

uSDX QRP SDR TRCV Project

Norsk Hammeeting 2022

12.03.2022

presentation by PE1NNZ, DL2MAN, WB2CBA and LA7WRA

uSDX QRP TRCV Project – highlights

- **USDX Project highlights:**

- Open source project
- All mode QRP SDR transceiver-can be used for SSB contacts on 80-10m and also for digital modes such as FT8, JS8, FT4
- Based on QRPLabs QCX CW transceiver platform -still use the Atmega 328P processor.
- Project started by PE1NNZ(Guido) in 2019 – developing an open source SW & HW SSB hack for QCX CW QRP transceiver
- DL2MAN(Manuel) added uSDX sandwich design and introduced E-class power amplifier with serial low pass filter (LPF) and a multiband version.
- Later on came several own uSDX designs (still based on QCX HW concept & PE1NNZ SW):
 - DL2MAN sandwich – single and multiband
 - WB2CBA (Barb)– single, multiband, SOTA, ATU+power meter, mOnO single band...
 - PE1NNZ & DL2MAN (tr)uSDX – smallest size multiband (80-20m), not open source

- **uSDX QRP TRCV Main features:**

- QRP SDR All Mode HF transceiver -cover most of HF band – 80-10m;
- TX power ca 5W @ 13.8V;
- TX current ca 500-700 mA;
- RX current ca 60-80 mA (depending on display choice);
- E-class based Power amplifier with serial LPF;
- Efficiency ca 85%:

