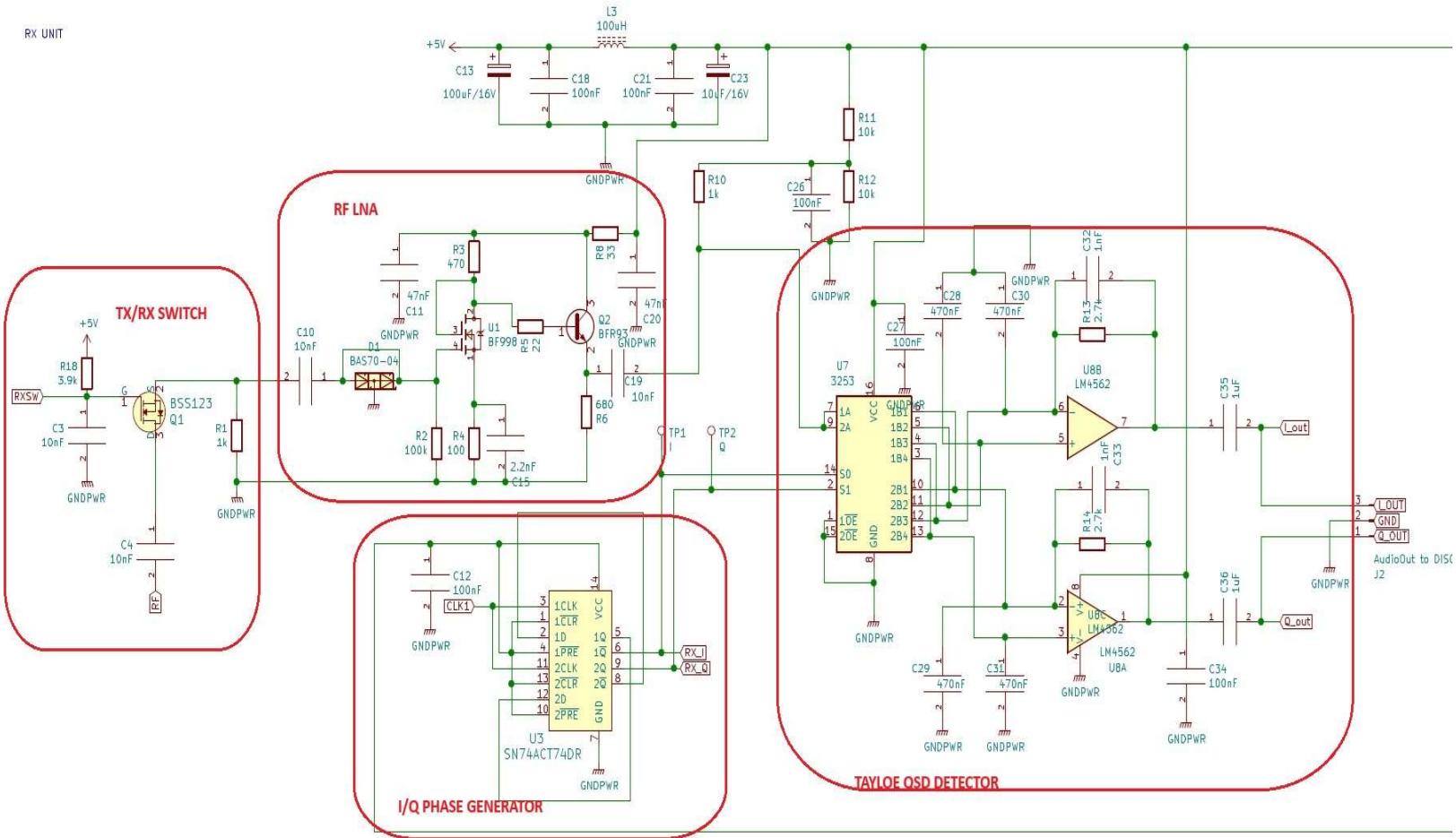
## DX FT8 TRANSCEIVER RF BOARD BLOCK DIAGRAM



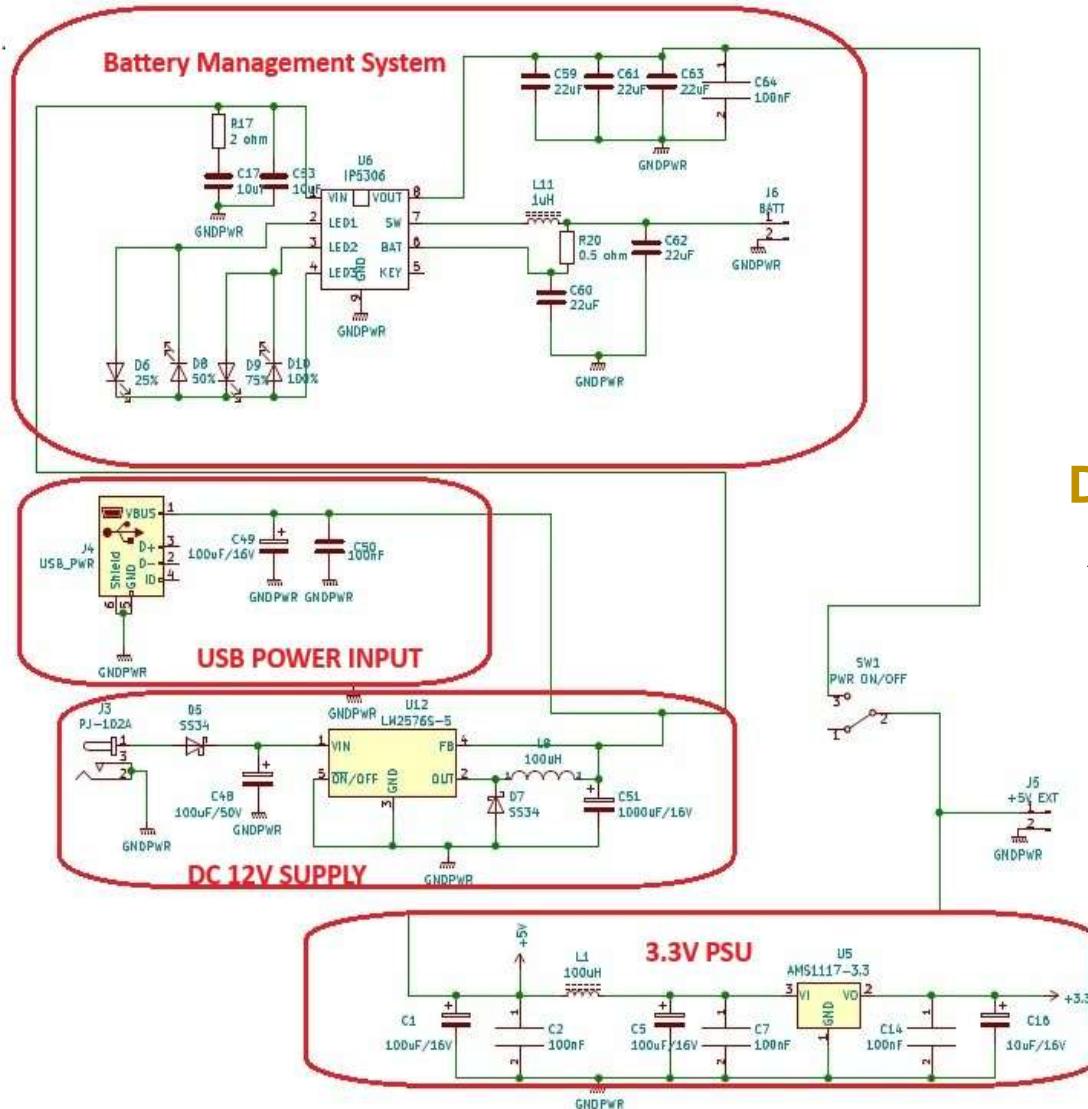
# DX FT8 TRANSMITTER SCHEMATIC



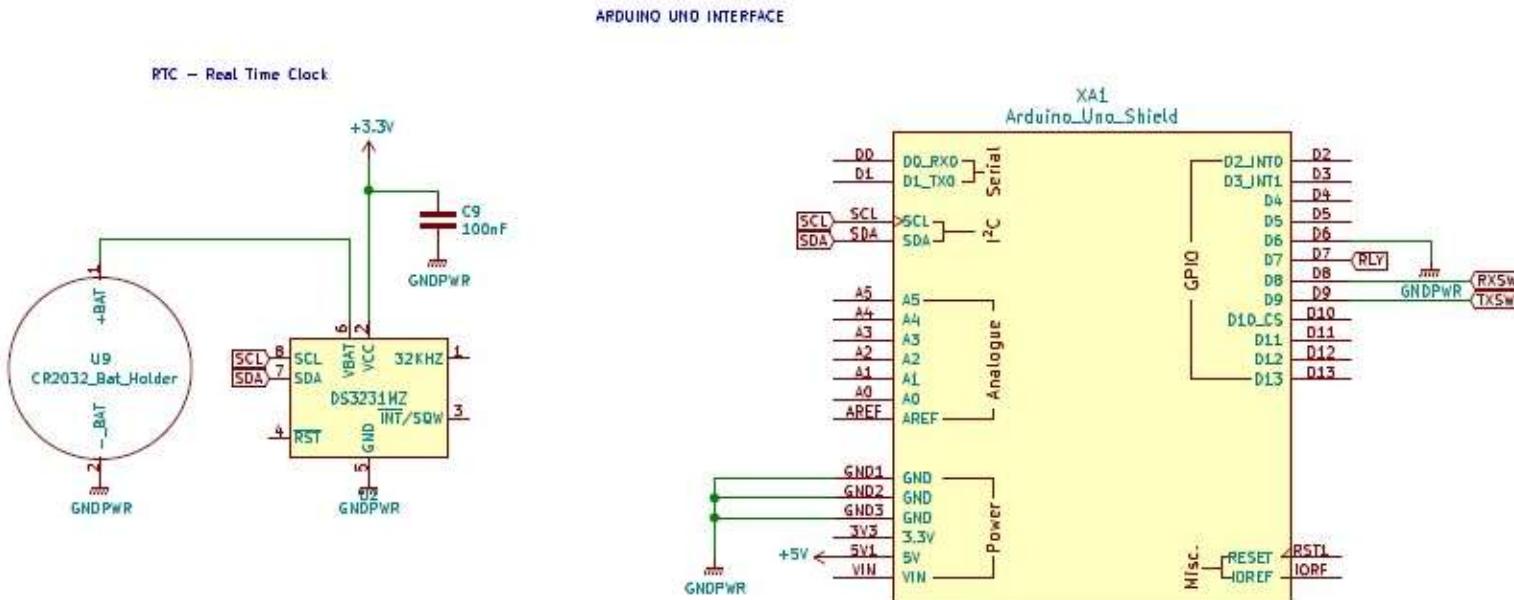
# DX FT8 RECEIVER SCHEMATIC



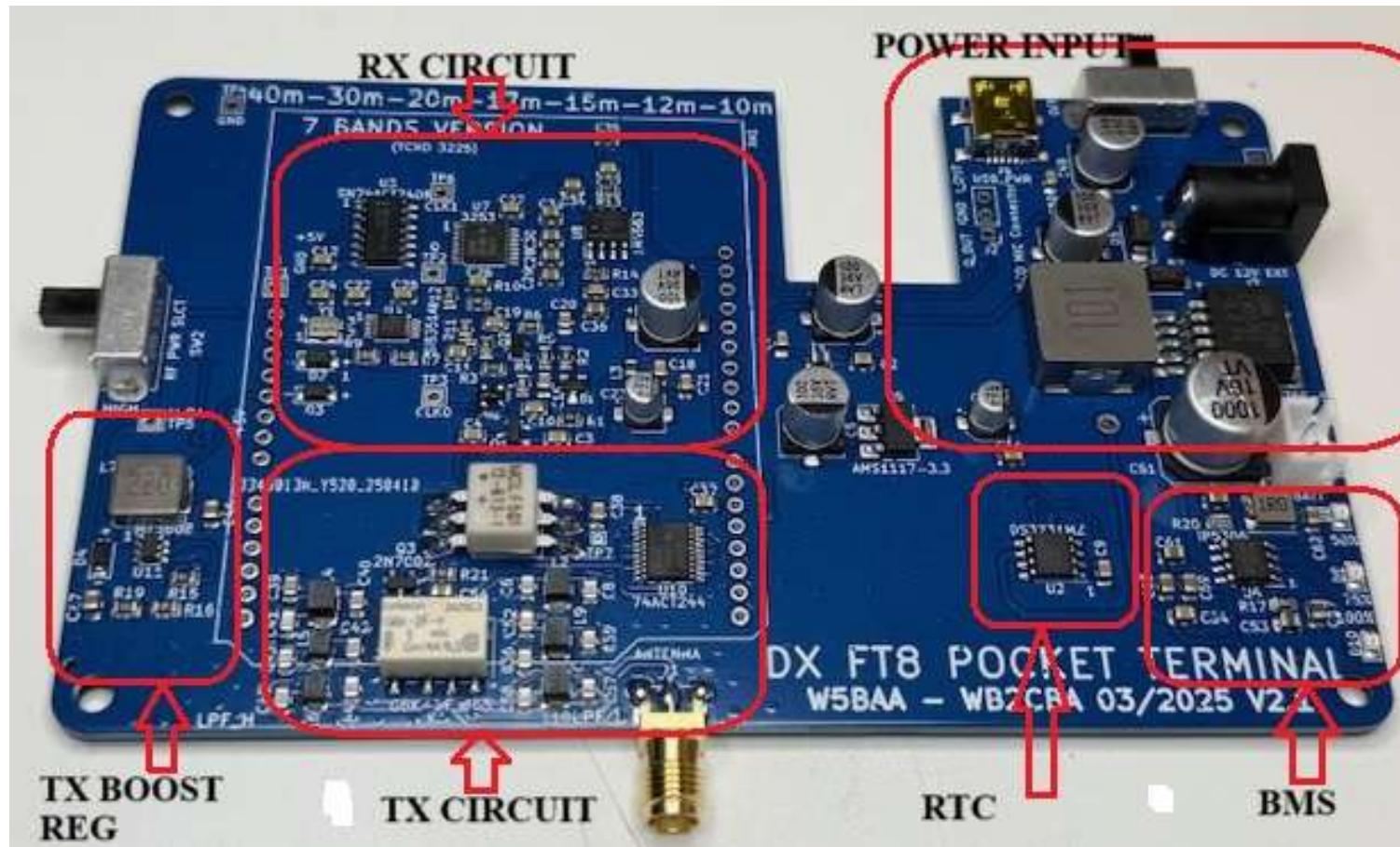
# DX FT8 BATTERY MANAGEMENT SYSTEM SCHEMATIC

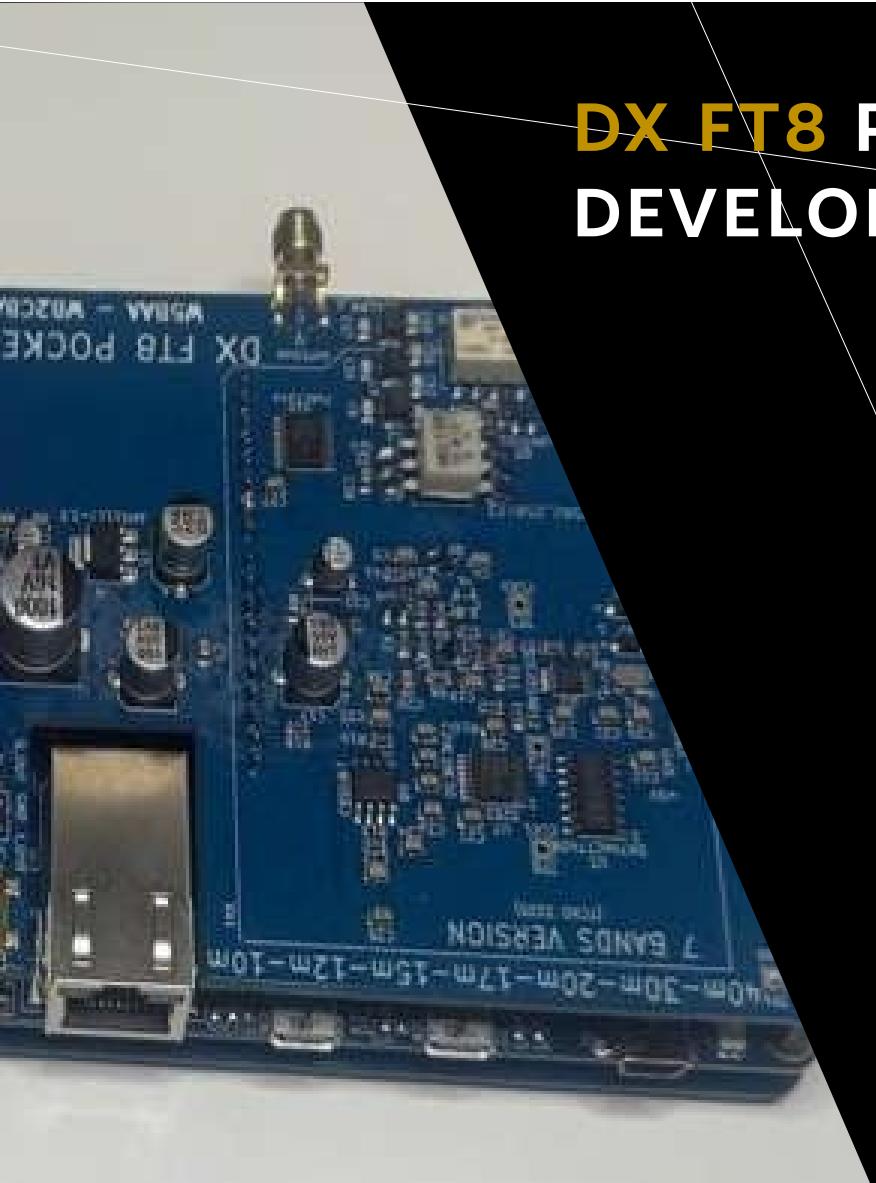


# DX FT8 RTC AND ARDUINO COMPATIBLE PIN INTERFACE



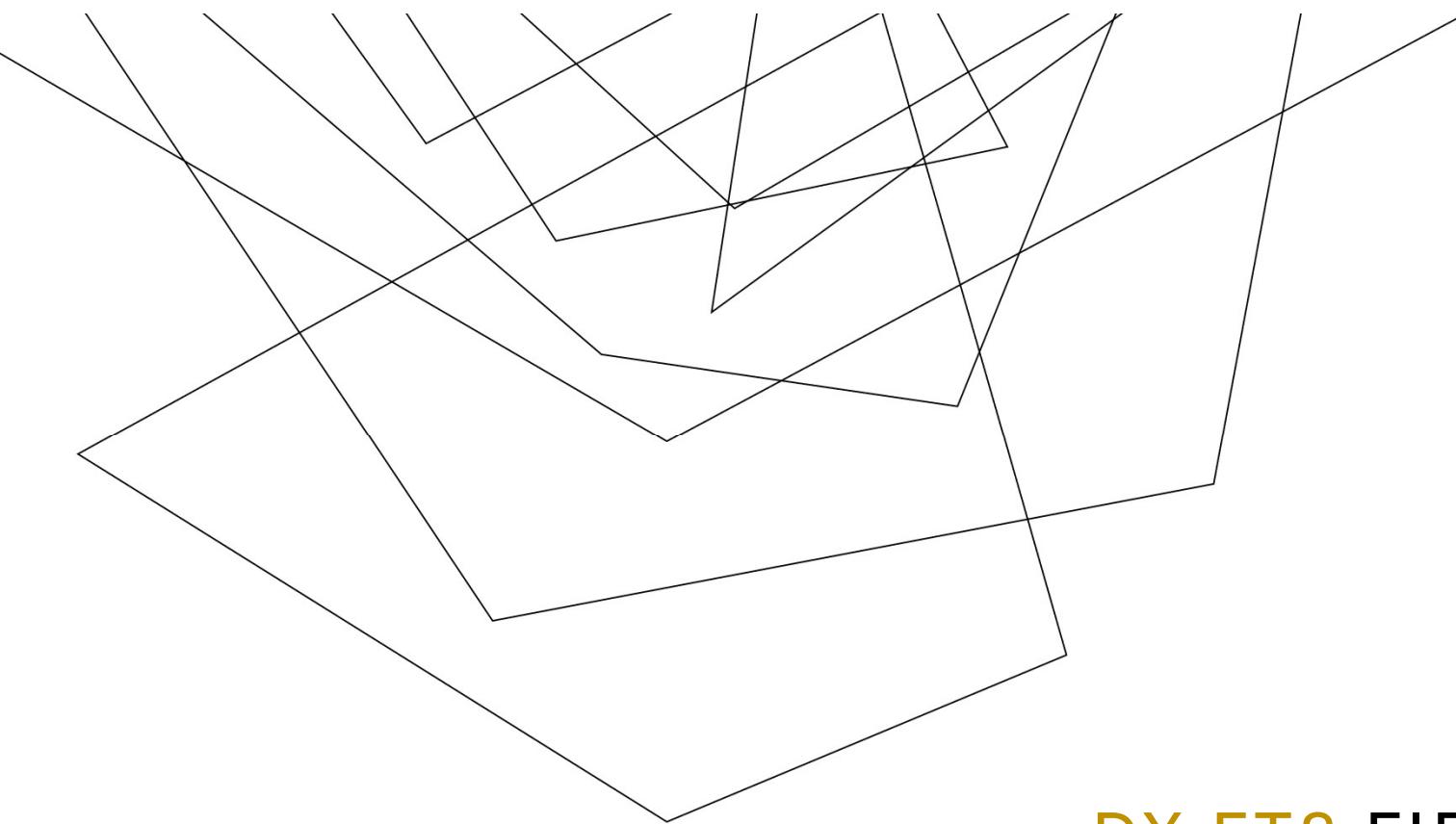
## DX FT8 RF BOARD



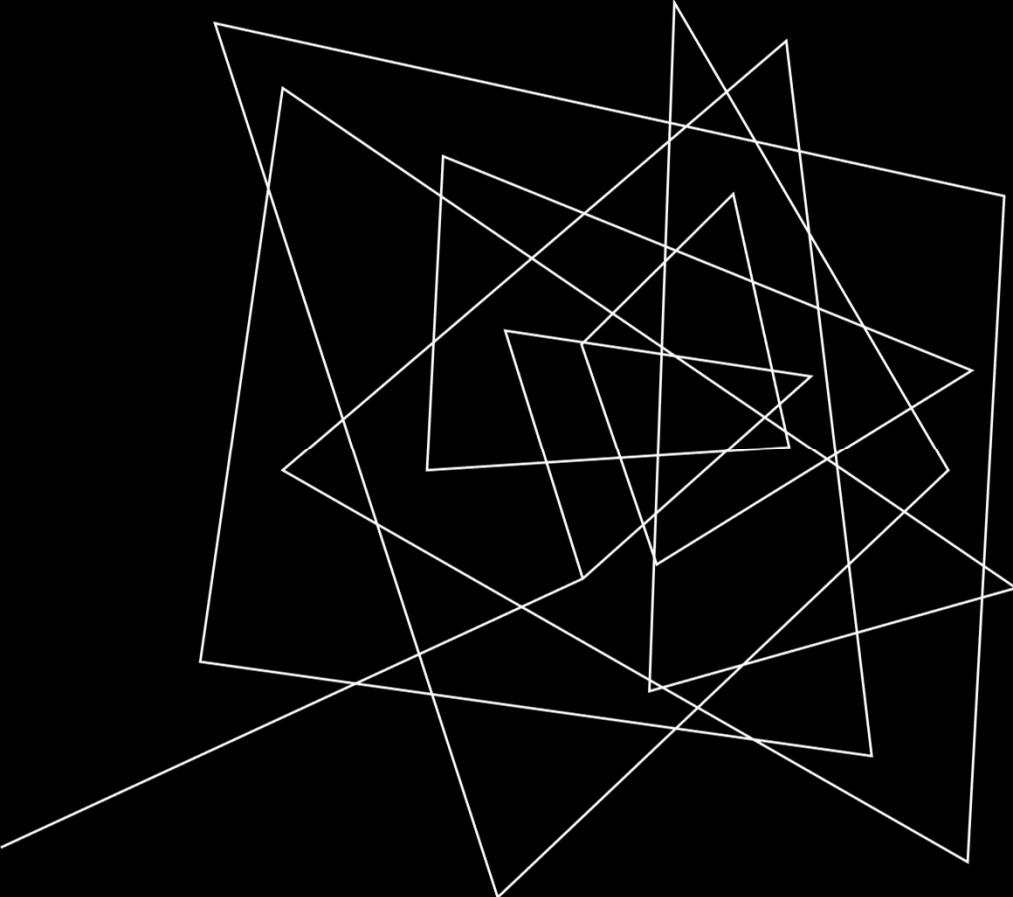


