ADX-S V2 Kit Assembly Manual

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2024/5/2 V1.0: Formal release
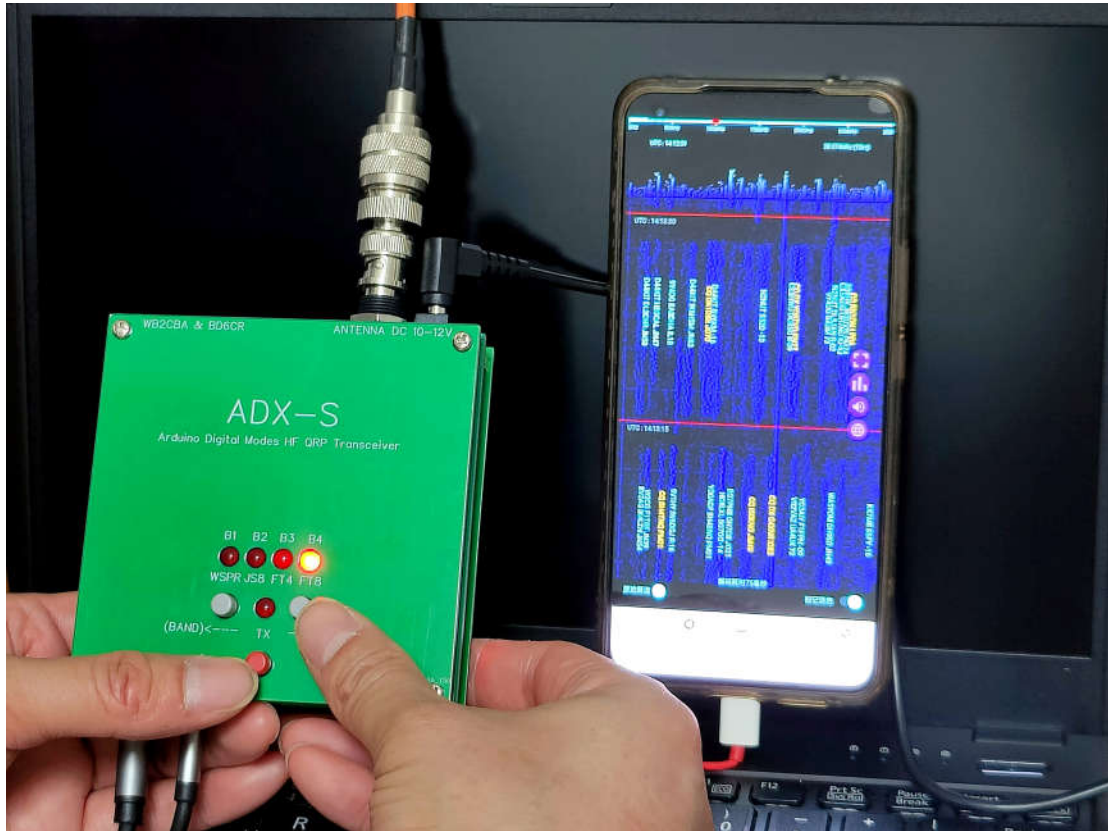

Photo: Jack Liang, BG7IKK who achieved DX contact of over 18,000 km with his EFHW antenna

Change history:

2024/5/2 V1.0: Formal release.

Contents

The ADX (Arduino Digital Xcvr) is an open source Arduino based digital modes HF QRP transceiver designed by Barb, WB2CBA, who is known as one of the designers of uSDX. The ADX-S is a superhet modification by BD6CR. The V2 incorporated all the necessary modifications and added new features to work with mobile devices better. The normal building time is 3 hours, and the minimum requirement for test instruments is a frequency counter or just your commercial ham radio transceiver. You can use ADX-S V2 with WSJT-x or JTDX on PC or FT8CN on your Android. For Apple phone or tablet, the new iOS App iFTx is supported as well.

What's New

1. RX modifications: AGC and ATT are enabled by default.
2. ATT toggle and reuse TX LED to indicate.
3. BFO indicator is added.
4. Power jumper is added to easily cut the 12V power when CAT is used.
5. Band filter module automatic detection is implemented.
6. Significantly reduce toroids from 21 down to 11 to cover 40-10m 7 bands.
7. TCXO module is added to rework the 5351 module to stabilize the frequency.
8. Audio Cable Adapter kit is supplied to support 4-pole audio connector on mobile devices.
9. Bluetooth module is optionally supported to enable wireless audio connection with mobile devices.

Part List

Please follow the latest part list in the folder https://groups.io/g/crkits/files/ADX-S/V2 to do parts inventory first. Report missing parts to your seller. If you are not yet a member, please subscribe to our group first.
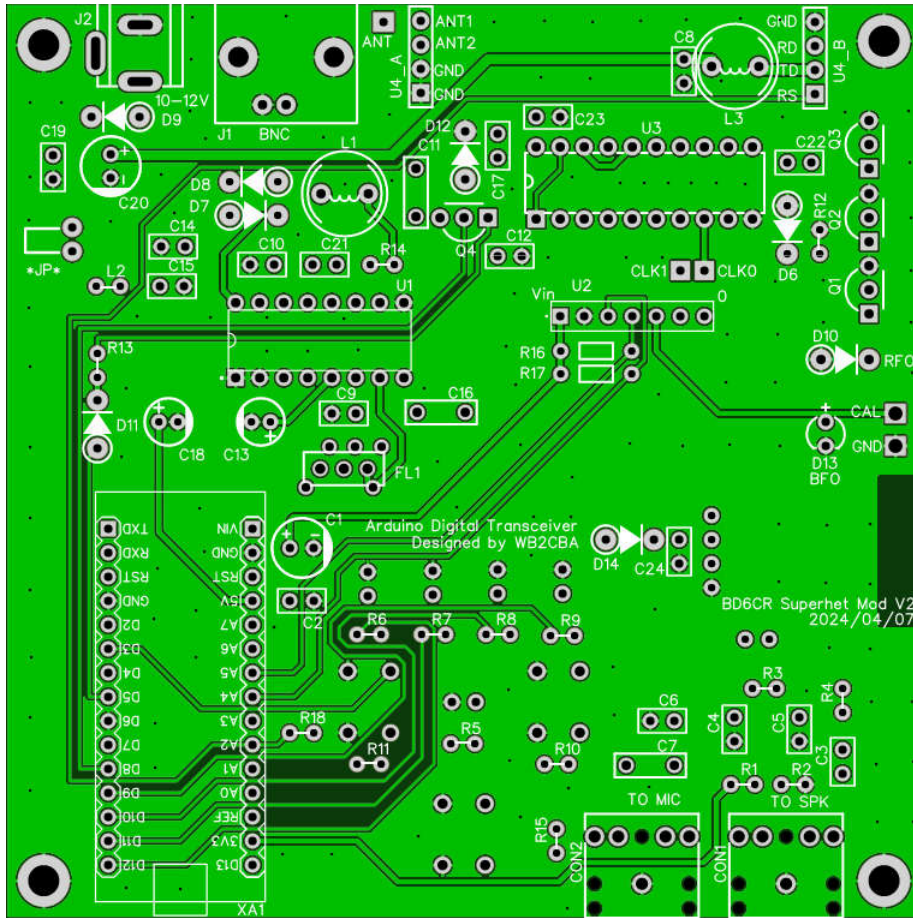
Step by Step Kit Assembly

It is highly recommended that you study the schematic before you start soldering. You can download the latest version from the above file folder. It is a kit of all though-hole components, so it is much easier for your eyes. It is recommended you use a fine tipped soldering iron since the pads are not very big. You will need to supply solder wire by yourself. 0.8mm diameter, 63% Sn and 37% Pb with flux is recommended.

