1 Scope

This document is a reproduction for off-line use of the on-line (tr)uSDX five-band transceiver documentation.

2 Overview

The (tr)uSDX is a 5-Band / Mulitmode QRP Transceiver in Pocket Format (90x60x30mm — 140g). It features a highly efficient Class E PA and supports CW/LSB/USB and AM/FM. It covers by default 80/60/40/30/20 m.

It is supplied with an OLED Display, on-board Mic, (tiny) onboard speaker and for improvised QSO an onboard PTT Key that can be used as emergency CW Key.

Further on, the (tr)uSDX has a (Micro)USB CAT and Programming Interface, and while it produces typically 5W at 13.8V input voltage, it can create 0,5W Output from 5V USB Supply alone.

Typically, it draws 80mA on RX (with MS5351 — less with Si5351) and 500mA on TX at13.8V and typical 85% PA Efficiency.

It is supplied with an OnBoard SWR Bridge and Voltage/Current measurement hardware, to help in tuning and operation.

3 Operating

3.1 External Connections & Controls

Figure 1: External Controls & Connectors

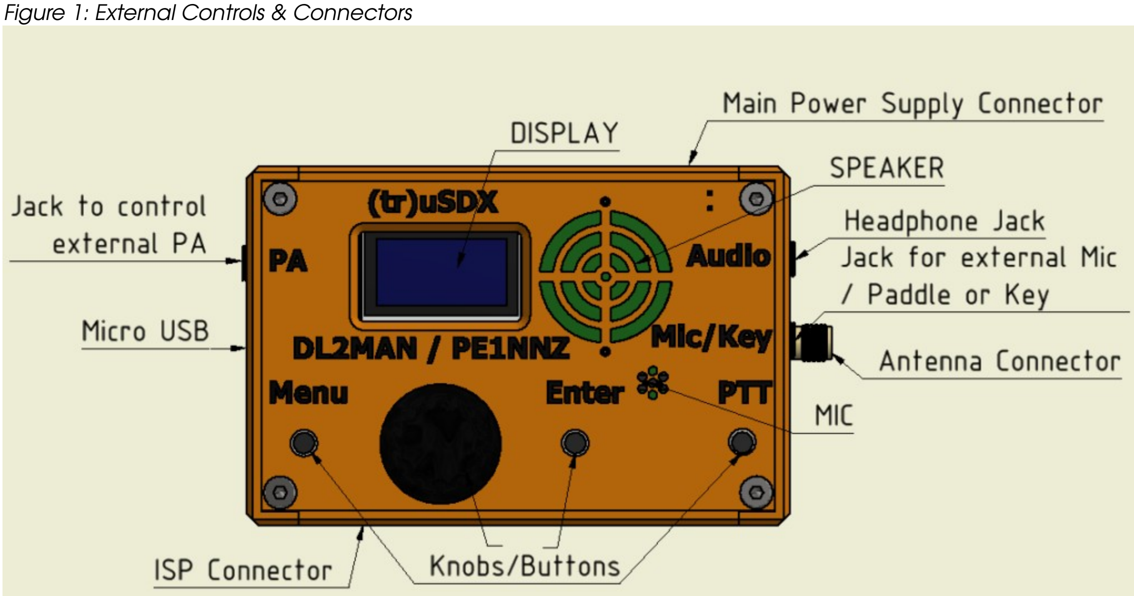
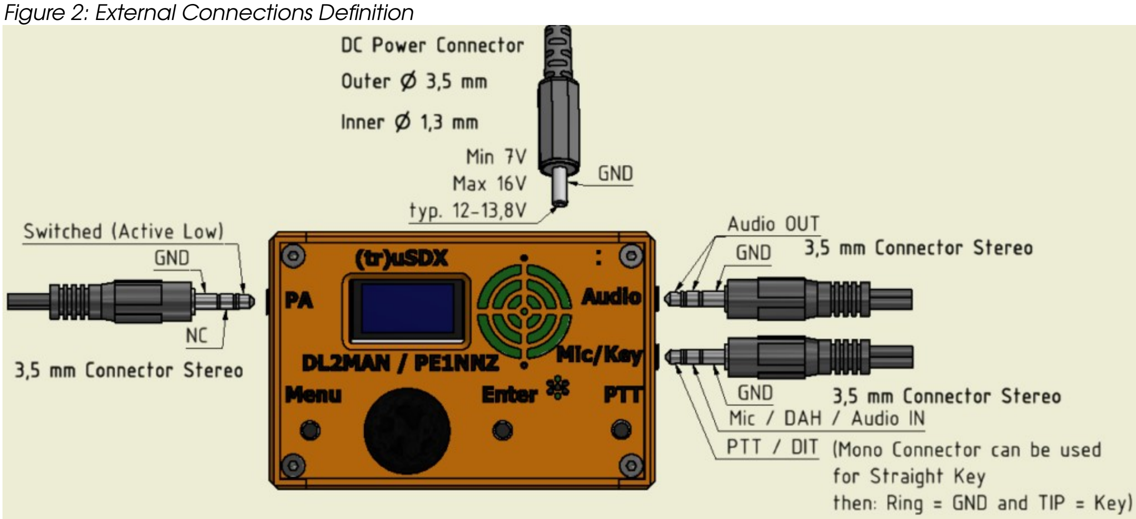


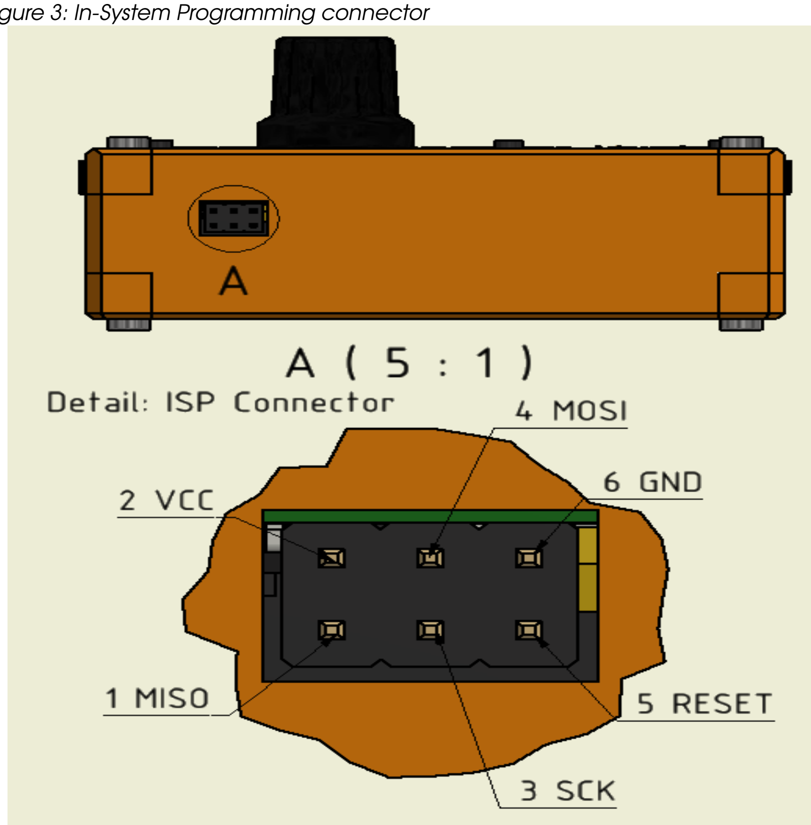
Figure 2: External Connections Definition



3.1.1 ISP Connector

Figure 3 shows the six-pin In-System Programming connector located behind the side panel of the 3D-printed housing. As delivered, inside there is a depression showing the location of the cut-out needed to expose the connector.

Figure 3: In-System Programming connector



3.1.2 Menu Button

Momentarily press the *Menu* button to open the menu. Rotate the knob to move forwards and backwards through available options, as shown in the following subparagraphs.

3.1.2.1 1.1 Volume

- Displays the current audio gain setting:

  +10

- To adjust the audio gain, momentarily press the *Menu* button again—or momentarily press the knob—which displays a right-pointing caret, indicating that you can adjust the gain by rotating the knob:

  >+10

- Under normal operation without entering the menu system, you can adjust the volume by pressing and holding the knob while simultaneously turning.
- To exit the *Menu* and return to normal operating mode, momentarily press the *Menu* button.
- To exit *Volume* adjustment and return to the *Menu* selection-level, momentarily press the knob and then rotate the knob to move to the next item on the menu.
- NOTE: Increasing the *Volume* will reach a point when the gain causes oscillation. This seems to happen at around settings above 13.

3.1.2.2 1.2 Mode

- Displays the operating mode:

  LSB, USB, CW, FM, or AM,

- Momentarily press the knob to change the mode, indicated by appearance of a right-pointing caret >, then rotate the knob to change the mode. Momentarily press the knob to save the menu setting.
- Momentarily press the *Menu* button to exit the menu system.

3.1.2.3 1.3 Filter BW

- Displays the filter bandwidth, which depends on the operating mode.
- Momentarily press the knob to activate adjustment of the filter bandwidth, indicated by appearance of a right-pointing caret >.
- Save the adjusted value by momentarily pressing the knob.
- Momentarily press the *Menu* button to exit the menu system.
- Double-clicking the *Enter* button will cycle through the filter settings.

3.1.2.3.1 SSB Filter BW

- This applies to LSB and USB
- 4k0 = 4.0 kHz 3k0 = 3.0 kHz 2k4 = 2.4 kHz 1k8 = 1.8 kHz

3.1.2.3.2 CW Filter BW

- 500 Hz 200 Hz 100 Hz 50 Hz

3.1.2.3.3 FM Filter BW

- 4k0 = 4.0 kHz 3k0 = 3.0 kHz 2k4 = 2.4 kHz 1k8 = 1.8 kHz
- These filters are options from the menu, yet seem to be available due to a bug in the software.

  500 Hz 200 Hz 100 Hz 50 Hz

3.1.2.3.4 AM Filter BW

- 4k0 = 4.0 kHz 3k0 = 3.0 kHz 2k4 = 2.4 kHz 1k8 = 1.8 kHz
- These filters are options from the menu, yet seem to be available due to a bug in the software.

  500 Hz 200 Hz 100 Hz 50 Hz

3.1.2.4 1.4 Band

- This menu option displays and allows you to change the operating frequency-band. Firmware version 2.00i allows you to select any of nine bands:

80	60	40	30	20	17	15	12	10

  Obviously, the RF board has toroids installed for only five of the nine bands, so selecting a band for which there is no corresponding LPF on the RF board will cause the transceiver to operate improperly.

- It is better to change bands by double-pressing the tuning knob. Doing it this way cycles through the available bands in accordance with the menu setting 8.7 LPF Config.

3.1.2.5 1.5 Tune Rate

- You can change the tune-rate assigned to the knob to any of these values:

MHz	MHz	MHz	kHz	kHz	kHz	Hz	Hz	Hz
10	1	0.5	100	10	0.5	100	10	1

- This menu item is an inconvenient way to change the turning-rate. Much easier is a single press of the knob to move a very small caret from left to right in sequence beside the digits then twisting the knob changes digits adjacent to the caret.

3.1.2.6 1.6 VFO Mode

- There are two Variable Frequency Oscillators, A & B, that can store different frequencies for split operation, though it may not be convenient to use unless there is some kind of shortcut to change from one to the other.

3.1.2.7 1.7 RIT

- You use Receiver Incremental Tuning to adjust the receiver frequency without changing the transmit-frequency. Purpose of this is to allow you to tune to signal that has drifted from or not quite on transmit-frequency.

3.1.2.8 1.8 AGC

- AGC is either ON or OFF.
- When ON, AGC regulates the receiver sensitivity relative to the strength of the received signal: the stronger the signal, the less automatic gain; the weaker the signal, the greater the automatic gain.
- When OFF, the volume control also controls the receiver sensitivity.

3.1.2.9 1.9 NR

- Noise Reduction is only active in SSB mode, it is a relatively simple algorithm. However, it is inactive in the 2.00i version of the firmware.

3.1.2.10 Attenuators

- The (tr)uSDX is equipped with two receiver attenuators, ATT & ATT2, that are adjustable when receiving a strong signal.
- However, the developers discovered that the dynamic range of the ADCs are optimal when ATT = 0 and ATT2 = 2.

3.1.2.10.1 1.10 ATT

- Best left at the default setting of 0dB, but adjustable in eight steps as shown below:

<u>0dB</u>	-13dB	-20dB	-33dB	-40dB	-53dB	-60dB	-73dB

3.1.2.10.2 1.11 ATT2

- Best left at the default setting of 2, but adjustable in sixteen 6dB steps as shown below:

0	1	<u>2</u>	3	4	5	6	7	8	9	10	11	12	13	14	15	16

3.1.2.11 1.12 S-meter

- Default setting is dBm, the S-meter offers five display options:

OFF	<u>dBm</u>	S	S-bar	wpm

  - S-bar is a bar graph of the signal level.
  - wpm is the Morse code speed detected when in CW mode.

3.1.2.12 1.13 SWR Meter

- SWR only works in CW, straight key mode, because the 8-bit microprocessor doesn't have enough cycles available in the other modes when it is operating at full load. Available settings show in the upper right corner of the display:

OFF	FWD-SWR	FWD-REF	PWR-EFF	PWR-VSS

  - FWD-SWR = Forward power and SWR
  - FWD-REF = Forward and reflected power

  - PWR-EFF = Power output and efficiency
  - PWR-VSS = Power output and input voltage

3.1.2.13 2.1 CW Decoder

- The CW decoder does what it says, decoding what it thinks is incoming Morse code. Available settings are either ON or OFF.

3.1.2.14 2.4 Semi QSK

- Available options are either ON or OFF. When OFF, you will hear received audio between your sent dits and dahs. When ON, you won't hear received audio when sending Morse code.

3.1.2.15 2.5 Keyer Speed

- Available setting for the electronic keyer is from 1 to 60, with the default setting at 25 wpm.

3.1.2.16 2.6 Keyer Mode

- Iambic-A
- Iambic-B
- Straight

3.1.2.17 2.7 Keyer Swap

- You can swap the dit-dah direction of your paddle.

3.1.2.18 2.8 Practice

- Either ON or OFF: ON disables the RF power amplifier, allowing you to practice sending Morse code without transmitting any energy, or as a safety measure to prevent accidental transmission without an antenna connected and potentially destroying the power transistors with high SWR.

3.1.2.19 3.1 VOX

- Either ON or OFF. Default is OFF. When ON, VOX causes voice-activated transmission either via the built-in microphone or via audio received through the microphone input.
- Digital modes like PSK31 use VOX audio to activate the transmitter.

3.1.2.20 3.2 Noise Gate

- Controls the sensitivity of VOX, 0-255 in 6dB steps, default value is 4.

3.1.2.21 3.3 TX Drive

- Determines the linearity of the SSB transmission. Available settings are 0-8 in 6dB steps, 8=constant amplitude. Default value is 4, which was found by the developers to be the best compromise.

- Developers recommend leaving at 4 and only adjust around that value when using different microphones, but mostly it is best left at the default setting.

3.1.2.22 3.4 TX Delay

- When using an external RF power amplifier, it is very important for the PA to be active before activation of the transmitter driving the PA. Available settings are from 0-255 ms. Default setting is 0 ms, which assumes absence of an external PA.

3.1.2.23 4.1 CQ Interval

- This is the interval between automatic sending of the message stored in menu item 4.2 CQ Message. Available values are from 0–60 seconds.

3.1.2.24 4.2 CQ Message

- This menu item contains the CQ message text, which you can change using the knob, but is usually filled with your call-sign when you download the firmware.

3.1.2.25 8.1 PA Bias min

- (0-255) representing 0% RF output.
- Default value = 0.
- This is the minimum bias of the PA in SSB or CW, and should always be set to zero.

3.1.2.26 8.2 PA Bias max

- (0-255) representing 100% RF output.
- Default value = 128. You can change this value judiciously to improve the efficiency, but don't set it too high, doing so will permanently drive the PA FETs on.
- The developers determined that the optimum bias value for BS170 FETs is 128.
- For the FDT86256 FET, DL2MAN says that he found 160 works well, but you can change it around this value to see what it does for the efficiency.
- To get more power output, DL2MAN recommends changing the DC Voltage input, not to exceed the absolute maximum of 16 Volts.

3.1.2.27 8.3 Ref Freq

- SI5351 crystal frequency in Hz
- You use the reference frequency to compensate for variations in circuitry and the crystal in order to get the RF frequency output to match the displayed value.
- Default value is 27000000.

- I calibrated my unit by connecting it to a dummy load, placing the dummy load by my Yaesu FT-891, then zero beating the received CW signal, and seeing how far off the (tr)uSDX happened to be. I also observed the FT-891 band scope.
- 26997700 is the value that put the RF output on frequency for me.

3.1.2.28 8.6 R Shunt

- Default value is 17.
- R Shunt adjusts the resistance of a PCB track involved with measuring the efficiency of the transmitter. During manufacturing, the inevitable variations change the efficiency values.
- Transmitter efficiency is the input voltage and current minus the current drawn by the receiver (power) divided by the RF output power. If the efficiency displayed doesn't match the calculated value, you can then adjust the efficiency display by adjusting the R Shunt value.

3.1.2.29 8.7 LPF Config

- Requires a corresponding RF board built for the band.
- Lo = 80, 60, 40, 30, 20 m bands
- Hi = 20, 17, 15, 12, 10 m bands
- Classic = 80, 40, 20, 15, 10 m bands

3.1.2.30 9.7 F/W

- Installed firmware version.
- Default 2.00i

3.1.3 Button & Knob Shortcuts

- Firmware version 2.00t introduced a band scope while sacrificing AM and FM modes of operation to make room in the 8-bit microprocessor for the new feature. A worthwhile compromise!
- In the following explanation of button and knob operation, the image shows presence of band scope, requiring installation of the latest beta version of the firmware.

press	enter menu
long press	spectrum scope
double click	-
press + rotary	tune spectrum

turn	tune
press	decrease step
press + turn	volume / sleep mode
long press	increase step
double click	band change

press	change mode
long press	RIT
double click	filter BW
double long press	toggle VFO A/B

4 Kit Assembly

Initially, not wanting to bother with kit assembly, I bought two assembled Low Band units[1]. My first SSB contact was during Route 66 On-The-Air on 80 m with N5DMK who said that I sounded slightly off-frequency, which caused me to wonder about the frequency calibration of the transceiver.

I went to the website of DL2MAN to find out how to check the frequency calibration and found this video [1]: https://youtu.be/LpQtqlrVFOk. Having watched the short video, I used the band-scope on my Yaesu FT-891 without an antenna connected, and the (tr)µSDX connected to a dummy load, which I placed near the FT-891. There is enough RF energy radiated by the dummy load to peak the band scope of the FT-891. I then adjusted the value of menu *8.3 Ref freq* until the peak coincided with the frequency tuned on the FT-891.

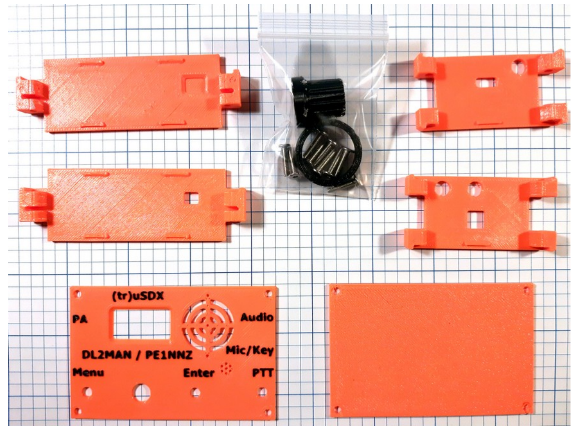
This experience made me think that I should learn how to align the (tr)µSDX by assembling a kit. Consequently, I bought two Classic-band[2] kits. What follows documents my experience.

