

Peaberry SDR V2 by AE9RB

Welcome to homebrew SDR The Peaberry SDR V2 is designed as an advanced project for assembly by hand. No compromises have been made for accommodating thru-hole parts or low-Q inductors. Instead, the PCB was carefully designed to allow easy assembly with an ordinary soldering iron.

Many people find SMT assembly is faster and easier than thru-hole. Tutorial videos on SMT soldering may be found on the Internet. There are hundreds, perhaps thousands, that are easily searched for. A written guide that I recommend is "SMT Soldering—It's easier than you think!" available here:

<http://www.siliconfarmers.com/smtmanga/>

SPOILER: The secret to SMT soldering ICs is the flux. You must use extra flux and your desoldering wick must be embedded with good quality flux.

Required Tools

- Safety glasses
- Illuminated magnification
- Soldering iron with 1/32" tip
- Flux core solder, 0.020" or 0.015"
- Solder flux, pen or syringe
- Desoldering wick
- ESD-safe work area and parts trays
- #1 and #2 Phillips screwdrivers
- Pliers for #4 & #6 nuts
- Electronics multimeter
- Measuring tape or ruler
- SMT tweezers
- Wire cutters
- Scissors or knife

Optional Tools

- Oscilloscope
- RF signal generator
- Hot air rework tool

Additional Equipment

- CW or SSB receiver
- USB cable, standard A-B
- 13.8V 1A regulated power supply
- Power supply wire, 20AWG or better
- 50 ohm antenna, BNC terminated
- 50 ohm dummy load
- Computer to run DSP software

Most of the time, a simple multimeter is the only diagnostic tool you will need to successfully assemble the Peaberry SDR V2. If there's a difficult problem then you may find it necessary to use a signal generator and oscilloscope. Soldering errors can be found with a 5X or 10X illuminated magnifier. A bad part is extremely rare. Even electronics built by robotics will have almost all of the problems due to soldering error. Work slowly and take lots of breaks.

A support forum has been set up to collect and share experience. The Peaberry SDR V2 is produced entirely by one person. I will try to help you but solving problems for a radio not on my own bench often requires more than a single point of view. Building a Peaberry SDR V2 is meant to be an educational experience so it is not unusual to be stuck on a problem until you learn more about the circuits. Muster your patience and know that even the experts can be stumped by a new scenario. Please use the support forum to ask for help and help others.

<http://AE9RB.com/forum/viewforum.php?f=4>

□ Preparation

Download the schematic and choose the bands you want to build. Page 4 of the schematic shows the parts that vary. It may be convenient to print out the entire schematic or at least page 4. You can build the Peaberry SDR to cover up to four adjacent bands. The options are 160/80/75m, 80/75/60/40m, 60/40/30/20m, 30/20/17/15m, and 17/15/12/10m.

<http://AE9RB.com/forum/viewtopic.php?f=4&t=96>

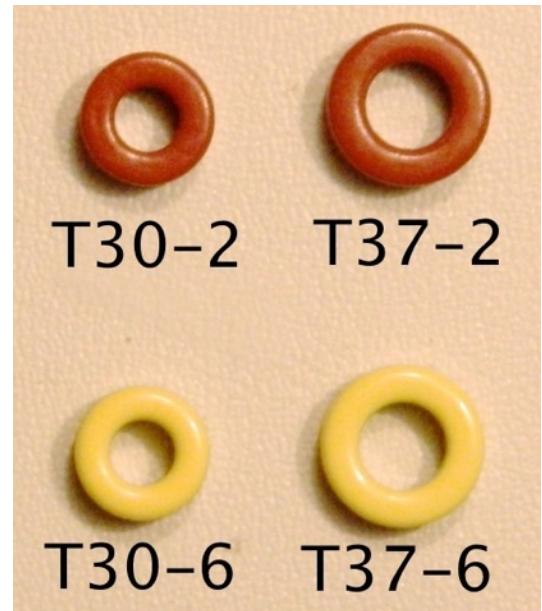
Observe ESD precautions and don't forget your safety glasses when cutting wire or soldering.

□ Identify the magnetic parts

The toroids are very easy to identify. T30 cores are 0.30 inches in diameter and T37 cores are 0.37 inches. The red cores are -2 and yellow are -6.

There are two kinds of binocular cores which are not obvious to differentiate. The six BN-43-2402 cores are in the bag with the red toroids and wire. If you've opened the bags already and mixed these up then you can still identify them. The BN-61-2402 cores are flat black and there are only four. The six BN-43-2402 cores are shiny black. The difference is subtle but you can easily make the distinction when they are side-by-side.

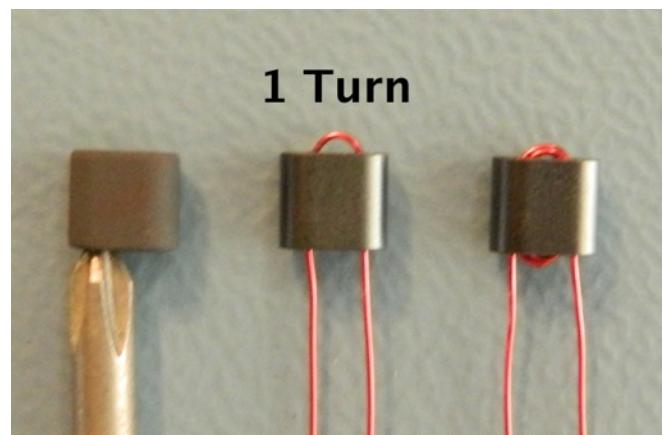
Two sizes of wire are included. The #26 wire is thicker than #30 wire. There's some extra so don't worry if you have to rewind a mistake.



□ Wind the RF Chokes

The schematic indicates 4T BN-43-2402 6" #26. This means use 6 inches of #26 wire to create 4 turns on a BN-43 core. Remove any burrs with a #1 Philips screwdriver.

Up one hole and down the other is one turn. The wire is shaped like a U at this point. Do this three more times and you're done. You'll end up with 4 strands of wire in each hole with the ends coming out of the same side.



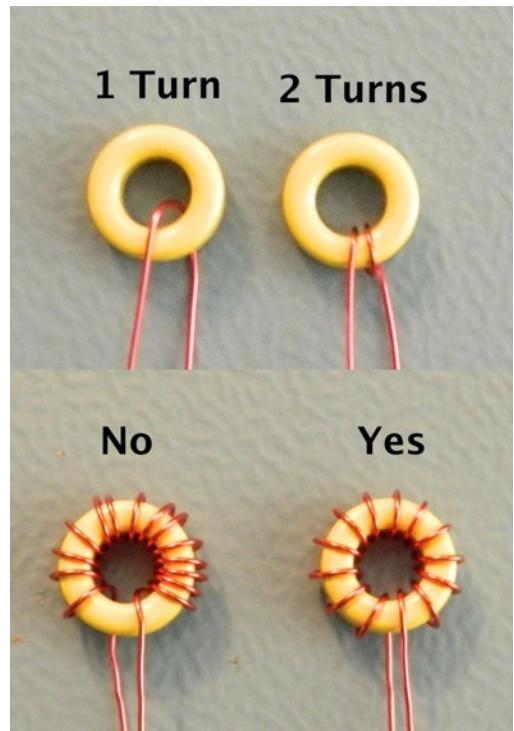
Wind the toroids

Use the schematic to determine the configuration of toroids L1-L9. Each pass through the core counts as one turn. Refer to the picture to ensure you don't make a common mistake.

You'll notice that there's two directions you can wind these toroids. Electrically, it doesn't matter. However, you'll find that one direction will fit on the PCB better. The photos show the preferred direction. It's worth a test fitting after winding the first one just to make sure.

The coils should be pulled tight with only your fingers. Don't use pliers and don't leave the loops sloppy. Space the windings evenly all the way around the toroid. Use the entire 360 degrees.

More than about 29 turns will require a second layer of winding.



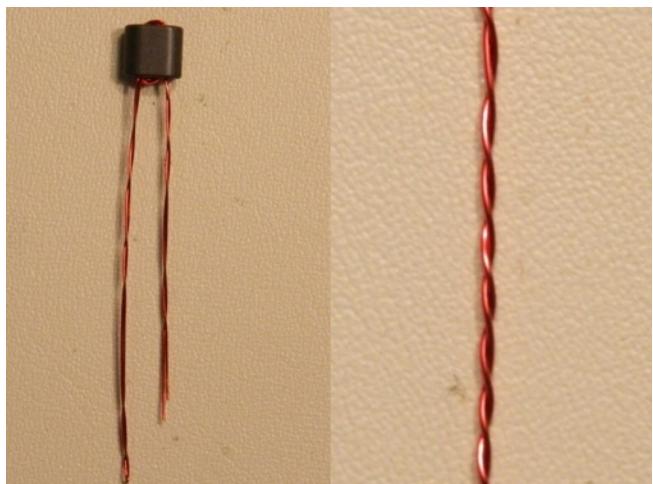
Wind the bifilar transformer T1

Cut off 12 inches of #30 wire. Fold in half and twist together. The schematic refers to this as 2x6". You could twist two 6 inch lengths but having one end folded makes it easier to thread.

A bifilar wire is simply two wires that are in very close proximity. We are twisting the wires to make sure they don't separate during construction. Several turns per inch is sufficient.