Here are the current PCB photos. Check the date for revisions. The dates in 2024 or later indicate

V2 or later PCB. Note: Mount all the parts flush with the PCB before soldering.
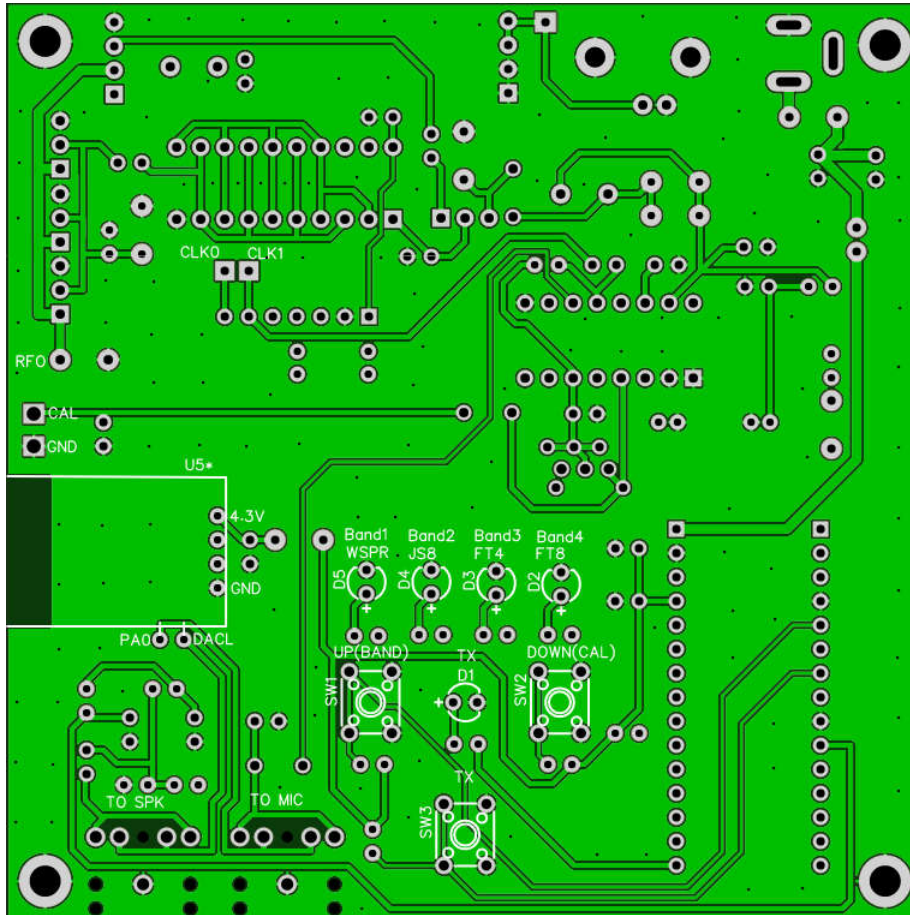
Step 1: DC IN, Diodes and Major Changes

The photo shows the major changes from V1. The step by step assembly and test in V1 is still a good reference. Please download the manual from https://groups.io/g/crkits/files/ADX-S. Jump to Step 10 for the photo of black FT37-43 toroid winding of 12 turns. D9 and D12 are the same 1N4007, while D10 – zener diode is bigger than D6, D7, D8, D11 and D14 – 1N4148.
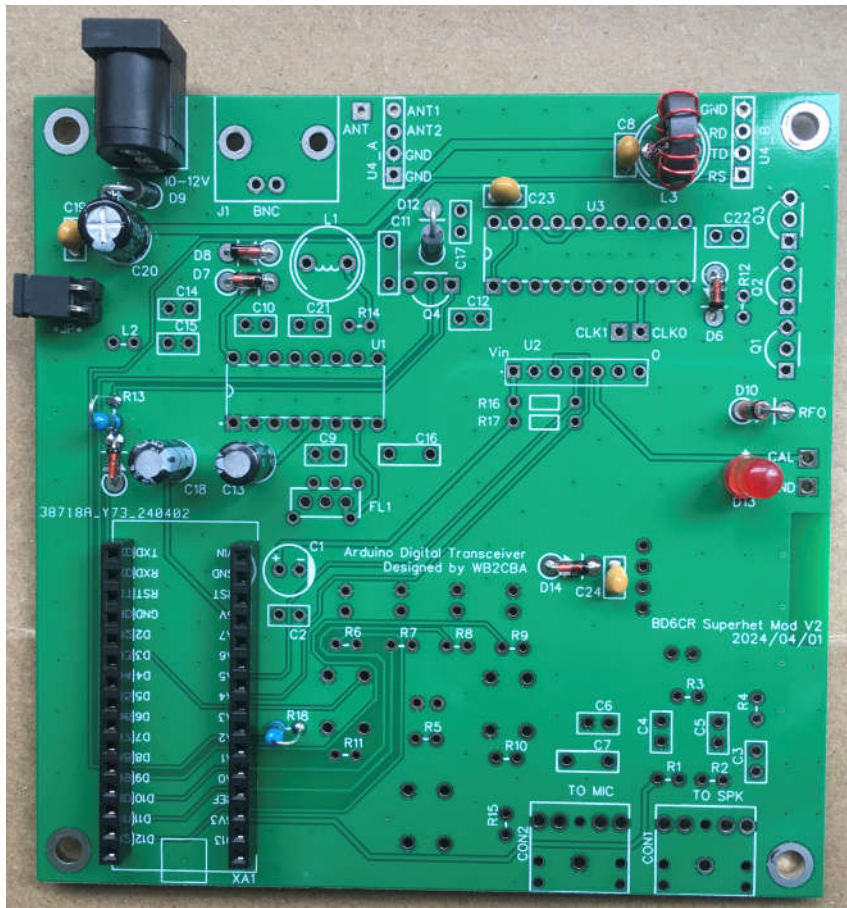
D13 – RED LED is the BFO indicator. *JP* is the power jumper switch. D14 – 1N4148 and C24 – 100nF are used to power the optional Bluetooth module U5* on the back. L3 – FT37-43 12 turns and C8 – 100nF are moved from the band filter board to save toroid winding efforts. R18 – 1k and the resistor on the band filter board are used to automatically detect the band of the filter board. C13 – 10uF is to enable AGC of U1 (CD2003). R13 – 1k, D11 – 1N4148 and D12 – 1N4007 are parts for ATT. The low profile sockets are used for XA1 – Arduino Nano module. Note: Plug in pin headers and Nano module to try out before you solder the sockets.

Step 2: Arduino Nano Module and +5V and +3.3V Power

The XA1 - Arduino Nano Module serves as the +5V and +3.3V power supply for the main board, so we will measure them after soldering the Nano module.