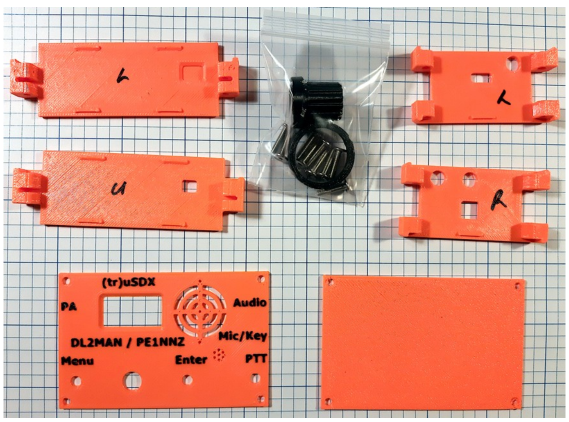
4.1 Classic Bands 80/40/20/15/10 Meters Kit Assembly

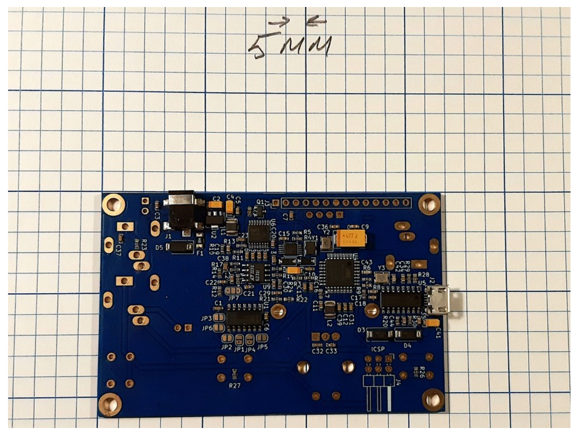
These bands are more useful to me and more attractive to Technician licensees who subsequently earn their General class license upgrades. However, this is non-standard for DL2MAN and only available in kit form.

1 Lo band kits cover 80, 60, 40, 30, 20 meters.
2 Hi band kits cover 20, 17, 15, 12, & 10 meters.

4.1.1 Enclosure







4.1.2 Schematics

I downloaded these annotated, comprehensive schematics redrawn by KD4SGE & WA4ITD [2]: https://dl2man.de/2-trusdx-assembly/. From this ten-sheet drawing package, these eight sheets are relevant to the Classic Bands kit.