Wind T1 just like you did for the RF chokes. 2x4T means 4 turns of the bifilar wire you just twisted.

When you are done you will have eight strands in each hole with four wires coming out the same side.

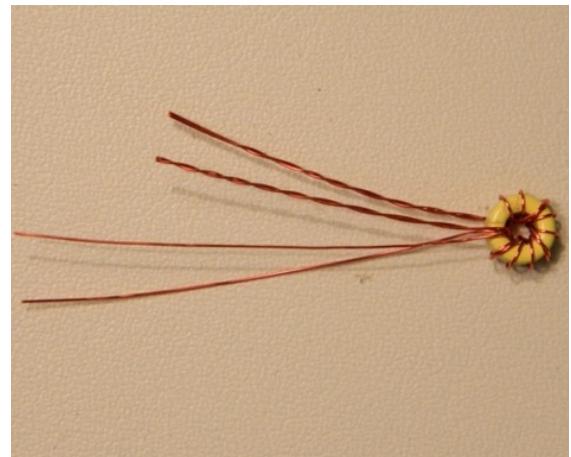


□ Wind the toroid transformer T3

This has a single winding and also a bifilar winding. I find it easier to wind the bifilar first then put two single winds between each bifilar winding.

Be sure that both windings are done in the same direction. It doesn't matter which so long as they are all the same.

Cut the wires to different lengths before you untwist the bifilar pairs. If you fail to do this then it will be impossible to know how to install the toroid on the PCB.



□ Wind the binocular transformers

T2, T4, and T5 are transformers similar to T3. Winding the bifilar first is recommended because the single wire is easier to fit when things get tight. Use a toothpick if you need to make a bit more room. Wood won't damage the insulation. Don't use anything metal or plastic.

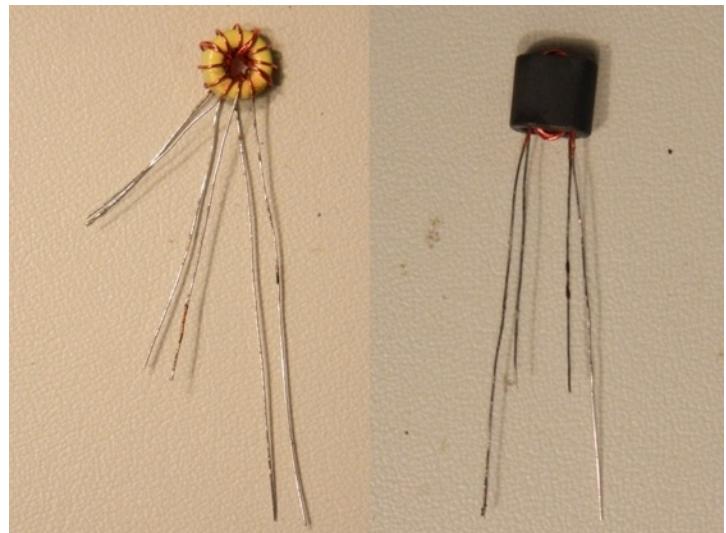


□ Prepare the leads

If your soldering iron has temperature control, turn it up to 750 degrees F or more. I use 850. If not, you will need to scrape off some of the coating first.

Use your soldering iron and flux core solder to prepare the wires for mounting on the PCB. The bifilar wires can now be identified with the continuity feature of your multimeter. Cut one of the bifilar pairs a little shorter.

There are lines on the PCB that correspond to the pairs of wires you have identified. Don't install any inductors yet but take a look now so you know for later. The heavy line indicates where the single winding goes. The other lines are for the bifilar pairs. The bifilar pairs are electrically identical. It is only critical you don't install them crossed over. If this is confusing, use the schematic to work it out. The PCB is only 2 layers so you can easily see all the traces.



□ Identify electronic parts

Open the foil shielded bags and put the parts in an ESD-safe tray they can't fall out of. I use a metal cake pan with 2" sides.

Parts with confusing, unusual, or varying markings, such as the transistors, will be identified with the possibilities in square [brackets]. You may need to peel off the covering and use a magnifier to read these parts.

Resistors are marked using numbers with the last digit being a positive exponent of 10 or an R to indicate a decimal. For example, 50R0 is 50.0 ohms, 5000 is 500 ohms, 5001 is 5k and 5003 is 500k. Surface-mount capacitors are not available with markings. Many of the values are too small to read with a multimeter so don't remove them from the parts sheets until necessary.



The resistors and capacitors are mounted to sheets of paper. The larger parts sheet will be used in its entirety except for one extra 0.1 μ F capacitor which you may discard. The smaller parts sheet contains the parts which vary depending on the band selection you make. Only about half of these will be used.

□ Mounting hardware

Installing the mounting hardware will make assembly easier as well as protecting the components. The screw heads and washers should be on the bottom of the board with the 1/4" spacer and nut on the top to protect the coils after they are installed.

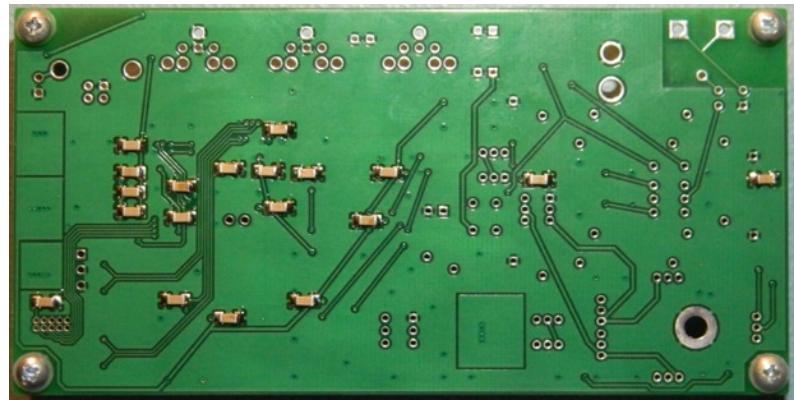
The board will slide around if you are working on a hard surface. An ESD-safe work mat will not have this problem. The screws will protect budget mats from soldering iron heat.



Don't bother with a PCB vise or helping hands. These devices sound good in theory, but holding your hands and arms up in the air while soldering is tiring and makes it difficult to keep from shaking.

Bypass capacitors

The bottom of the board has no silkscreen printing. To avoid needing a map, all parts on this side are $0.1\mu\text{F}$ capacitors. Twenty capacitors are included in the kit but only 19 are used. There are no $0.1\mu\text{F}$ capacitors on the top of the board.



These are the first parts you will remove from the Cs & Rs sheet. I use an X-ACTO knife but scissors with also work. In addition to the obvious tape the parts strips have another piece of tape over them that is sometimes tricky to peel off.

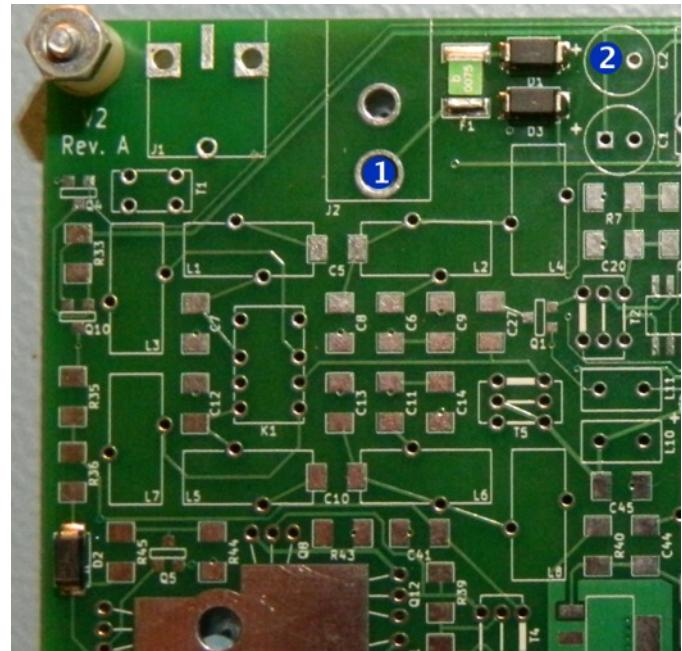
- C22, C24, C28, C38, C40, C48, C49, C50, C51, C52 - $0.1\mu\text{F}$
- C54, C55, C56, C57, C58, C60, C62, C63, C64 - $0.1\mu\text{F}$

Inspect your work with illuminated magnification. Component failures are extremely rare. Bad soldering, even by experts or automated machinery, happens all the time.

Power Protection

Fuse F1 is a polymeric positive temperature coefficient device. In an over-current condition it will substantially increase in resistance as a safety precaution. The device will reset itself when allowed to cool so no replacement is necessary. If you observe the radio using more than 0.75A of power then see a sudden drop to 0.20A or less then F1 has probably been tripped because you have a short on the PCB.

Diode D1 will protect the radio from a power supply with reversed polarity. To make assembly faster we will also install diodes D2 and D3. This practice of installing all the parts of the same kind at once will be repeated throughout the entire assembly process. This only happens in a few places and none of these "future parts" complete circuits.



Make sure the diodes are installed with the correct polarity. There is a line on the package that corresponds to the line on the PCB silkscreen.