Plug in the pin headers into the sockets, watch out the holes in the four corners before soldering. Solder XA1 – Arduino Nano module, C1 – 100uF, C2 – 100nF, R16 – 10k and R17 – 10k in this step.
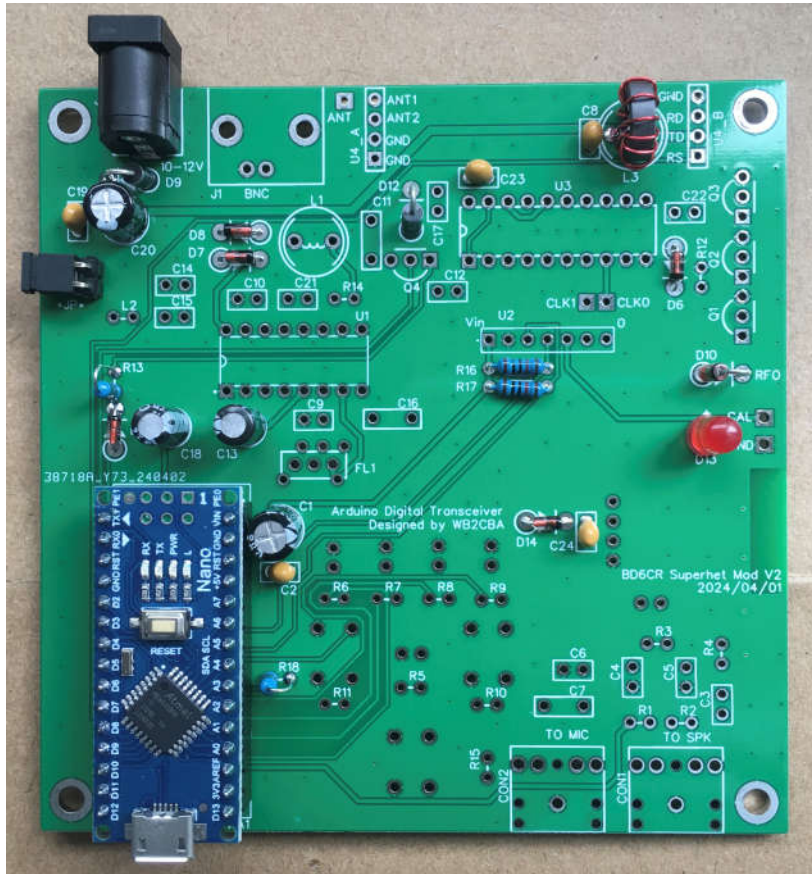
Test 5V at the Vin pin of U2, and 3.3V at left pin of R1. Note: Don't short circuit in this step, or the regulator will be damaged. If 5V is not within +/- 0.25V, you should look for a replacement, before you proceed.

Step 3: 5351 Module and TCXO Rework

Let's rework the 5351 Module first before soldering it to the main board. Apply solder to three pads (XA, V and G) of the TCXO Module, and two ends of the chip capacitor near 5351 chip.
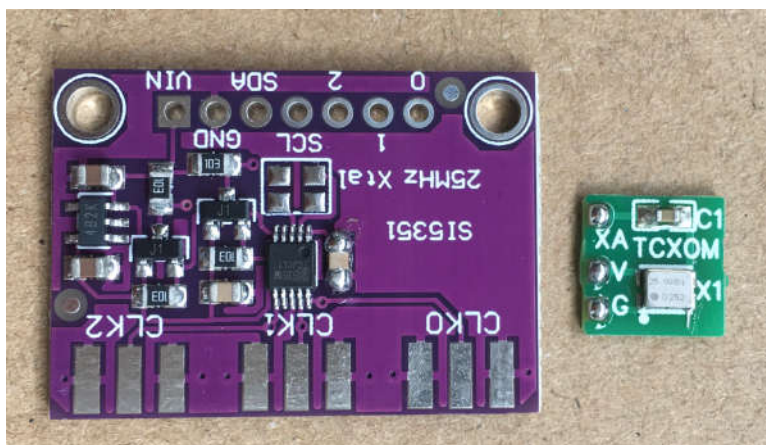
Use solder bridges to solder V and G pads to the two ends of the chip capacitor. Adjust solder iron temperature lower so it will be easier to generate solder bridges. If you feel it is too difficult, you can use short leads to solder. Use short leads to solder XA pad to the top right pad of the original crystal.
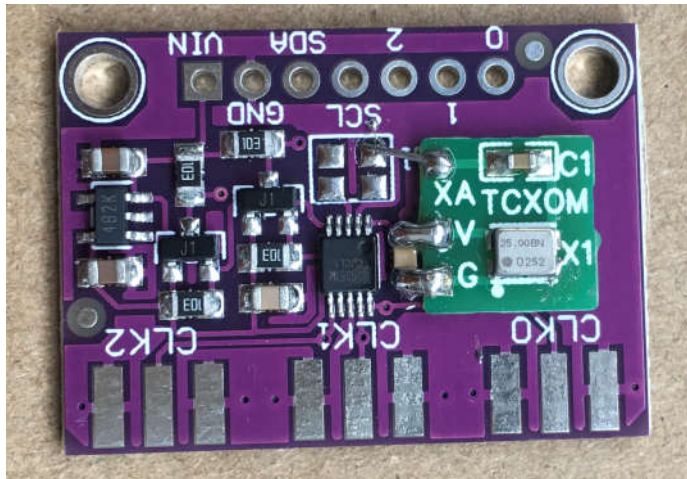
The 5351 module has a 8-pin header but it only needs 7 pins, so you will need to trim 1 pin first, and plug in the 7-pin header, shorter lead side on the top.
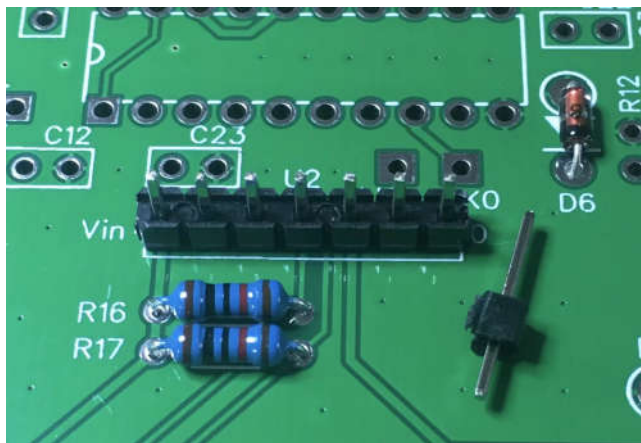
Plug in the 5351 module on the pin header and solder. The chip on the module might be a Chinese compatible chip with SI5351, but it works just fine.
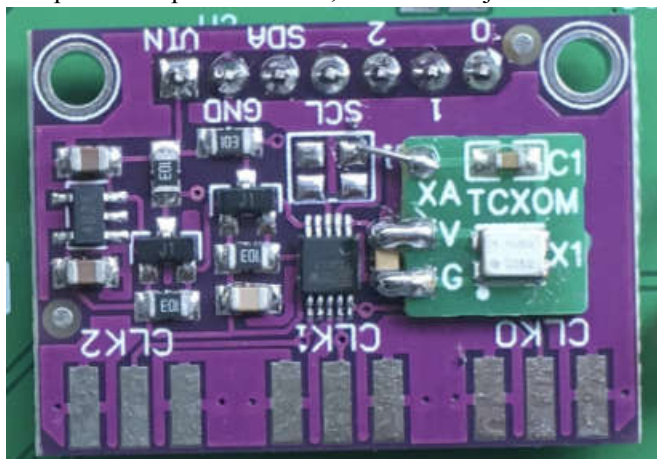
Turn the main board and solder the pin headers. Don't need to trim the extra leads.

Step 4: LEDs and Buttons

Populate the 1K resistors R5-R9 and the 10K resistors R10, R11, R15 and solder.