Figure 4: Sheet-1 (tr)uSDX Overview and Subsheets

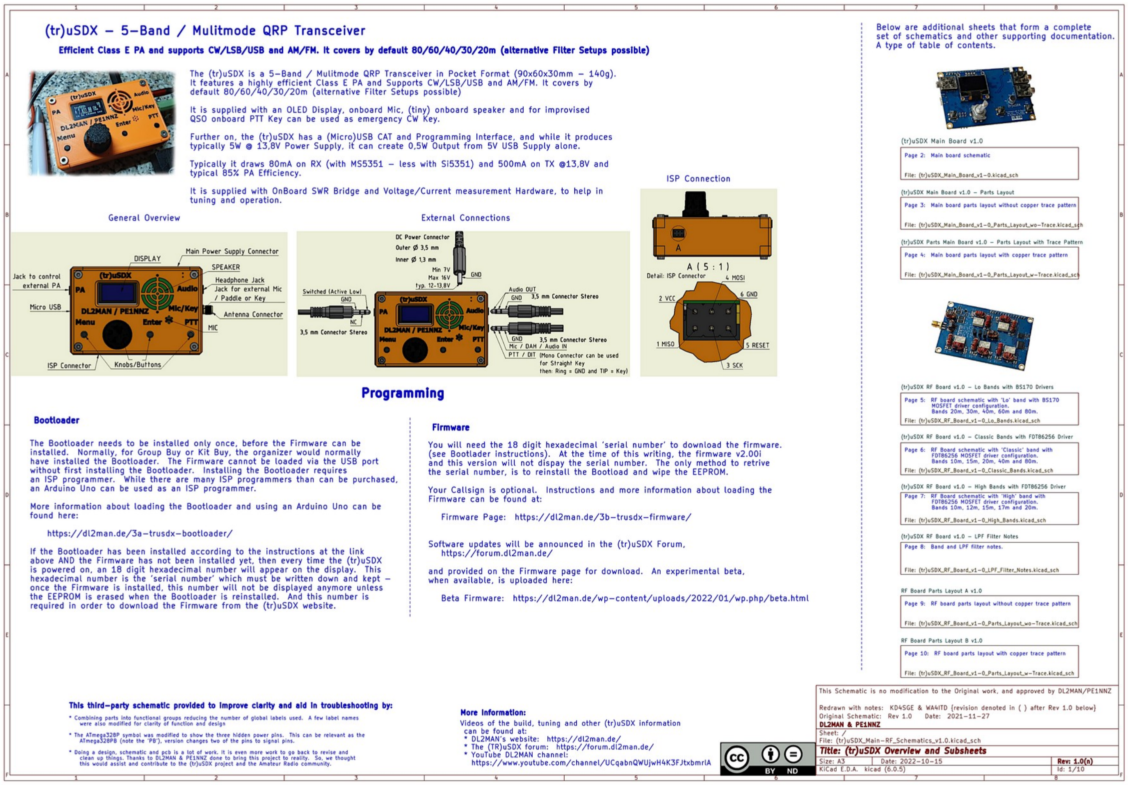


Figure 5: Sheet-2 (tr)uSDX Main Board

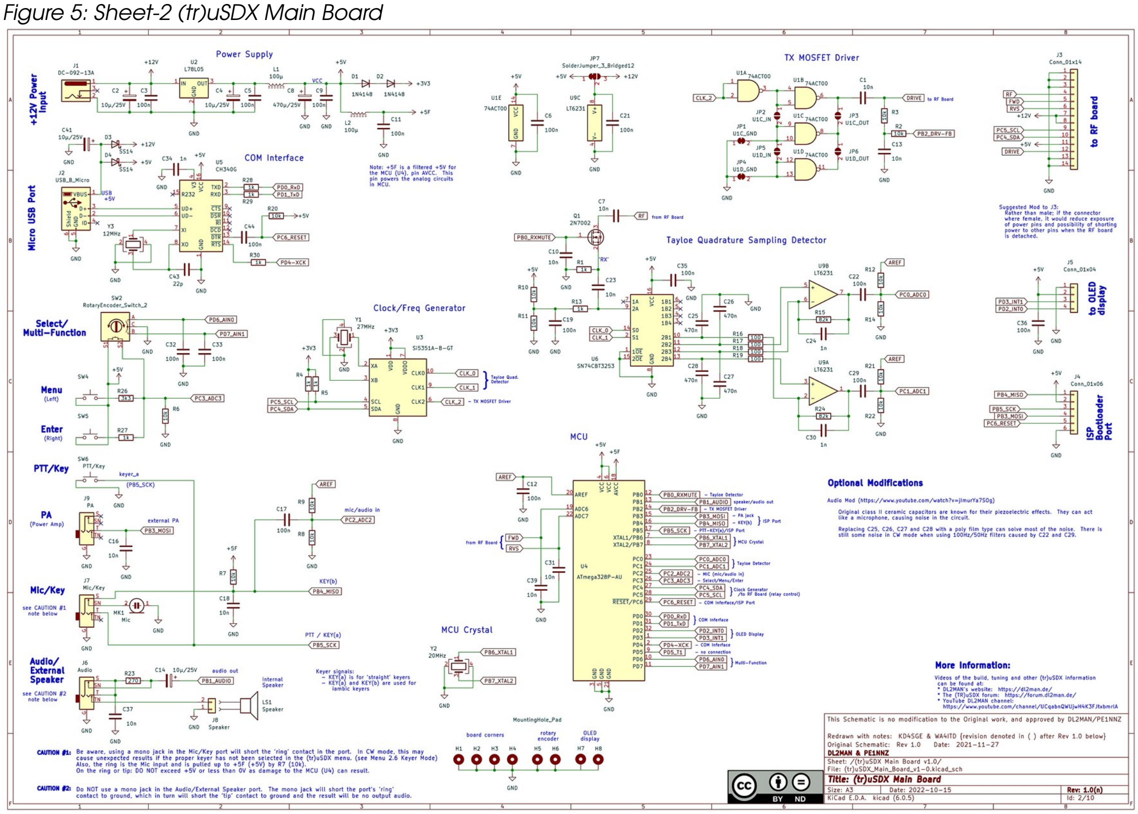


Figure 6: Sheet-3 (tr)uSDX Main Board Parts Layout Without Trace Pattern

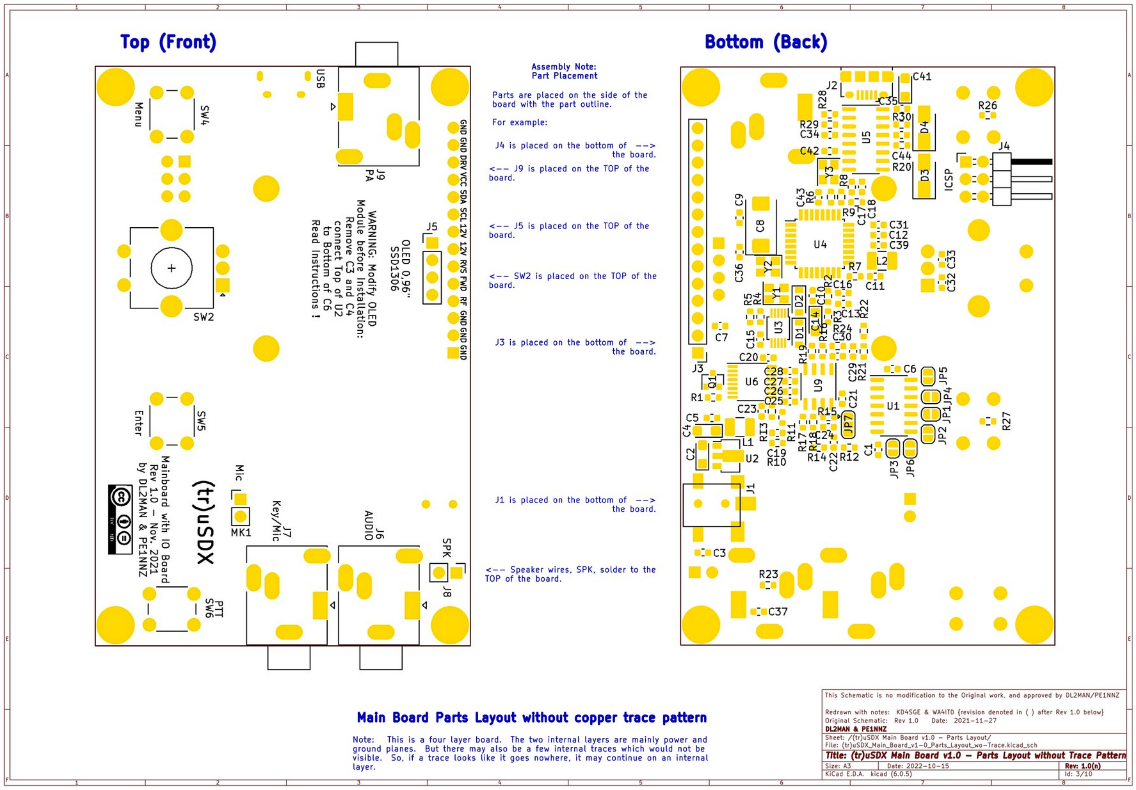


Figure 7: Sheet-4 (tr)uSDX Main Board Parts Layout With Trace Pattern

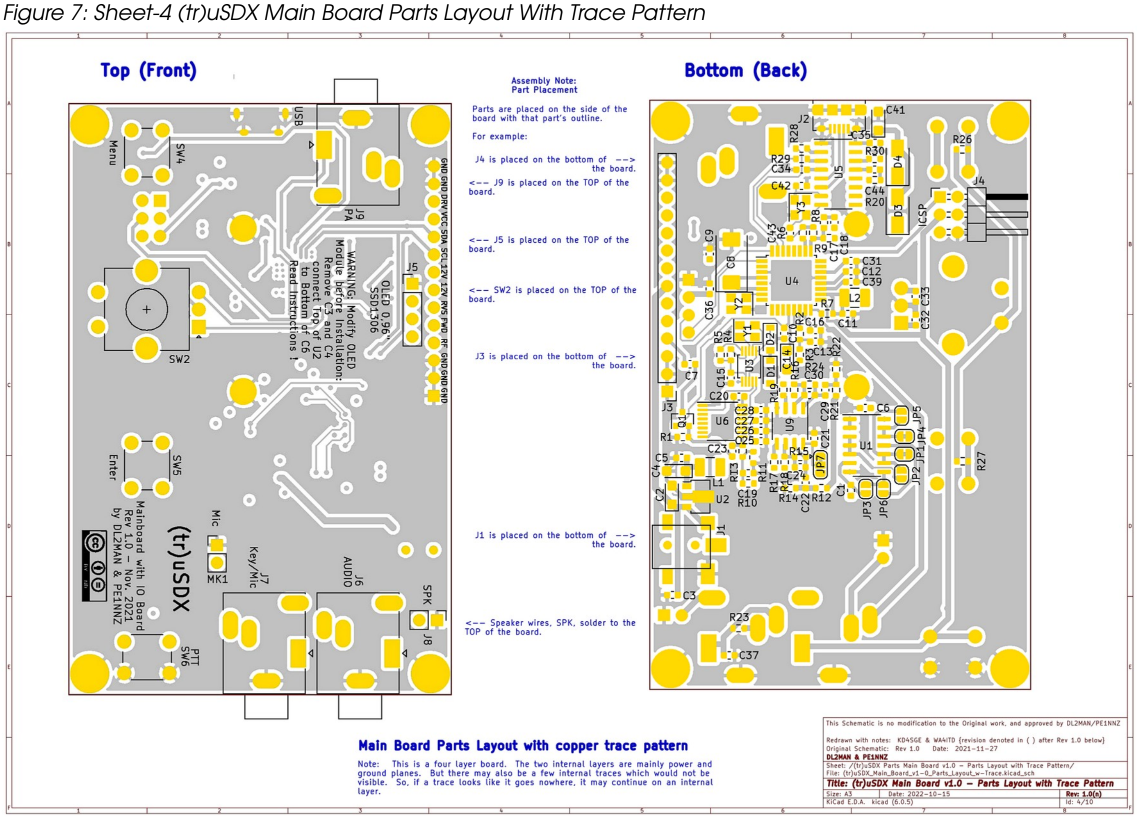


Figure 8: Sheet-6 (tr)uSDX RF Board With Classic Band With FDT86256 Driver

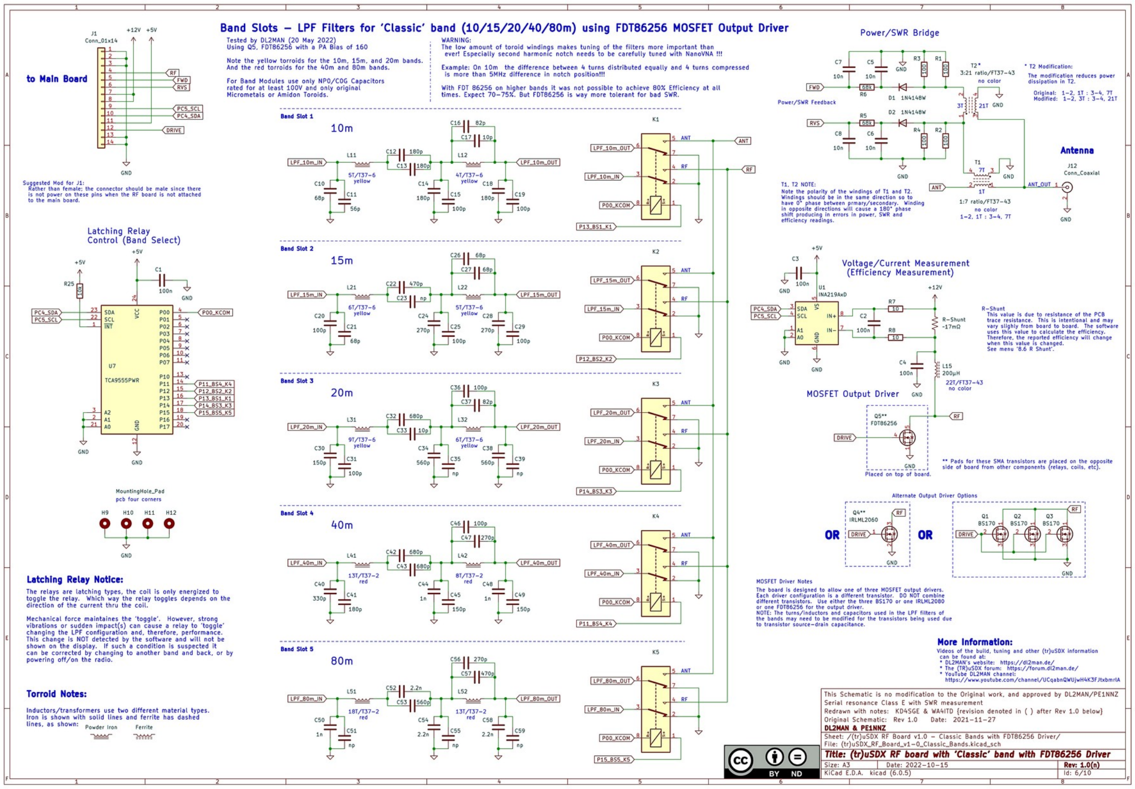


Figure 9: Sheet-8 (tr)uSDX RF Board LPF Filter Notes

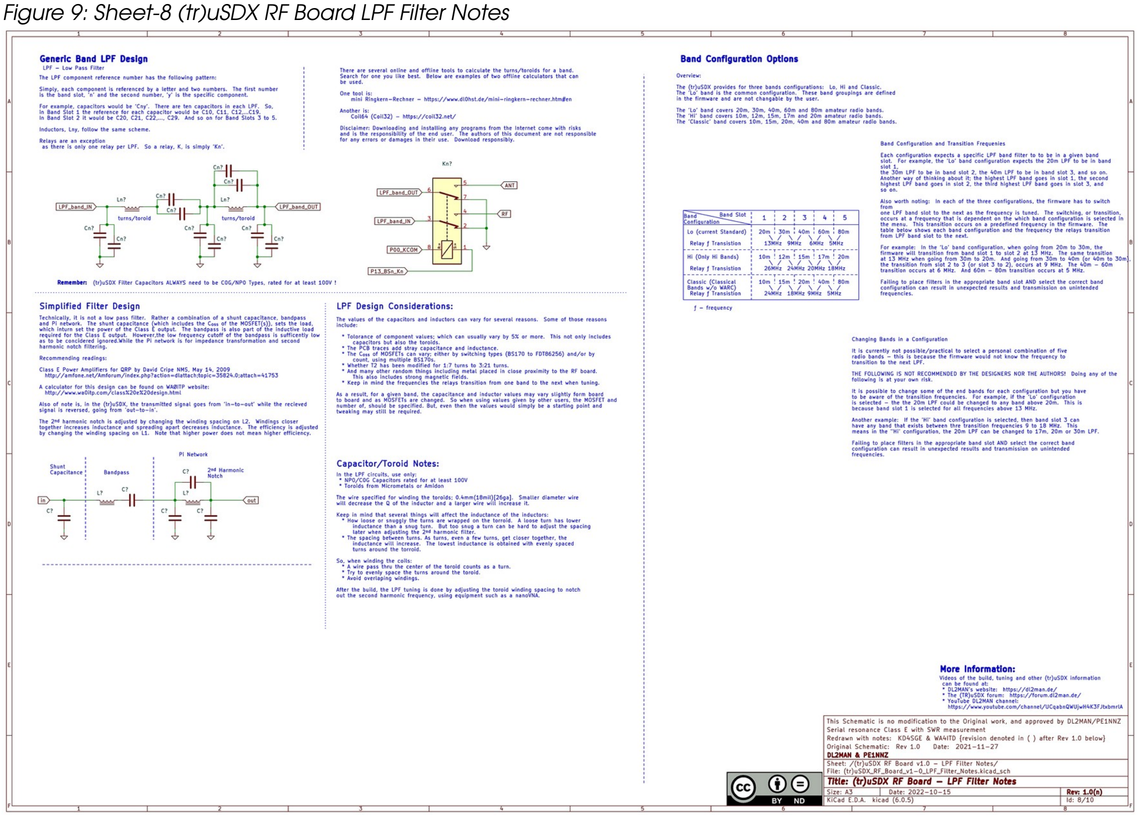


Figure 10: Sheet-9 (tr)uSDX RF Board Parts Layout Without Trace Pattern

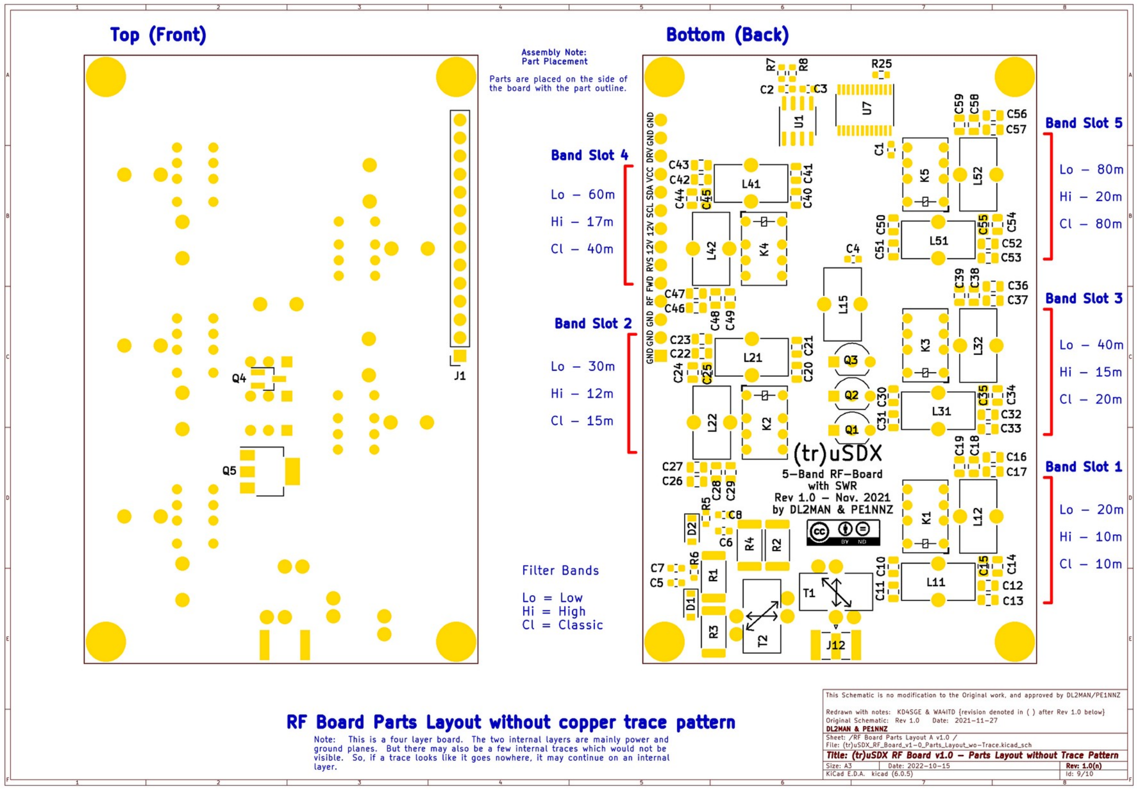
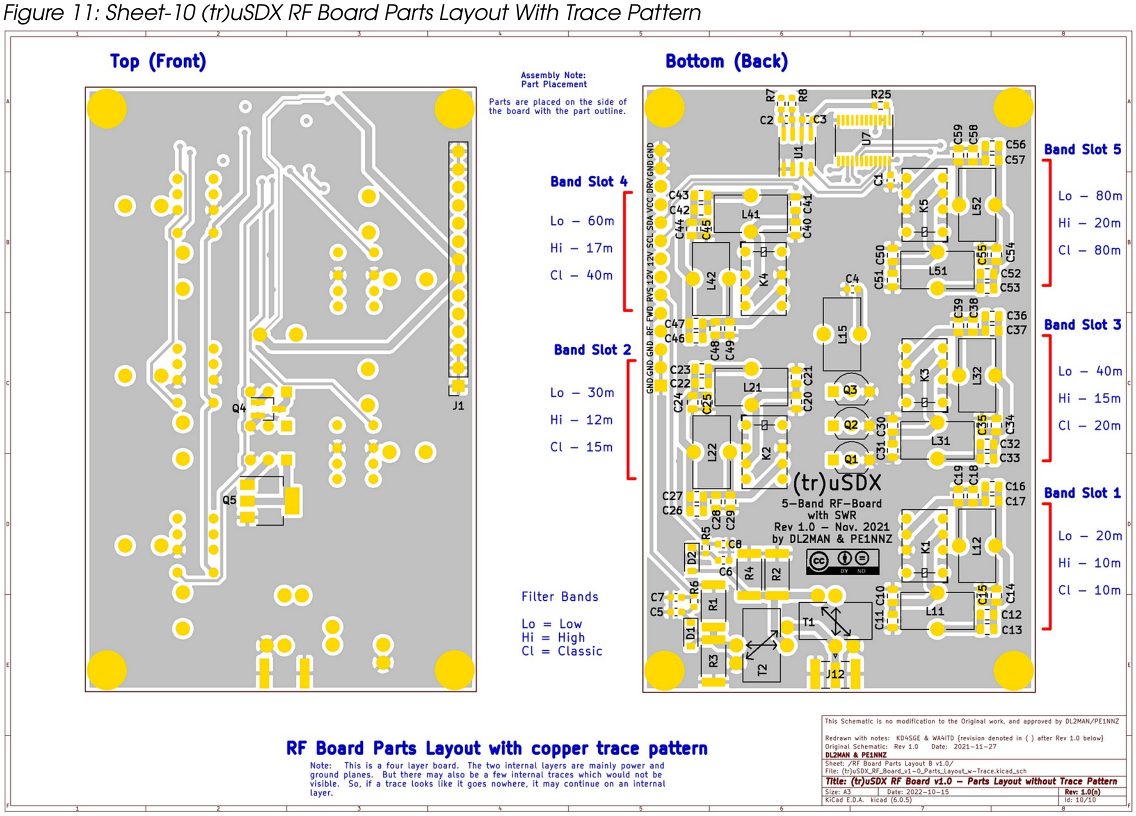
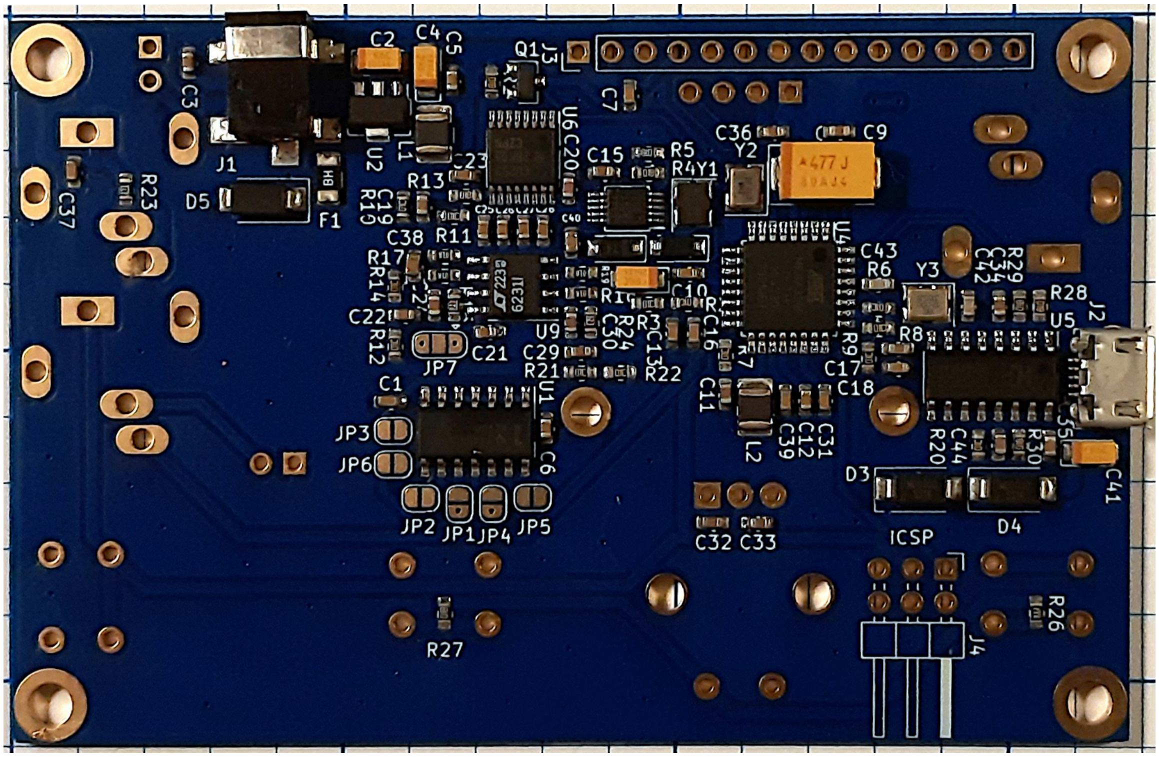


Figure 11: Sheet-10 (tr)uSDX RF Board Parts Layout With Trace Pattern

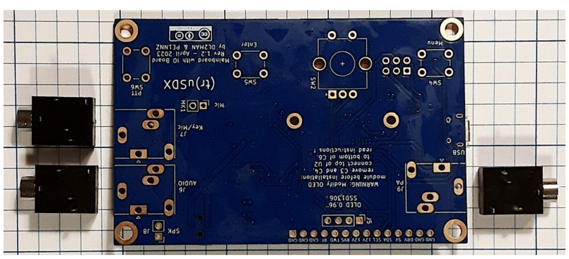


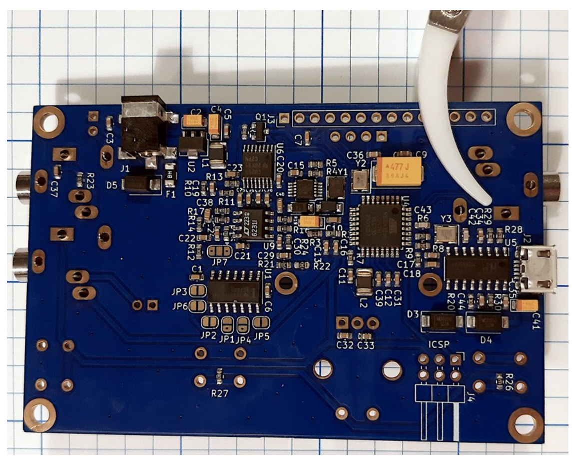
4.1.3 Main Board Assembly

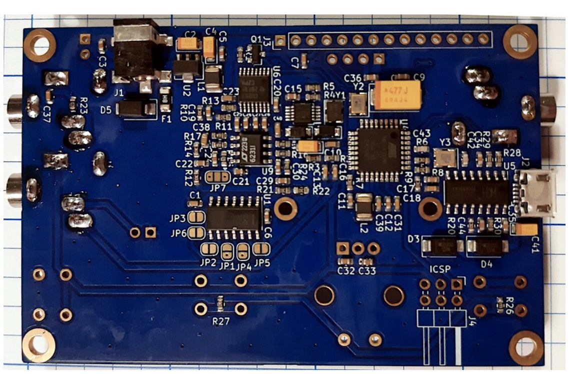


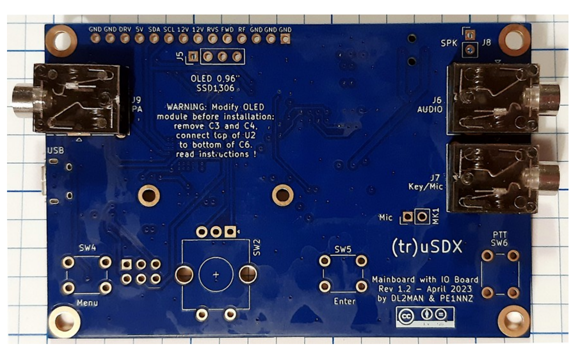
4.1.3.1 Install 3.5 mm Jacks Track Side

To install the jacks, it helps to use a pair of reverse tweezers to hold the jacks firmly in place while soldering.

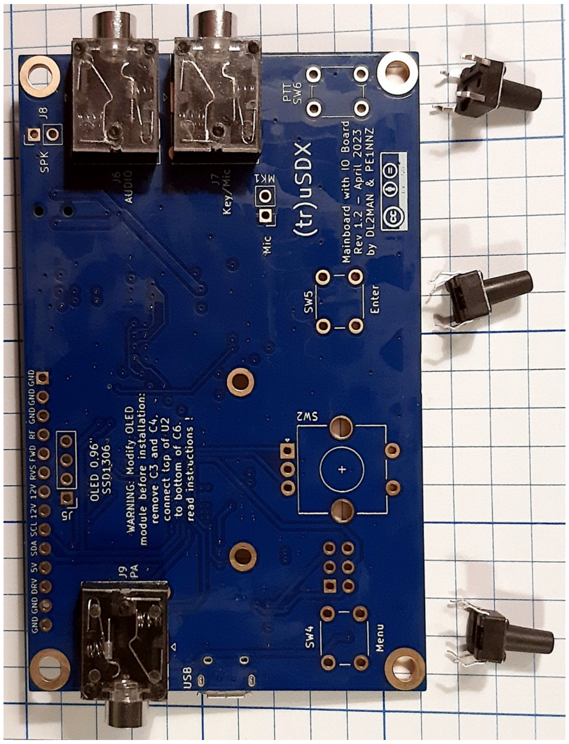


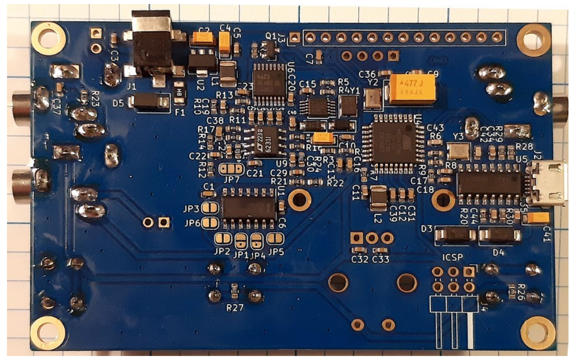


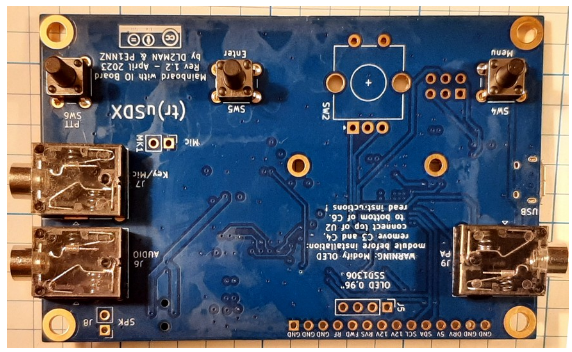




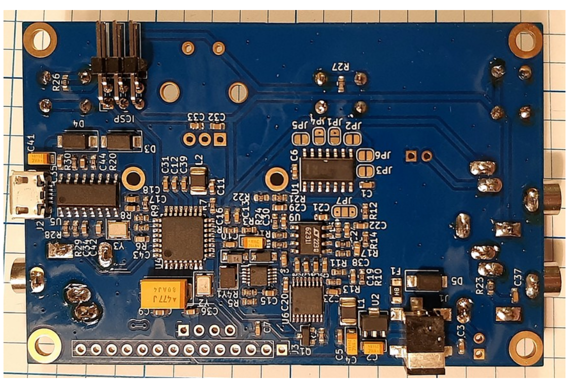
4.1.3.2 Install Push-buttons Track Side

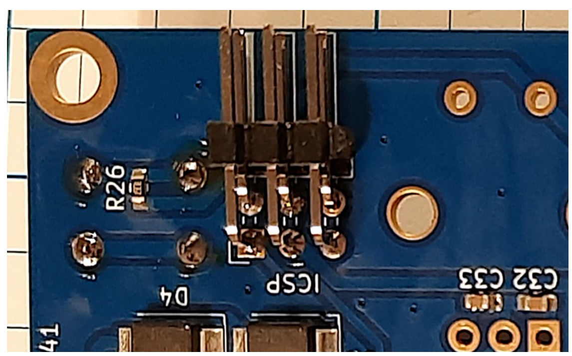




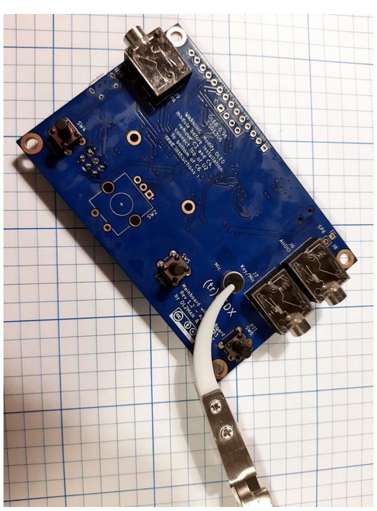


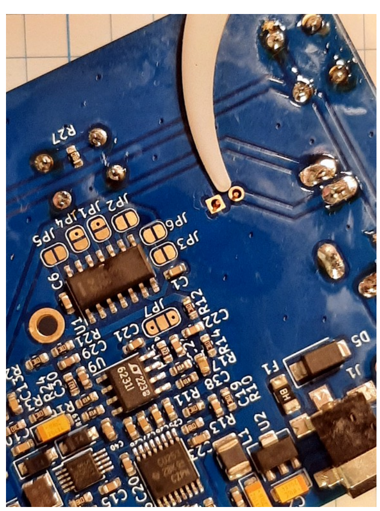
4.1.3.3 Install ISP Connector Component Side

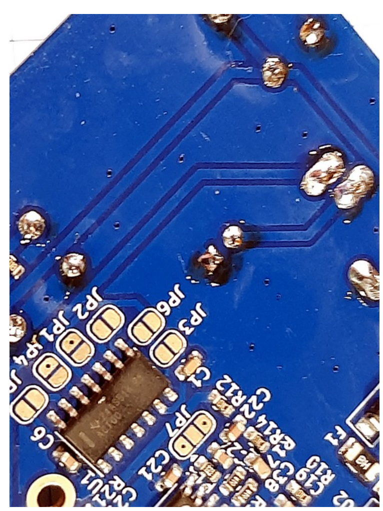




4.1.3.4 Install Microphone



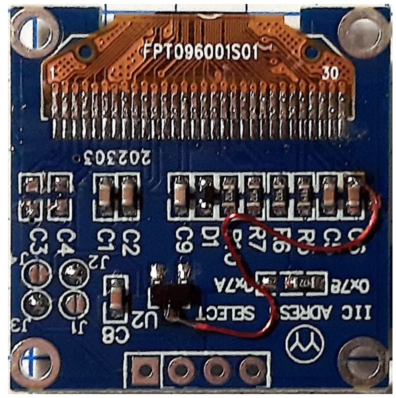




4.1.3.5 OLED

OLED installation requires modification, preparation, and installation.

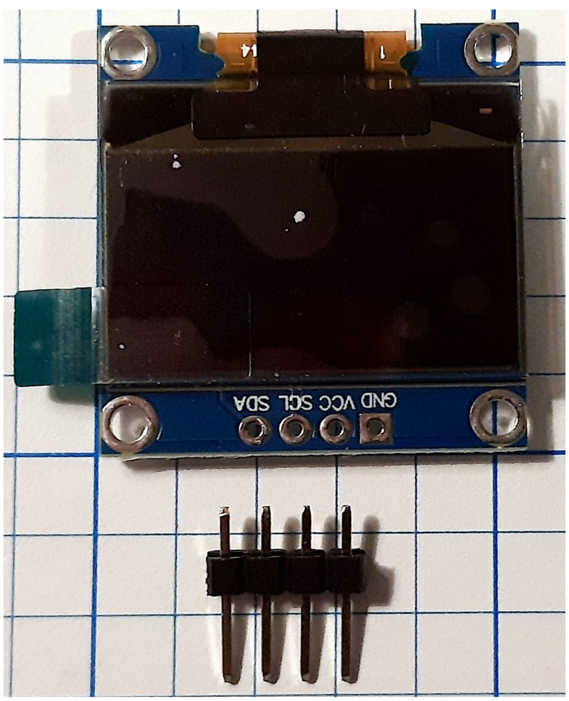
4.1.3.5.1 OLED Modification

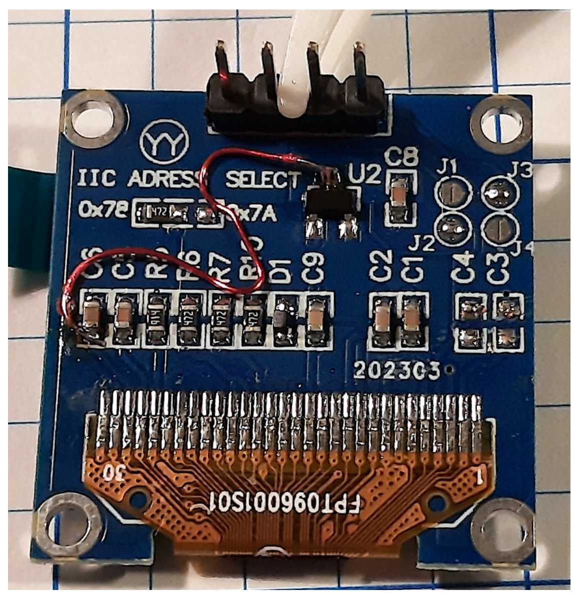


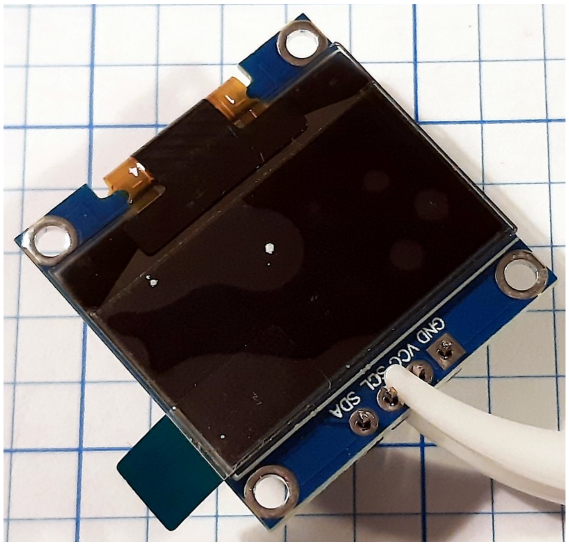
First, you must modify the OLED module by removing C3 & C4 with a hot soldering iron that has a tip big enough to melt the solder at both ends of each capacitor simultaneously, then connect the top of U2 to the bottom of C6 with a piece of wire. I chose to use lacquer insulated copper wire because it is easier to handle than a short piece of PVC insulated wire.