- F1 - [0075] 0.75A PPTC resettable fuse
- D1, D2, D3 - [R13] 1N4003 diode

Testing

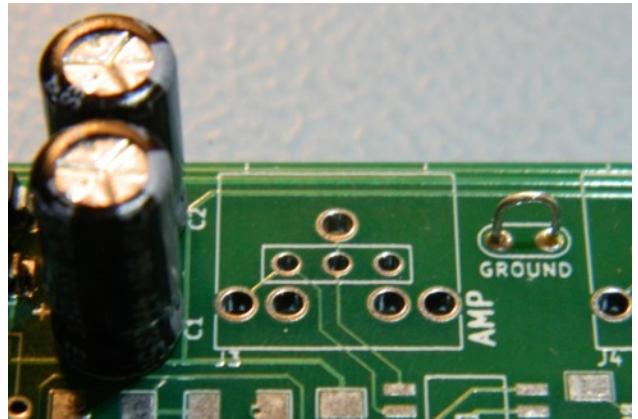
The diode tester in your multimeter should see 0.5-0.7V of forward voltage between test points 1 and 2. The positive lead goes on TP1 with negative on TP2.

- F1 + D1 forward voltage of 0.5-0.7V

If any of the tests fail at any point in this guide then it is best to stop building until the problem is resolved. There is no chance that continuing a build will magically resolve a problem. In fact, it will make things more difficult for others to assist you or possibly destroy parts. In almost all cases the problem is due to bad soldering or incorrect parts placement so an illuminated magnifier will be your best diagnostics tool.

Ground test point

Install C1 and C2 saving one of the leads you cut off. Install the scrap lead as a loop on the ground test point between J3 and J4. This is an attachment point for the alligator clip of your multimeter and oscilloscope.



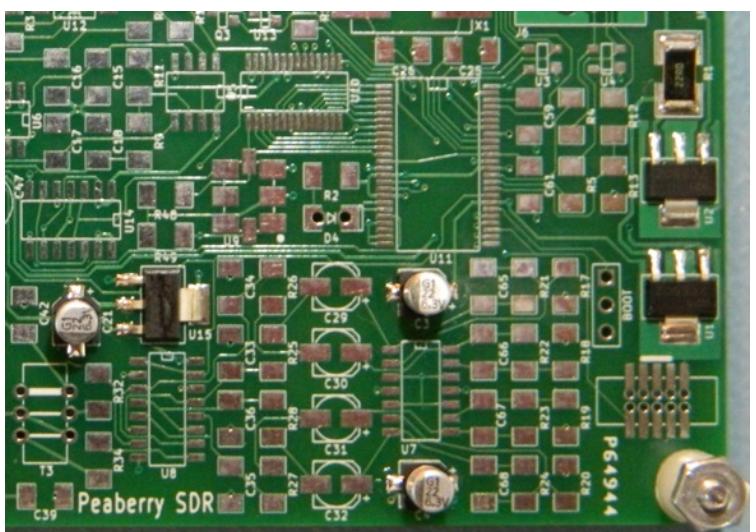
Don't forget that electrolytic capacitors are polarized. The PCB is marked with a (+) and the package is marked with a (-).

- C1, C2 - 47 μ F
- GROUND - scrap wire

Power supply

R1, U1 and U2 will get very hot during normal operation of the radio. You will burn yourself if you touch them. These devices are designed to operate properly up to 150°C/300°F. The regulators have a thermal shutdown feature so if they are working they are not too hot.

- J2 - Power jack
- R1 - 22Ω
- U1 - [50Z][17-50] 5V linear regulator
- U2 - [17-50] 5V linear regulator
- U15 - [33Z] [17-33] 3.3V linear regulator
- C3, C4, C21 - 22 μ F



Testing

A power plug is included in the kit. Wire it up to your 13.8V DC power supply with the center positive. Test the current draw of the radio. You will see a surge of power as the capacitors charge but this will settle in about a second.

Current measurements are not a good test for this radio. Many people have asked for them so I recorded what I observed. Your readings may differ by $\pm 50\text{mA}$ or more.

- J2 - <30mA

Ensure the regulators are putting out the correct voltage by probing their large tab.

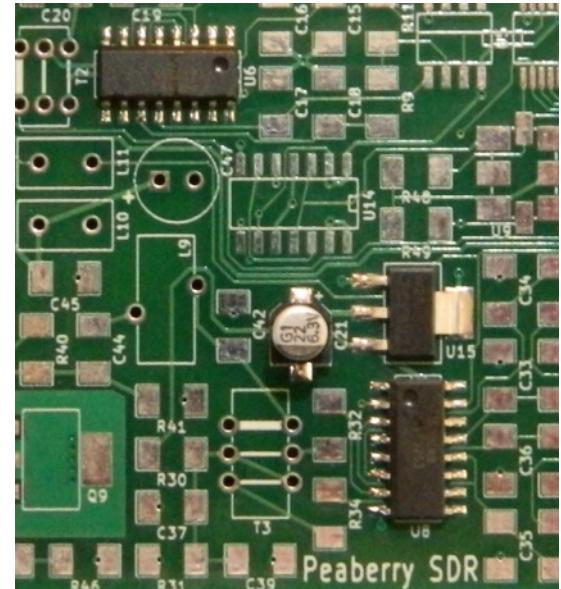
- U1 tab - 5.0V $\pm 2\%$
- U2 tab - 5.0V $\pm 2\%$
- U15 tab - 3.3V $\pm 2\%$

FET Mixers

Before installing the PSoC it is a good idea to practice installing ICs with something a little easier. The Peaberry SDR uses FET multiplexers for RF mixing. Before installing any IC make sure you identify pin 1 and match it to the PCB. Take your time and work carefully.

When installing SMT ICs using a soldering iron always begin by attaching only a single corner pin. Any corner is fine. Once you have the alignment perfect you can attach the opposite corner and proceed with the remaining pins. Before applying any solder it may be helpful to practice using your tweezers to find a comfortable position and illumination.

- U6, U8 - [3253] FET multiplexer



DO NOT ATTEMPT TO REMOVE INTEGRATED CIRCUITS EXCEPT WITH A HOT AIR TOOL. YOU WILL DAMAGE BOTH THE IC AND CIRCUIT BOARD.

Testing

- U6 pin 16 - 5.0V
- U8 pin 16 - 5.0V
- J2 - <40mA

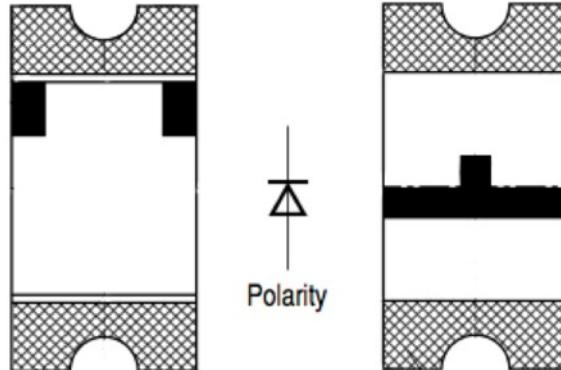
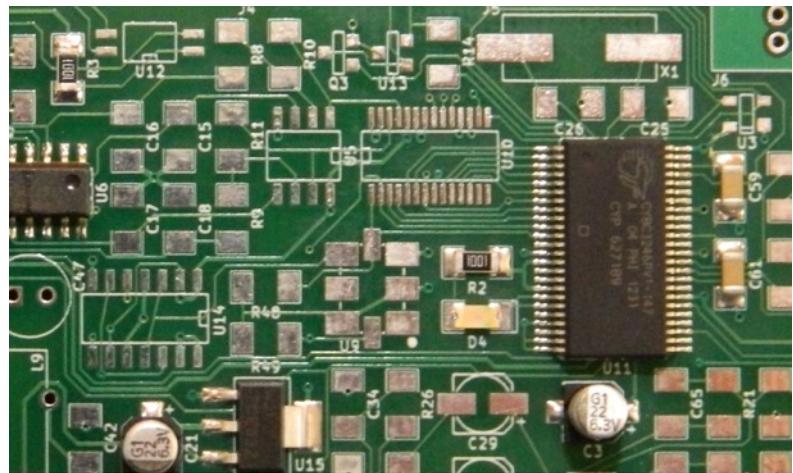
Cypress PSoC

Install the PSoC and carefully inspect your work. It's very easy to bridge these pins with solder. Excess solder is easily removed with desoldering wick. Clean off the flux and check your work again.

We'll also be installing the diagnostics LED. There's holes in the pads if you want to install a LED on your enclosure panel. Only a surface-mount LED is included in the kit.

- U11 - Cypress PSoC 3
- C59, C61 - $1\mu\text{F}$
- R2, R3 - 1k
- R13 - 100k
- D4 - LED

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BOARD.**



Testing

The PSoC will perform a power-on self-test and report critical failures. The LED sends errors using morse code (see appendix A). At this stage you will have a critical error. Indeed, we have not yet installed the 24 MHz crystal.

J2 - 45-60mA
LED - sending XTAL

If the LED fails to light at all, check its polarity. The LED can withstand reverse voltage so just flip it around if that's the problem. If it's not the LED then the the PSoC is failing to start. Check for solder bridges, recheck the output of the voltage regulators, and reflow all the PSoC pins. Other than power, no support circuitry is needed for the PSoC to drive the LED. Really, it's a very easy device to get running and extremely tolerant of soldering iron heat.