Populate D1-D5 and SW1-SW3 as close to the PCB as possible and solder. For LED, long lead goes to the pad with + marking.
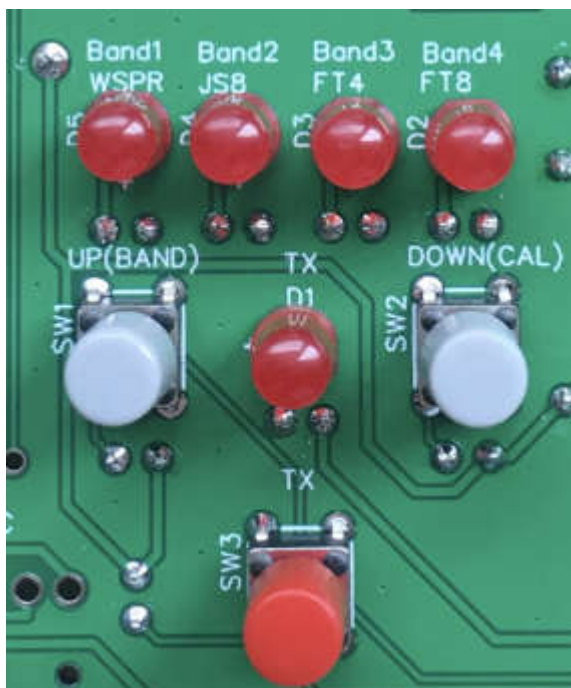
No frequency calibration is required thanks to the accuracy of the TCXO module. If you still wish to fine tune, you can follow the instructions from the ADX-S manual. If you plug in the power supply of 10-12V now, all the LEDs should be ON if the band filter module is not inserted. It is normal that there is no response to the key input at this moment.

Step 5: TX Driver 74ACT244

Populate C22 -100nF, R12 – 2.7k and U3-74ACT244 and solder. It is recommended you use a

socket. The new chip comes with the leads not very vertical. You can carefully hold the chip with both hands and press on a table to make them vertical, so you can easily plug into the socket. Don't bend the pins one by one.

Step 6: Complete the TX

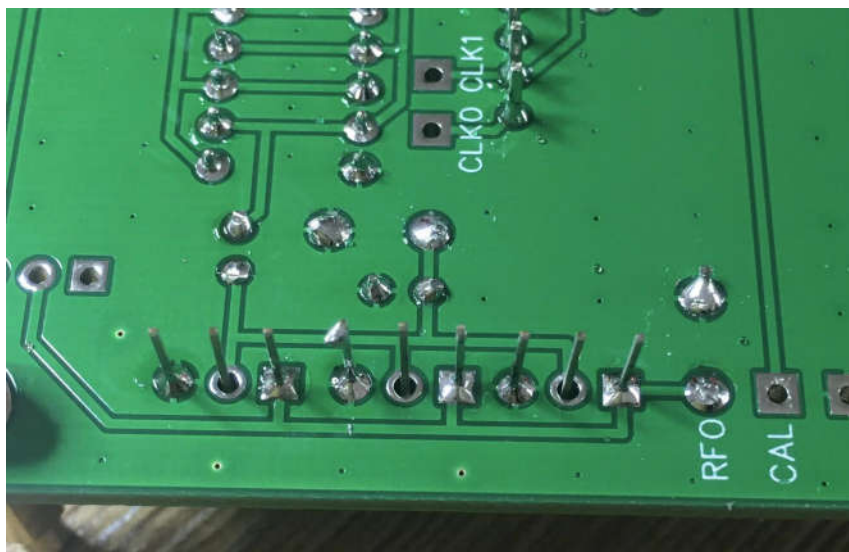Complete the TX with Q1-Q3, U4_A and U4_B sockets, and J1 BNC connector.

Populate Q1-Q3 – BS170 and solder all the leads but the center leads. Don't touch the leads with your hands as they are static sensitive.

Make sure your solder iron is well grounded. If not, you can unplug the power of your solder iron and solder the 3 center leads.

Please jump to Step 10 to make at least one LPF band filter module, say 20m. It is recommended you plug in the pin header sockets on the LPF band filter board first to make sure they are matched. Plug the pin header sockets to the main board and solder. If you don't have the LPF band filter board ready, please make sure both of the pin header sockets are vertical to the main board.

Populate J1-BNC in place and solder. Please make sure it is not floating as it sets the height limitation of the board.
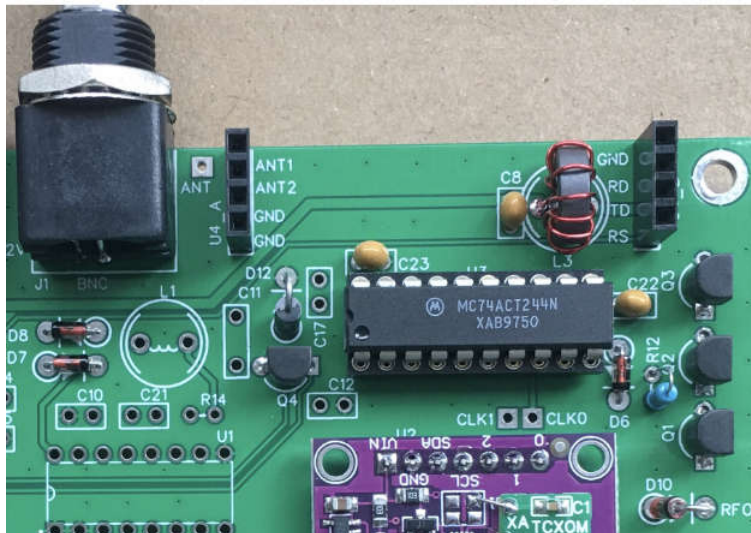
Now you have done the assembly of the TX portion. You can plug in the LPF band filter module and it will be automatically detected. Warning: Please don't misalign the pins, or it will cause serious damage to the board. You can find the mistake by seeing all LEDs ON.
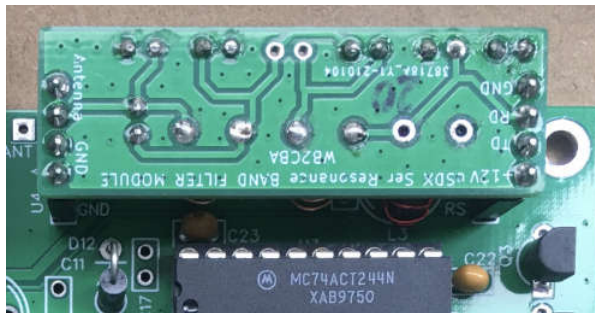
Now let's connect the TX to a RF power meter or a spectrum analyzer if you have. Make sure you have proper 50 ohm load for the TX. In my case, I have a -45dB power attenuator inserted between the TX under test and the spectrum analyzer, so I can measure the RF output and spurious by pressing the SW3-TX button. It looks good that the RF output is 3.13W and the spurious is -50dBc or so. The RF output varies with the voltage of the power supply. If your spectrum analyzer reads 35dBm or around, it equals to 3W or around on a 50 ohm load. Please double check if your overall current is around 600mA.
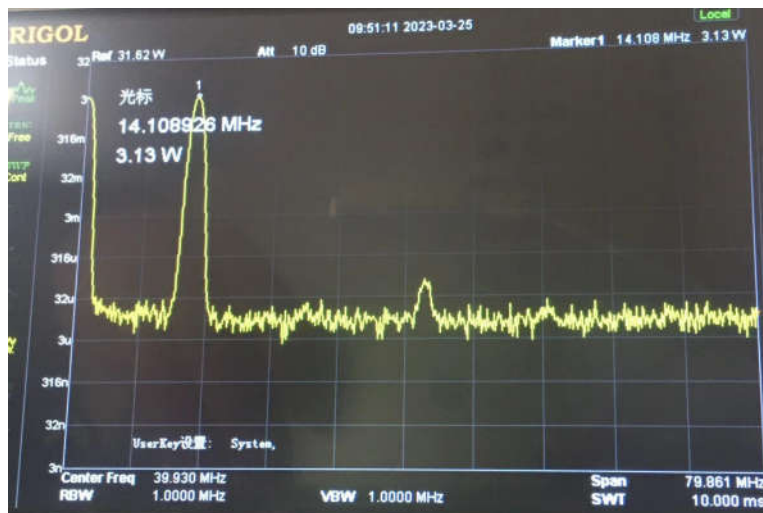
Step 7: Audio Jacks

Populate R1 – 1M, R2 – 4.7k, R3, R4 – 10k, C3, C6-100nF, C4, C5-10nF, C7-1uF, CON1-TO SPK and CON2-TO MIC, and solder.