## DX FT8 PROJECT FUTURE HARDWARE DEVELOPMENT WISH LIST

- DX FT8 RF V1.0 Board design is 5 Band version then 2 more bands were added to bring it to final 7 bands version.
- A 6m band might be possible to up the band coverage to 8 bands
- Increasing PA output from Sub 1 Watt to around 3 Watts with Class-D Mosfet PA
- Replacing Dual Gate Mosfet LNA with MMIC type LNA
- Adding a Manual Antenna tuner to cover all portable antenna conditions



**DX FT8 FIRMWARE**



# **DX FT8**

## **FIRMWARE**

- Origins
- Inner workings
- DX FT8 – FT8 FLOW Chart
- DX FT8 Operation Insights

## SECRET TO SDR FIRMWARE DEVELOPMENT

Plagiarize, Plagiarize, Plagiarize

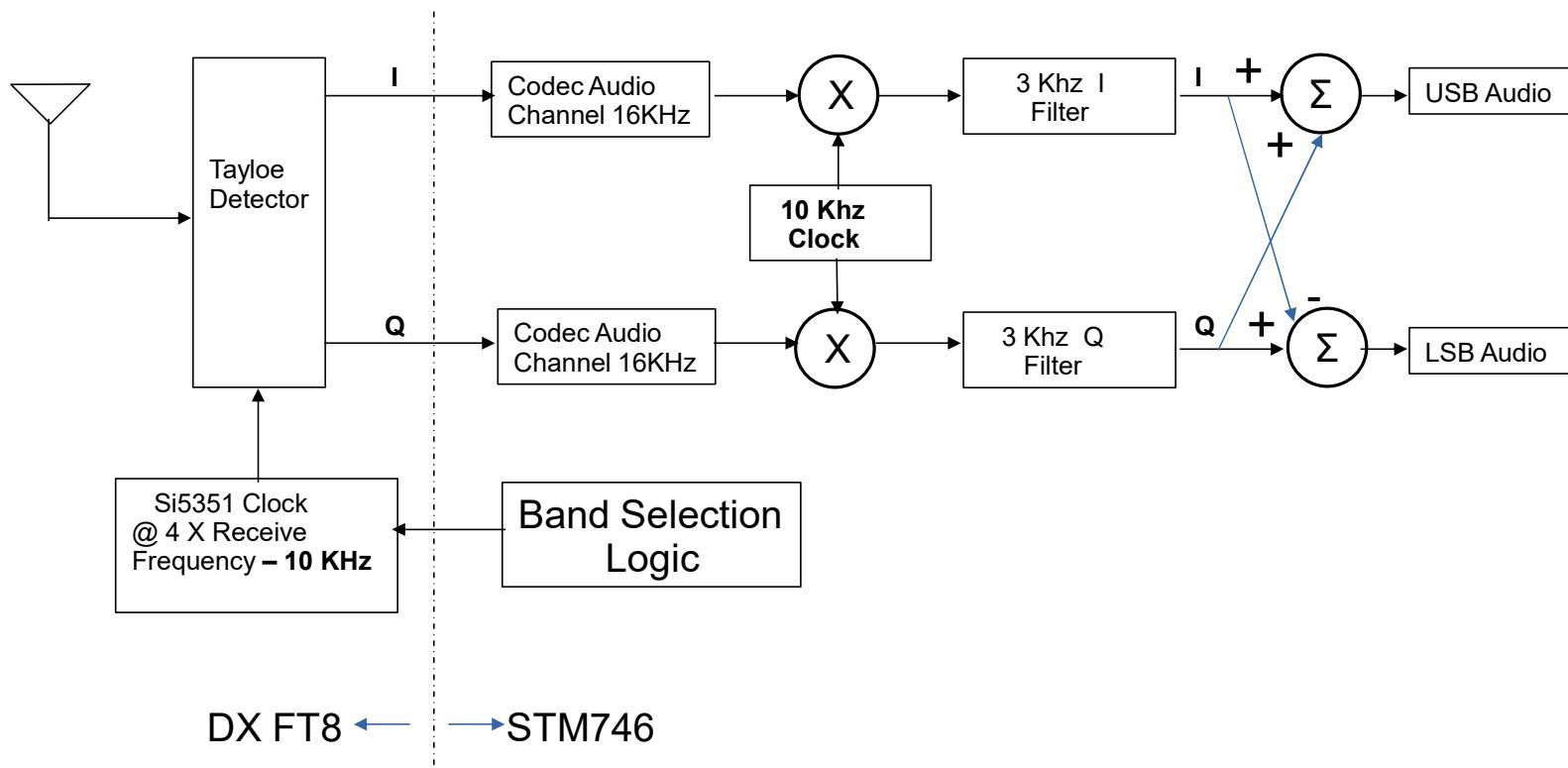
- In 2019 Spotted Karlis Goba's GitHub Site  
[https://github.com/kgoba/ft8\\_emb](https://github.com/kgoba/ft8_emb)
- We Corresponded Via Email
- Karlis Was Most Helpful and Supportive

Karlis Goba

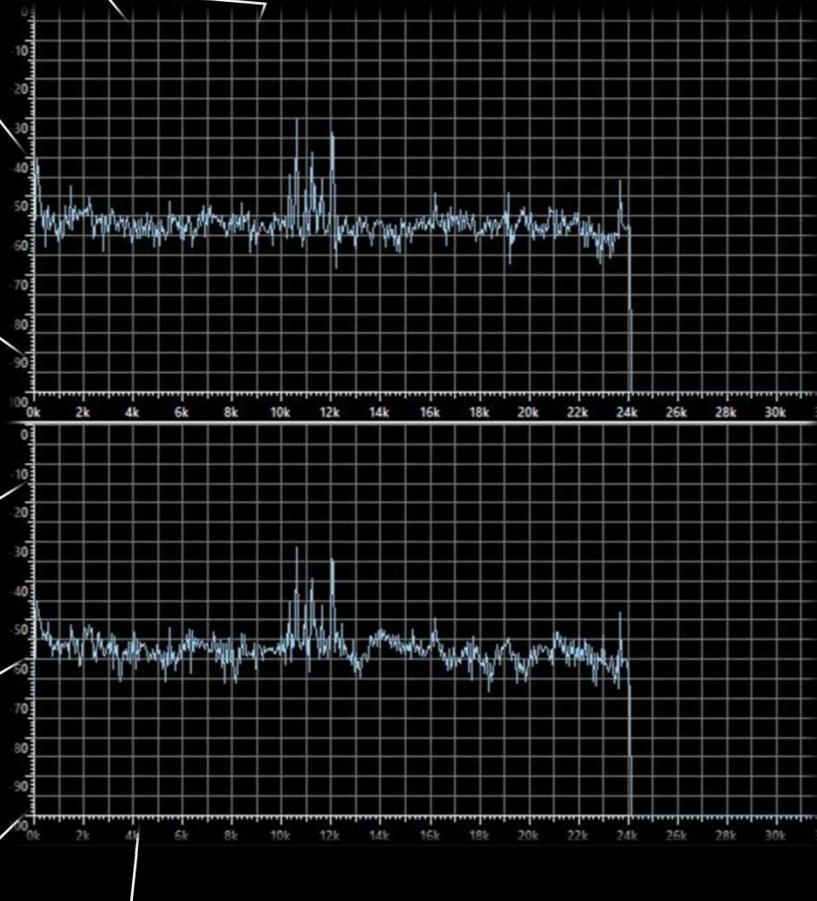


## DX FT8 RECEIVER SYSTEM OVERVIEW

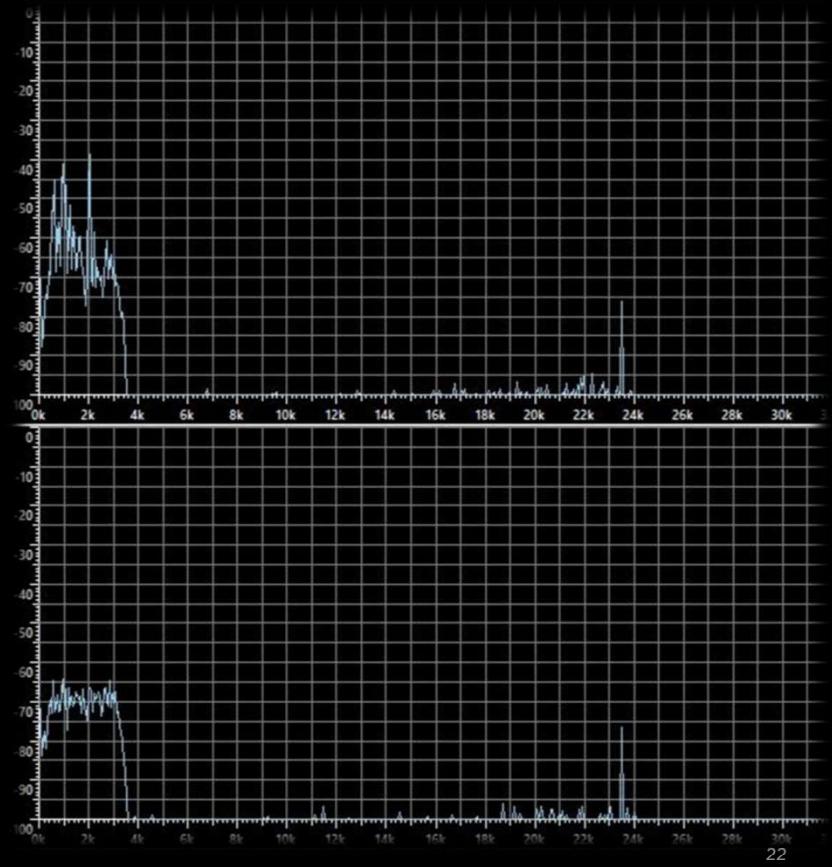
DX FT8 MSD Measured < -110 dBm On ALL Seven Bands