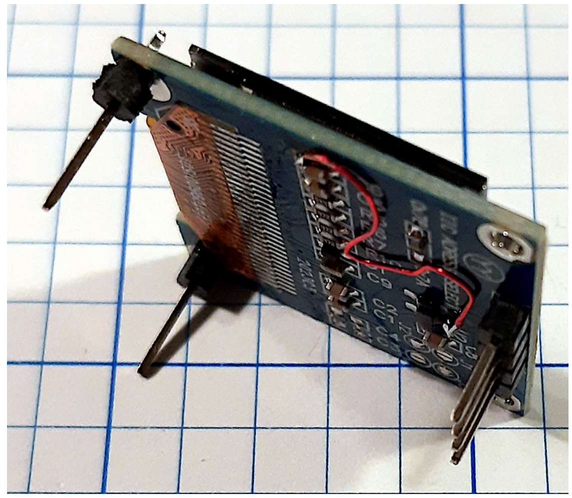
4.1.3.5.2 OLED Preparation

Prepare the OLED by installing the inter-PCB connector and the support posts that are single pieces cut from a header strip. First, install the inter-PCB connector on the OLED then loosely place the support pins in the main PCB with the OLED PCB in position on top. Solder the OLED to the support pins. Doing it this way will ensure that you have the pins correctly aligned. Finally, remove the prepared OLED ready for final installation.







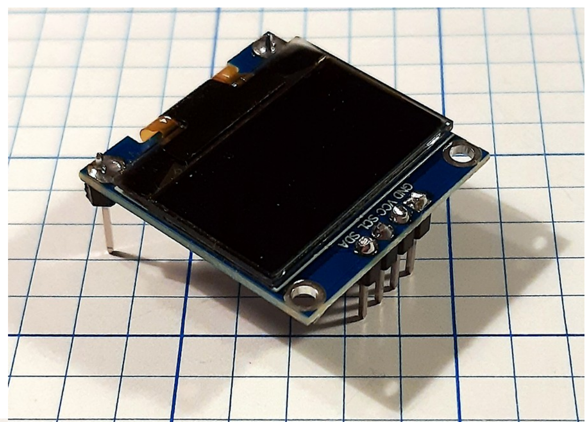


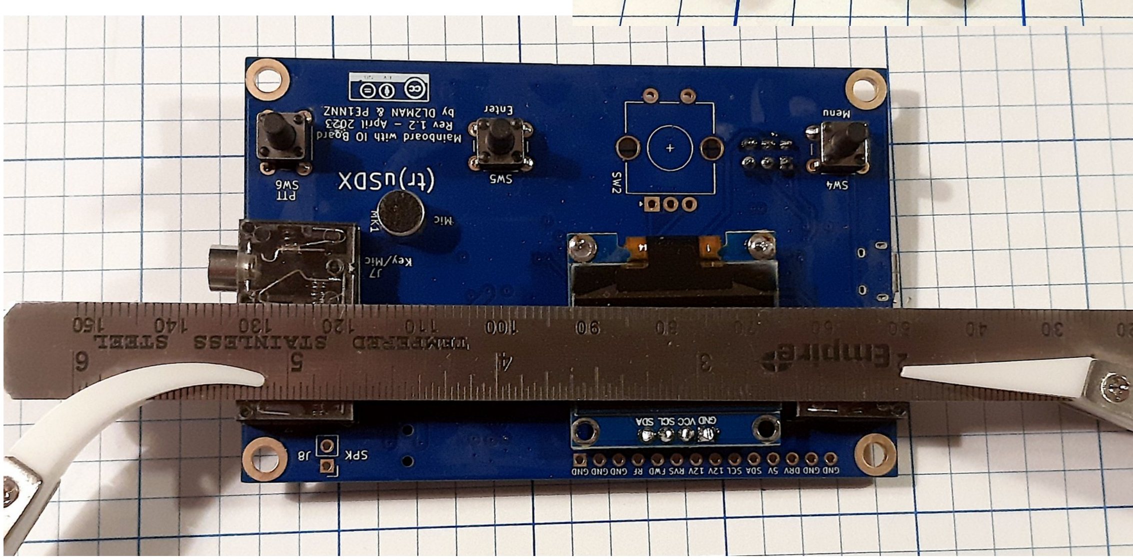
4.1.3.5.3 OLED Installation

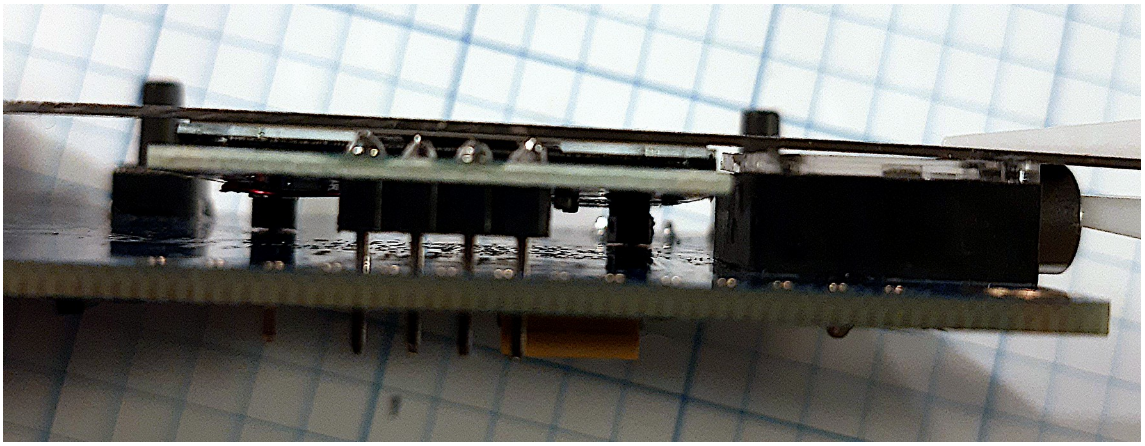
Loosely mate the OLED PCB with the main board.

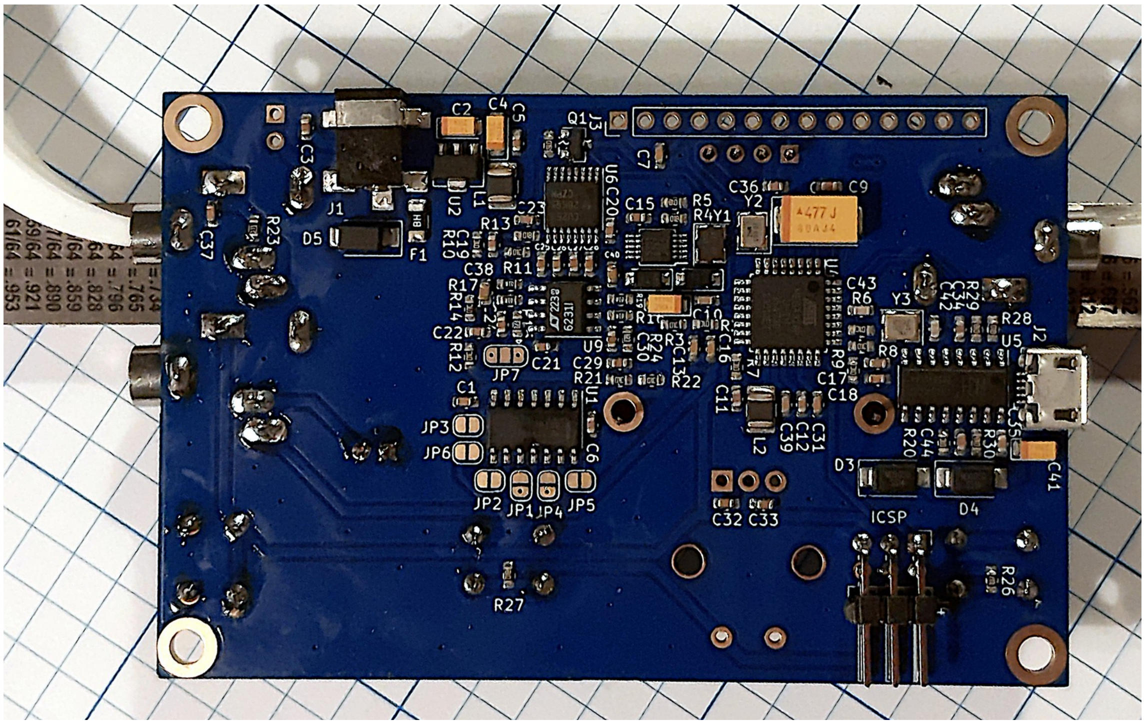
Using reverse tweezers, clamp a 6-inch machinist's rule across the jacks to act as a stop against which the OLED can rest while soldering it in place.

This ensures that the face of the OLED is exactly level with the underside of the enclosure opening.



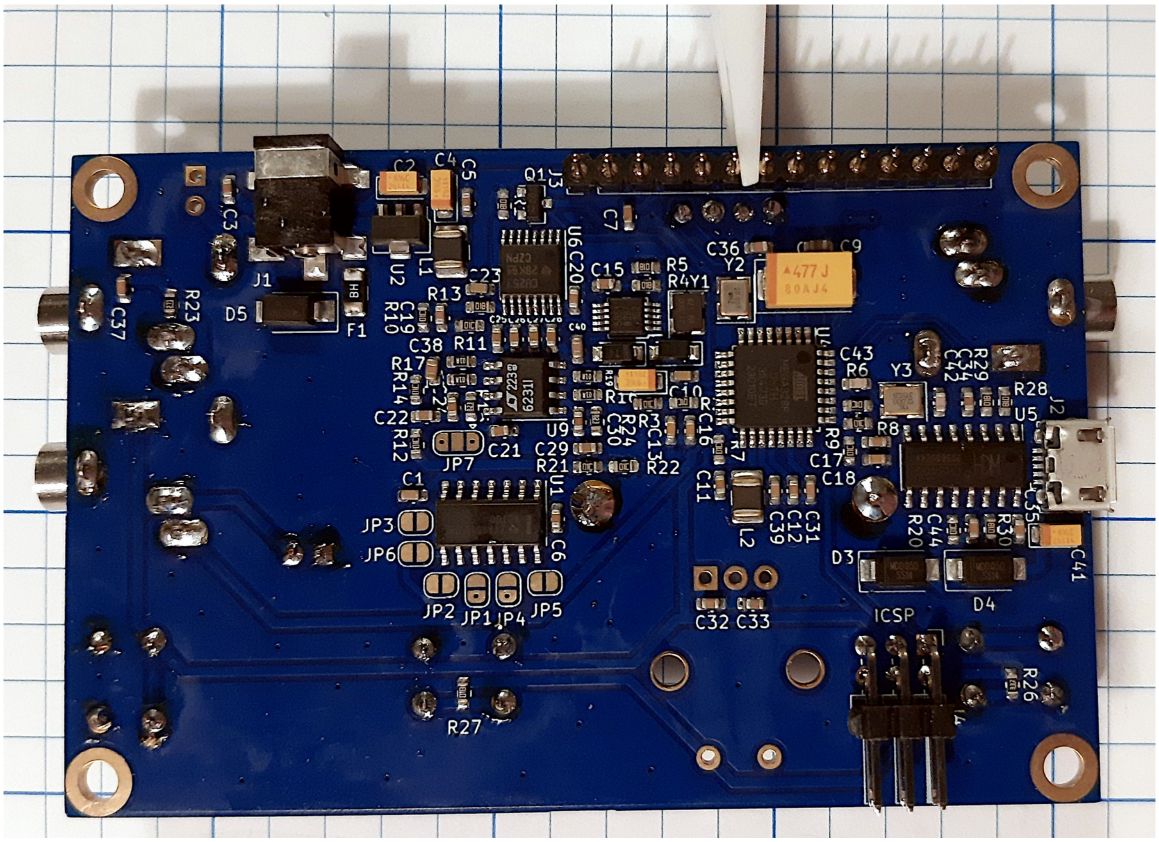





C2
C4
C5
Q1
J3
C3
C7
J1
D5
U2
L1
F1
C37
R23
C36
C9
Y2
C15
R5
R4Y1
C43
R6
Y3
R28
U5
J2
C17
C18
JP7
C21
C1
JP3
JP6
JP2
JP1
JP4
JP5
C32
C33
ICSP
D3
D4
C41
R27
R26

4.1.3.6 Install Inter-PCB Connector

Installing the inter-PCB connector between the main board and the RF board is much easier when you clamp the pin-strip to the main board using a pair of reverse tweezers. Once clamped and straight, solder one pin of the pin-strip then remove the tweezers and check to ensure that the strip is straight before soldering the remaining pins. The pin-strip is inserted from the component-side of the main board.



4.1.3.7 Install Rotary Encoder

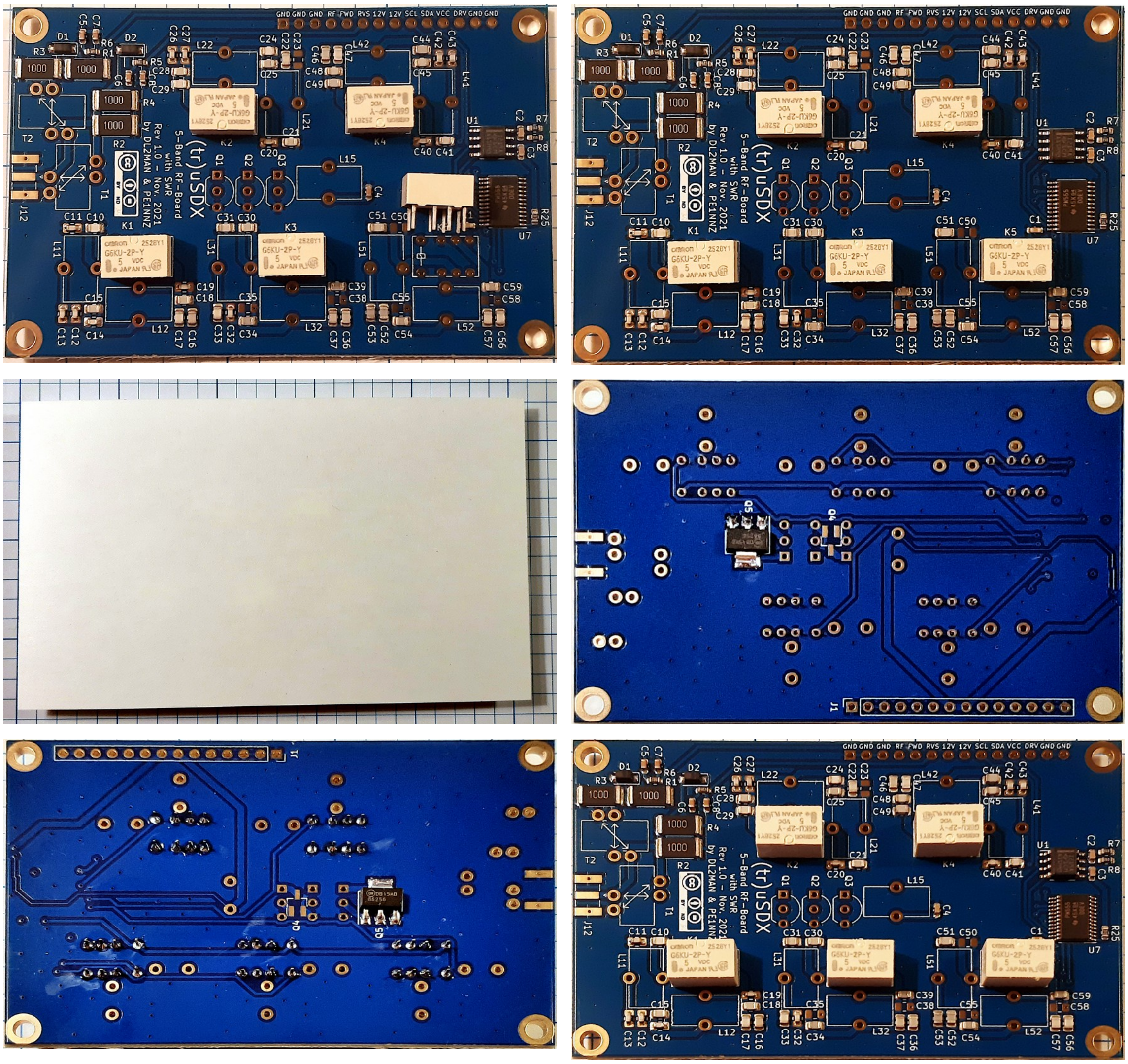
Installing the rotary encoder on the same side as the push-buttons and jacks should be straightforward, once you cut the anti-rotation peg from the body of the encoder with a pair of diagonal cutters.

Clamp the encoder in place with a pair of reverse tweezers to ensure that it is flat against the PCB before soldering.

4.1.4 RF Board Assembly

4.1.4.1 Install Relays

The band-switch relays are through-hole mounting. Loosely insert the relays. Place a piece of card over the relays. Keeping the card in place with one hand, turn over the RF board and place it on a flat surface with the card between the top of the relays and the surface. The card holds the relays in place while turning the board to expose the track side for soldering of the relay pins.



4.1.4.2 Install Inductors and Transformer

Refer to Figure 8, sheet-6 of the schematics, showing the band slots for the Classic band.

When winding the toroids and transformers, each passage of the wire through the toroid represents a single turn; so, for seven turns there will be seven loops of wire through the toroid, or seven passes of the wire through the center of the toroid.

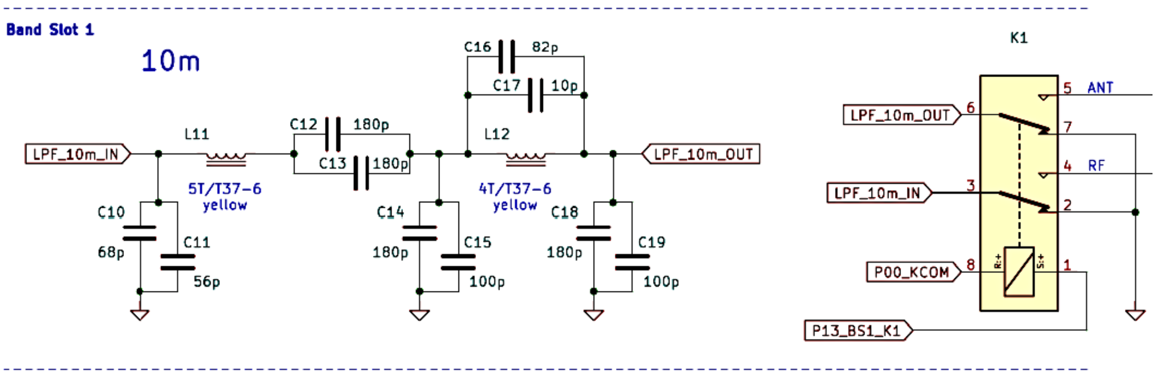
Loop the wire turns firmly, not overly loose nor overly tight.