Use an audio signal generator like Sonic Tools App on iPhone to inject audio to CON1-TO SPK jack. Turn the volume to MAX and it should trigger TX, and the TX LED should be on. When you perform this test, please make sure the 50 ohm load is still connected to J1-BNC.

Step 8: CD2003 RX

The ceramic filter FL1 marking should be facing to CD2003.
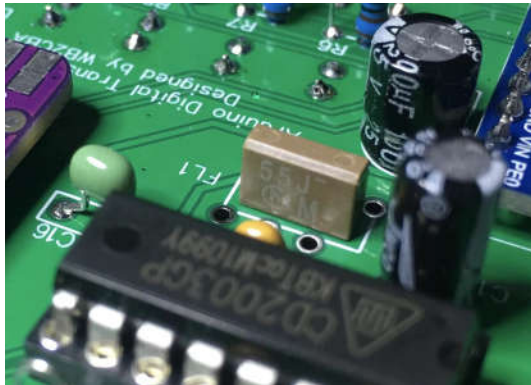
Populate C11 – 680p, C16 – 5.1p, R14 – 100 ohm, L1 – 1uH, L2 – 100uH, C12, C17 – 10nF, C9, C10, C14, C15, C21 – 100nF, and solder.
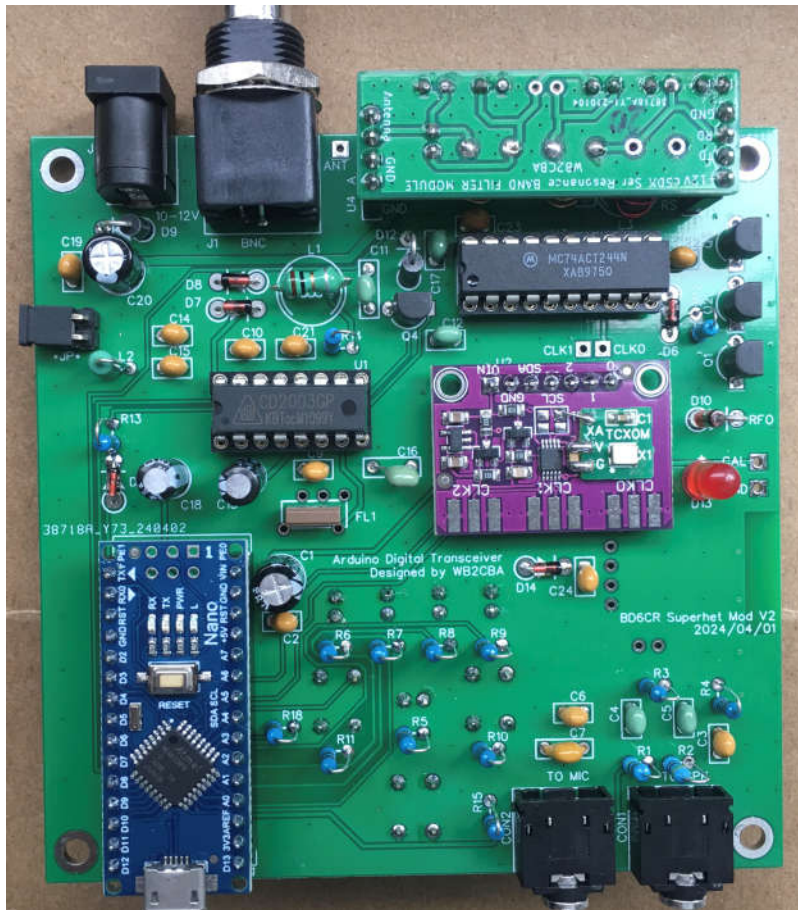
Step 9: Optional Bluetooth Module

Note: It is not surface mount. Mount pin header flush with the PCB and solder the longer pin ends on the component side.
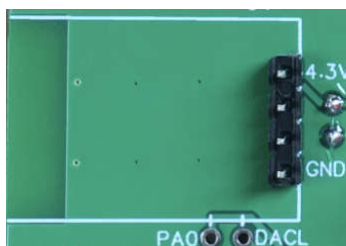
Plug the Bluetooth module and solder the 4-pin header and two free pads PA0 and DACL with extra leads, as shown. PA0 serves as the audio input to the Bluetooth module, and DACL serves as the audio output. Please make sure not to short circuit with the nearby pins. Trim extra leads if they are too long for the covers.
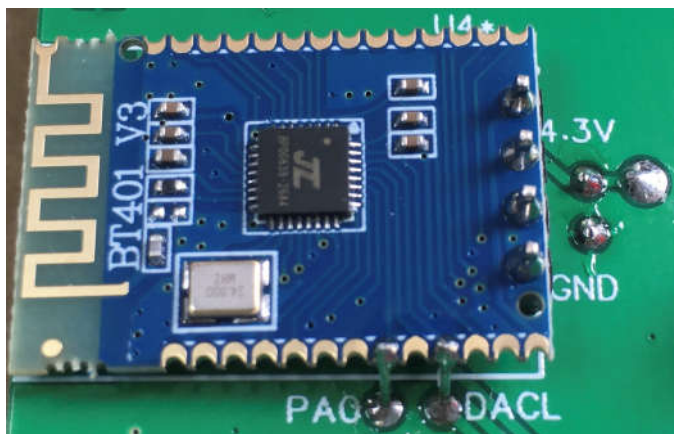
To test the Bluetooth module, you can confirm the voltage of power supply at 4.3V against GND. It should be very close. The current draw is about 20mA if you can measure it separately. Once it is powered, you can search for Bluetooth device named ADX-S with your smart phone and pair it. In order to transmit and receive audio, you should remove the audio cables from two jacks TO SPK and TO MIC.

Now you can put on the top cover and fasten the screws. Put on the caps of the switches. Red for SW3-TX.

And put on the bottom cover and fasten with M3x5 standoffs.

To avoid misalign of the LPF band filter board, it is recommended that you mark two dots on the back cover.

Now, the main board assembly is completed.

Step 10: LPF band filter board

Follow the schematic to build the LPF band filter boards.