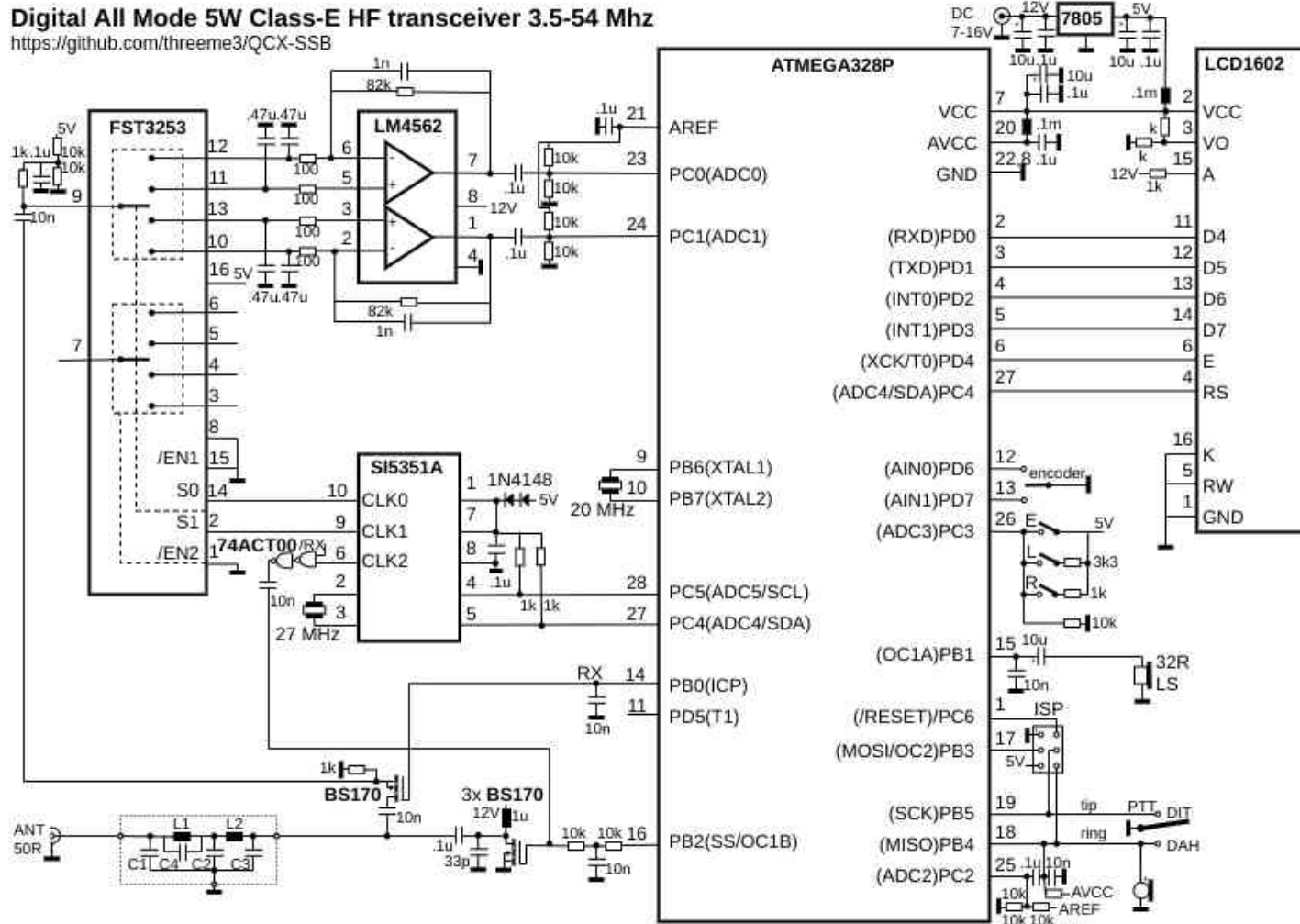


*picture from <https://github.com/threeme3/usdx>

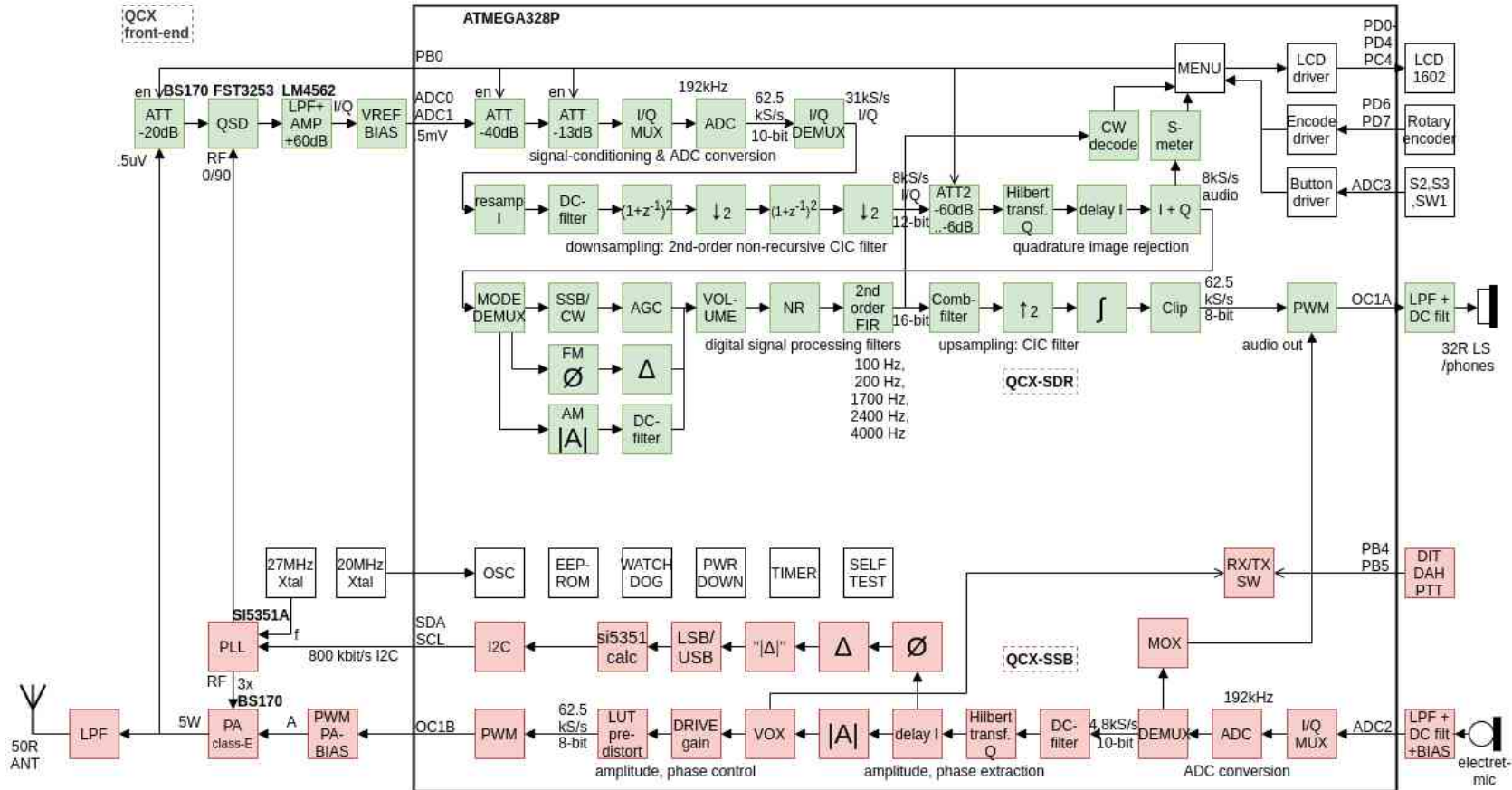
uSDX ORP Transceiver Schematic Diagram

Digital All Mode 5W Class-E HF transceiver 3.5-54 Mhz

<https://github.com/threeme3/QCX-SSB>



uSDX QRP Transceiver Block Diagram



*Picture shown on this slide is from <https://github.com/threeme3/usdx>

uSDX QRP Transceiver Features Detailed:

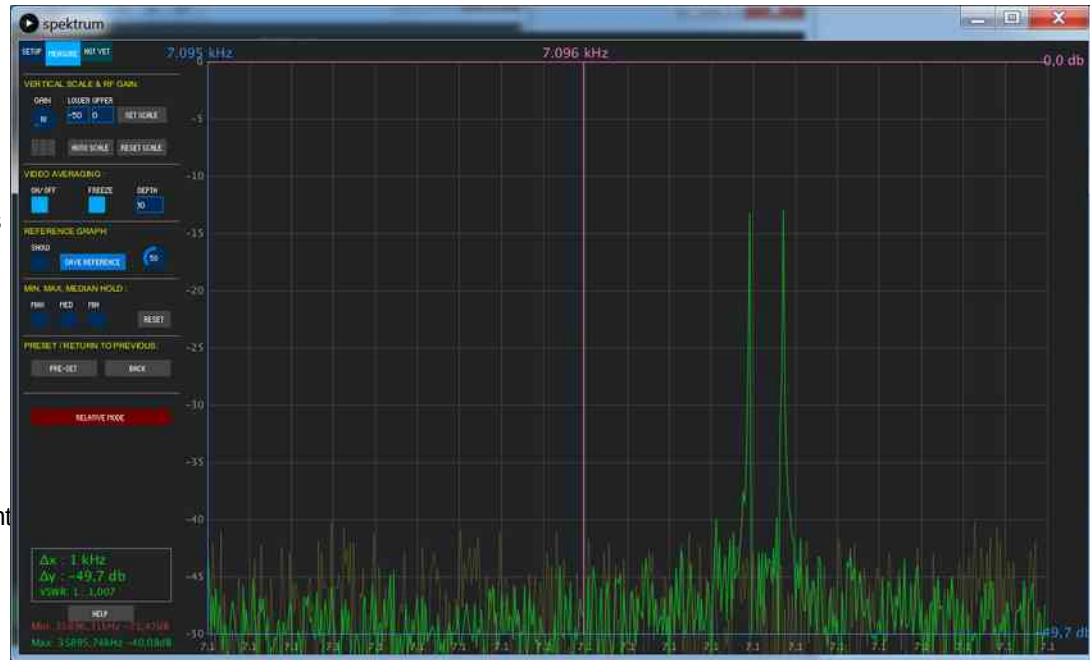
- Simple, fun and versatile QRP SSB HF transceiver with embedded DSP and SDR functions;
- EER Class-E driven SSB transmit-stage
- Approximately 5W PEP SSB output from 13.8V supply
- All-Mode support: USB, LSB, CW, AM, FM
- DSP filters: 4000, 2500, 1700, 500, 200, 100, 50 Hz passband
- DSP features: Automatic Gain Control (AGC), Noise-reduction (NR), Voice-triggered Xmit (VOX), RX Attenuators (ATT), TX noise gate, TX drive control, Volume control, dBm/S-meter.
- SSB opposite side-band/carrier suppression Transmit: better than -45dBc, IMD3 (two-tone) -33dBc, Receive: better than -50dBc
- Multiband support, continuously tunable through bands 160m-10m (and from 20kHz..99MHz with loss in performance)
- Open source firmware, built with Arduino IDE; allows experimentation, new features can be added, contributions can be shared via Github, software-complexity: 2000 lines of code
- Software-based VOX that can be used as fast Full Break-In (QSK and semi-QSK operation) or assist in RX/TX switching for operating digital modes (no CAT or PTT interface required), external PTT output/PA control with TX-delay