It is not recommended to probe around the PSoC. Standard test leads can too easily short two pins which will overload the GPIOs. The LED should be used to isolate problems for physical inspection.

□ 24 MHz Crystal

- X1 - 24 MHz XTAL
- C25, C26 - 22pF

Testing

- J2 - 55-65mA
- LED - sending I2C

With a working crystal the PSoC will attempt to initialize the Si570 and PCM3060. I2C is a digital bus protocol shared by these three chips. The I2C error message indicates a total failure to communicate with any other chip on the bus.



□ Silicon Labs Si570

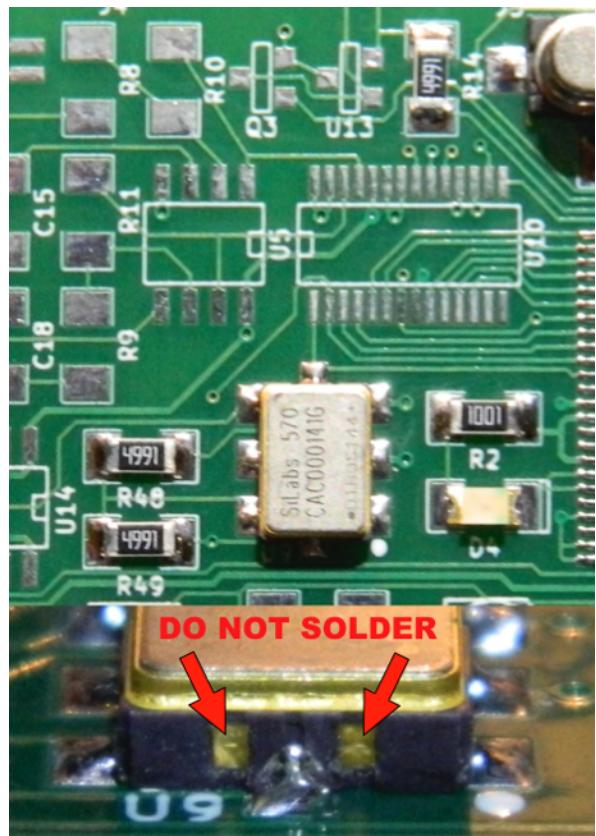
The Si570 is a programmable clock which we use as the local oscillator for mixing. It has no leads so you must get the solder to flow under the chip. The pads on the bottom are also slightly exposed on the sides so the trick is to get your iron tip to touch both the pad on the PCB and the pad on the edge of the Si570. With heat on both pads the solder will flow freely. The dot on the package aligns with the dot on the PCB.

R48 and R49 are pullup resistors for the open-drain I2C bus. R14 is a current limiter for a future circuit.

- U9 - Si570
- R14, R48, R49 - 4.99k

Testing

- J2 - 130-150mA
- LED - sending PCM3060
- U14 pin 3 - 3.3V p2p square wave 56.32MHz



If you don't have an oscilloscope your multimeter will read about 1.65VDC (3.3÷2) on U14 pin 3. Inexpensive oscilloscopes will show a sine wave instead of a square wave. Don't worry about getting an accurate reading.

If the LED is still blinking I2C then you have probably shorted the bus to ground. On the narrow sides of the Si570 package are two extra pads that must not get soldered. These are part of the housing, not intended for an electrical connection.

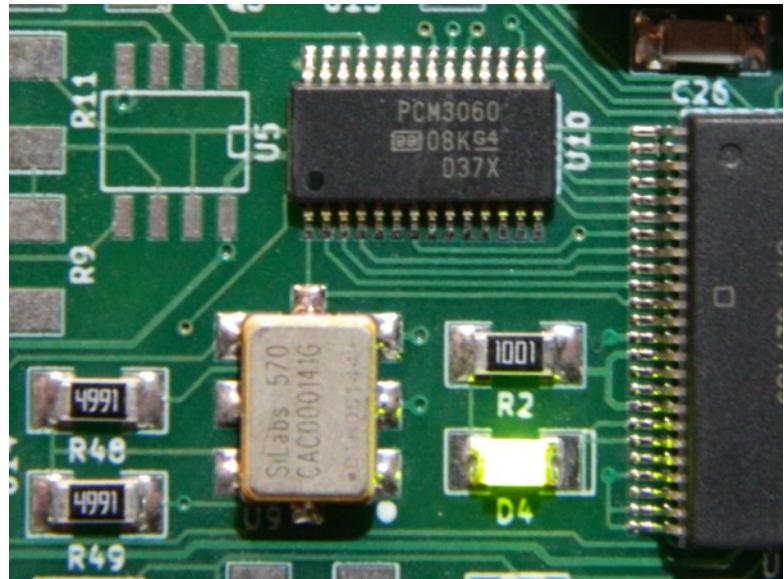
TI PCM3060

The PCM3060 is a 64x oversampling Delta-Sigma ADC and DAC. It is controlled with a custom program in the PSoC which allows it to appear on your computer as a standard sound card. Its settings are locked to the ideal for software defined radio so there's nothing in the operating system to adjust for maximum performance.

- U10 - PCM3060

Testing

- J2 - 130-150mA
- LED - Steady On

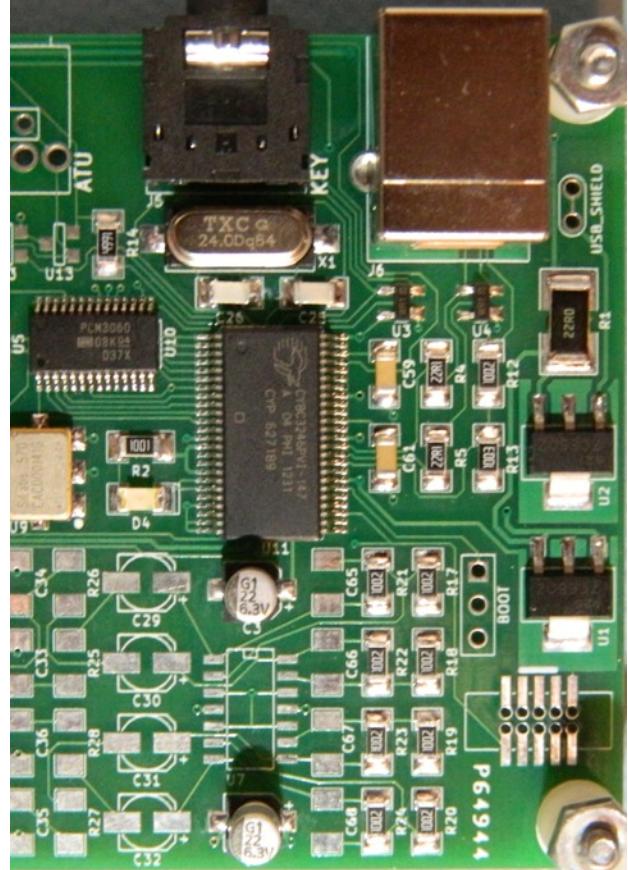


The PCM3060 sleeps when there is no USB connection so expect no additional current from adding this part. You should no longer be getting any error codes from the LED. The steady on LED indicates the PSoC has successfully completed all self-tests and is ready for operation.

USB and KEY

U3 and U4 protect the PSoC from ESD entering through the USB and KEY jacks. R33 and R35 are future parts on the very left of the PCB and not shown in the picture.

- R4, R5, R35 - 22.1Ω
- R12, R17-R24, R33 - 10k
- U3, U4 - [WR1] ESD Diode
- J5 - Stereo jack
- J6 - USB jack



Testing

Upon connecting the USB to a computer, the PCM3060 will power up. The Peaberry SDR does not use USB power so there is no need to measure current on J6.

- J2 - 180-210mA

□ Windows Device Driver

This manual will cover testing the Peaberry SDR V2 under a Windows operating system. Windows XP or newer is known to work. The application we'll be using is HDSDR. When done, your radio and software will be fully ready for use.

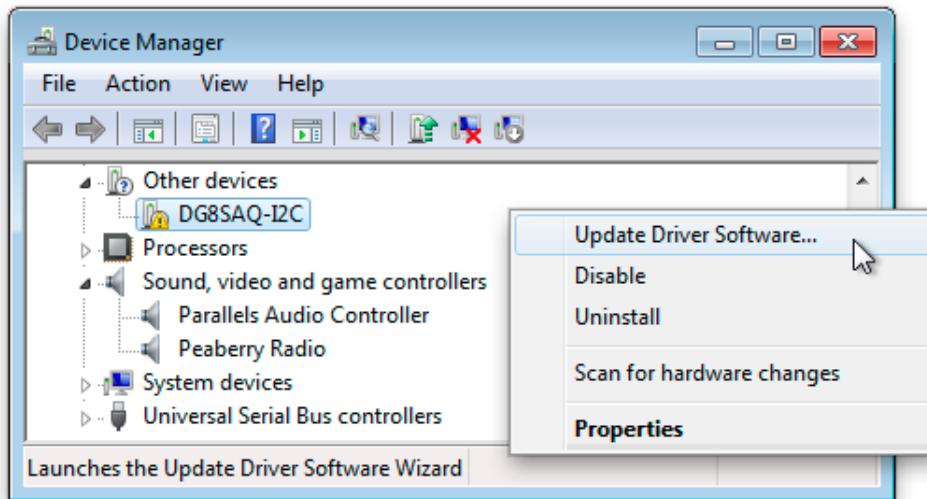
You're welcome to use another operating system or application but you'll have to figure it out on your own. There are dozens of compatible applications across all modern operating systems. Please remember that the Peaberry SDR is produced entirely by one person. Radio software is vast and complex so I am unable to provide application support. Use the Peaberry SDR support forum or the application's support forum to connect with other users who can help.