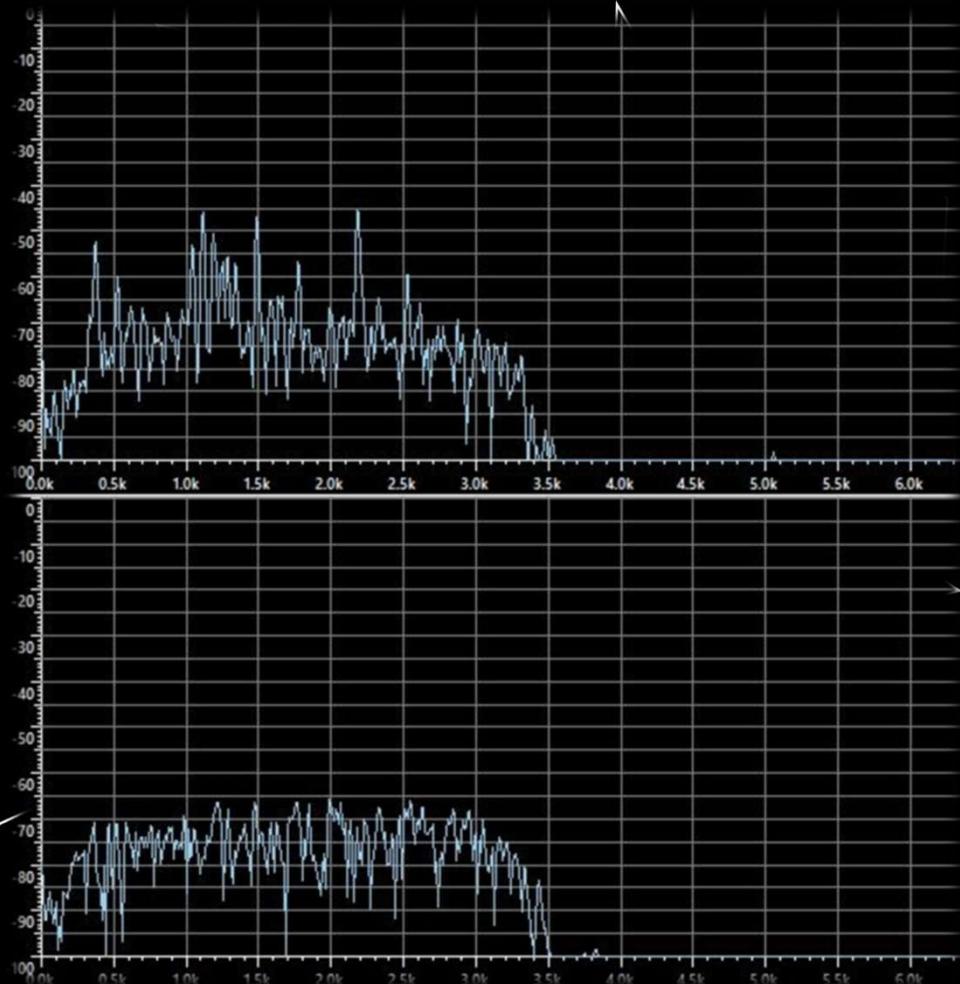
## **DX FT8 RECEIVER SYSTEM DSP INPUT**



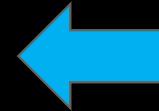
## **DX FT8 RECEIVER SYSTEM DSP OUTPUT**