- Simple hardware design with only 4 ICs, a micro-controller and few transistors/passives
- Lightweight and low-cost transceiver design: because of the EER-transmitter class-E stage it is highly power-efficient (no bulky heatsinks required), and has a simple design (no complex balanced linear power amplifier required)
- Fully digital and software-based SSB transmit-stage: samples microphone-input and reconstruct a SSB-signal by controlling the phase of the SI5351 PLL (through tiny frequency changes over 800kbits/s I2C) and the amplitude of the PA (through PWM of the PA key-shaping circuit)
- Fully digital and software-based SDR receiver-stages (optionally): samples I/Q (complex) signal from Quadrature Sampling Detector digital mixer, and performs a 90-degree phase-shift mathematically in software (Hilbert-transform) and cancels out one side-band by adding them
- Three independent switchable analog front-end receiver attenuators (0dB, -13dB, -20dB, -33dB, -53dB, -60dB, -73dB)
- Receiver Noise floor MDS: -135 dBm at 28MHz (in 200Hz BW)
- Receiver Front-end selectivity: steep -45dB/decade roll-off +/-2kHz from tuned-frequency
- Blocking dynamic range: 20kHz offset 123dB, 2kHz offset 78dB
- CW decoder, Straight/lambic-A/B keyer
- VFO A/B + RIT and Split, and corresponding relay band-filter switching via I2C
- CAT support (TS480 subset), possibility to stream audio, keys, display-text over CAT
- Optional SWR/Power measurement and PA efficiency/overload control
- Battery voltage indicator
- Probably the most cost effective and easy to build standalone SDR/SSB transceiver that you can find. Very much simplified circuit and versatile in use.