Once you have wound each toroid, carefully scrape the insulating lacquer from the ends of the wire to expose the conductive copper. Thread the ends of the windings through the corresponding mounting holes in the PCB, then twist the wire ends together on track side of the board to hold the inductor in place in preparation for soldering.

When you have all inductors soldered in place, trim excess wire with diagonal cutters, and then evenly distribute the windings around each toroid using your fingernail or plastic tool. DL2MAN says that on the higher bands, the difference between close and open windings is as much as 5 MHz.

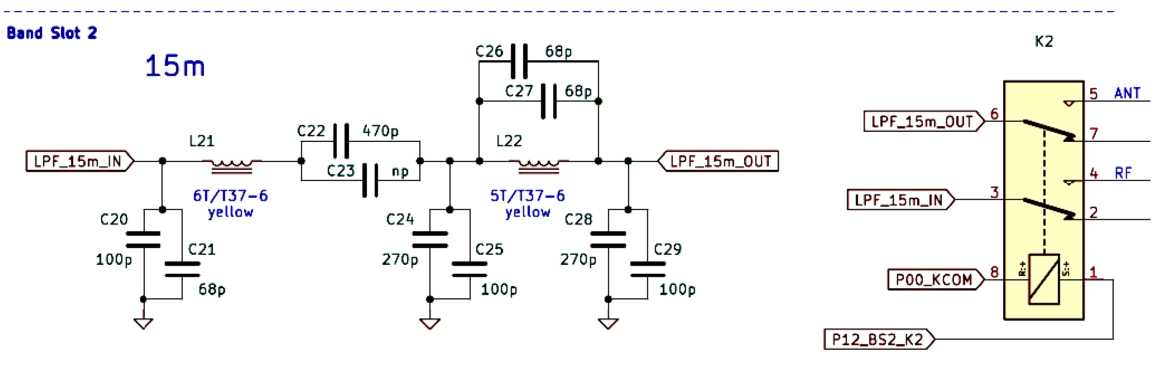
4.1.4.2.1 Band Slot 1 for 10 m

Inductor L11 is five turns on a yellow toroid, inductor L12 is four turns on a yellow toroid, as shown in the following schematic extract.



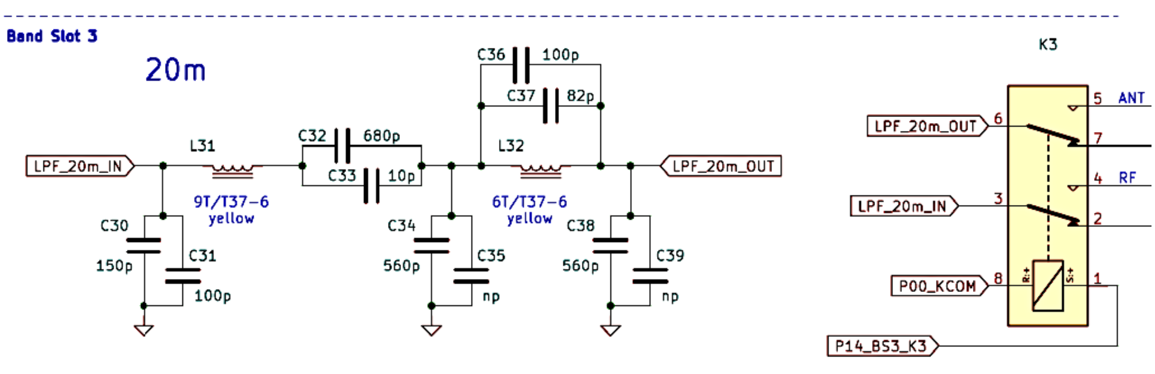
4.1.4.2.2 Band Slot 2 for 15 m

Inductor L21 is six turns on a yellow toroid, inductor L22 is five turns on a yellow toroid, as shown in the following schematic extract.



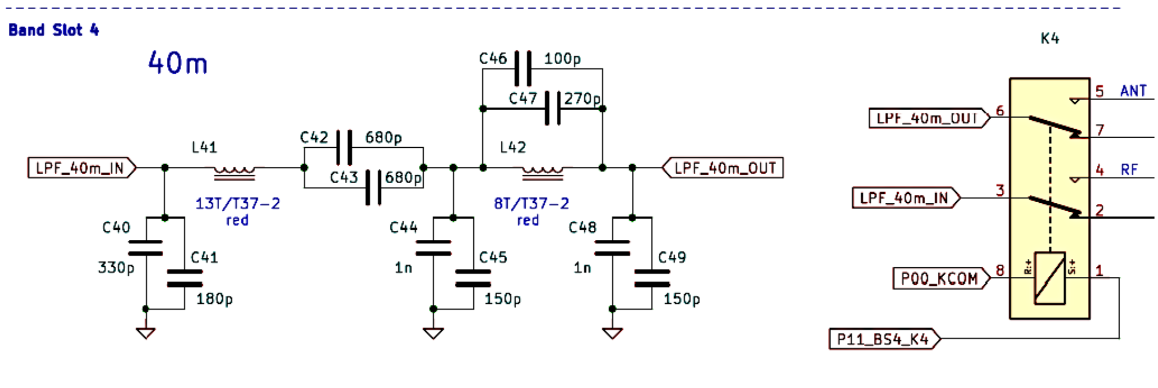
4.1.4.2.3 Band Slot 3 for 20 m

Inductor L31 is nine turns on a yellow toroid, inductor L32 is six turns on a yellow toroid, as shown in the following schematic extract.



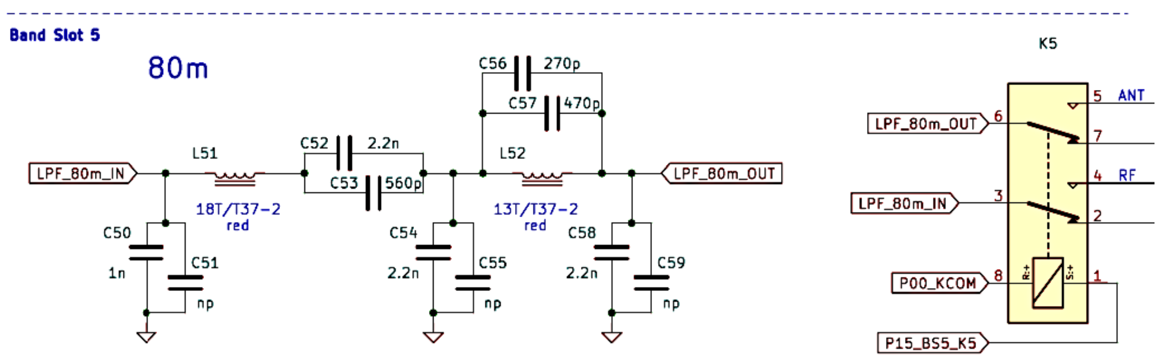
4.1.4.2.4 Band Slot 4 for 40 m

Inductor L41 is thirteen turns on a red toroid, inductor L42 is eight turns on a red toroid, as shown in the following schematic extract.



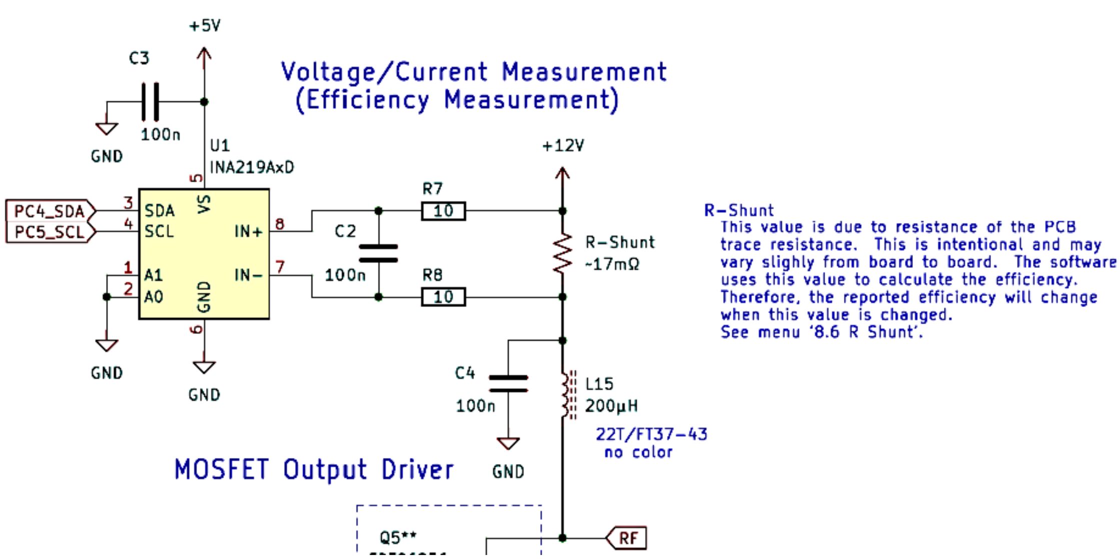
4.1.4.2.5 Band Slot 5 for 80 m

Inductor L51 is eighteen turns on a red toroid, inductor L52 is thirteen turns on a red toroid, as shown in the following schematic extract.



4.1.4.2.6 Inductor L15

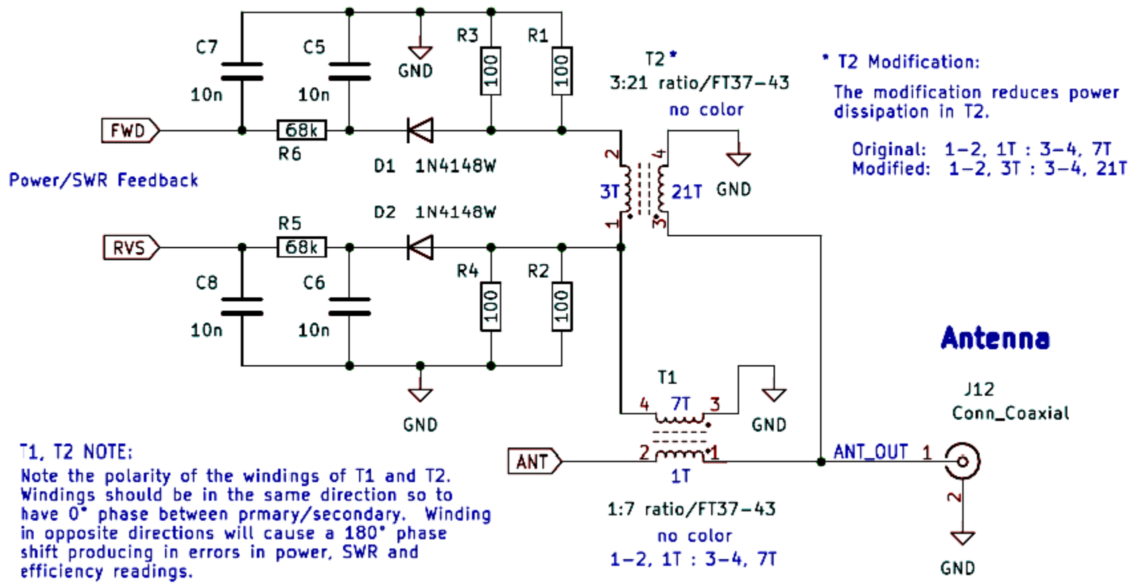
Inductor L15 is twenty-two turns on a no-color toroid, as shown in the following schematic extract.



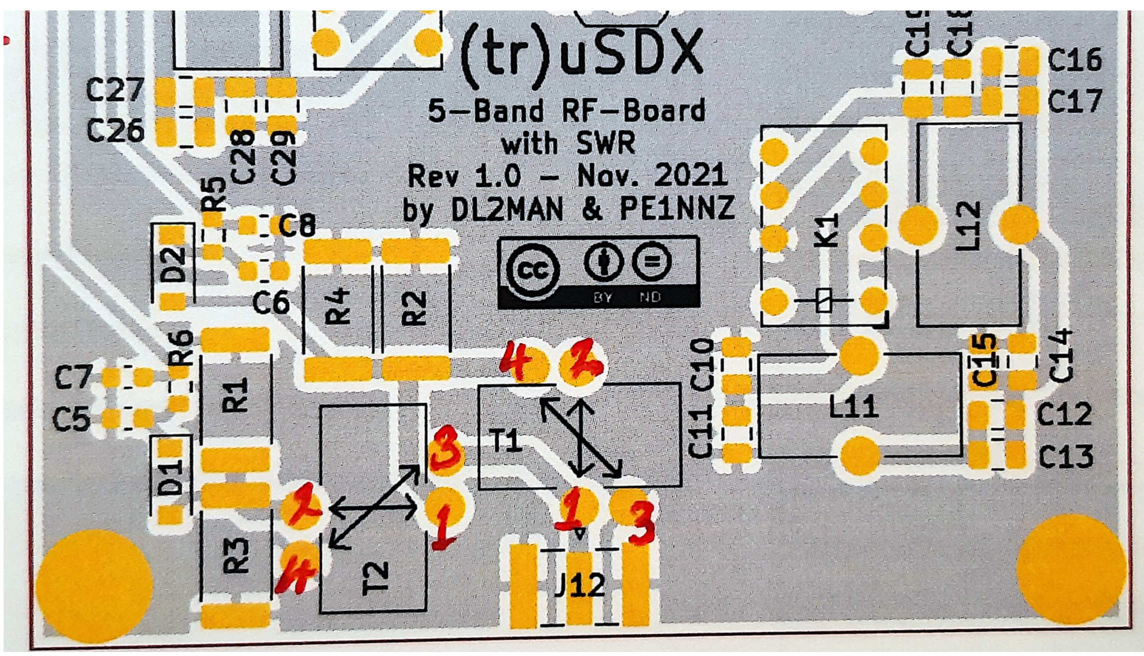
4.1.4.2.7 Transformers T1 and T2

Transformer T1 has a one-turn primary and a seven-turn secondary on a no-color toroid. Pay close attention to the note shown in the following schematic extract and be sure to wind the toroid correctly to avoid a phase inversion between primary and secondary windings.

Transformer T2 has a three-turn primary and a twenty-one-turn secondary on a no-color toroid. Again, pay close attention to the note in the following schematic. Instead of the wire included in the kit, I used 28 AWG wire to ensure that all windings fit comfortably on the toroid, which DL2MAN recommended in one of his videos. Originally, the number of turns was three times less, which caused undesirable heating of the transformer. Overall, the turns-ratio is the same.

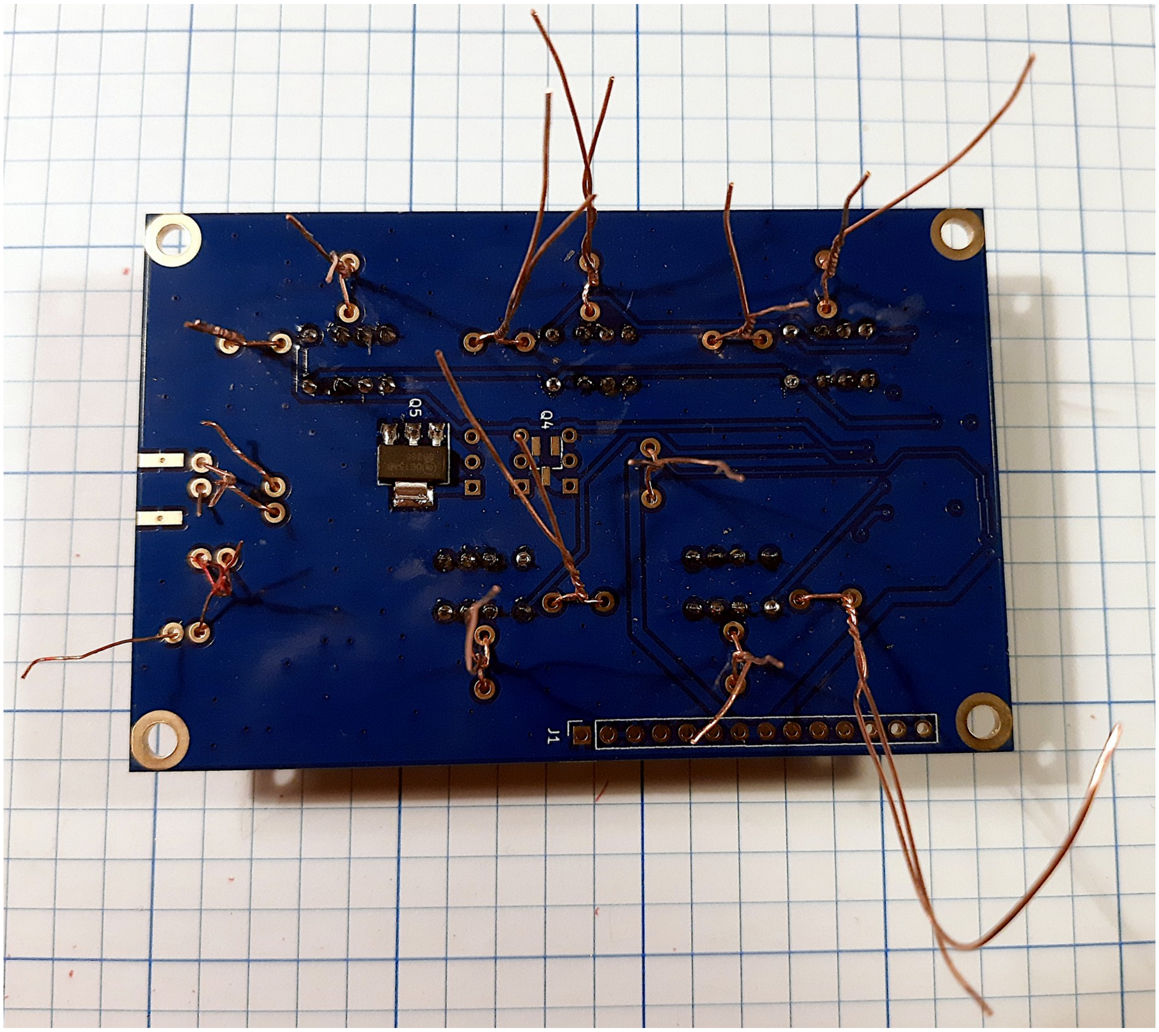


Note the transformer connection numbers and insert into the PCB each transformer as shown in the following image.



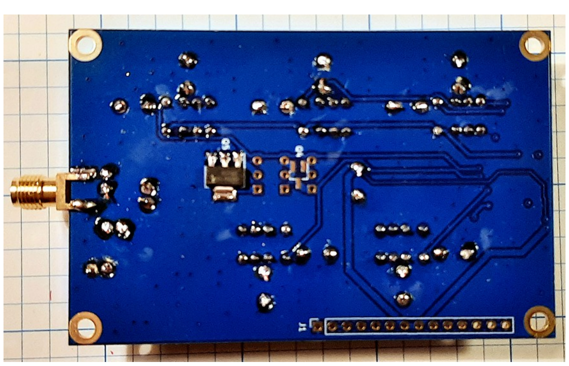
4.1.4.3 Solder the Inductors and Transformers

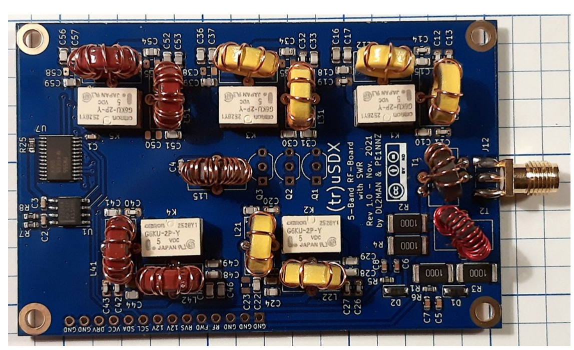
Solder the inductors and transformers in place, being careful to ensure that each connection is good. Trim the excess wire lengths from the board after the soldering operation.