# **DX FT8 RECEIVER SYSTEM BASEBAND OUTPUT**

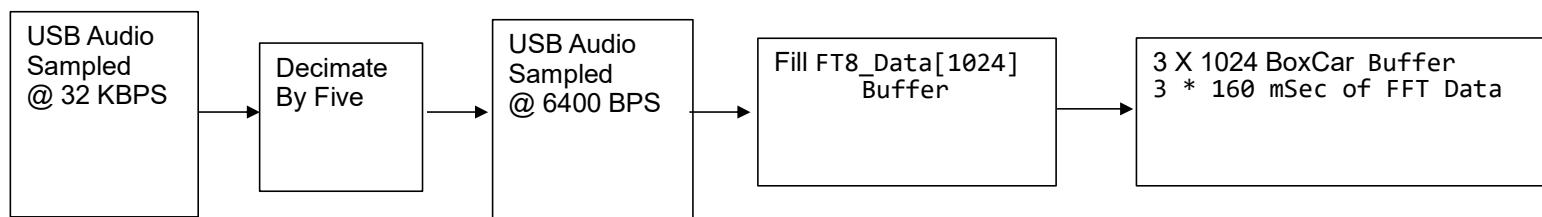


**USB Audio Output**

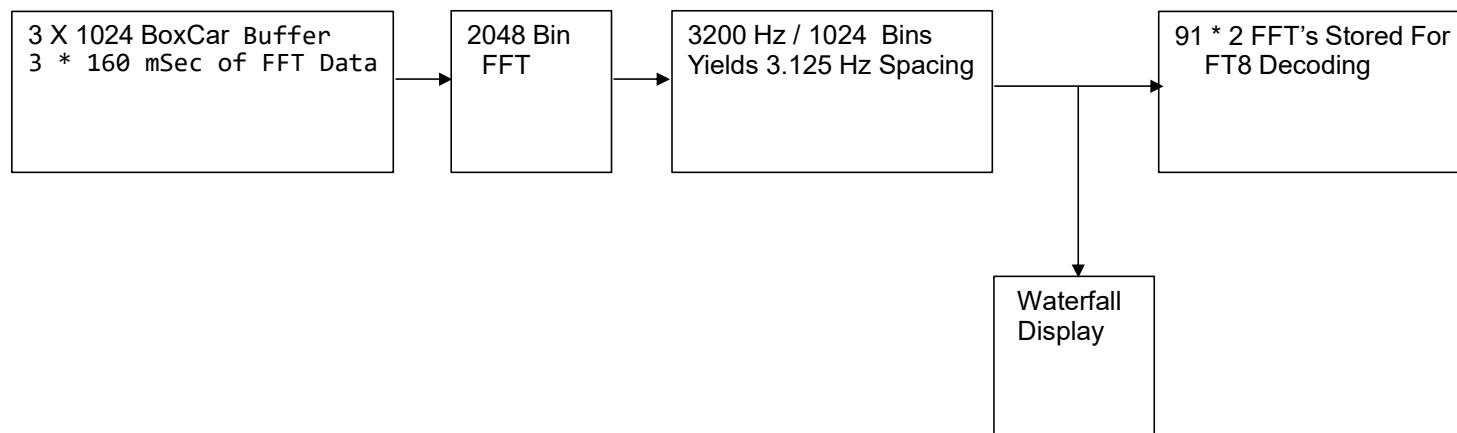


**LSB Audio Output**

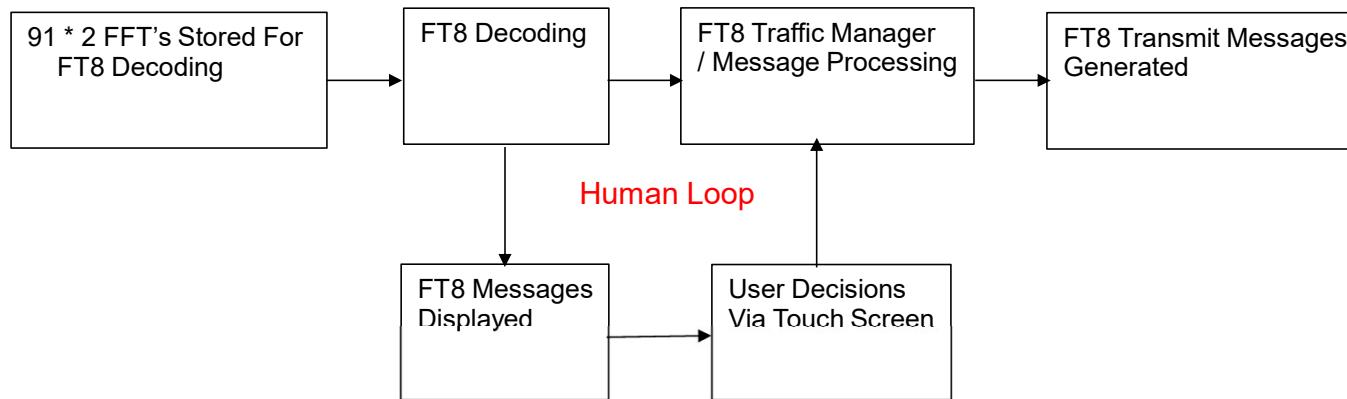
## TIME DOMAIN PROCESSING OF RECEIVED SIGNAL



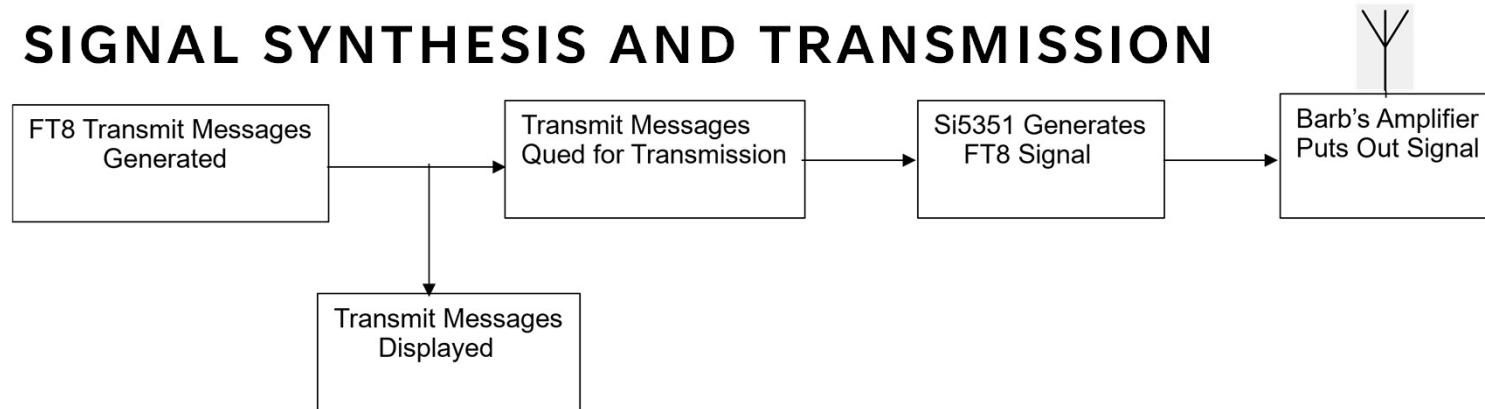
## FREQUENCY DOMAIN PROCESSING OF RECEIVED SIGNAL



## FT8 DECODING, TRAFFIC MANAGEMENT, FT8 ENCODING



## FT8 SIGNAL SYNTHESIS AND TRANSMISSION



# DX FT8 SLOT CHARTS

To Synthesize or Analyze FT8 Traffic Flow FT8 Time Slots Must Be Considered

QSO Mode Slot Chart

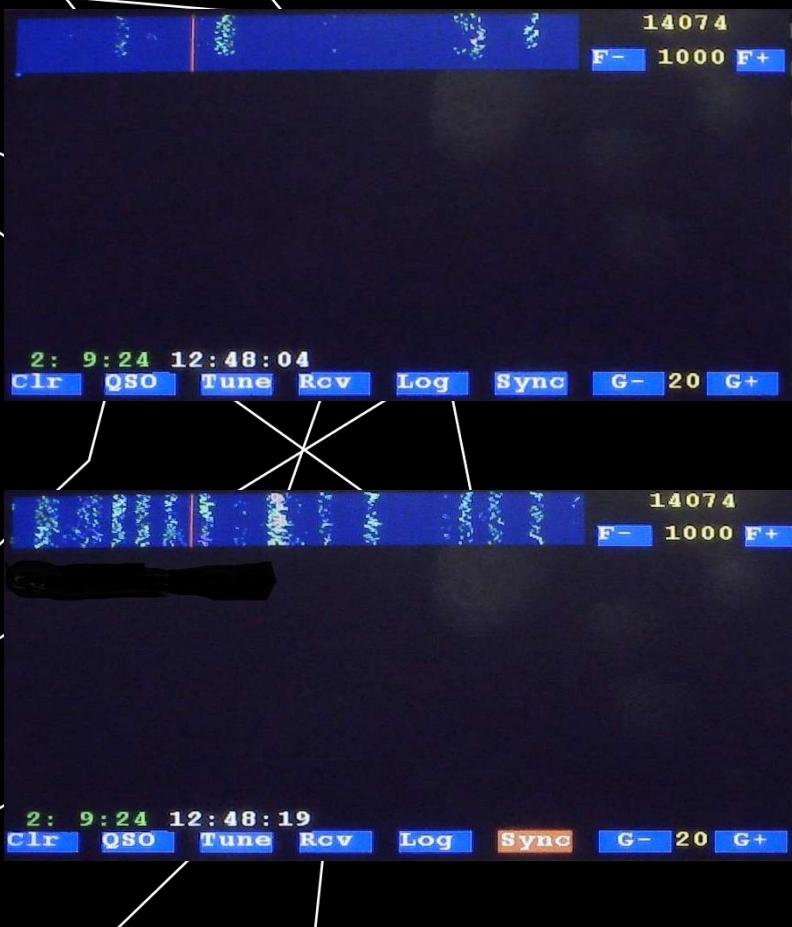
Slot	0	1	2	3	4	5	6	7	8	9	10	11
<b>QSO Mode Of Operation</b>				Respond to Some Other Station Call			Call CQ Again			Call CQ Again		
				Respond to Some Other Station Call	Call CQ Again			Respond to Some Other Station Call		Respond to Some Other Station Call		
<b>Action</b>	<b>None</b>	<b>Target Calls CQ</b>	<b>Target Listens For Reply</b>	<b>Call CQ Again</b>	<b>Target Station Listens For Reply</b>	<b>Target Station Sends RSL Message</b>	<b>Target Station Listens For Reply</b>	<b>Target Station Sends RR73 Message</b>	<b>Target Station Listens For Reply</b>	<b>Target Station Sends 73</b>		
<b>CQ KELSU EM00</b>		<b>KELSU EM00</b>	<b>KELSU W5BAA EM00</b>	<b>W5BAA KELSU +07</b>	<b>KELSU W5BAA R-03</b>	<b>W5BAA KELSU RRR</b>	<b>KELSU W5BAA RR73</b>	<b>W5BAA KELSU 73</b>				
	02:33:15 PM	02:33:30 PM	02:33:45 PM	02:34:00 PM	02:34:15 PM	02:34:30 PM	02:34:45 PM	02:35:00 PM	02:35:15 PM			
<b>Target CQ Message Displayed</b>	User Selects Target Station	Que Up Locator Message To Target	Send Locator Message to Target	Detects Station Call In Message From Target	Send RSL to Target Station	Que Up RR73 Message to Target	Send RR73 Message	Terminate QSO				
	Messages Composed			Que Up RSL Message to Target		Write ADIF Log Data						
<b>Locator Message Displayed</b>				Station Call Not Detected In Message	Send Repeat Locator Message to Target	Detects Station Call In Message From Target	Send RSL to Target Station	Que Up RR73 Message to Target	Send RR73 Message	Terminate QSO		
				Que Up Repeat Locator Message to Target Station	Que Up RSL Message to Target			Write ADIF Log Data	Terminate QSO			

## DX FT8 SLOT CHARTS

### Beacon Mode Slot Chart

Slot	0	1	2	3	4	5	6	7	8
Beacon Mode Of Operation									
	Target Station Composes Messages	Target Waits		Target Ques Up Reply RSL					
Station CQ Message Displayed	Target User Selects Station CQ	Target Ques Up Locator	Target Sends Locator	Target Listens	Target Sends Reply RSL	Target Ques Up RR73	Target Station Sends RR73		
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Station Calls CQ	Station Listens	Station Calls CQ	Station Listens	Station Sends RSL	Station Listens	Station Sends RR73			
Displays Messages			Displays Messages		Displays Messages	Terminate QSO			
Checks For Station Call in Messages			Checks For Station Call in Messages		Checks For Station Call in Messages				
			Ques Up RSL If Station Is Called		Ques Up RR73 If Station Is Called				

## TIME SYNCHRONIZATION WITH FT8 WORLD

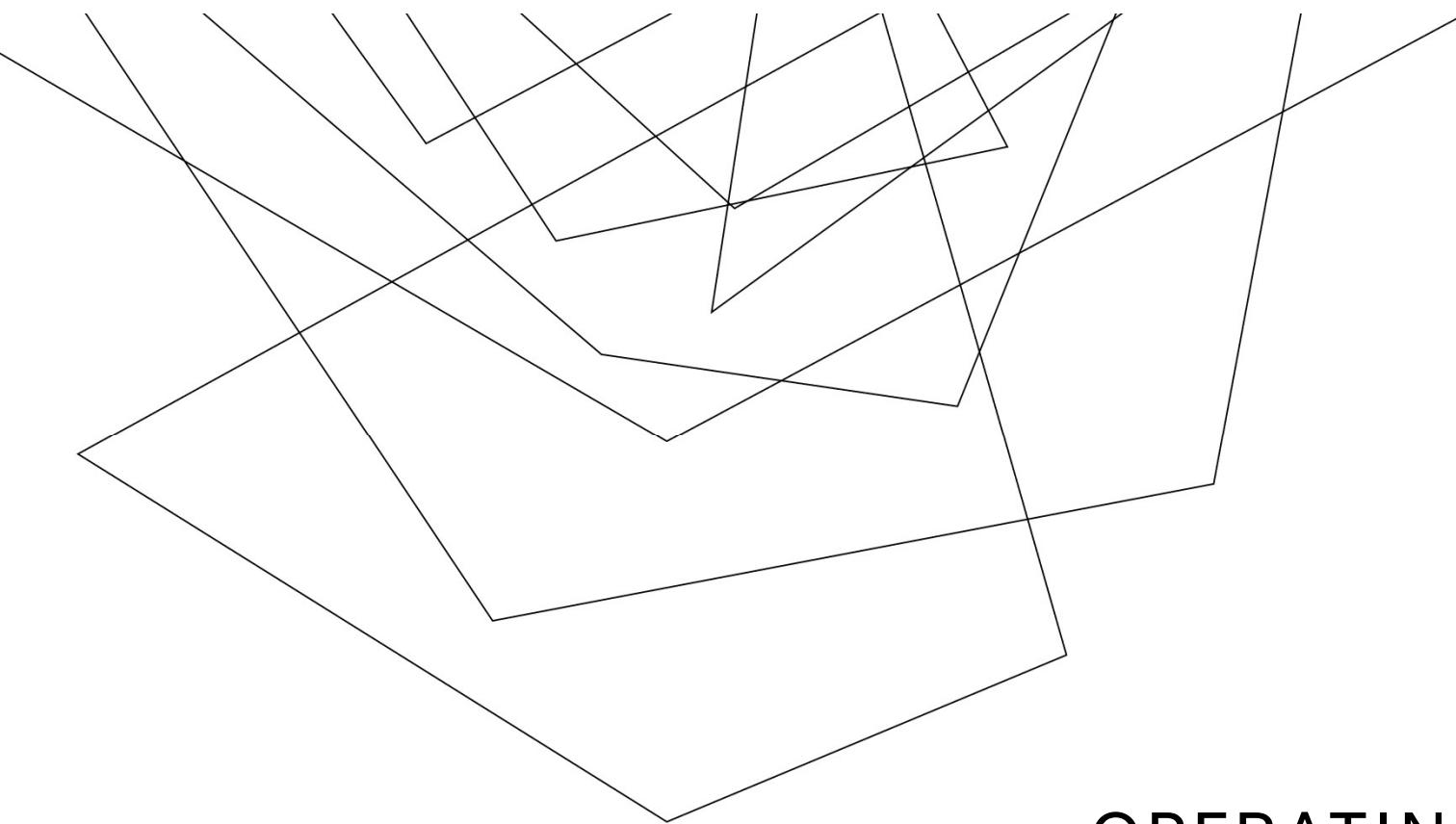


- DX FT8 Broke The Myth That < 1 Sec Clock Sync Is Required
- DX FT8 Proved That Manual Synchronization Works Well Without RTC
- DX FT8 Includes Automated Synchronization