*Information is from
<https://github.com/threeme3/usdx> .

uSDX QRP Transceiver Test Results:

Measurements:

- The following performance measurements were made, a modified RTL-SDR, Spektrum-SVmod-v0.19, Sweex 5.0 USB
- Audio device and Audacity player. It is recognized that this measurement setup has its own limitations, hence the dynamic range of the measurements is somewhat limited by the RTL-SDR as this device goes easily into overload.
- Measurements were made with the following settings:
 - } USB modulation,
 - } no pre-distortion,
 - } two-tone input 1000Hz/1200Hz where audio level is set just before the point where compression starts



Results:

Intermodulation distortion products (two-tone; SSB with varying envelope) IMD3, IMD5, IMD7: respectively -33dBc; -36dBc; -39dBc

Intermodulation distortion products (two-tone; SSB with constant envelope) IMD3, IMD5, IMD7: respectively -16dBc; -16dBc; -19dBc

Opposite side-band rejection (two-tone): better than -45dBc

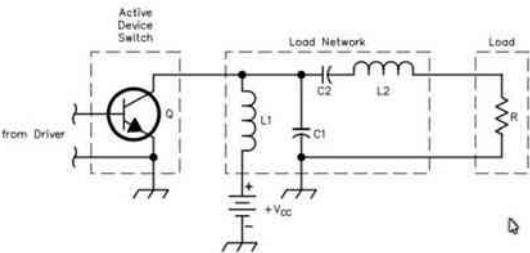
Carrier rejection (two-tone): better than -45dBc

Wide-band spurious (two-tone): better than -45dBc

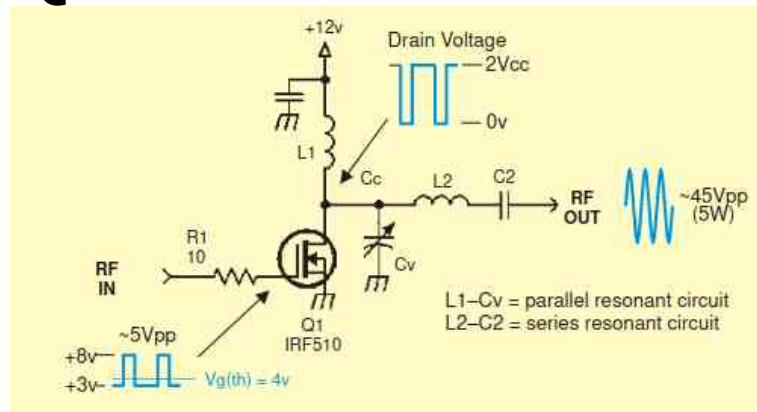
3dB bandwidth (sweep): 0..2400Hz

*Information / Picture shown on this slide is from <https://github.com/threeme3/usdx> .