Windows requires a device driver. Other operating systems do not. You can get a ready-to-use libusb-win32 driver from the support forum:

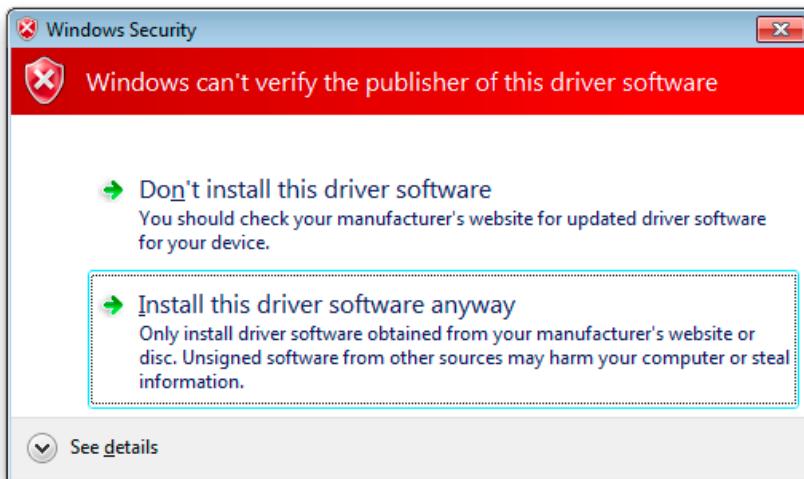
<http://AE9RB.com/forum/viewtopic.php?f=4&t=96>

Unzip the driver and launch Device Manager. The "Peaberry Radio" appears as a sound card and should have been automatically installed by Windows because it is a standard USB audio device. You should also have a "DG8SAQ-I2C" device which needs a device driver.

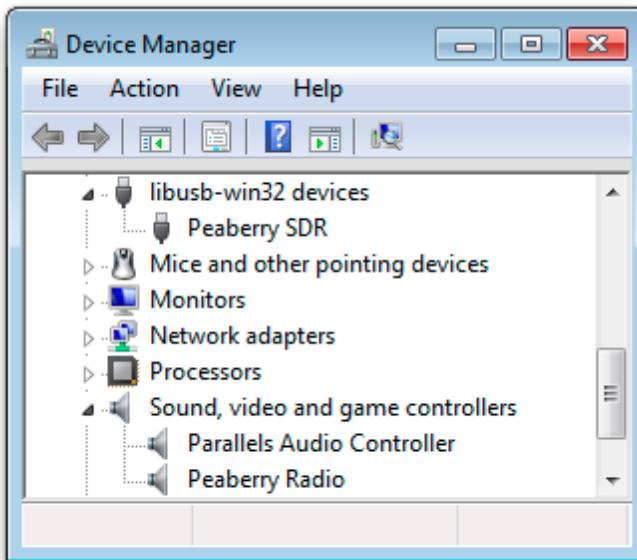
The steps vary slightly with different version of Windows. The examples here are from Windows 7. Right click on "DG8SAQ-I2C" and choose "Update Driver Software..." .



Select "Browse my computer for driver software" and provide the path where you unzipped the driver. Select "Next" and you'll probably get a security warning. Install the driver anyway.



If everything goes well then the other/unknown “DG8SAQ-I2C” device is replaced by “Peaberry SDR” showing as a libusb-win32 device.



Not seeing the Peaberry Radio sound device?

If you have ever used the automatic installer (.exe) from PE0FKO for a SoftRock then you must uninstall and delete the driver. After selecting “Uninstall” from Device Manager, check the box to delete all files.

Errors with Windows 8?

You must disable driver signature enforcement in Windows 8. Do an internet search for “disable driver signature enforcement” if you do not know how to do this.

□ HDSDR Application

Install the latest version of HDSDR. It's a standard Windows installer. Take note of the path it installs to. If you already have HDSDR installed then run the "delete_settings.cmd" so you have a clean start. If at any time you have a problem following this guide, come back to this beginning and run "delete_settings.cmd" to start anew.

<http://www.hdsdr.de/>

Install the latest version of CFGSR. The setup.exe generally works better than the msi installer.

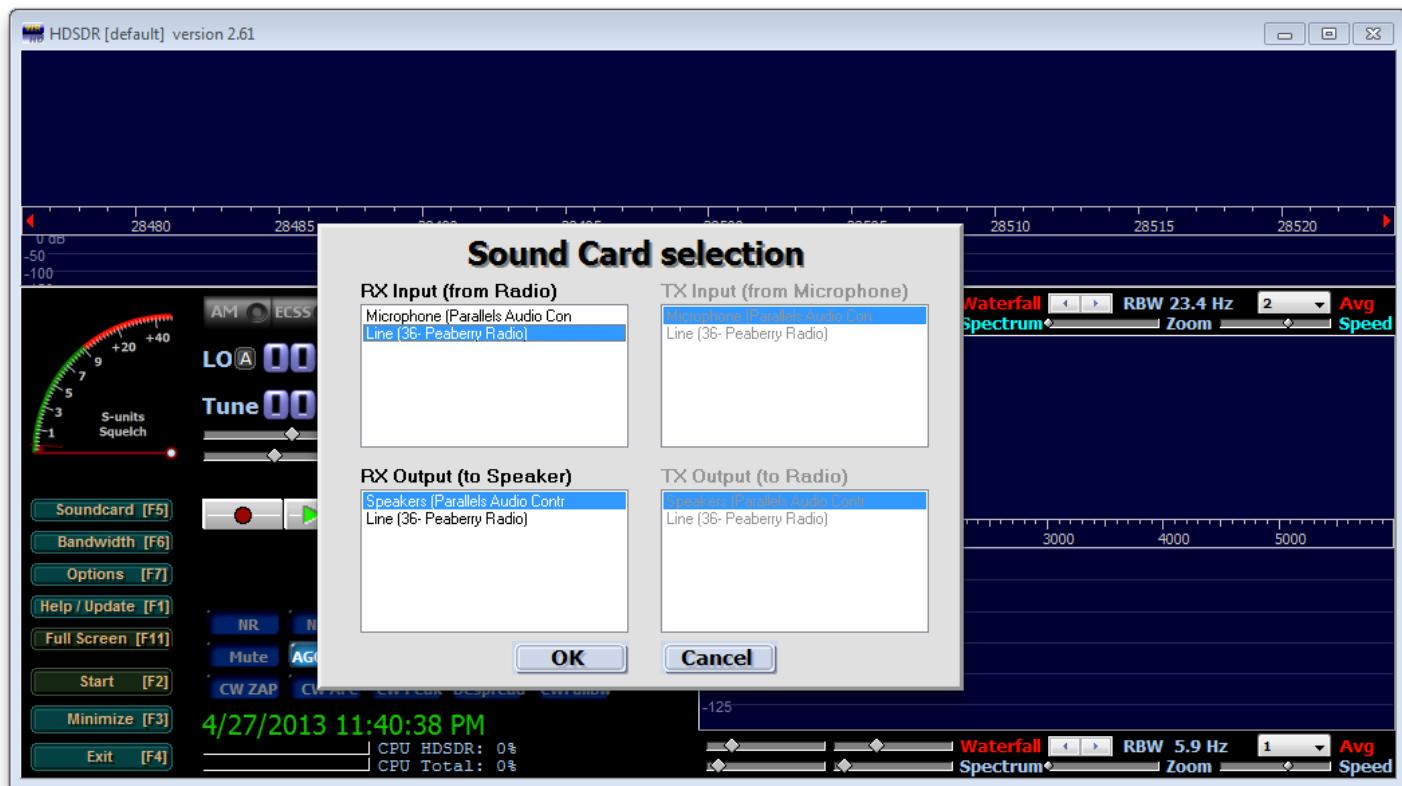
<http://pe0fko.nl/CFGSR/>

You have to figure out where CFGSR was installed. It doesn't always tell you. It's different on the various versions of Windows. When you find it, somewhere within is a ExtIO_Si570.dll file. Copy this file to the HDSDR folder. Here are the paths for my Windows 7 system:

C:\Program Files (x86)\CFGSR\ExtIO_Si570\ExtIO_Si570.dll

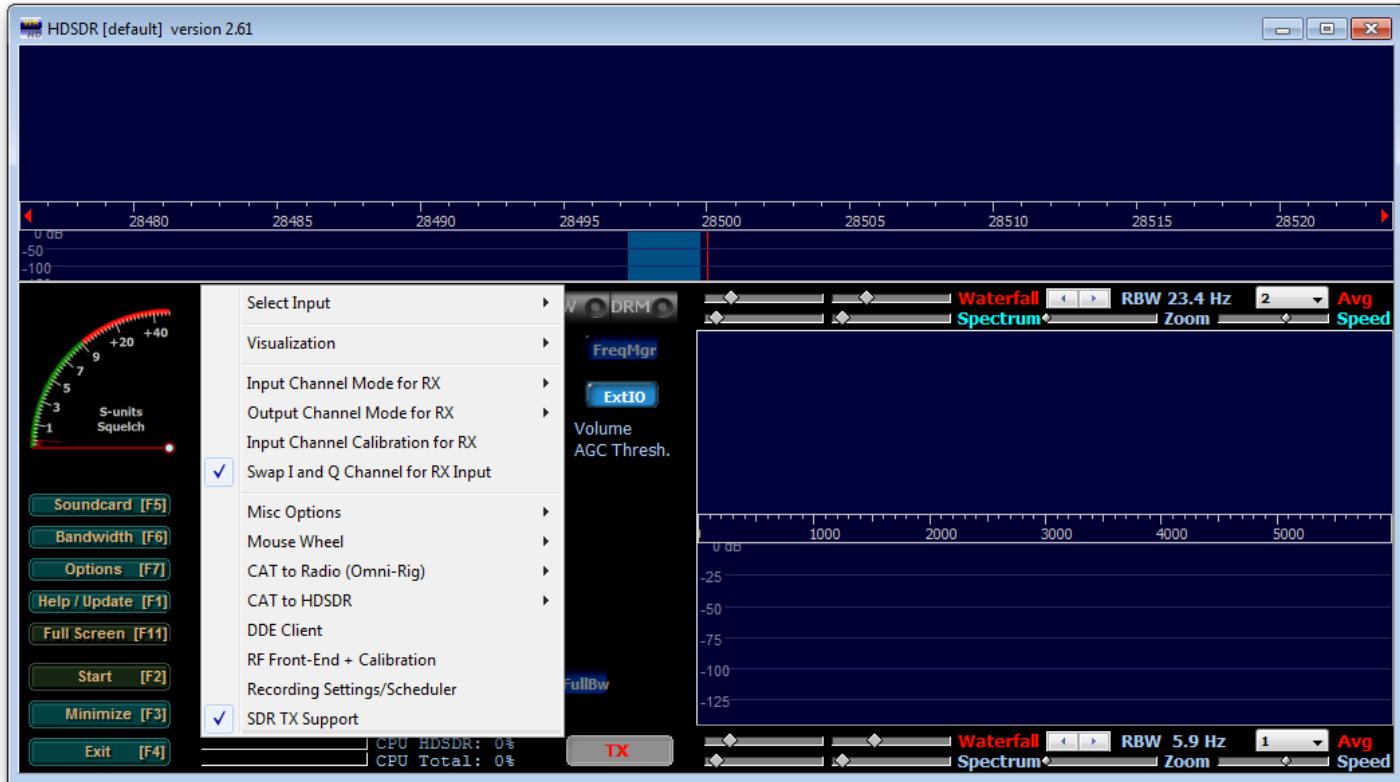
C:\Program Files (x86)\HDSDR\ExtIO_Si570.dll

Do not run the CFGSR tool. It will conflict with HDSDR. All we needed was the DLL. Launch HDSDR now.

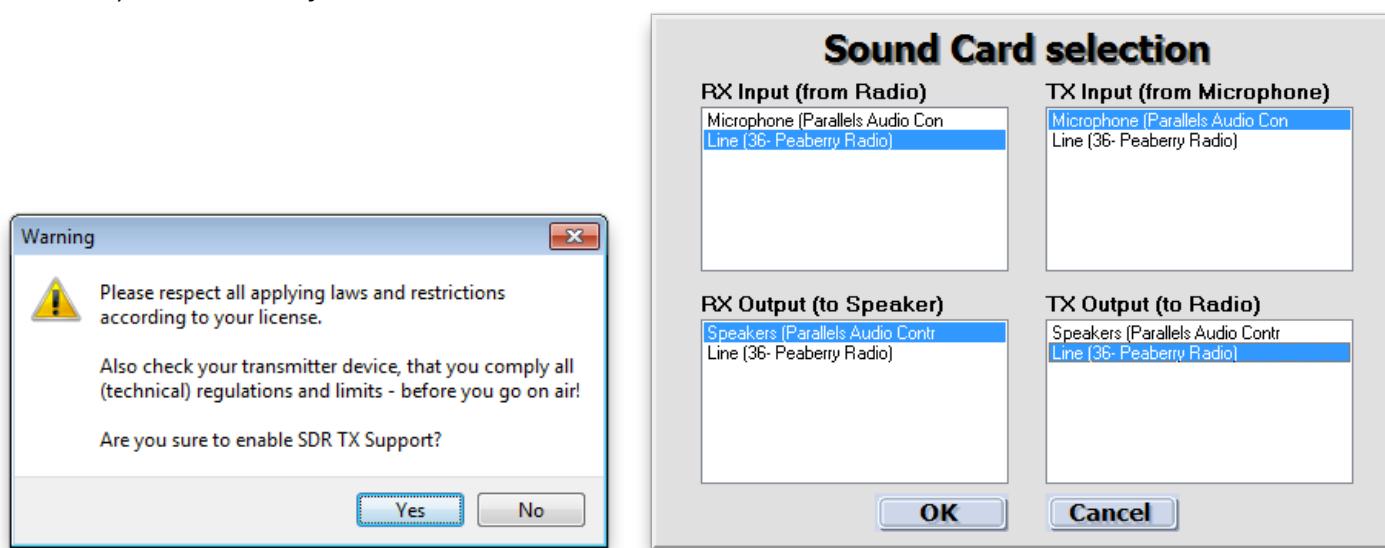


Set the “RX Input (from Radio)” to “Peaberry Radio”. Set the “RX Output (to Speaker)” to wherever you want to hear audio. Press OK.

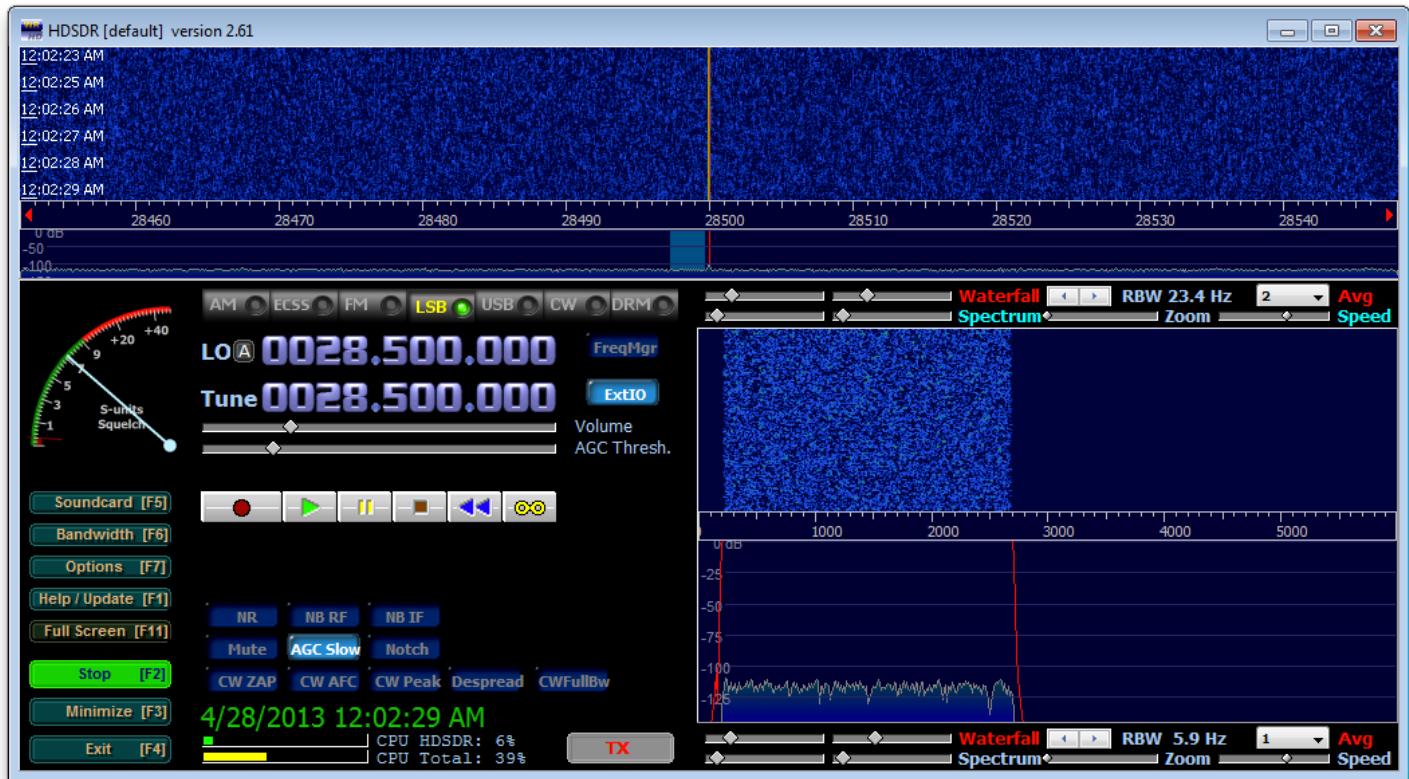
Click on the “Options [F7]” button. Enable “Swap I and Q channel for RX Input”.