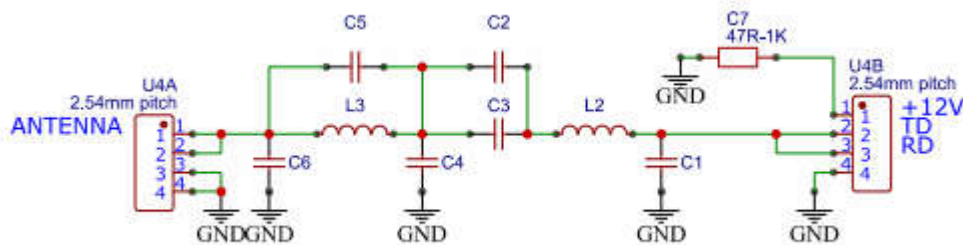| LPF BAND MODULE										
Band	C1	C2	C3	C4	C5	C6	C7	L1	L2	L3
40m	150	1000	NC	1000	300	1000	1kΩ	NC	15T/RED	10T/RED
30m	100	680	NC	680	220	680	680Ω	NC	12T/RED	8T/RED
20m	68	470	NC	470	150	470	470Ω	NC	10T/RED	7T/RED
17m			Share 15m band filter							
15m	68	330	NC	330	100	330	220Ω	NC	11T/YELLOW	7T/YELLOW
12m			Share 10m band filter							
10m	39	270	NC	270	68	270	47Ω	NC	9T/YELLOW	6T/YELLOW

Unit: pF by default

Wind the toroids based on the BOM, and prepare the pin headers and capacitor leads. The black toroid has 12 turns, and the red toroids have 10 turns and 7 turns. Remove the enamels of the wires ends before soldering. Some people use sandpapers. Wire length: 1.5 cm per turn plus 5 cm. For 12 turns, the length is 23 cm.
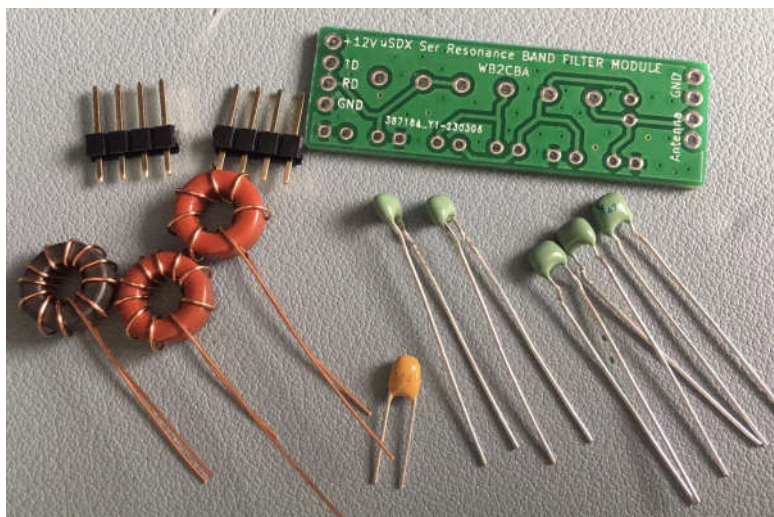
It is recommended you use the sockets on the main board as support. Populate the parts correctly and solder. Some schematic and BOM of the original design ADX does not match the PCB very well, so please double check the ADX-S V2 BOM. Note that the blue capacitors are 1000pF.

Use a marker pen or label to mark the LPF band filter board. The completed LPF band filter boards look like this.

Step 11: Box the ADX-S V2

If your plastic container looks still nice after shipping, you can consider using it as the chassis, although the sandwich PCBs look great too. If your container is broken, please don't hate us as it happens.

Align the BNC hole location and mark it with a dot. The belt line of the container defines the upper limit of the BNC hole.
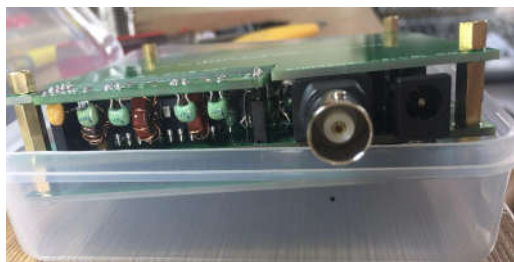
Drill a small hole, enlarge it gradually so you can protrude the BNC connector. The electric drill sold by IKEA for screw fastening will do the job here.

Press the board down so you can get correct locations for audio jacks, power supply jack and USB port on container sides, or the buttons will lift the board. Now mark the locations.
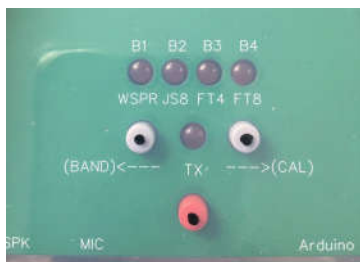
The finished chassis looks like this on the left but without USB cable. If you wish to drill a hole for USB cable, consider drilling the button holes on the top cover, as shown on the right.

Step 12: Audio Cable Adapter

The audio cable adapter kit is used to directly connect to audio jack of your mobile devices. The resistors make microphone detection possible. Use the supplied audio cables to connect this adapter to ADX-S V2, like this.
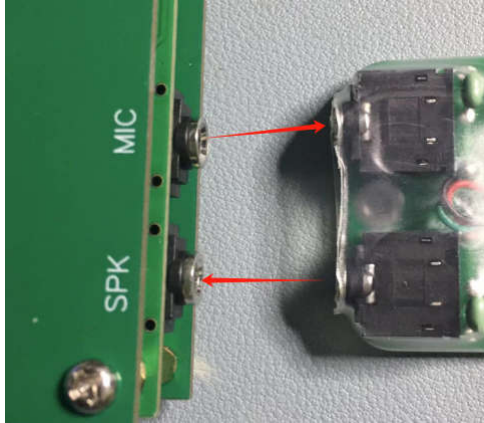
You will build it from a simple kit which is a part of the ADX-S V2 kit. Since the 4-pin audio jacks have two definitions, CTIA or OMTP, see the diagram for CTIA wiring, and you need to swap green and black wires for OMTP. You always cut white wire as it is unused, and connect the red wire to the pad on the left near 47 ohm resistor. Tighten the nylon cable tie and put on the heat shrinkage tube and use hot air 200C to shrink well.
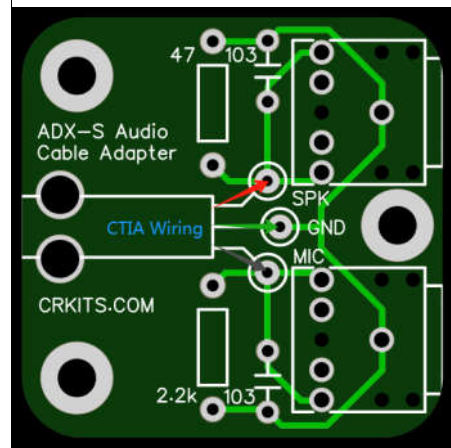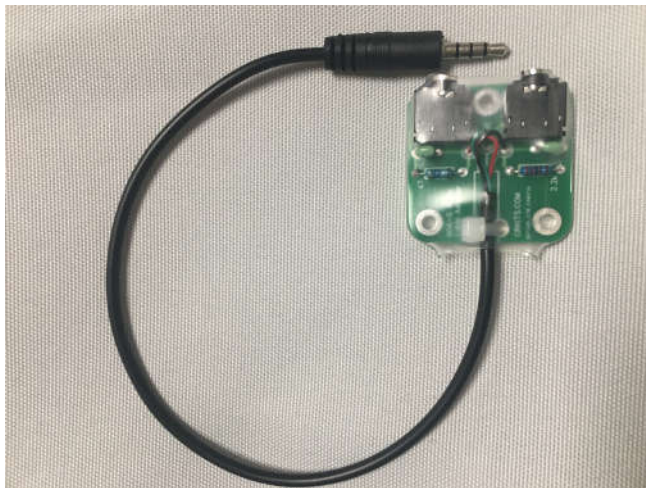
Settings and Calibration

There are two settings: BAND setting and MODE setting. Please note, BAND setting is a design change from the original design ADX.