uSDX QRP Transceiver E-class PA:



*Picture from QEX Jan/Feb 2001



*Introduction to Class C,D,E and F by Paul Harden, NA5N

Class E Design Spread Sheet, 7 MHz

QEX Jan/Feb 2001 Class E Design Equations

Class E Output Network Calculator
Q_L must be larger than 1.708. Normally, Q>6.

User Inputs				User Outputs			
P (watts)	Vcc (V)	Fw (MHz)	Q _L	C1 (pF)	L1 (uH)	L2 (uH)	C2 (pF)
2.25	18	7.000	6.0	243	66	1.36	740

Output Data:

Q	Q _L	Q ₁	Q ₂
20.5	93.8	2700	50.8

Set XL1 above Input Bias: 2613

L1	L2
67.43	137.2
40 Turns	40 Turns

Note: Need to Subtract Transmitter output C from C1

Trans. Coeff Fix: Q_L = 223

Efficiency Estimate: 2x B510M, 89%

High Efficiency At 7 MHz

Use Q and exact Power to get C1, L2, C2 to standard values

April-04 Copyright 1994, All rights reserved N7VE / Ozarkcon Class E Presentation

Why Class E?

Class C final, 2w

40 to 45% efficient, ~ 370 to 410 ma*

Class E final, 2w

88% efficient, ~ 190 ma*

Almost 50% less TX current required...

Very battery friendly!

* Does not include PA driver. Class E can require very little driver power!

Class E Efficiency Secret

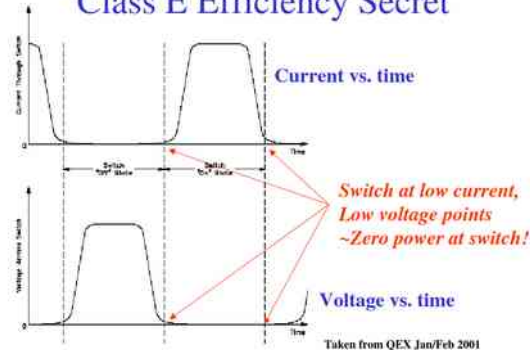
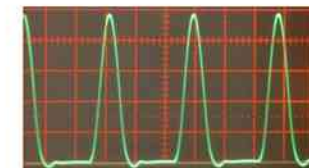


Fig 1—Conceptual "target" waveform of transistor voltage and current.