4.1.4.4 Install the Antenna Connector J12

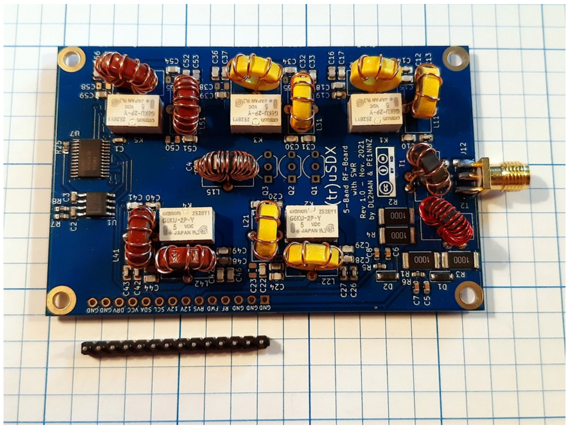
Install the antenna connector J12, holding it in place with reverse tweezers then solder the signal connection first, remove the tweezer and then solder the remaining ground connections. Be careful to ensure that it is perpendicular to the edge of the PCB.

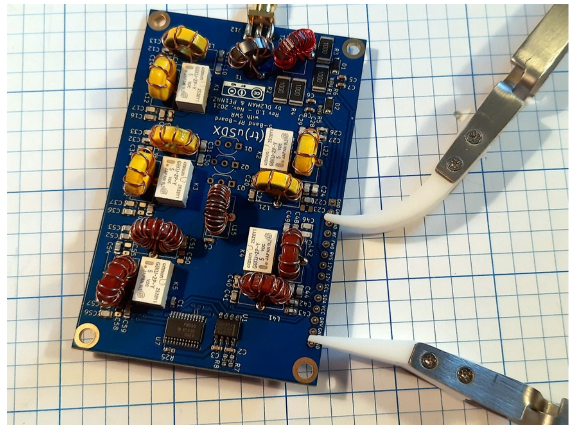




4.1.4.5 Install Inter-PCB Connector

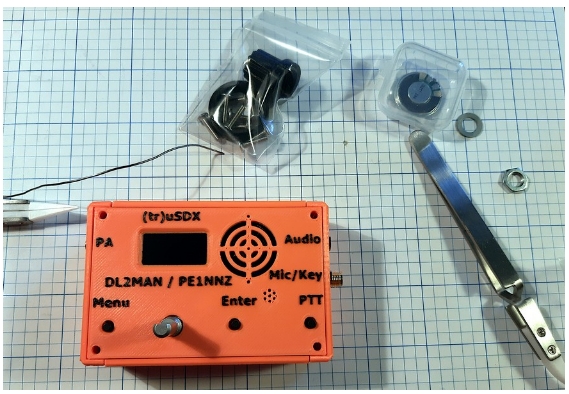
Install the inter-PCB socket on the RF board and clamp it in place with reverse tweezers as shown below. Solder one pin first then check the alignment of the connector and adjust as needed. Finally, remove the tweezers and solder the remaining pins.





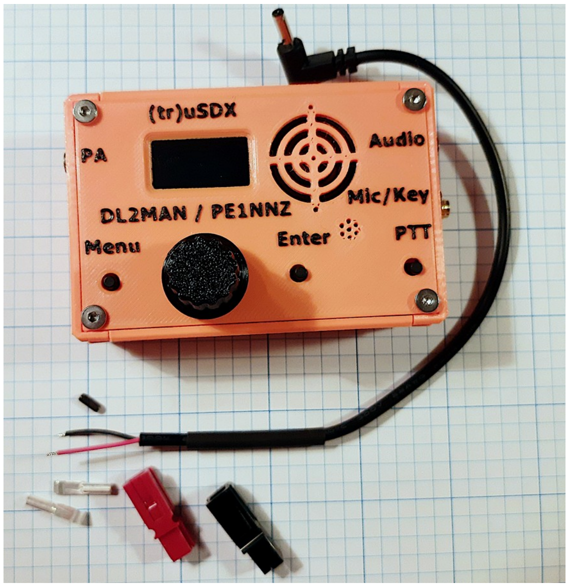
4.1.5 Final Assembly

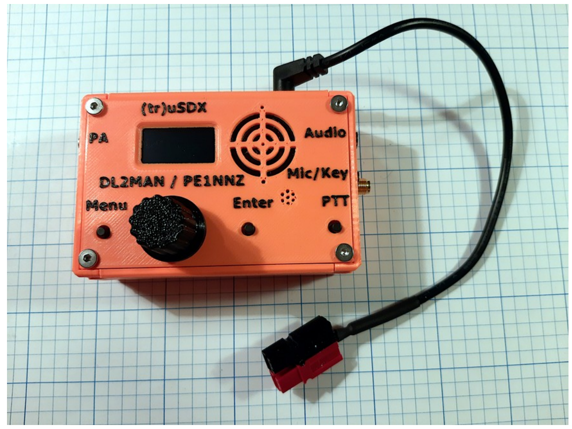
Final assembly is somewhat fiddly. Review the process as shown by DL2MAN in his construction video, https://youtu.be/VVGBapoCUls?t=1751, which includes installing the loudspeaker.



4.1.6 Power Connector

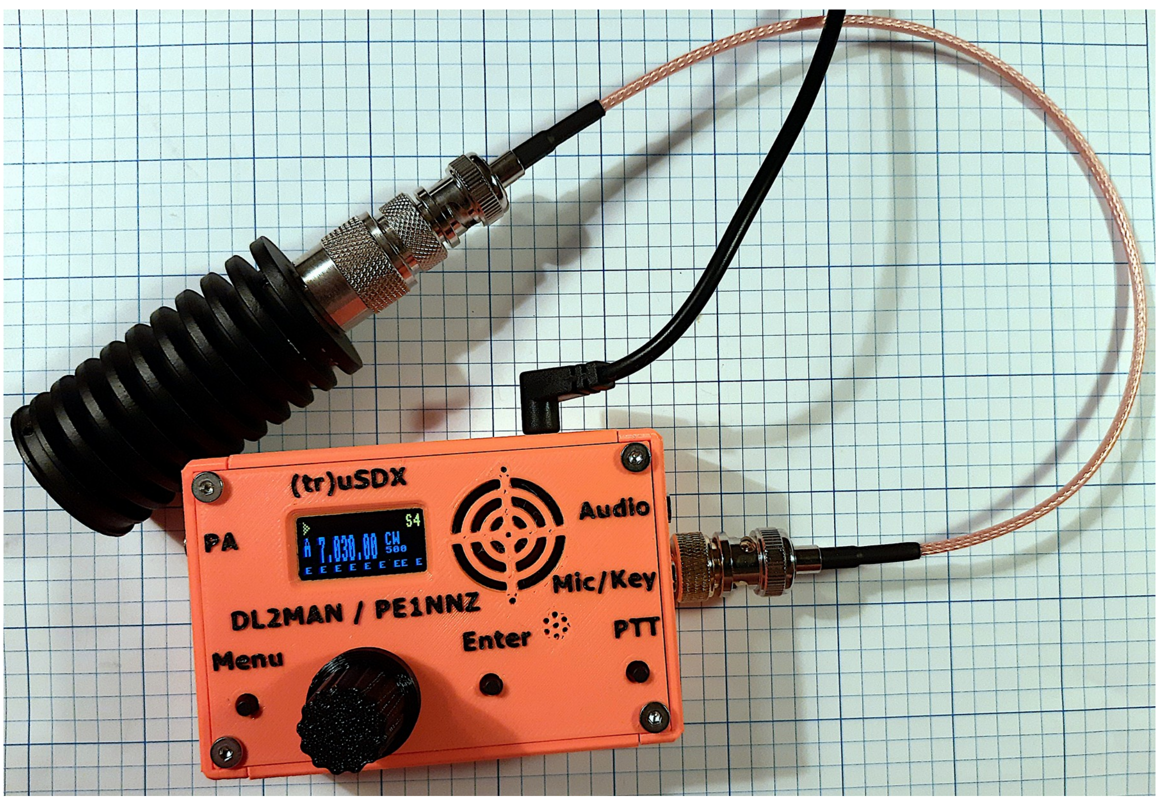
To make operation easier, install Anderson PowerPole connectors on the individual wires of the power-cord pigtail. I added a piece of heat-shrink tubing pushed up against the PowerPole connectors as a final nice touch.





4.1.7 Power-on Test

As you can see in the image below, the transceiver powered on and worked immediately. Default setting is Lo band, which meant that I had to change menu item *8.7 LPF Config* from *Lo* to *Classic*, cycle power and then check availability of the correct bands.



5 Firmware

Updating the firmware under Linux is easy. I derived these instructions from the YouTube video by KB9RLW [3].

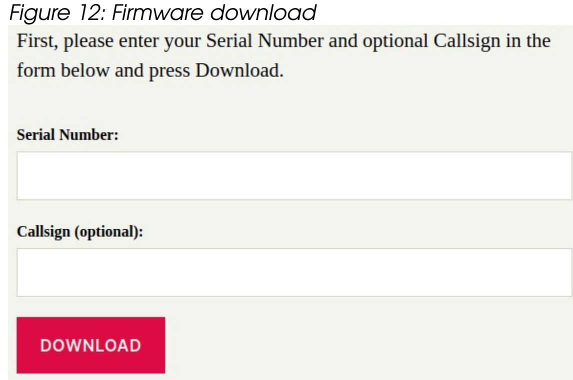
5.1 Firmware Download

- Go to this URL:

  https://dl2man.de/3b-trusdx-firmware/

- Scroll down to the section shown in Figure 12 and enter serial number of the (tr)uSDX and your call-sign then click on the Download button.
- Move the firmware hex file to a convenient location.

Figure 12: Firmware download



5.2 Firmware Programmer

If not on your computer already, download the AVRDUDESS programmer, which is a GUI for AVRDUDE, a tool for programming Atmel microcontrollers.

- Go to this URL:

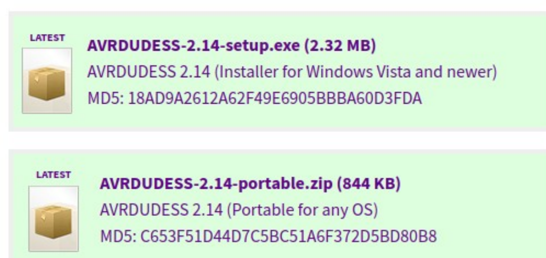
  https://blog.zakkemble.net/avrdudess-a-gui-for-avrdude/

- Scroll down to the downloads section and download the portable version of the application.
- Verify integrity of the download by checking that its MD5 hash matches that shown on the webpage, using md5sum.

  C653F51D44D7C5BC51A6F372D5BD80B8

- Move the application to a convenient location and unzip the archive file.

Figure 13: AVRDUDESS download



5.3 Mono Installation

AVRDUDESS requires the presence of Mono. Install mono using this command:

- `sudo apt-get install libmono-system-windows-forms4.0-cil`

5.4 AVRDUDE Installation

Now install AVRDUDE that underlies the AVRDUDESS GUI:

- `sudo apt-get install avrdude gcc-avr`

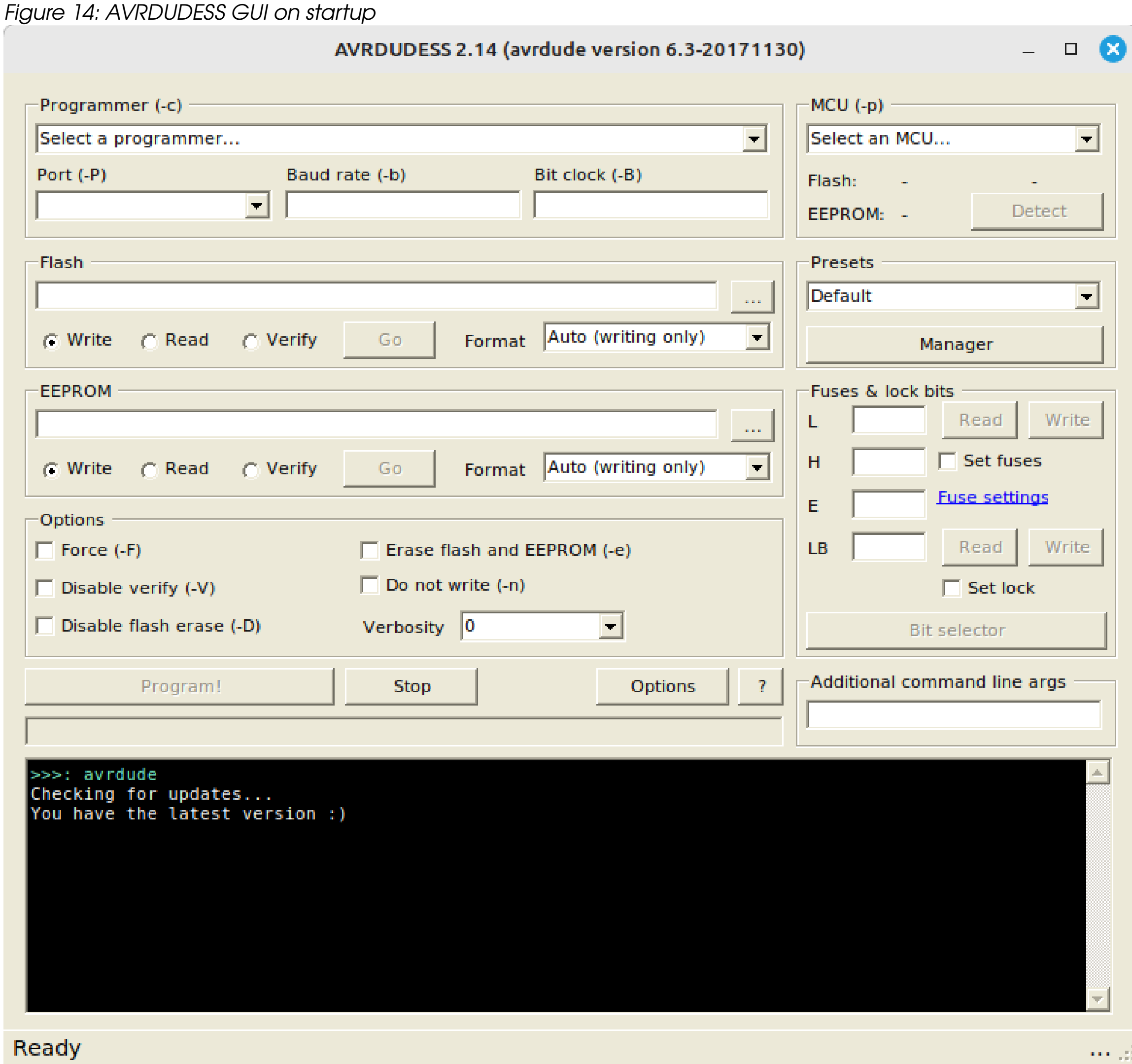
5.5 Running AVRDUDESS

Run the AVRDUDESS GUI using this command line:

- mono avrdudess.exe

Figure 14 below shows the AVRDUDESS GUI on startup.

Figure 14: AVRDUDESS GUI on startup



5.6 Bootloader

If you don't see your Serial Number on the Display after powering up your device, you either have a hardware defect, or there is no Bootloader installed.

5.6.1 Bootloader Installation

Thus far, I have had no need to install the bootloader because the manufacturer of the kit did so before shipment to me. Sometime in the future, I may expand this section to include detailed instructions, meanwhile here is the link to the procedure described on DL2MAN's website: https://dl2man.de/3a-trusdx-bootloader/.

5.7 Firmware Update

It is important that before you flash new firmware to an already programmed and operating (tr)uSDX, you record the following parameters that writing new firmware to the device will overwrite. After firmware upgrade, reenter your recorded values.

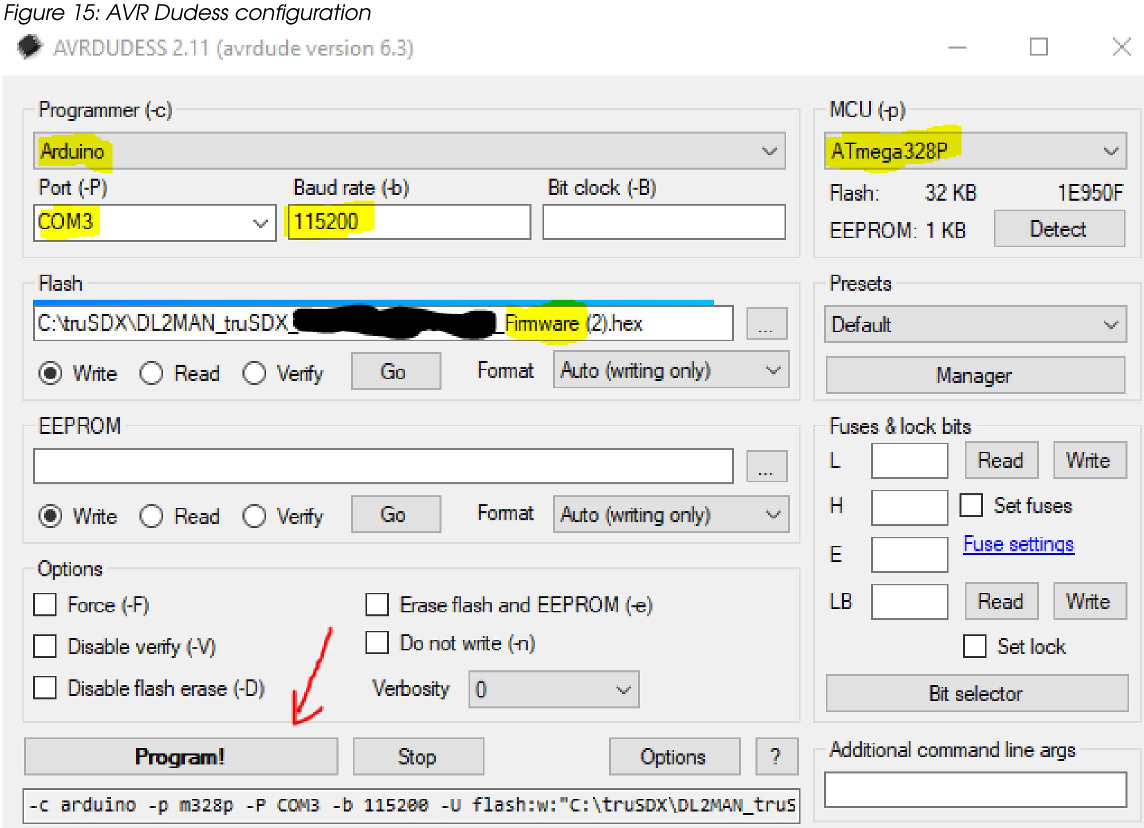
- 8.3 Ref Frequency
- 8.7 LPF Config (Lo, Hi, Classic depending on the RF board)
- 8.2 PA Bias max (128 for BS170, 160 for FDT86256)
- 8.6 Rshunt (potentially to correct power efficiency measurement errors)

5.7.1 Firmware Installation

Install new firmware on the (tr)uSDX as follows:

- Connect the (tr)uSDX to a USB port on a computer running the Linux operating system. In my case, this is Linux Mint.
- Start AVR DUDESS and adjust the settings to look similar to Figure 15.

Figure 15: AVR Dudess configuration



- In the *Flash* entry of Figure 15, select the path to the previously downloaded firmware.
- The *Port (-P)* selection should be something like */dev/ttyUSB0*.
- Once you have set all the parameters correctly, click on the *Program!* Button to send the firmware to the (tr)uSDX.
- For a video explanation, see the one by KB9RLW in Ref-[3].

6 Frequency Calibration and Verification

Before putting the rig OTA, check calibration of the frequency, and that the RF signal is normal.

6.1 Frequency Calibration

I calibrated the frequency as described in paragraph 8.3 Ref Freq. You could adjust the frequency by adjusting the 8.3 Ref Freq to align the spectra as shown in the following paragraphs.