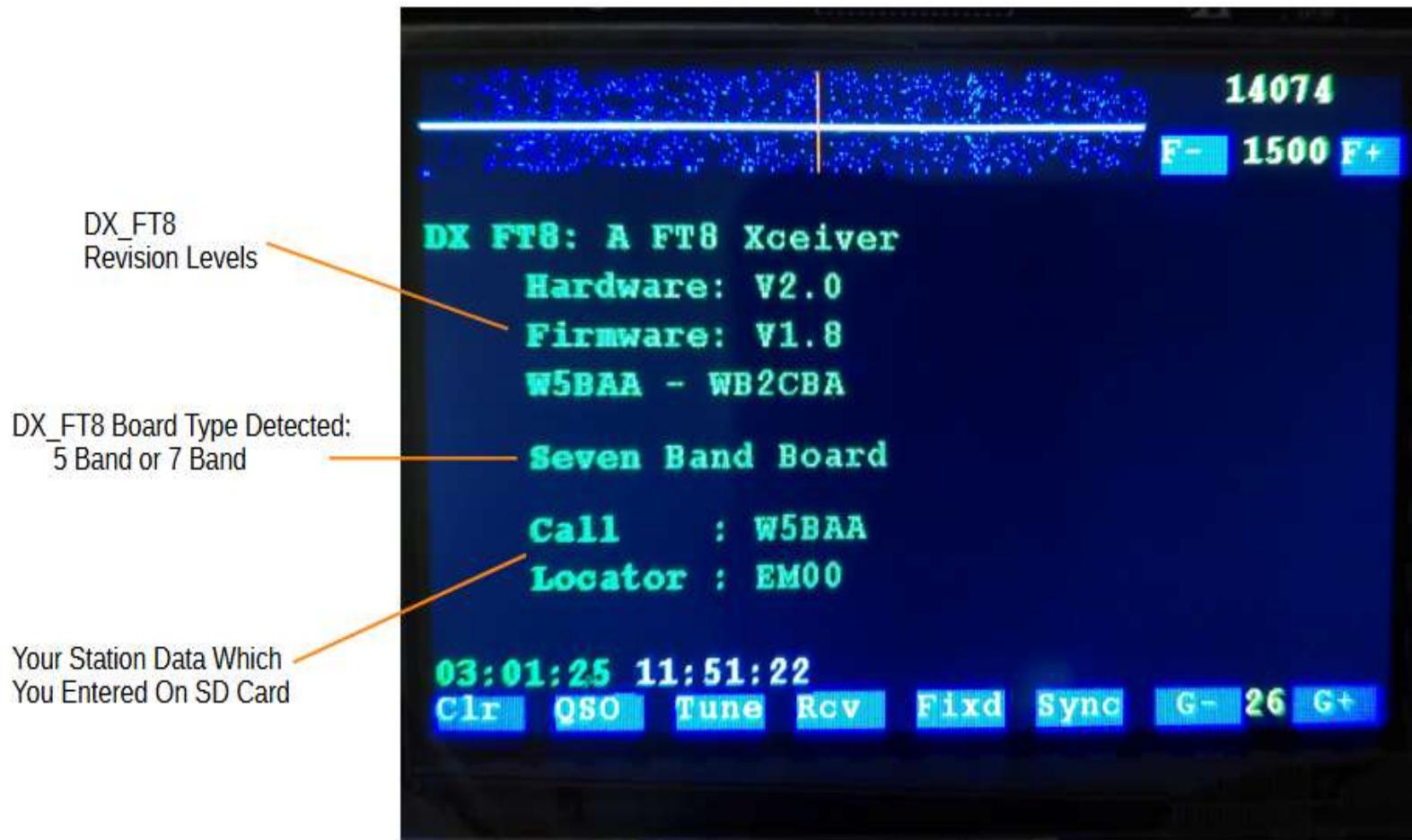
# DX FT8 FIRMWARE SUPPORTS SOTA / POTA



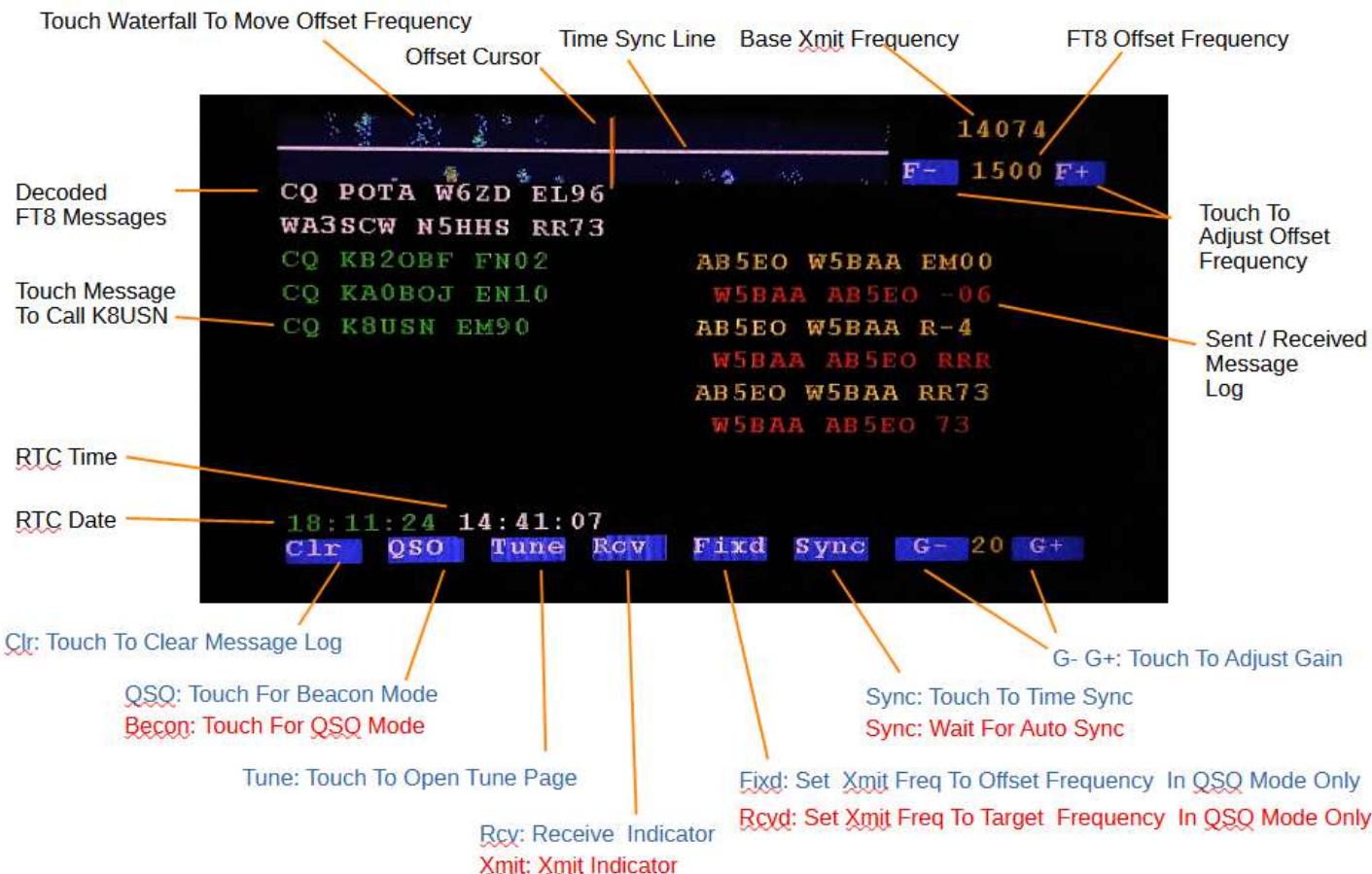


OPERATING DX FT8

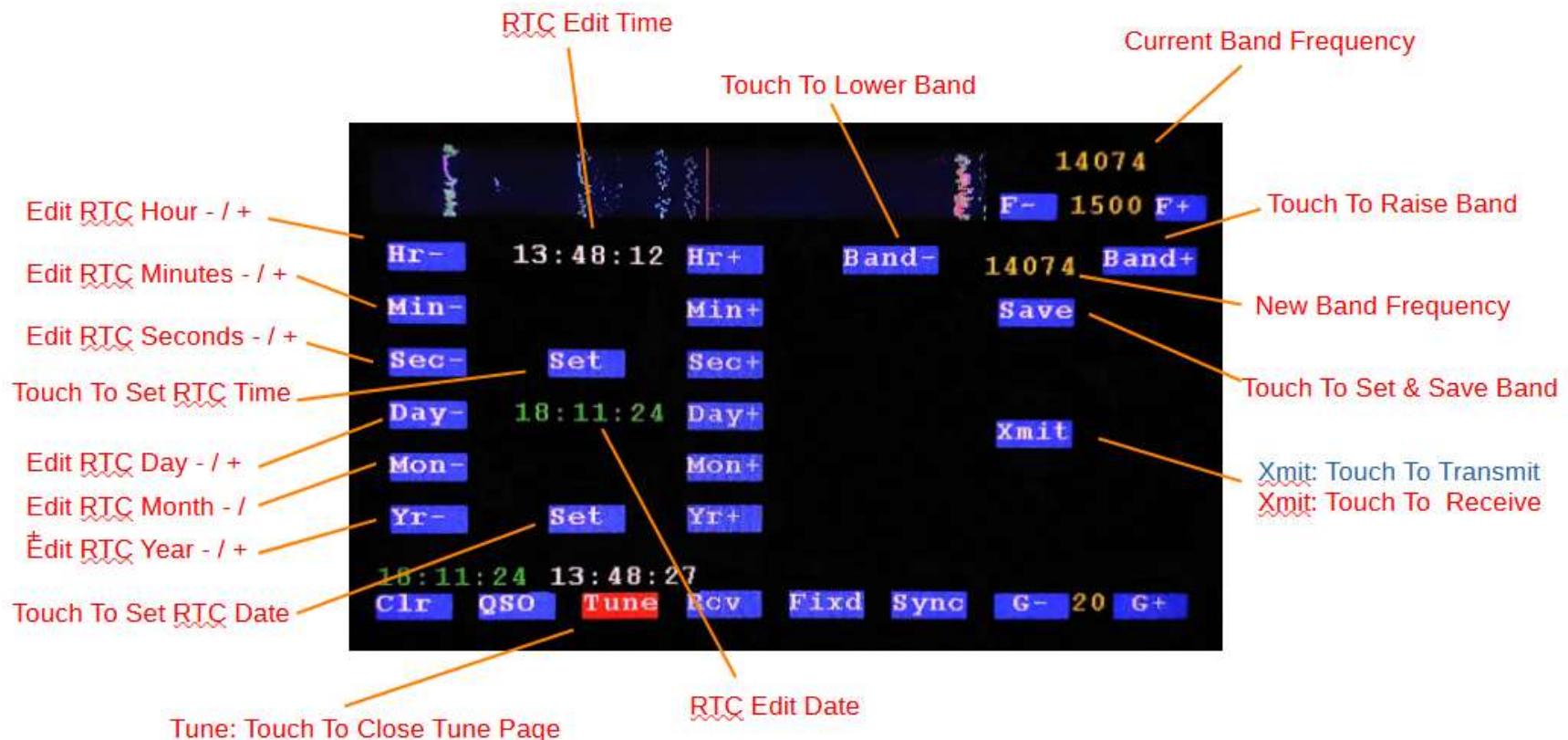
## DX FT8 V1.8 CHEAT SHEET PAGE 1: BOOT UP PAGE