April-04

N7VE / Ozarkcon Class E Presentation

Class E Drain Voltage Waveform



Scale 10v/division

~ 48v at peaks for 5 w, ~40v for 2w

For comparison, Class C devices run only 24v peaks

April-04

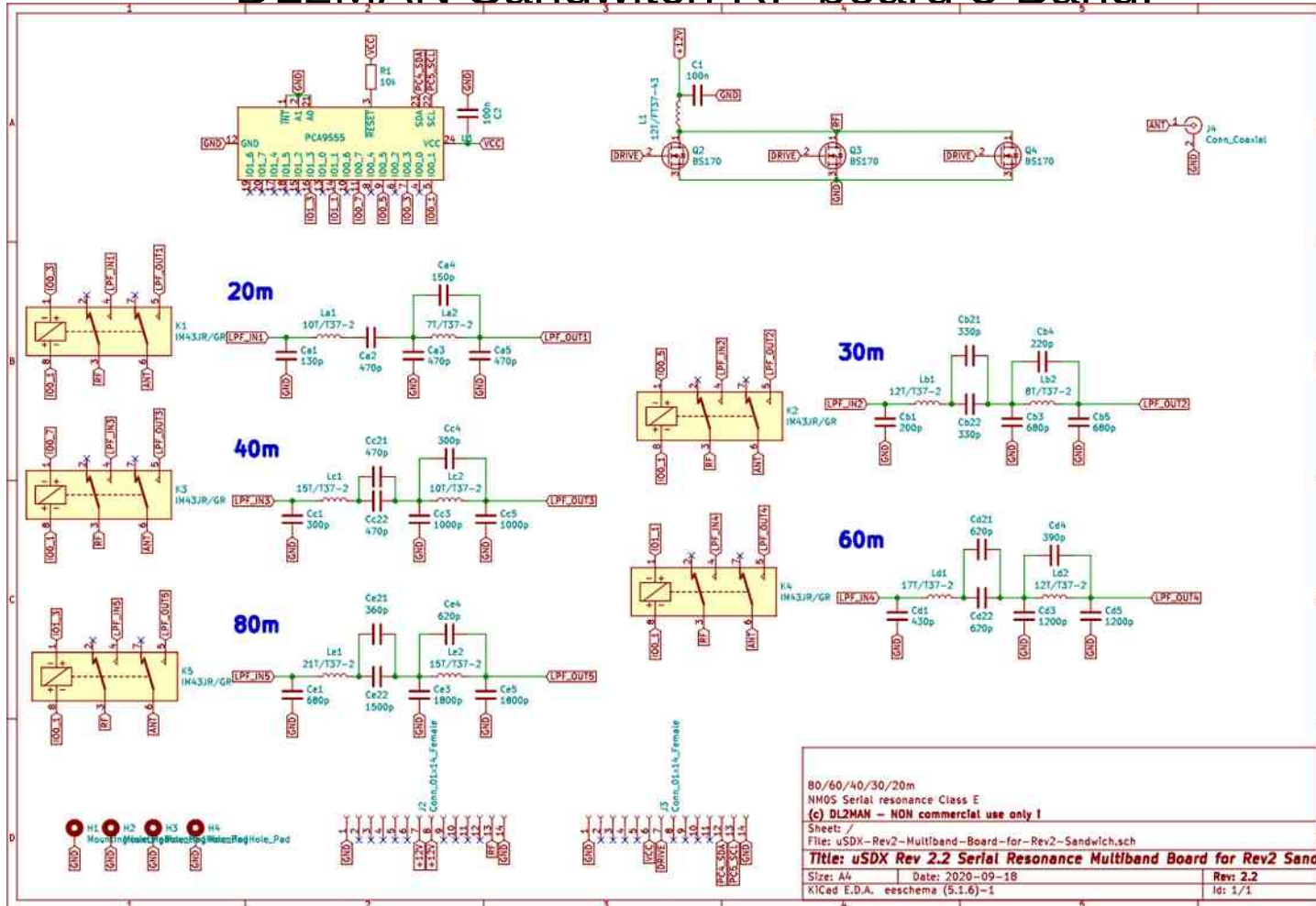
Copyright 1994, All rights reserved

N7VE / Ozarkcon Class E Presentation

*Information from: http://www.norcalqrp.org/files/Class_E_Amplifiers.pdf

uSDX QRP Transceiver

DL2MAN Sandwich RF board 5 Band:



uSDX QRP Transceiver Variants:

DL2MAN uSDX Sandwich

- 5 or 8 band versions
- LCD or OLED display
- Ca 5W output
- not provided as a kit



DL2MAN (tr)uSDX

- 5 band
- SWR + Power meter
- OLED display only
- Ca 5W output
- No open source SW
- **Can be ordered as a kit**



QCX mini uSDX hack

- single band
- Based on QCX Mini CW QRP Kit
- Ca 5W output
- Require re-building of QCX Mini board and adding an extra board (included in the QCX mini kit)



WB2CBA uSDX mOnO & v1.02

- Multi band by LPF replacement
- LCD or OLED display
- Ca 5W output
- THT component based
- **Only mOnO can be ordered as as a kit**