6.2 Frequency Verification

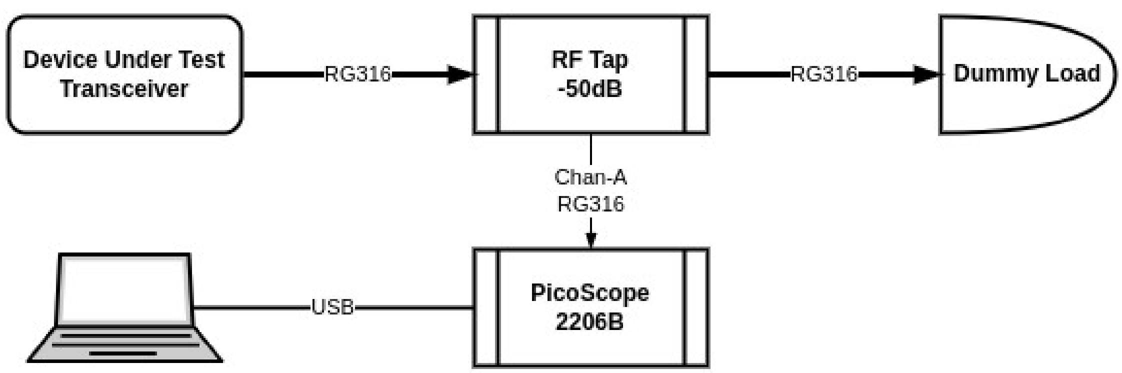
As amateur radio operators, we are required to perform due diligence, but, more importantly, I wanted to be reasonably certain that the (tr)uSDX kit does not cause interference.

My problem is that I am at the bottom of the RF analysis learning curve, whereas Yaesu, the manufacturer of my radios does know what they are doing and don't put troublesome rigs on the market.

Solution to my problem is to compare the spectral output of the (tr)uSDX transceiver kit against that of my FT-818ND. So, I used my PicoScope to capture spectrum views of my FT-818ND and of the (tr)uSDX for each of the five bands, using the same PicoScope configuration and test environment for each radio.

6.2.1 Test Environment

Below is a block diagram of my test environment.



Pico Technology Ltd. don't believe in instruction manuals for their products, which means that novice users would have to spend much time exercising a search engine then trolling through results and watching how-to videos to familiarize themselves with the equipment.

Fortunately, I at least know what an oscilloscope looks like, and was able to do what I needed to do by guessing, informed by prior experience, trial and error.

Initially, since my equipment is QRP at 5W, I thought that the PicoScope ±20V input range meant that I could tap the raw RF signal directly using a BNC Tee adapter, but the spectrum view flashed an over-range warning, In response, I installed a -50dB resistive tap to attenuate the signal input to the PicoScope.

6.2.2 Test Methodology

Using this environment, I captured the RF spectra output from the FT-818ND and the (tr)uSDX at the center of each amateur radio band. What follows in paragraph

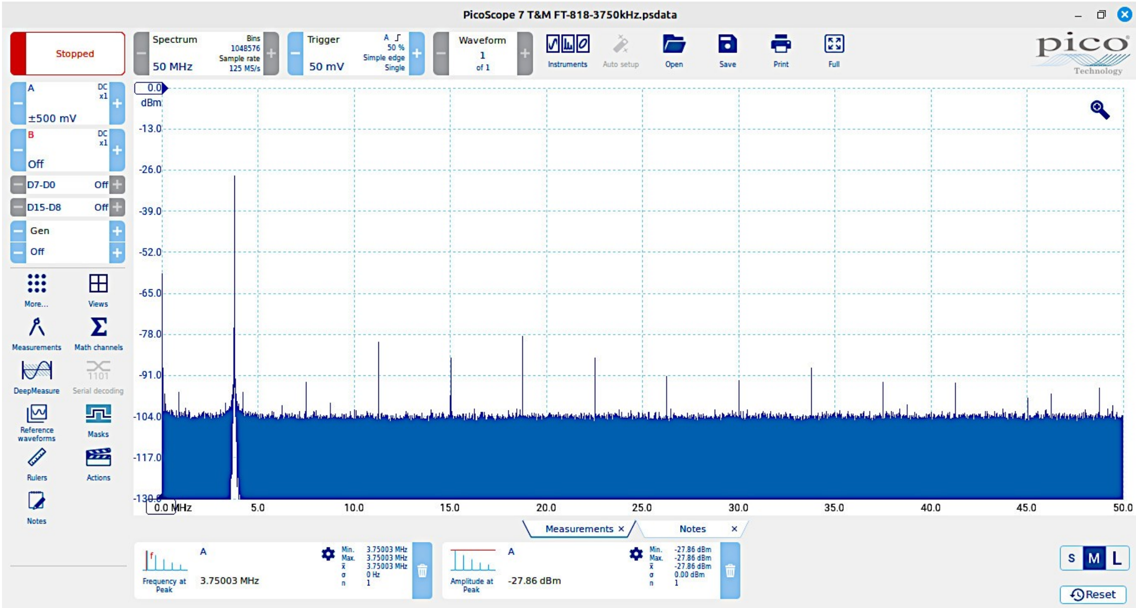
6.2.3 is a side-by-side comparison of the FT-818ND, the raw (tr)uSDX spectra on first application of power, and the (tr)uSDX calibrated spectra for each band.

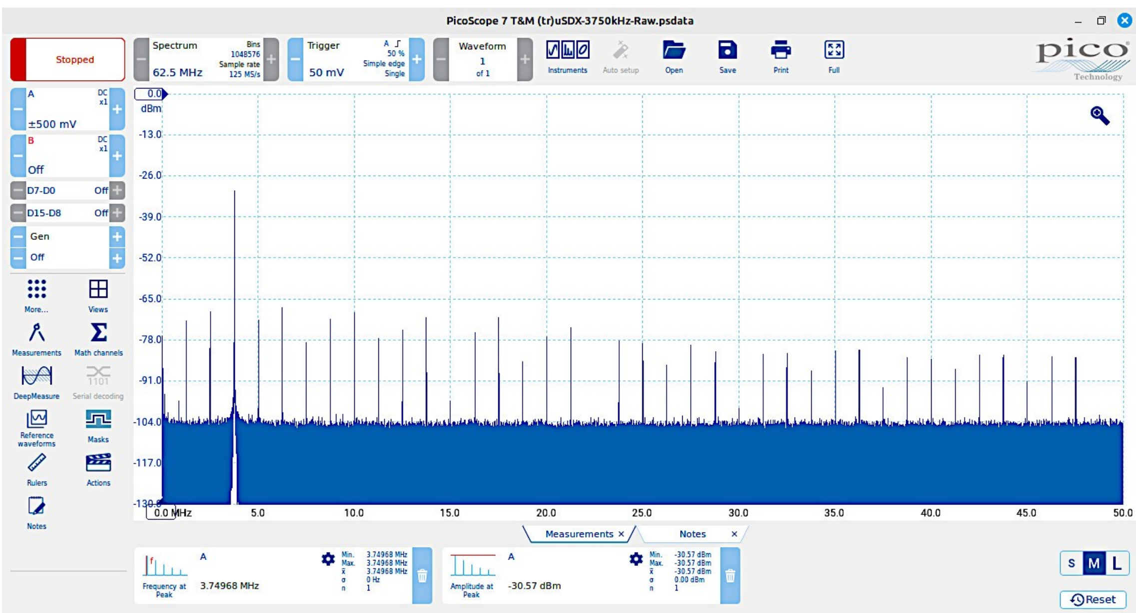
I set the PicoScope spectrum view to its maximum bandwidth and maximum number of bins with one-shot triggering on a rising edge above a threshold of 50 mV, which seemed to work in that nothing happened until I keyed the transceivers in CW mode at full power, giving me a usable display using the rectangular window function.

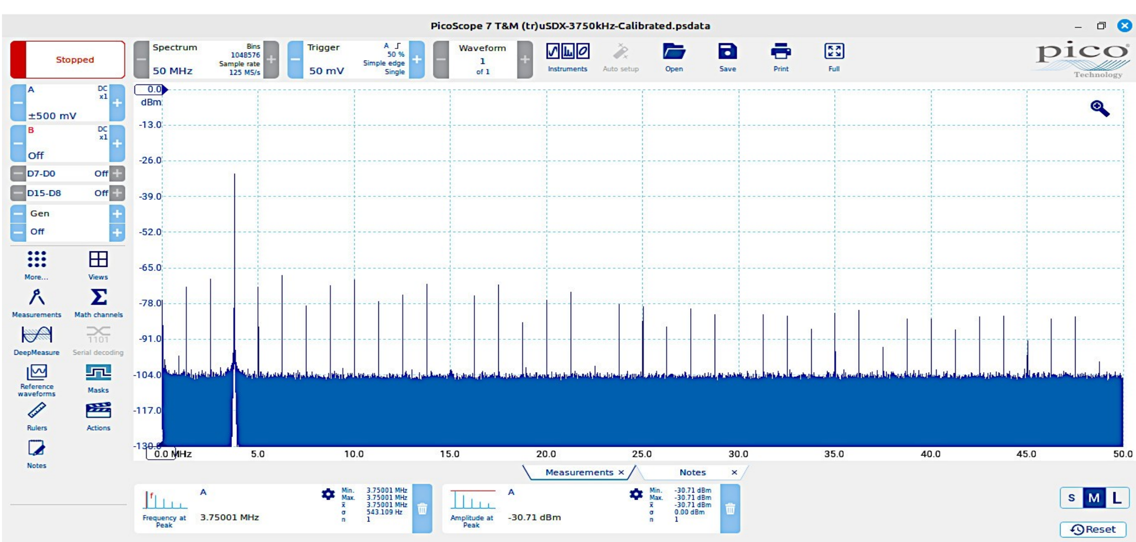
6.2.3 Spectral Comparisons

In the following sub-paragraphs, for each band there is first a screenshot of the spectrum view for the Gold-standard Yaesu FT-818ND, in the next screenshot is the spectrum view of the (tr)uSDX as it appeared after initial application of power following assembly, and the last screenshot is the spectrum view after calibration of the frequency.