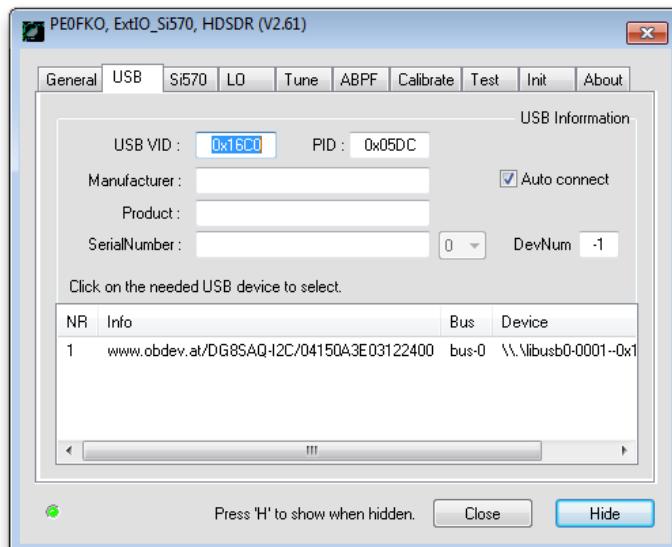
Click on the “Options [F7]” button again. Select “SDR TX Support”. Choose “Yes” after reading the warning. Set the “TX Input (from Microphone)” to where you have a microphone. Set the “TX Output (to Radio)” to “Peaberry Radio”. Press OK.



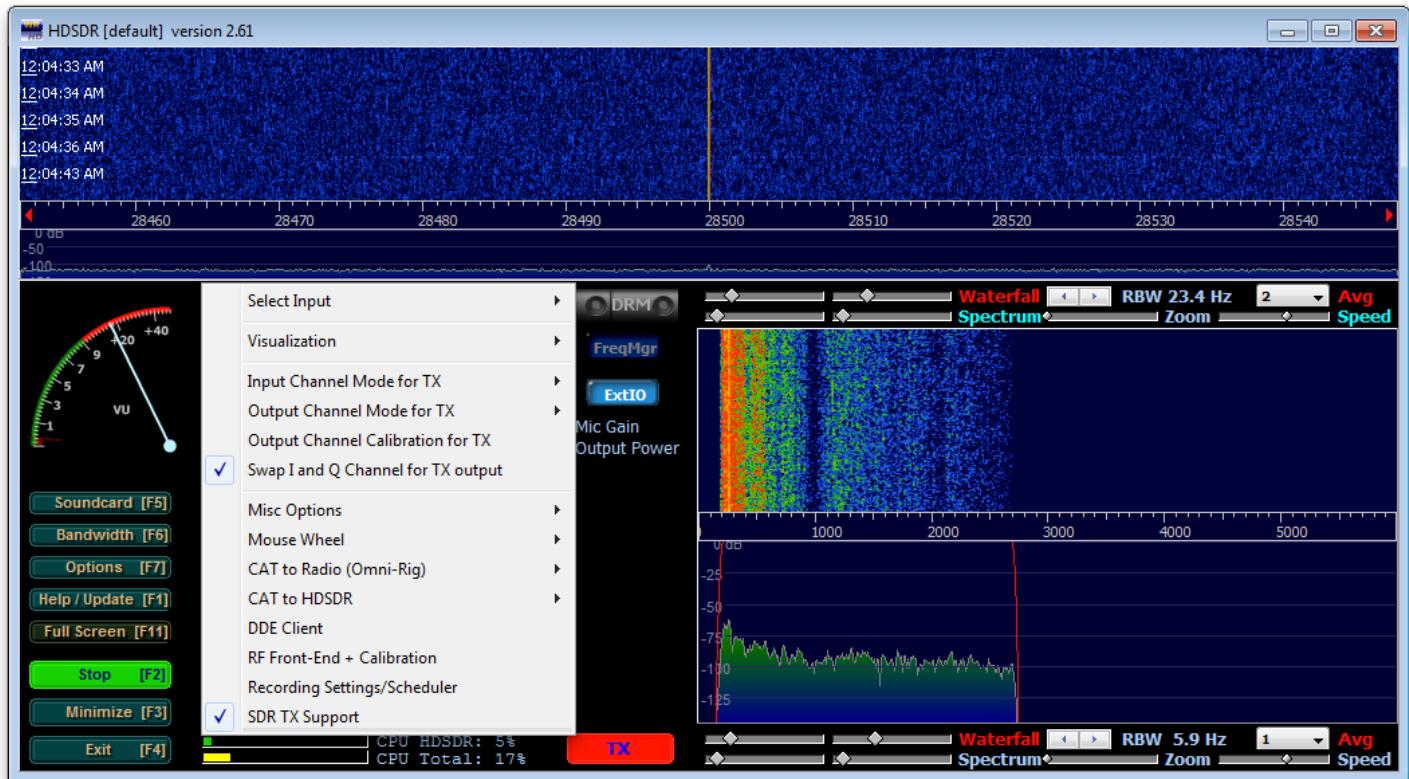
Click on the “Bandwidth [F6]” button. Select 96000 for the sampling rate. Close the dialog with the “X” button. Click on the “Start [F2]” button. The radio will begin working and you’ll hear static from the speaker.



Click on the “ExtIO” button. You should see a message about the Si570 being connected. If not, you can try to figure out what’s going on from the USB tab.



Click on the “TX” button. The LED on the radio will blink rapidly while HDSDR is transmitting. You haven’t built the transmitter yet so nothing is really being transmitted.

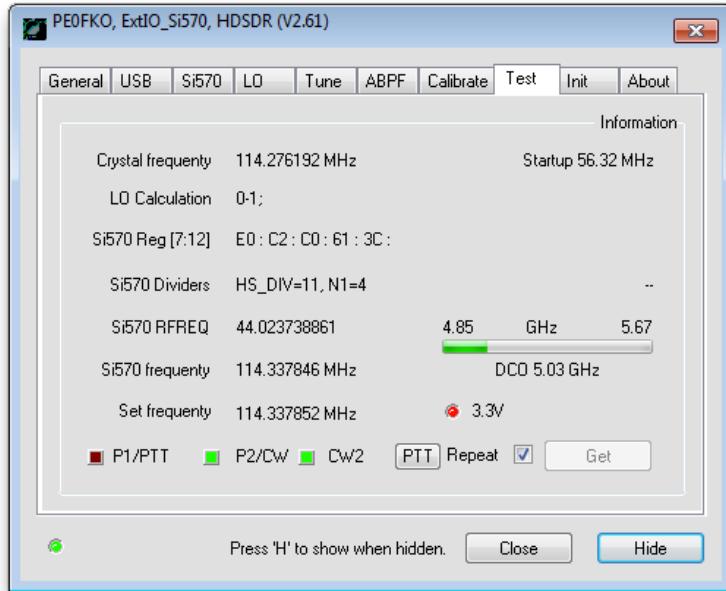


Click on the “Options [F7]” button. Enable “Swap I and Q channel for TX Output”. You must be transmitting to do this.

Press “TX” to turn off the transmitter. All the critical setting are done. If you like, take a moment to play around with the tuning and different modes.

□ Testing the KEY jack

Press the “ExtIO” button in HDSDR. Select the “Test” tab from the dialog. Check the “Repeat” box. The P2/CW and CW2 lamps will go out when the key contacts are closed.



Note that you can not send CW from HDSDR using a key or paddle plugged into a Peaberry. Try Quisk, Rocky or PowerSDR-IQ instead.

□ AMP and ATU jacks

- U12- Optocoupler
- U13 - [V5] ESD diode array
- Q3 - [K1N] MMBT3904
- J3, J4 - Stereo jacks

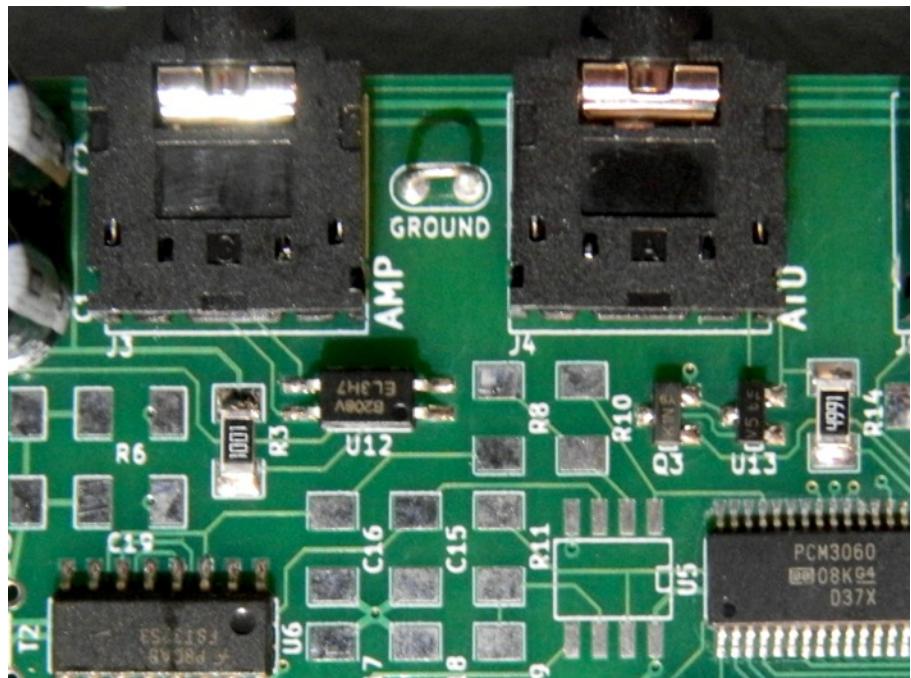
The AMP jack will trigger an external RF amplifier. Many amps include an RF detector and timer but if it has a manual trigger then you don't have to worry about SSB missing a first syllable or cutting out during a long pause.