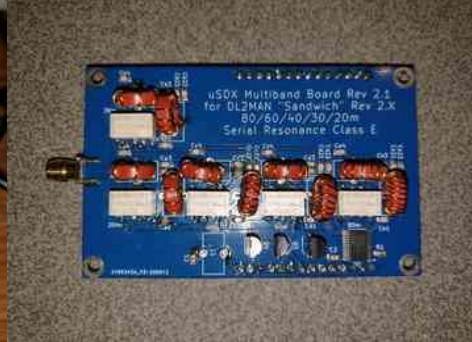
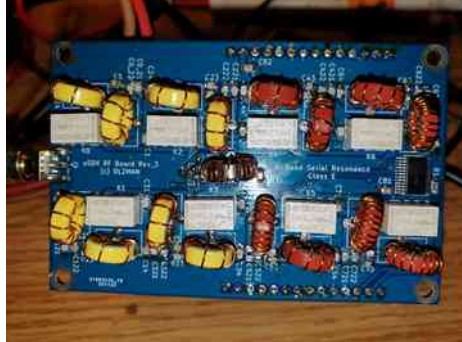
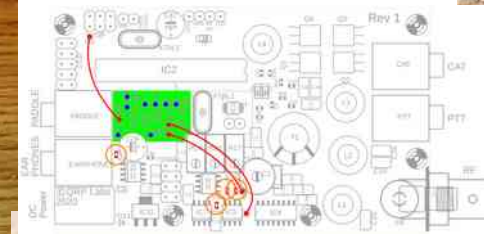


WB2CBA TriBand uSDX

- 3 band by LPF switching
- LCD or OLED display
- Case option
- Ca 5W output
- THT component based
- not provided as a kit



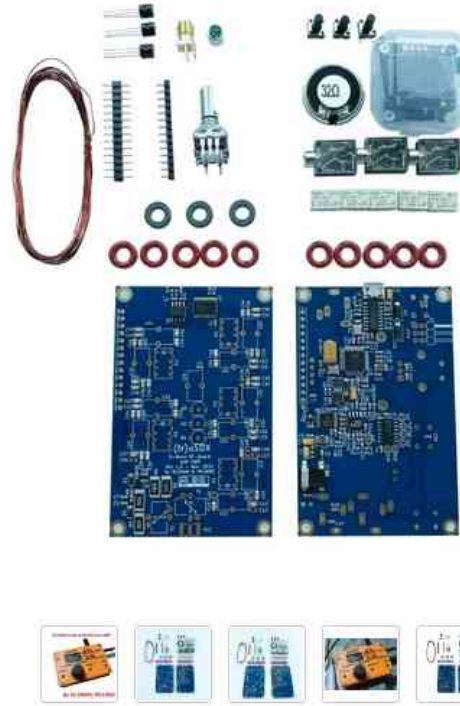
uSDX DL2MAN designs & QCX mini uSDX mode:



(tr)uSDX QRP Transceiver :



(tr)uSDX

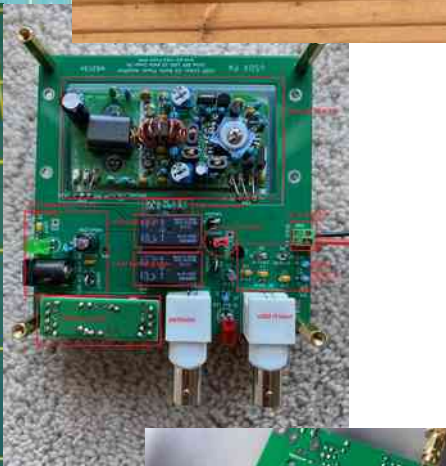
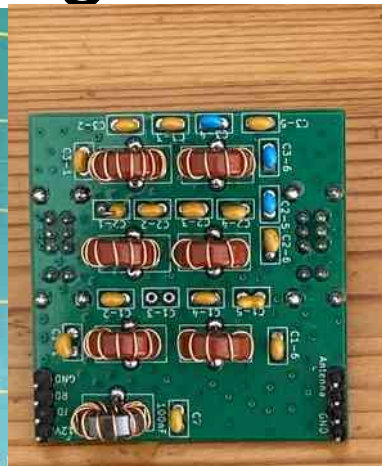


(tr)uSDX kit on AliExpress
-kit for 86 USD
-ready built for 136 USD



(tr)uSDX partly populated PCBs
Produced and delivered by JLCPCB.

uSDX QRP Transceiver WB2CBA designs:



Info on :
<https://www.qrz.com/db/WB2CBA>

uSDX QRP Transceiver Performance:

1.DXing with uSDX:

LA7WRA had a few DX SSB contacts with uSDX QRP transceivers:

- last DX contact with KN4IRM (ca 7000 km) on 25.12.2021 from Oslo, Hvervenbukta area (DL2MAN 5 band sandwich uSDX and EFHW for 20m , 12V battery)

2.Contesting with uSDX

LA7WRA used uSDX QRP TRCV in CQWW 2021 SSB contest - QRP All Band Single Operator category