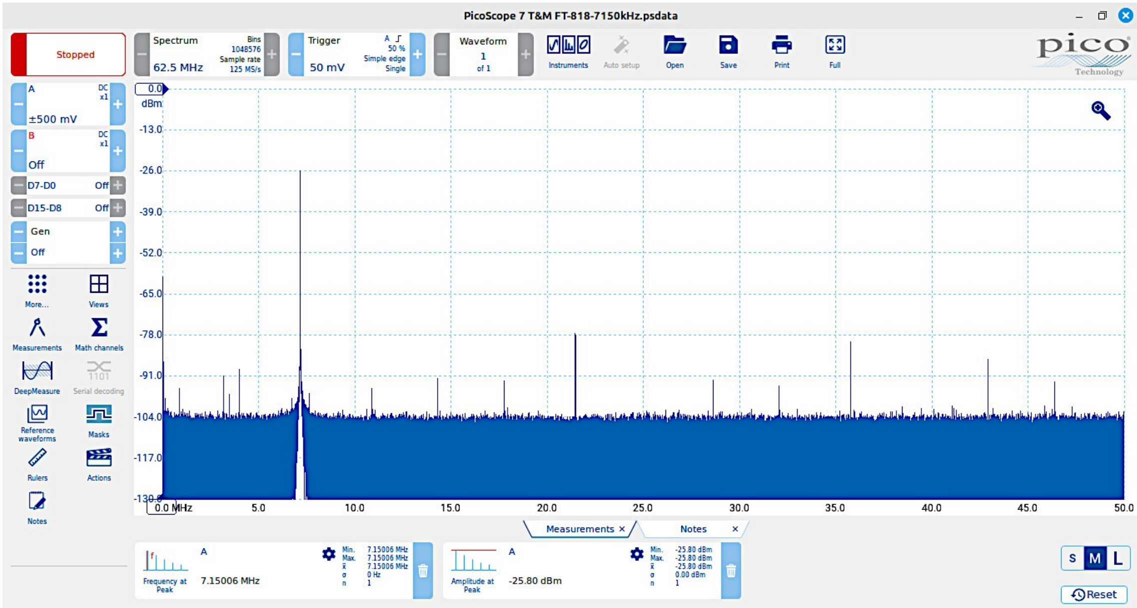
6.2.3.1 80 Meters at 3750 kHz

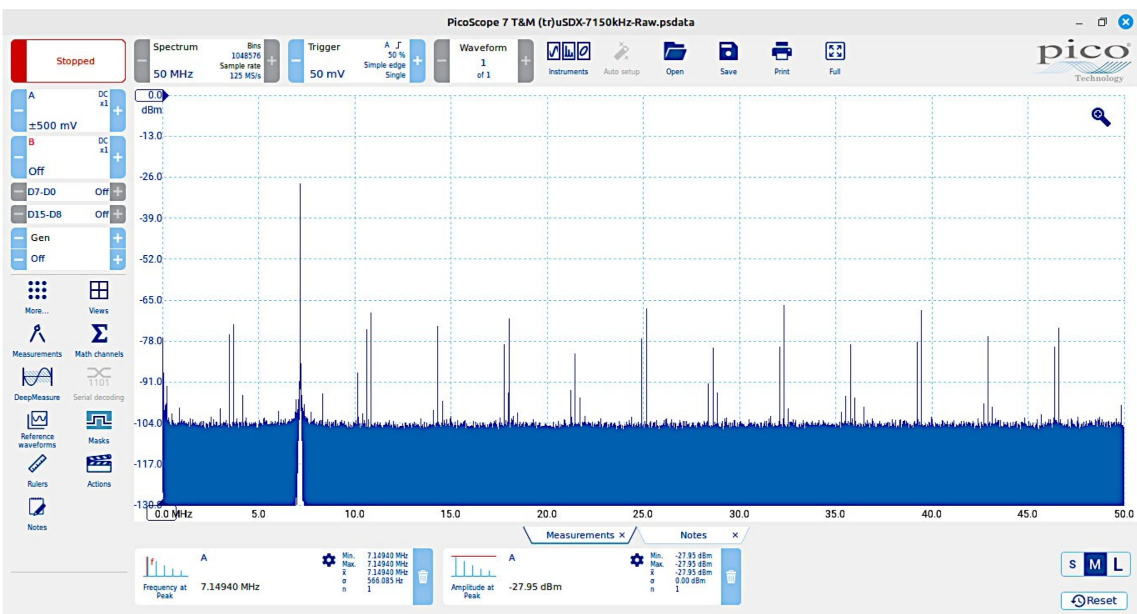


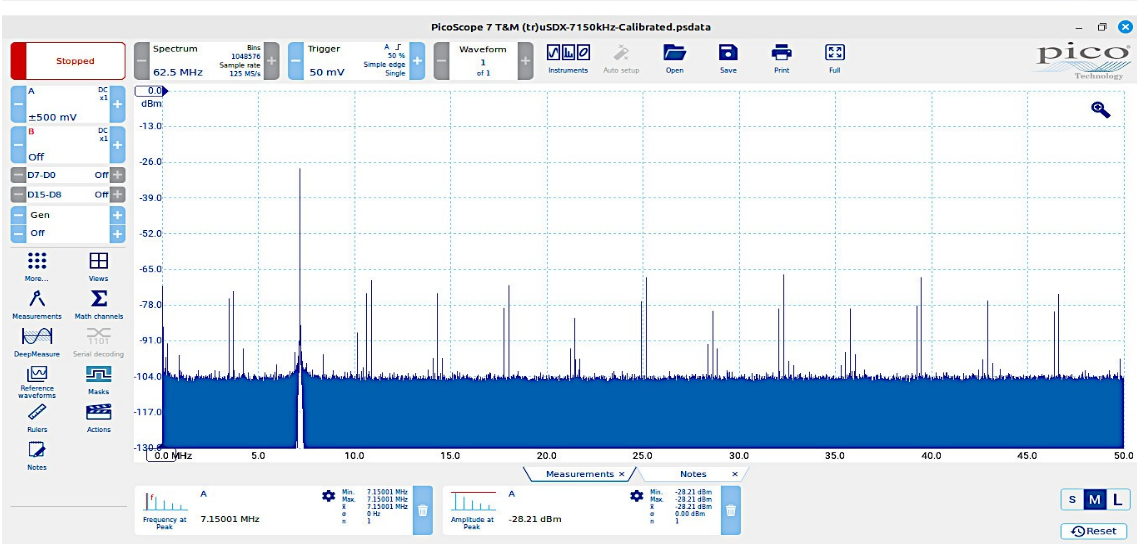




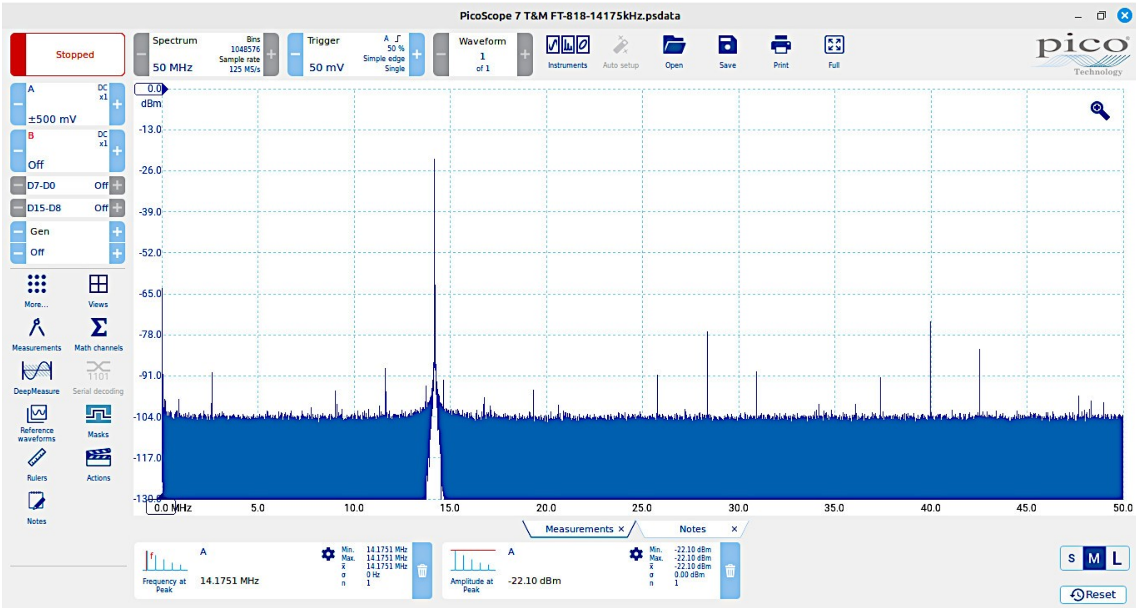
6.2.3.2 40 Meters at 7150 kHz

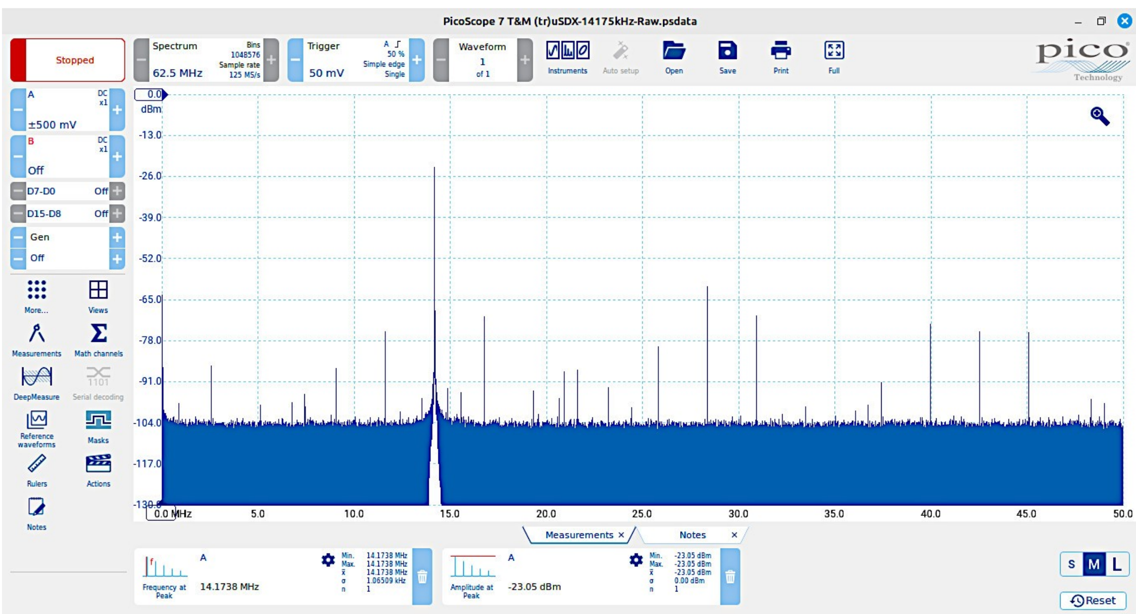


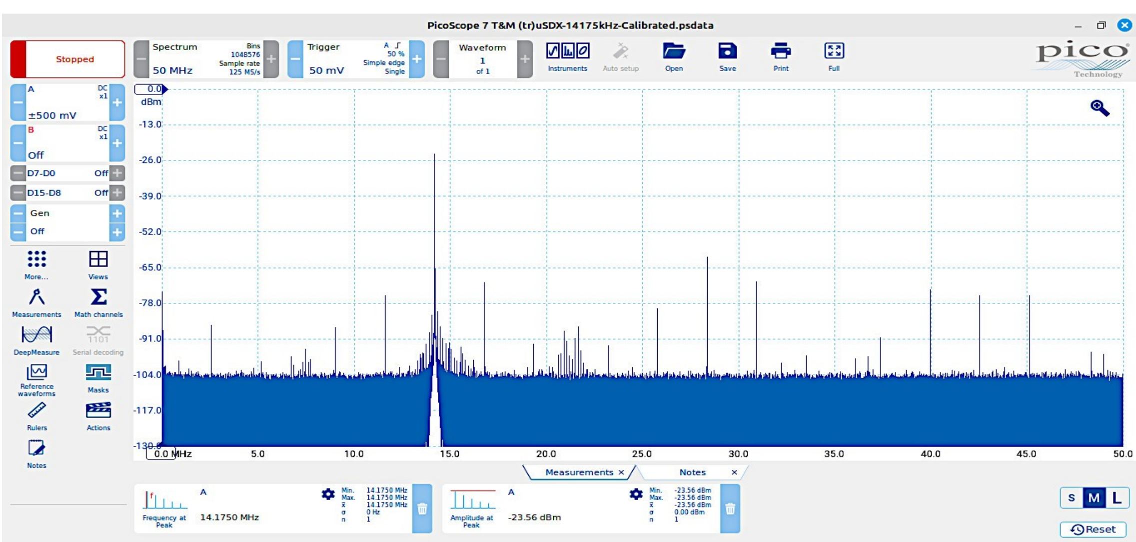




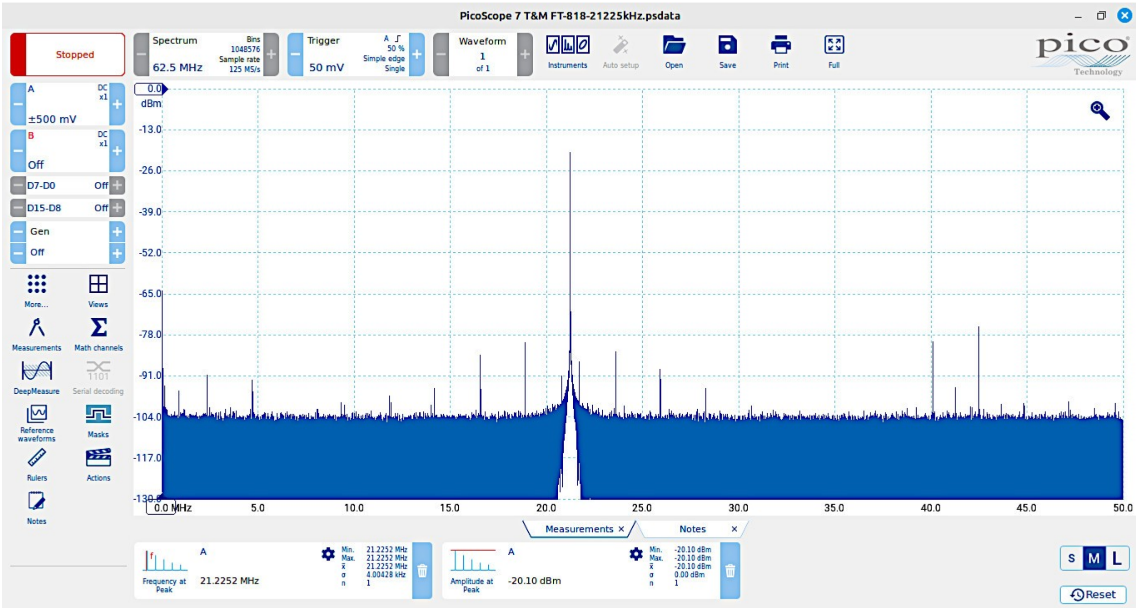
6.2.3.3 20 Meters at 14175 kHz

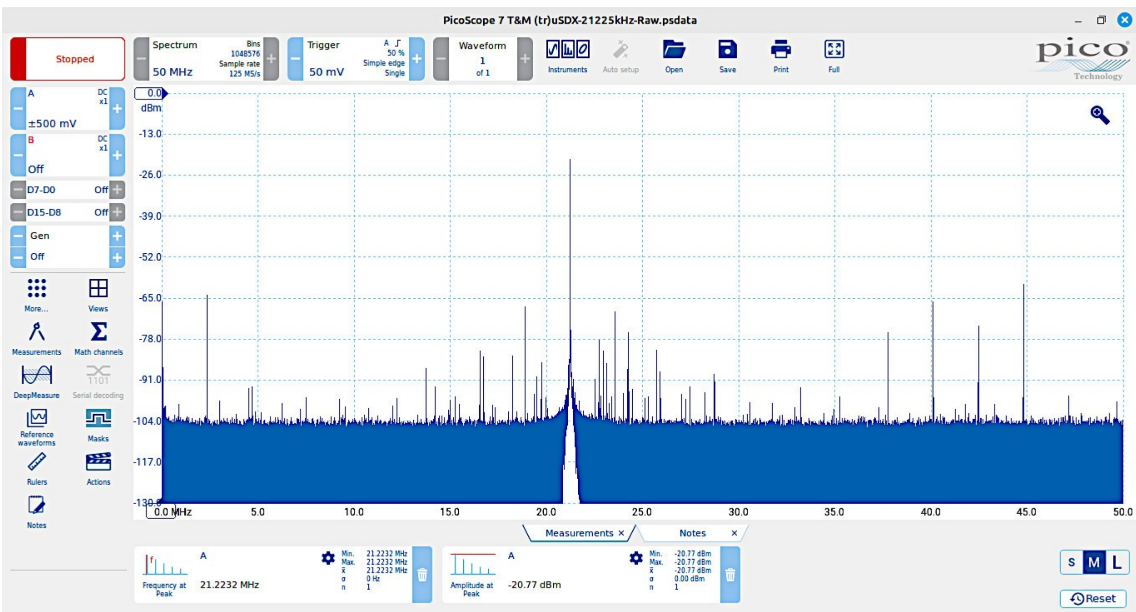


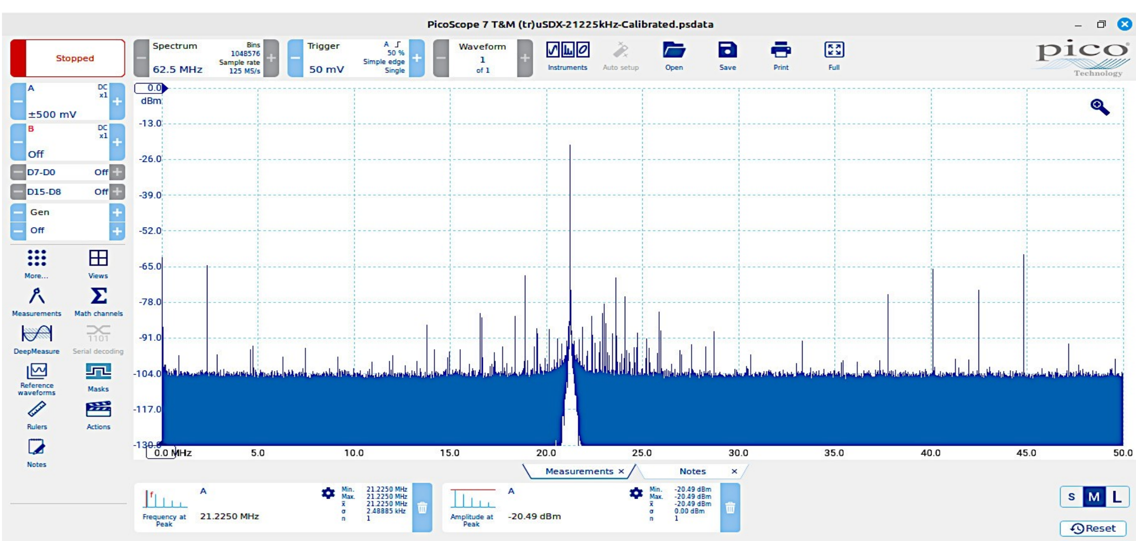




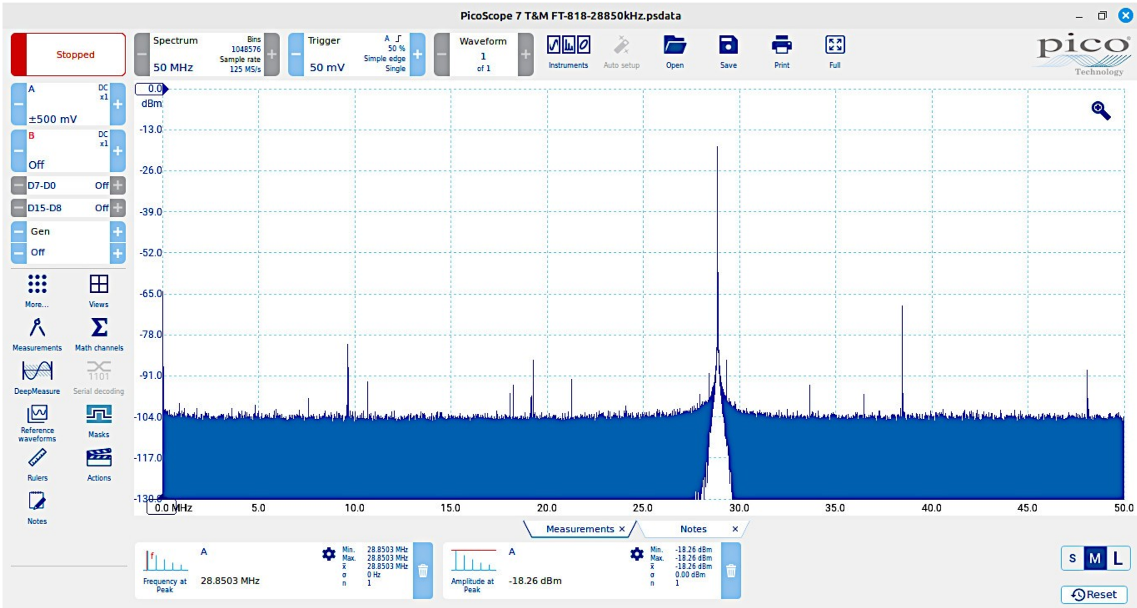
6.2.3.4 15 Meters at 21225 kHz

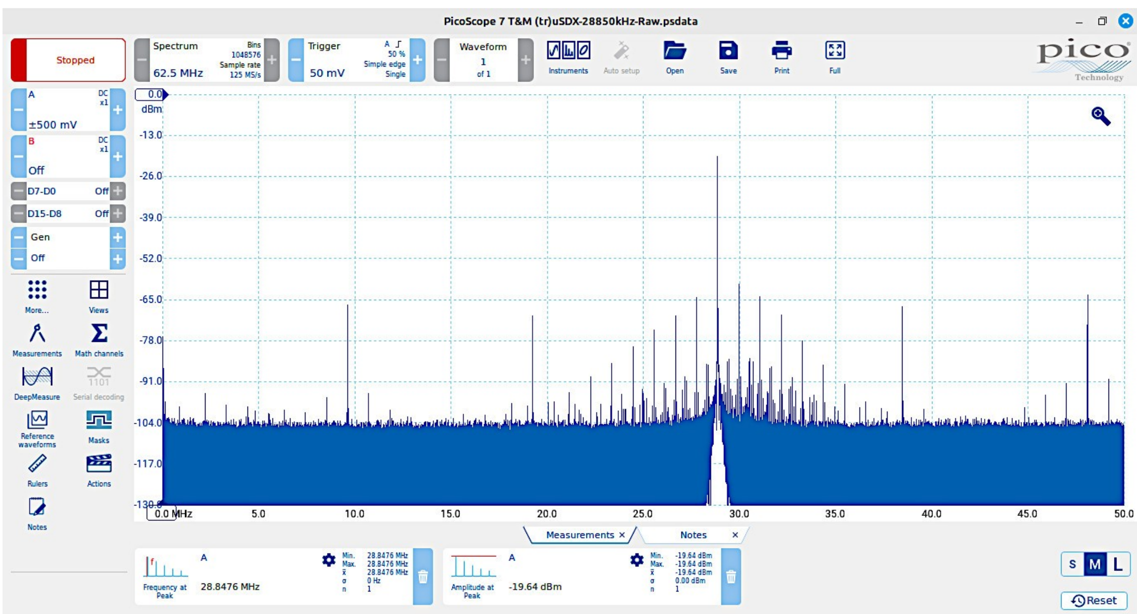


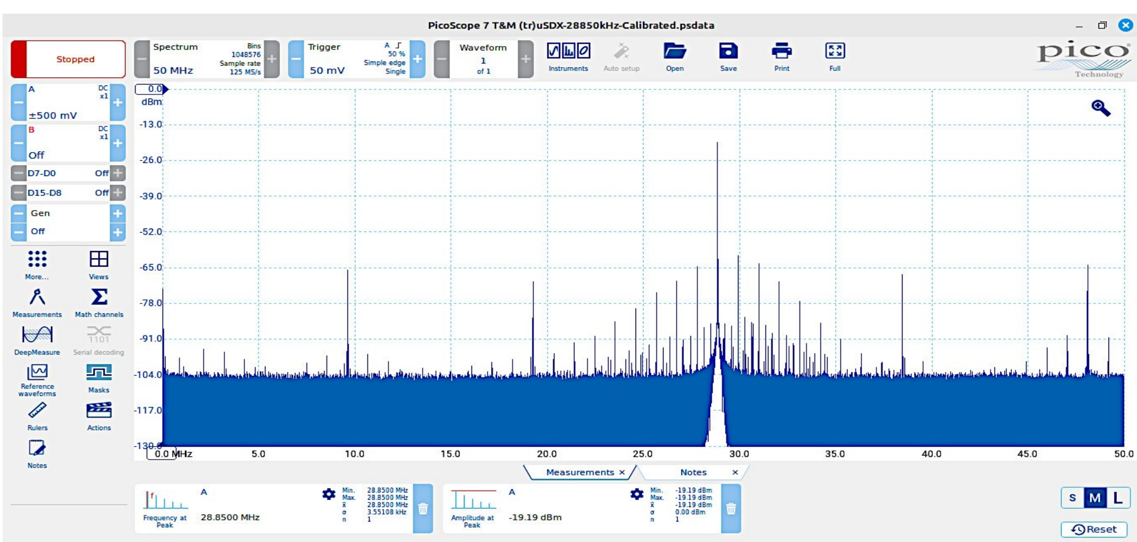




6.2.3.5 10 Meters at 28850 kHz

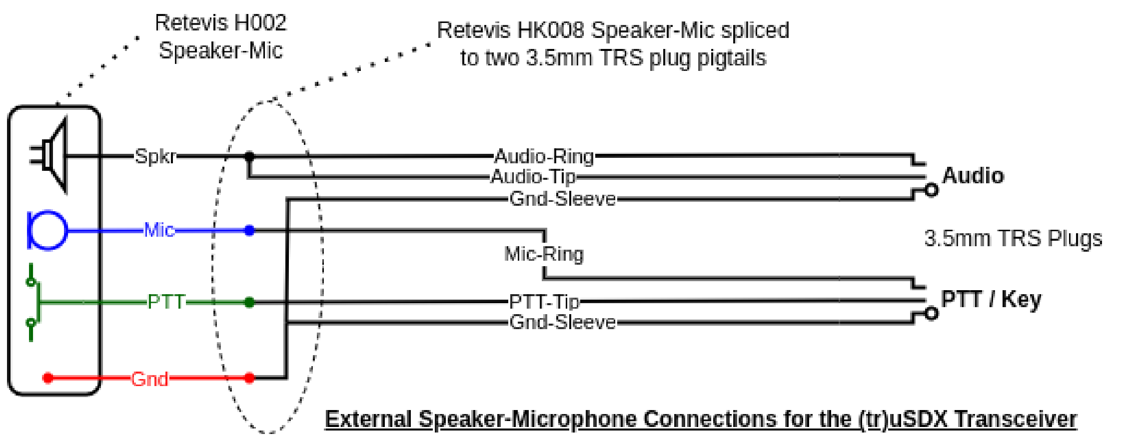




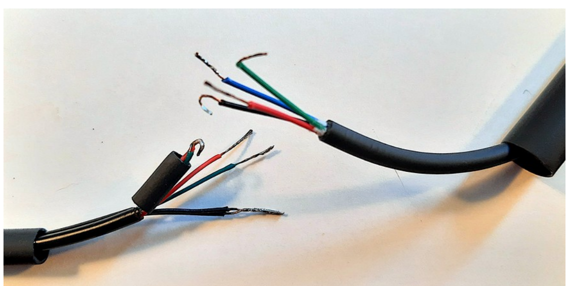


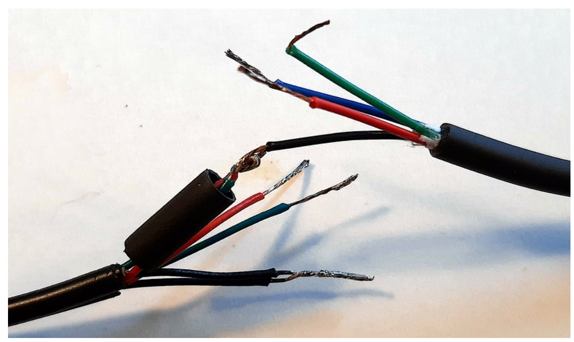
7 External Speaker-Microphone

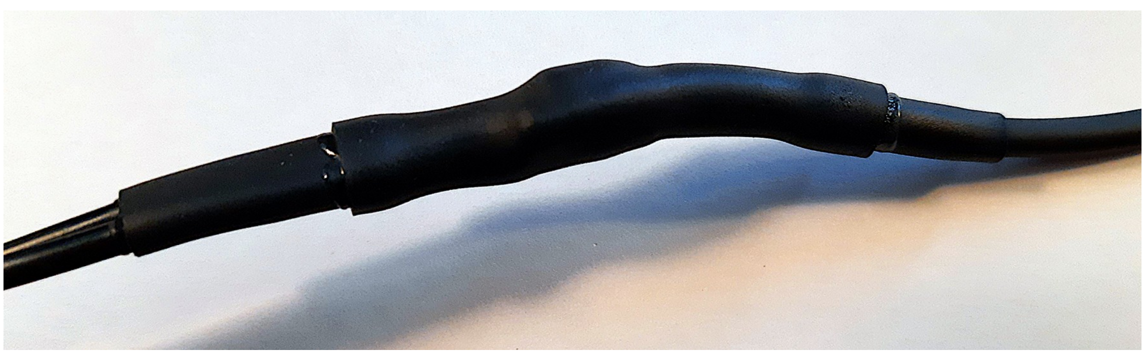
Although the internal microphone is good, the internal speaker isn't wonderful. In order to give a more traditional feel this section describes building a powered hand-held speaker-mic, using a powered Retevis HK008 speaker microphone.



External Speaker-Microphone Connections for the (tr)uSDX Transceiver







8 References

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2: DL2MAN PE1NNZ KD4SGE WA4ITD, (tr)uSDX-Main-RF-RF-Boards-with-Notes-v1.0(n), 2022
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9 Glossary

AGC............Automatic Gain Control
AM.............Amplitude Modulation
BNC...........Bayonet Neill–Concelman
BW.............BandWidth
CW.............Continuous Wave synonymous with Morse code
FM..............Frequency Modulation
GND...........Ground
GUI............Graphical User Interface
ICSP...........In-Circuit Serial Programming
ISP.............In-System Programming, or ICSP
LPF.............Low-Pass Filter
LSB............Lower SideBand
MISO..........Main In Sub Out (data output from sub)
MOSI..........Main Out Sub In (data output from main)
NR..............Noise Reduction
OTA............On The Air
PA..............Power Amplifier
PCB............Printed Circuit Board
RF..............Radio Frequency
RIT.............Receiver Incremental Tuning
SCK............Serial Clock

SSB............Single Side Band, Single Sideband
SWR...........Standing Wave Ratio
URL............Universal Resource Locator
USB............Upper Sideband
VCC............Voltage, Common Collector
VFO............Variable Frequency Oscillator
wpm...........word per minute