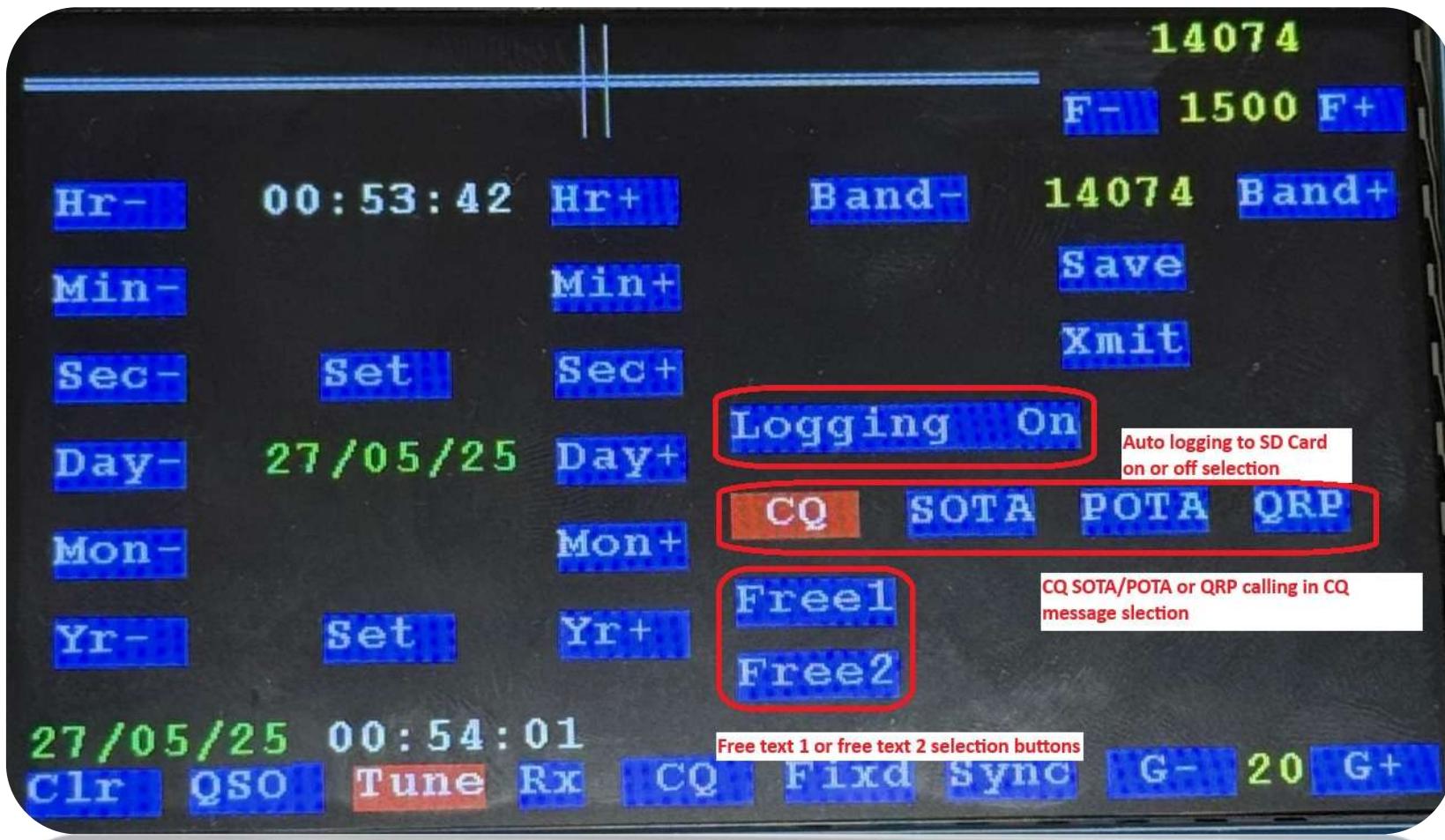
# DX FT8 V1.8 CHEAT SHEET PAGE 2: OPERATING PAGE

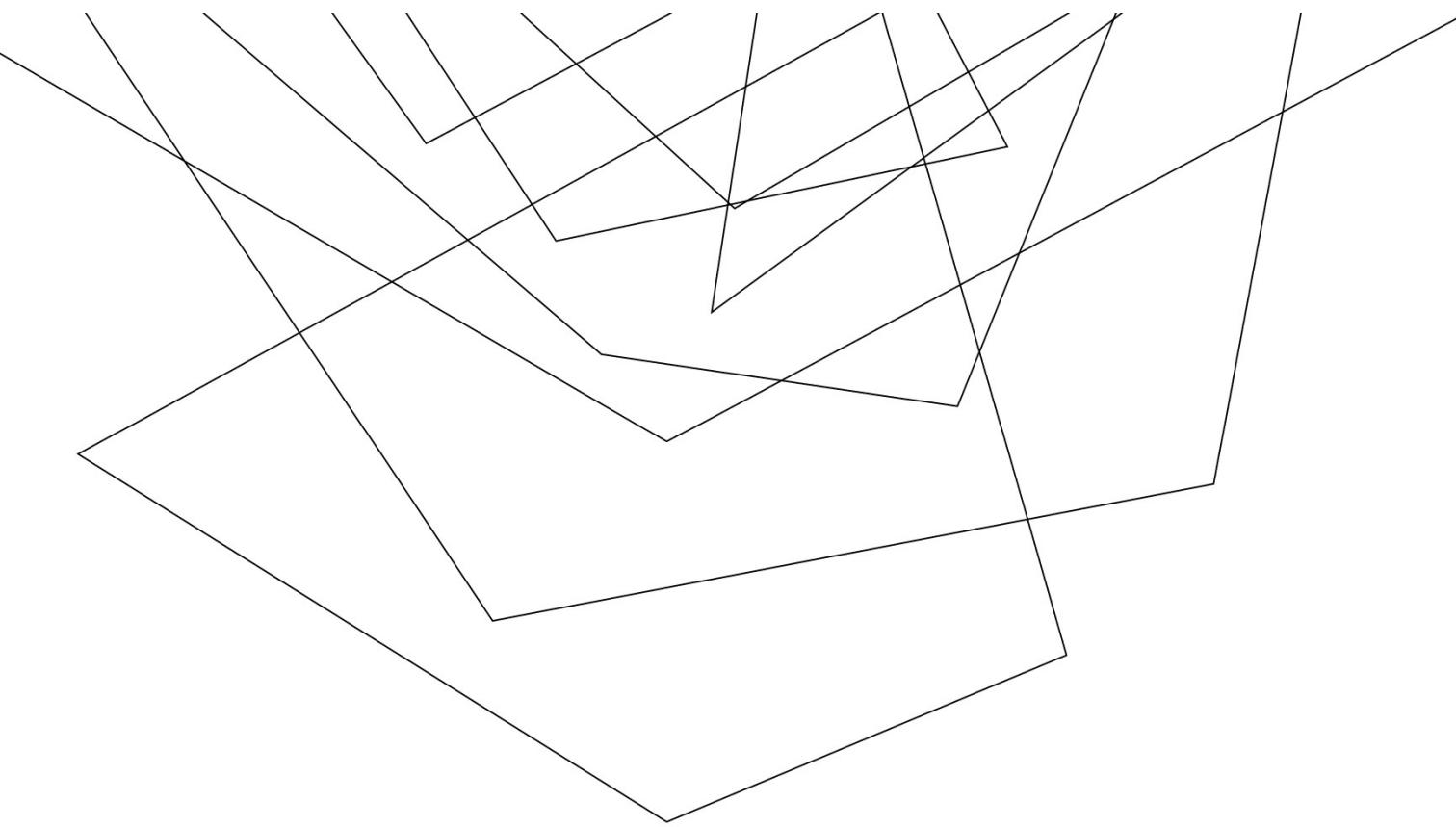


# DX FT8 V1.8 CHEAT SHEET PAGE 3: TUNE PAGE



## CUSTOM CALL MESSAGE SELECTION





**DX FT8**  
**FT8 TRAFFIC HANDLING**

## EXAMPLE QSO MODE TRAFFIC HANDLING

UTC	dB	DT	Freq	Message
02:33:15 PM	13	0.2	14075259	CQ KI5LSU EM30
02:33:30 PM	-6	0.2	14075503	CQ ND0Y EM29
02:33:45 PM	14	0.2	14075259	CQ KI5LSU EM30
02:34:00 PM	25	-0.9	14075257	KI5LSU W5BAA EM00
02:34:15 PM	3	0.2	14075259	W5BAA KI5LSU +07
02:34:30 PM	23	-1.1	14075257	KI5LSU W5BAA R-03
02:34:45 PM	15	0.2	14075259	W5BAA KI5LSU RRR
02:35:00 PM	27	-0.8	14075257	KI5LSU W5BAA RR73
02:35:15 PM	11	0.2	14075259	W5BAA KI5LSU 73

## EXAMPLE BEACON MODE TRAFFIC HANDLING

UTC	dB	DT	Freq	Message
01:42:30 PM	25	-0.7	14075514	CQ W5BAA EM00
01:43:00 PM	24	-0.7	14075514	CQ W5BAA EM00
01:43:30 PM	24	-0.7	14075514	CQ W5BAA EM00
01:43:45 PM	2	-0.2	14075507	W5BAA W5ITU DM62
01:44:00 PM	-7	-0.7	14075394	W5ITU W5BAA -08
01:44:15 PM	3	-0.2	14075507	W5BAA W5ITU R-14
01:44:30 PM	25	-0.7	14075515	W5ITU W5BAA RR73
01:44:45 PM	3	0	14075507	W5BAA W5ITU RR73
01:45:30 PM	24	-0.5	14075514	CQ W5BAA EM00

## EXAMPLE ADIF LOG REPORT

The screenshot shows the ADIFMaster application window. The title bar reads "ADIFMaster - C:\STM32F746\_32k\_AXD\_QSO\_RTC\_Bands\_ADIF\_DX\_Un0\_EditRTC\_QSO\_6\12Nov2420M.adi". The menu bar includes File, Edit, Search, View, Tools, Settings, and Help. Below the menu is a toolbar with icons for file operations like Open, Save, and Print, as well as tools for search, refresh, and settings. The main area displays a table of QSO data:

#	CALL	GRID SQUARE	MODE	QSO_DATE	TIME_ON	FREQ	STATION_CALLSIGN	MY_GRID SQUARE	RST_SENT	RST_RCVD	TX_PWR
1	WA1HXH	FN43	FT8	20241112	114406	14.075	W5BAA	EM00	-1	-20	0.5
2	K3JGJ	OI71	FT8	20241112	115051	14.075	W5BAA	EM00	-13	-17	0.5
3	VA3KTT	FN03	FT8	20241112	121921	14.075	W5BAA	EM00	7	-14	0.5
4	N4IO	EL96	FT8	20241112	122121	14.075	W5BAA	EM00	-3	-9	0.5

At the bottom left is the status "Ready" and at the bottom right is "QSOs: 4".



## DX FT8 PROJECT CONCLUSIONS AND REFLECTIONS

- DX FT8 Rig Works
- Performs Well With Other Well Behaved FT8 Stations
- Review and Study Of Off the Air Traffic Leads to Conclude Most Traffic Is Automated
- Significant Number Of Stations Are Naughty
- Naughty Stations Are Hard To Deal With When Designing FT8 Traffic Handling Routines
- There Are A Significant Number Of High Power Stations ( 800 KW For Example)
- Author Has Perception That There Is Not Consensus In FT8 Community On How To Operate
- We Received A Lot Of Valued Help (Testing), Recommendations **And Patience** From Users



# IT'S A JUNGLE OUT THERE

<https://www.kk5jy.net/about-ft8/>

**About FT8**  
Matt Roberts - matt-at-kk5jy-dot-net  
Published: 2023-01-31  
Updated: 2024-10-18

**KK5JY.Net**

FT8 is unquestionably popular in the amateur radio world. Among some, zealously so. My experiences with these modes are not typical of most operators, so I want to share some thoughts on the mode—some technical, and some not.