2.1.CQWW 2021 SSB Contest setup was:

2.1.1.TRCV:

*2xTriBand uSDX QRP TRCV (WB2CBA design):

-80/40/20 band

-17/15/10 band

*ATU-100 antenna tuner designed by N7DDC

2.1.2.Antennas:

*3 el. portable yagi for 20m (Super Antenna , YP-3)

*Endfed half wave 80-10m antenna

2.2.CQWW 2021 SSB Contest results:

*Claimed points=24564

*Total 211 contacts:

-40m contacts – 26

-20m contacts – 147 (27 DX)

-15m contacts - 38 (5 DX)

uSDX QRP Transceiver

How to Build it:

1. Buy it as a kit – so far is only (tr)uSDX and mOnO are available as a kit :

-(tr)uSDX kit (ca 90 Euro):

<https://rowaves.com/product/trusdx-5-band-multimode-qrp-transceiver-kit-assembled/>

-(tr)uSDX kit(ca 86 USD):

<https://de.aliexpress.com/item/1005003908457475.html>

-Mono uSDX (ca 60 USD):

can be ordered from K5BCQ via uSDX forum on www.group.io

2. Start Own / Group uSDX QRP TRCV building project:

- Download the project files (schematic, gerber files, SW)
- Order PCB boards from JLCPCB (www.jlpcb.com)– information and how to on the related uSDX desing sites
- Order the components:
 - From Mouser - www.mouser.no
 - From DigiKey – www.digikey.no
 - From Reichelt – www.reichelt.de
 - Ebay/Aliexpress
 - Other sellers
- Solder the components
- Install the ATMEGA 328P SW – boot loader and FW
- Build the RF board with related relays / LPF
- Test and align the uSDX QRP transceiver
- **Come on air and have a fun** ☺

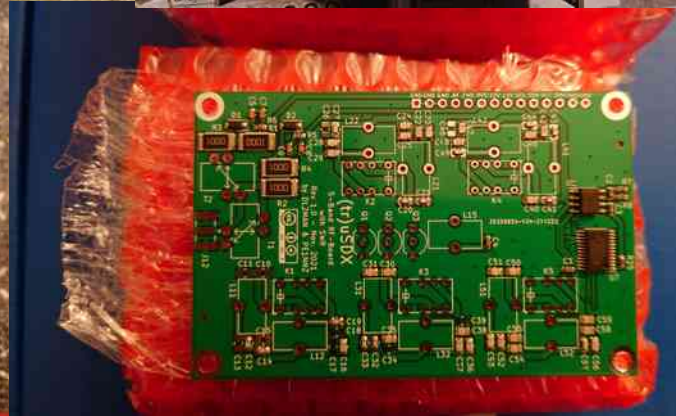
What will you learn:

1. How to order a production of PCBs with /without mounted components;
2. How to order electronic components;
3. How to program an Atmega 328P processor;
4. How to adjust the uSDX source code to the own built TRCV;
5. How to build, test and align the bandpass filters
6. How is built the PA amplifier for QRP transceivers (very efficient class E);
7. How to adjust the bandpass filters for max power / best performance;
8. How to solder regular and SMD components;
9. Learn to measure / test and troubleshoot;
10. Learn a lot throughout uSDX QRP building process;

uSDX QRP Transceiver Pictures/Video:



[CQWW 2021 SSB 20m LA7WRA QSO](#)
[CQWW 2021 SSB 15m LA7WRA QSO](#)
[uSDX QRP SDR TRCV Video](#)
[QCX Mini SSB QSO](#)



uSDX QRP Clonings Invasion

uSDX QRP Cloning TRCV:

- from 80-200 USD on Internet
- variable quality
- no support



USDX QRP Transceiver Information Links

- **uSDX QRP SDR Transceiver Project on GitHub:**
 - <https://github.com/threeme3/usdx>
- **DL2MAN uSDX site:**
 - <https://dl2man.de/>
- **WB2CBA uSDX designs&blog:**
 - <https://www.qrz.com/db/WB2CBA>
 - <https://antrak.org.tr/blog/>
- **uSDX Project group:**
 - <https://groups.io/g/ucx>

uSDX QRP Transceiver

- Questions?

- Peter Petrov – LA7WRA / LZ1VPC
- lz1vpc@yahoo.com