Before any TX, please make sure the LPF band filter module and the band setting of Nano is matched. The automatic detection feature will make sure they are matched for 40m, 30m, 20m, 15m and 10m, but you still need to manually set for 17m and 12m. To adjust the BAND setting, please press and hold SW1-UP(BAND) button and power on. After LED flashes are done, you can press SW1-UP(BAND) or SW2-DOWN(CAL) to adjust. Press SW3-TX to confirm the band setting.
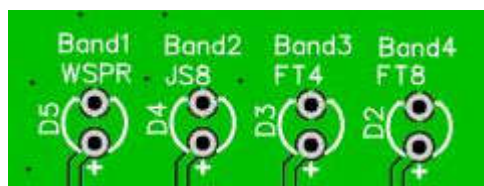
B1 – 40m
B1&B2 – 30m
B2 – 20m
B2&B3 – 17m
B3 – 15m
B3&B4 – 12m
B4 – 10m

MODE setting can be made during normal working mode. The LED shows the current MODE, from left to right: WSPR, JS8, FT4 and FT8. You also change frequency when you change MODE. The combination of the BAND and MODE setting defines the carrier frequency. For example, 20m band and FT8 mode defines the carrier frequency 14.074MHz. The frequency table in the firmware is as follows.

| (kHz)	40 m	30 m	20 m	17 m	15 m	12 m	10 m
WSPR	7038.6	10138.7	14095.6	18104.6	21094.6	24924.6	28124.6
JS8	7078	10130	14078	18104	21078	24922	28078
FT4	7047.5	10140	14080	18104	21140	24919	28180
FT8	7074	10136	14074	18100	21074	24915	28074

If you still wish to fine tune the frequency accuracy, you can refer to the method outlined in the ADX-S manual which can be downloaded from https://groups.io/g/crkits/files/ADX-S.

ATT ON/OFF toggle: You can press both SW1-UP(BAND) and SW2-DOWN(CAL) to toggle ATT ON or OFF. The TX LED flashes twice to indicate ATT OFF, and three times to indicate ATT ON. If your firmware does not work like this, please update your firmware to the latest.

Use the ADX-S V2

You can change band by inserting the correct LPF band module to ADX-S first, then setting by the BAND button at power on for 17m and 12m only. It is critical to insert the LPF band module in the correct orientation and avoid misalignment, especially when the bottom cover is not yet installed, or the board could get damaged. The capacitors and resistor on the LPF band module should be on the outer side of the main board. The V2 firmware will detect mistake to make all the LED lit for about 2 seconds at power up.

Please power the ADX-S V2 with 10-12V. The maximum is 3 Li-Ion battery in series or 12.6V. The RF output is in QRP range. It draws about 400-600mA.

You can switch to QRPP range by powering by the USB port at 5V. Never power by both 12V and USB ports, or the Arduino Nano module will get damaged. The output is about 1/10 of the QRP power. Less heat is generated in QRPP and much more stable for WSPR. Some people also use QRPP to pursue more challenging DX communication and it is a lot of fun.

Because ADX-S V2 has built in VOX code, only two audio cables are required to operate. One audio cable is connected between the jack marked TO MIC or MIC on the ADX-S V2 and the MIC jack on your sound card. The other audio cable is connected between the jack marked TO SPK or SPK on the ADX-S V2 and the PHONE or SPEAKER jack on your sound card. If you swap them, you will see strange lines on the spectrum and the audio output cannot trigger transmitter. The ADX-S V2 prefers higher audio input level, and you don't have to worry about over modulation. If the ADX-S V2 audio output is too low for your sound card, you can adjust the MIC gain if your system supports. Take WSJT-x as example, you need to set **Radio as None**, **PTT method as VOX**. In the main window, you need to manually choose the correct band, frequency

and mode, for correct logging purpose.

In setting window, choose Radio as None, PTT method as VOX, and click OK to confirm

In main window, manually choose band the mode to display the correct working frequency. For example, if you choose WSPR and 20m band, the frequency will be 14.095600 and it is the same as the setting of the ADX-S V2 firmware

If you have installed the optional Bluetooth Module, search for a Bluetooth device named ADX-S, and pair it. You will find a logo of a headphone with a battery when it is ready for use.
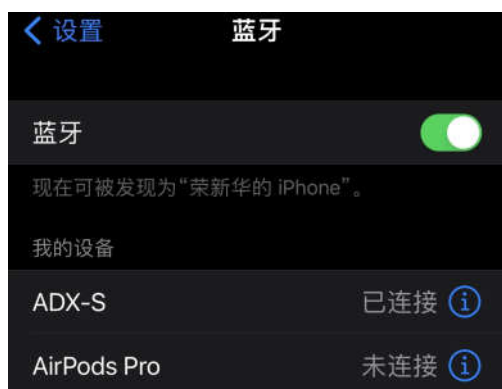
The Bluetooth module provides 2-way audio connection when the audio cables are not connected. If your receiver ATT is ON, you will find little signal on the spectrum waterfall. You can toggle

ATT to see more signal. The following screen snapshot shows Bluetooth audio connection is used for iFTx App on iPhone. No additional setting is required. If you use FT8CN on Android devices, you will enter Bluetooth headset mode automatically, the only settings in FT8CN are PTT control - VOX and radio - None. Note: Due to the limitation of the Hands Free Profile and hardware implementation, please choose transmit audio under 1kHz to improve audio quality.

To make a successful QSO, you will need to calibrate time and frequency. Type time.is in your browser to make sure your computer time is accurate (1 sec accuracy is fine). Frequency calibration is recommended before you put the ADX-S V2 in actual QSO. Since the power level is QRP, you can start with calling a strong station, at least -5dB SNR. Later, you can try to call weaker stations. It is not difficult to achieve DX contacts if you have a full sized antenna.

By default, the firmware enables ATT for the receiver. Of course, you can update the firmware to disable ATT by default. If your receiver still suffers from strong broadcast interference, you can try a tuned antenna like magnet loop antenna or add a Z-match ATU in between the ADX-S V2 and the antenna. If you feel the signal is too weak, you can press both SW1-UP(BAND) and SW2-DOWN(CAL) to toggle ATT ON or OFF. The TX LED flashes twice to indicate ATT OFF, and three times to indicate ATT ON. If your firmware does not work like this, please update your firmware to the latest.

Open Source Code Modification and Update

The Arduino code ADX_S_Vx.ino is open source, so you can modify and compile by yourself. Normally the Arduino Nano module is pre-programmed. If you wish to browse the code and customize your own, you will need to download the Arduino IDE from https://www.arduino.cc/en/software