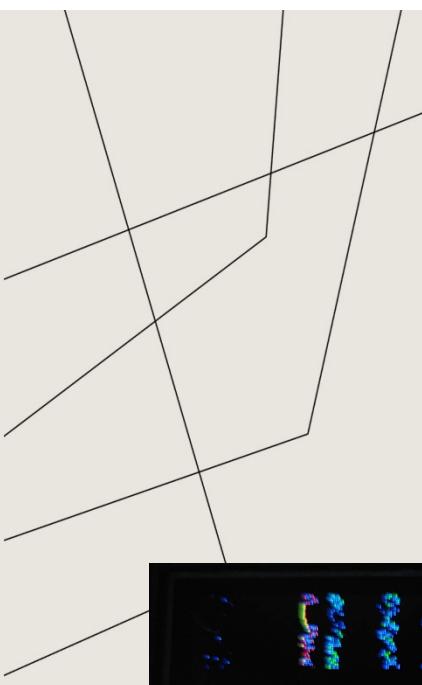


L7 AKC

ITU-Zone 28

DOK D 03

**NICE**



14074  
F- 1187 F+  
CQ W5BAA EM00 -1  
KN4QT W5BAA 1  
W5BAA KN4QT R-13  
KN4QT W5BAA RR73  
W5BAA KN4QT R-13  
W5BAA KN4QT R-13  
W5BAA KN4QT R-13  
W5BAA KM6CWV CM88  
KM6CWV W5BAA -4  
W5BAA KM6CWV R-13  
KM6CWV W5BAA RR73  
22:01:25 16:01:55  
Clr Becn Tune Rcv CQ W5BAA EM00  
Rcvd Sync G- 20 G+

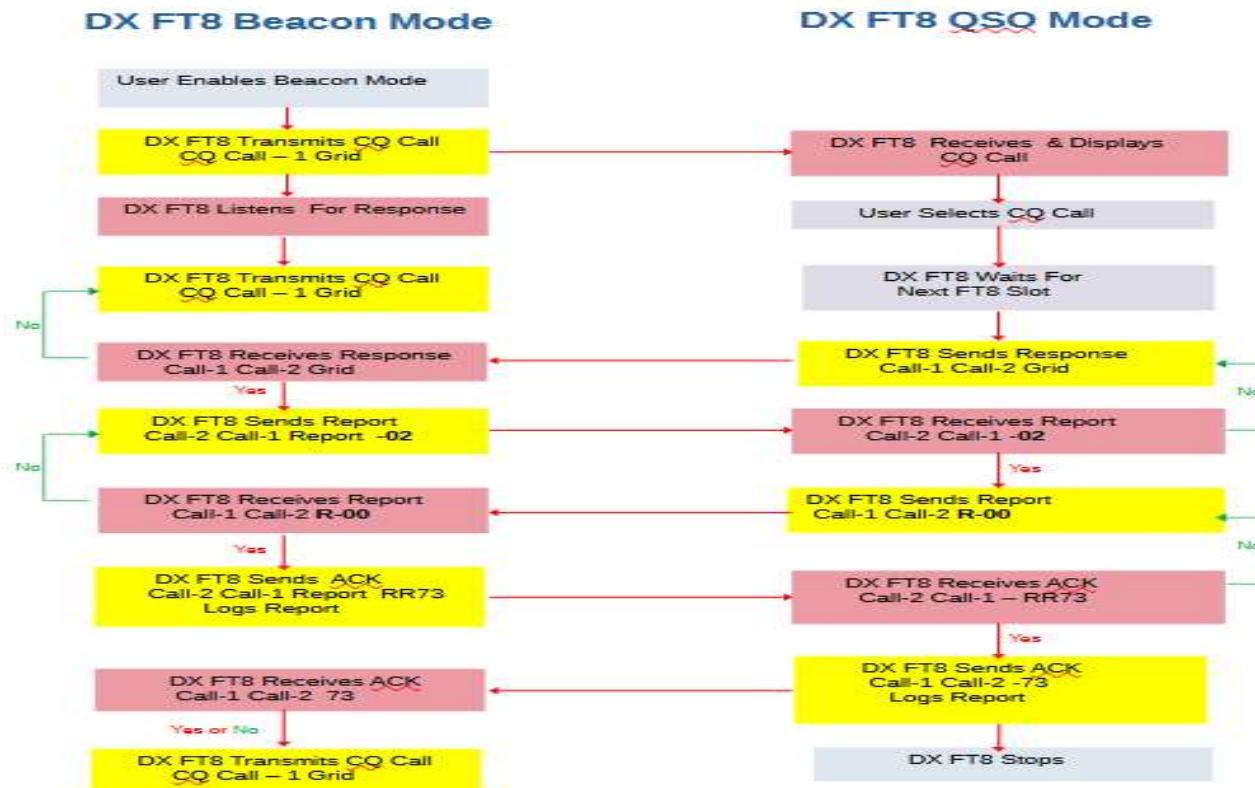


18100  
F- 1550 F+  
W5BAA WD4OIN FM14  
WD4OIN W5BAA -5  
W5BAA WD4OIN R-07  
WD4OIN W5BAA RR73  
W5BAA WD4OIN 73  
W5BAA N2RDT FM05  
N2RDT W5BAA -10  
W5BAA N2RDT R-05  
N2RDT W5BAA RR73  
W5BAA N2RDT 73  
CQ W5BAA EM00  
22:01:25 15:37:58 Clr Becn Tune Rcv Fixed Sync G- 25 G+

**NAUGHTY**

# DX FT8 FLOW CHART

## DX FT8 Auto Sequence Process Operation



# **DX FT8 PROJECT IS OPEN SOURCE**

## **SOURCE CODE LINKS**

## **ACKNOWLEDGEMENTS**

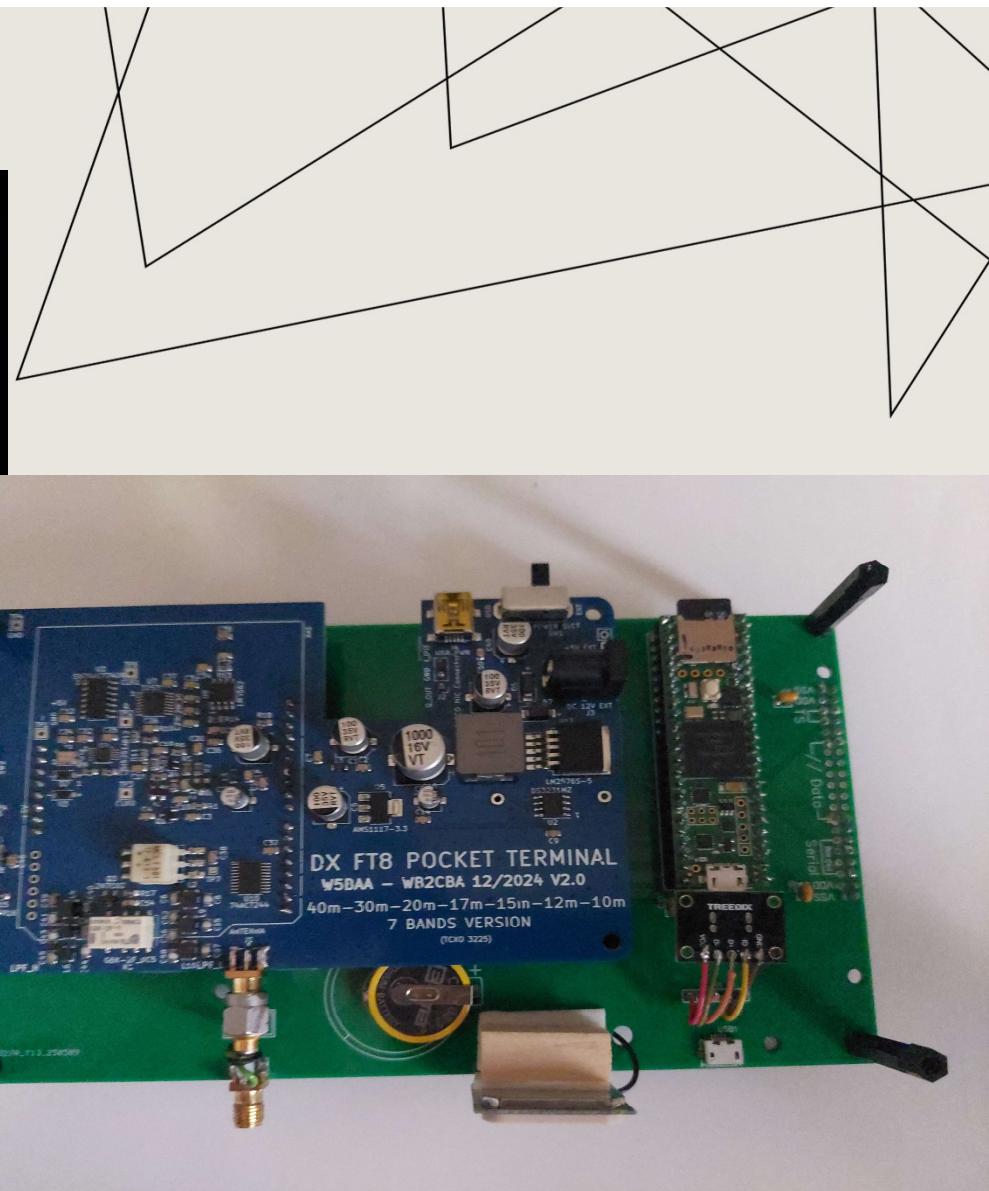
- **Source Code Is Available On DX FT8 GitHub:**

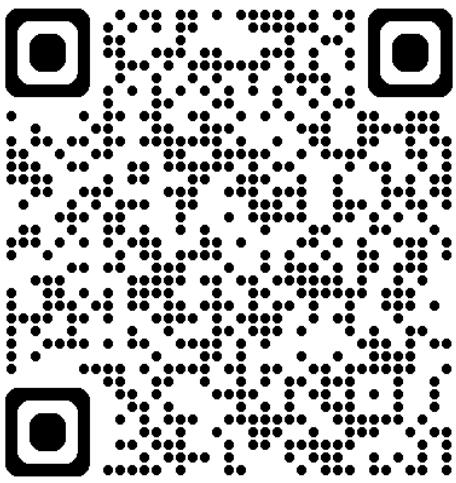
<https://github.com/WB2CBA/DX-FT8-FT8-MULTIBAND-TABLET-TRANSCEIVER>

- And Paul Winwood's (G8KIG) Site: GitHub Site: <https://github.com/g8kig/>
- We would like to thank:
- Karlis Goba, His excellent FT8 Library is instrumental on DX FT8 Realisation
- Paul Winwood, Paul has been Instrumental In Development of DX FT8 Firmware
- Wei Cheng (AG6AQ) for adding SOTA / POTA and Free Text Capability to DX FT8 Firmware
- Kees Talen (K5BCQ) for terrific DX FT8 Kit Assembly and Distribution

**DX FT8 Community Firmware Development is appreciated and valuable  
For the advancement of DX FT8 Project**

# WHAT'S NEXT? RA8876 DX FT8





DX FT8 OPENSOURCE  
PROJECT GITHUB LINK

[https://github.com/WB2CBA/DX-FT8-  
FT8-MULTIBAND-TABLET-TRANSCEIVER](https://github.com/WB2CBA/DX-FT8-FT8-MULTIBAND-TABLET-TRANSCEIVER)

Thank you  
QUESTIONS & COMMENTS



Charley W5BAA – Barb WB2CBA