Remove the 12V power supply first, then connect the Arduino Nano module to the USB port of your computer by your micro-B USB cable. The board can be powered by your USB port. You will choose Arduino Nano in board manager of the Arduino IDE, choose the correct port like COM5, then choose ATmega328P(Old Bootloader) in processor if your Nano module is blue. After loading the code to the Arduino IDE, you can compile and upload the code to the Nano module. If you get an error message saying the 5351 library is missing, you will need to load the library Si5351Arduino-master through menu Sketch – Include Library – Add .ZIP Library. You need to download both the source code and library file in the same place to avoid compatibility issues.
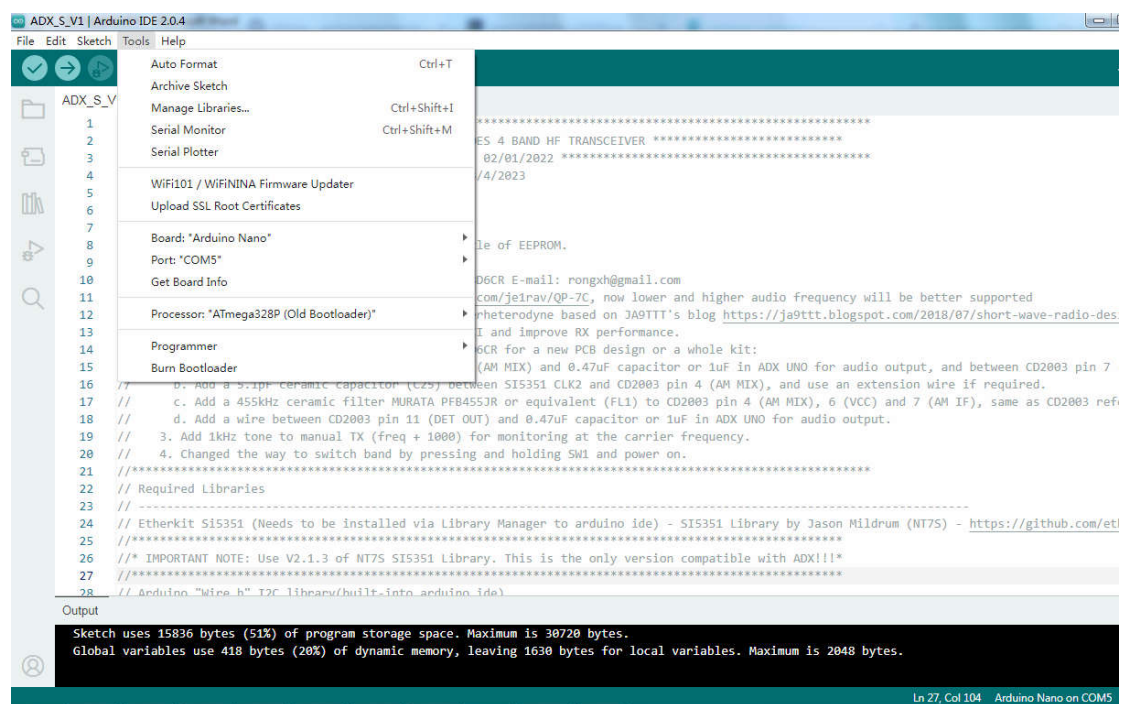
Since the ceramic filter has tolerance on bandwidth and center frequency, it is better that you fine tune your own beat frequency, so you can get higher SNR and less interference. In order to do so, you do a search in the source code and you will find two different beat frequencies. One is 460570, the other is 449430. For now, 449430 is only for 20 meter band. Adjust them at 500-1kHz step and compare with the default setting, so you will get the best value for your kit. This is the fun part of the open source kit.

SPECIFICATIONS

Part Number	3dB Band Width (kHz)	Selectivity +9kHz off (dB) min.	Insertion Loss (dB) max.	Composition
PFB455JR▼	5.5 ± 1.5	17 (23)	6 (3)	2 Elements

CAT Support

CAT is the abbreviation of Computer Aided Tuning. With this function, the PC software can automatically tune the radio. The CAT commands support is limited, but it should work with WSJT-x or JTDX. The implementation of CAT is well considered. The ADX-S V2 will stay in the original normal mode if CAT commands are not received. Once CAT commands are received, the ADX-S V2 will turn on both B2 and B3 LED's to indicate CAT mode. Now, the buttons are disabled and you can only control by CAT unless you recycle the power.

The firmware detects the CAT frequency and compares with the band set manually. If they are different band, it can receive but cannot transmit. This is a newly added protection to the finals.

Again, never power by both 12V and USB ports, or the Arduino Nano module will get damaged. Since USB port is always in use in CAT mode, either you can live with QRPP with USB 5V, or you can remove the short cap of the power jumper switch *JP* so you can power by both 12V and USB ports and transmit at 3-5W QRP level.
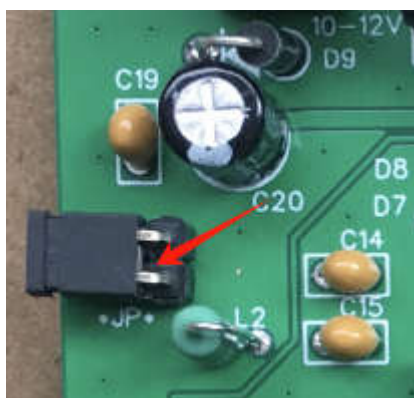
WSJT-x or JTDX radio settings: Kenwood TS-2000, Correct Serial Port, Baud Rate 115200, CAT, others are default. Press Test CAT to confirm it is working. You still need audio to trigger TX, so Test PTT should not work.

You can listen to SW broadcast stations in CAT mode.

	SW1 (UP)	SW2 (DOWN)	SW3 (TX)	Both SW1 and SW2
Normal Mode	Mode change	Mode change	TX (Never press it without dummy load or resonant antenna connected)	ATT toggle (ON: TX LED flashes three times; OFF: twice)
CAT Mode	-5kHz	+5kHz	AM mode toggle (See the BFO LED to tell if the BFO is on or off)	ATT toggle (ON: TX LED flashes three times; OFF: twice)

You will need to add your AM broadcast frequencies into the frequency list of your WSJT-x.

If Something Goes Wrong…

Always remember:
- Never power from both 12V and USB port unless you remove *JP* jumper first, or the Arduino Nano module will be damaged, and it could cause further damage to the main board.
- Never press TX button unless you make sure the LPF band module is properly inserted, the band is properly set, and the resonant antenna or dummy load is connected to the antenna socket. If you forget, you could damage the finals and you have to replace 3x BS170.
- Never use power supply higher than 12.6V, especially when you have the optional Bluetooth module installed. It could cause problems at both the Arduino Nano module and the finals.
- Never forget to insert or misalign the LPF band module or it could damage the finals.

What you can do to prevent problems:
- Add a 0.1uF capacitor in parallel to R18 to avoid damage to A2 pin of the Arduino Nano module
- Always use the latest firmware to show all LED ON at power on if your LPF band module is not properly inserted
- Remove PWR and L LEDs on Arduino Nano to save some power and reduce the load of the on board 5V regulator
- Always double check before you apply power supply and start transmission.

What you can do if something goes wrong:
- If you think the Arduino Nano is damaged, never apply 12V again before you make sure you have fixed the problem. Remove the module from the socket and replace with a new one. You can use any Arduino Nano on hand as long as you download the latest ADX-S V2 firmware. If you are an experienced builder, you can try to replace the on board AMS1117-5.0 regulator, as most of the problems are related with the regulator.
- If you think the finals are dead, for example, you see lumps on the package or big current of over 1A, you can desolder them and replace with new ones. The pin out of some BS170s are reversed (just like 2N7000), you can use diode tester to measure the integrated protection diode to make sure (search for datasheets to confirm), before you actually install them. If you don't have BS170 on hand, you can replace with 2N7000 but the pin out should be reversed.
- If your software does not decode, try to toggle ATT. If ATT toggle is not working, consider A2 pin damage and replace the Arduino Nano module.

Further readings

This document will be updated in the folder, together with other documents like schematic, part list and source code. If you are not yet a member, please subscribe first.
https://groups.io/g/crkits/files/ADX-S/V2
or, scan this QR code with your cell phone.

Reference and Acknowledgement

Barb, WB2CBA
https://antrak.org.tr/blog/adx-arduino-digital-transceiver/
https://github.com/WB2CBA/ADX

Burkhard Kainka, DK7JD
https://www.elektronik-labor.de/HF/FT8QRP.html
http://elektronik-labor.de/HF/SDRtxFSK2.html

JE1RAV
https://github.com/je1rav/QP-7C

JA9TTT
https://ja9ttt.blogspot.com/2018/07/short-wave-radio-design-2.html

QRPGUYS
https://qrpguys.com/qrpguys-digital-fsk-transceiver-iii

Jason Mildrum, NT7S
https://github.com/etherkit/Si5351Arduino