The AMP jack is designed for CMOS/TTL triggered amps. It will not allow enough current to directly trigger a relay.

The ATU jack supports the Elecraft T1 automatic antenna tuner. The Peaberry SDR will signal the tuner when you change bands. There is no configuration or setup needed. Simply connect the tuner with a stereo patch cable.

You can also connect the ATU jack to an Arduino and write a custom program to control an antenna switch or change bands on an amplifier. An example program which can read the band data is available in the source code repository.

<https://github.com/AE9RB/peaberry>



Receiver

R10 and R11 are on the option parts sheet. This will be the case whenever you see a capacitor or resistor that varies based on the build option.

- R10, R11 - see schematic
- R8, R9, R25-R28, R32, R34 - 49.9Ω
- C15-C18, C20, C23, C27 - 0.01μF
- C37, C41, C43, C45 - 0.01μF
- C19, C39 - 4.7μF
- R6, R7, R31, R36, R40 - 2.21k
- U5 - LT6231CS8
- U14 - [ACT74] D-type flip-flop
- Q1 - [LWW] 2N7002
- L11 - see schematic
- T2 - see schematic

Testing

- J2 - 190-210mA

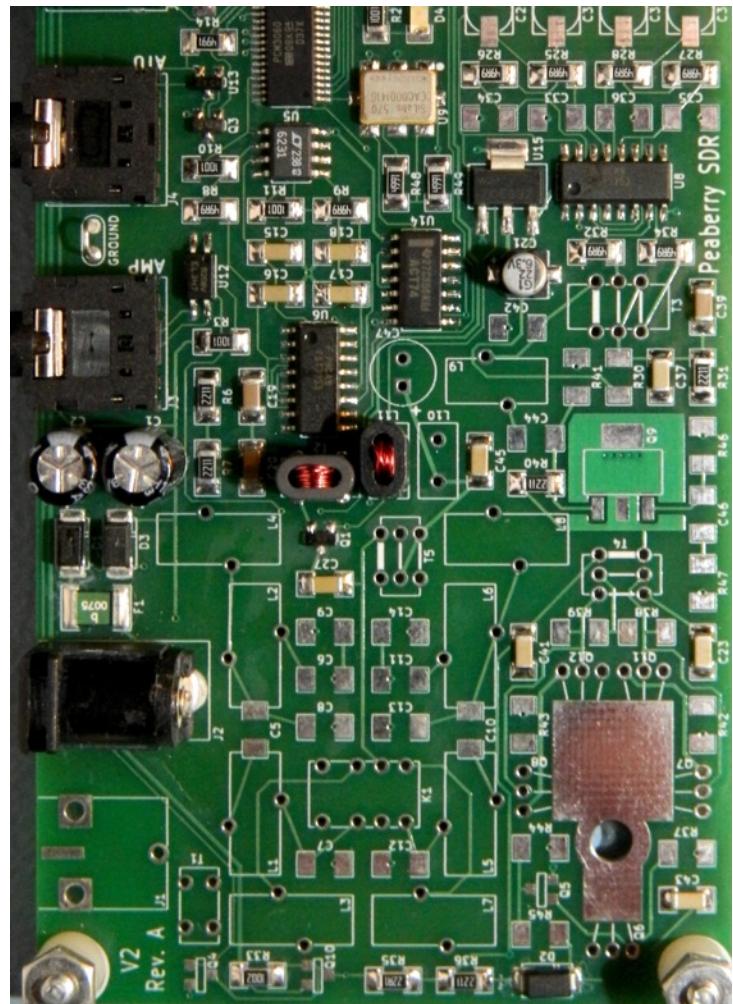
U14 divides the Si570 clock by 4 to generate two square waves 90 degrees out of phase. You can observe this on an oscilloscope. Changing the LO frequency in HDSDR will change the frequency you see here.

- U6 pins 2 and 14 - LO Hz 5V square wave

If you have a signal generator then inject an RF signal between -40dBm and -100dBm on C27. This range is easily seen in HDSDR.

- HDSDR RX SSB or CW - Injected signal
- U5 pins 2,3,5,6 - | Injected signal frequency - LO frequency |
- U5 pins 1,7 - Mixed signal amplified by OpAmp gain (R10÷R8)

If you don't have equipment then there's nothing practical to test here. Voltage measurements from a multimeter are not useful for tracing an RF signal path. If the receiver fails to function when you later get it hooked up to an antenna then you will have to find help from someone with the necessary tools.



Antenna connector

The BNC jack will require a lot of heat to attach. Remove the nearby mounting hardware while soldering this component. Give everything time to cool so you don't burn yourself. Restore the mounting hardware before continuing.

- J1 - BNC



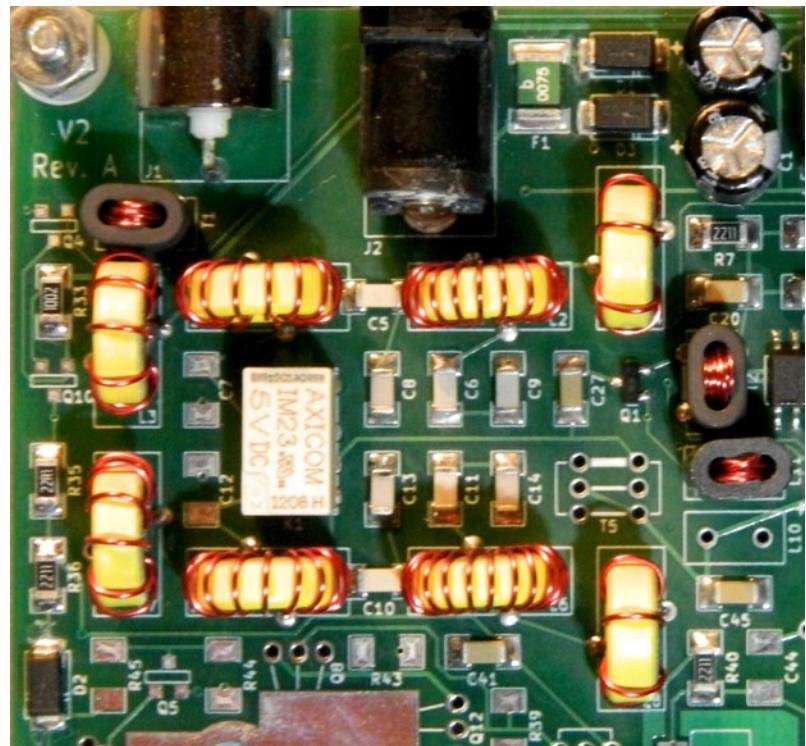
Band-pass filters

If the schematic calls for something like "630pF (300+330)" it is asking for two capacitors in parallel. Simply attach one to the board as usual then solder the other one right on top of it. You will find it much easier to install all the capacitors before the inductors.

- C5-C14 - see schematic
- K1 - Relay
- T1 - see schematic
- L1-L8 - see schematic

Testing

The receiver should be fully working in HDSDR. You will hear the relay click as you change bands. Either use a signal generator to test or have fun with your antenna.

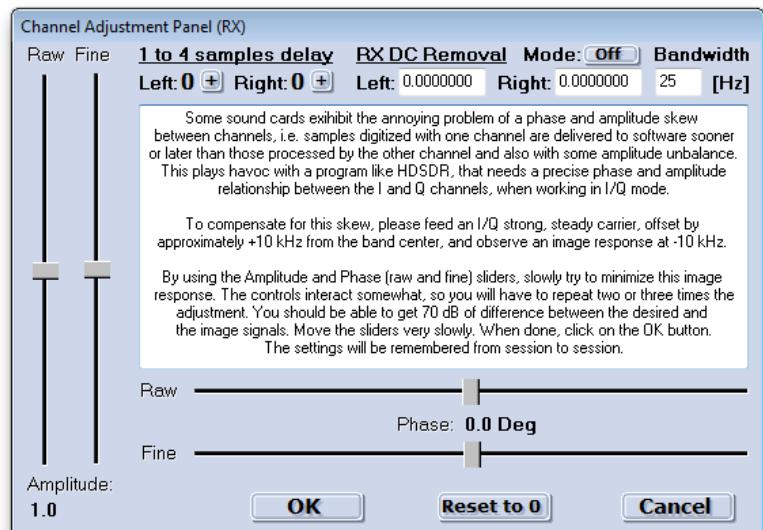


The Peaberry SDR is a transceiver so it expects an antenna that can transmit well. For example, a vertical with ground radials, a dipole, a yagi, etc. If you simply connect a random wire to the center of the BNC then receiver performance will be poor.

RX Adjustment

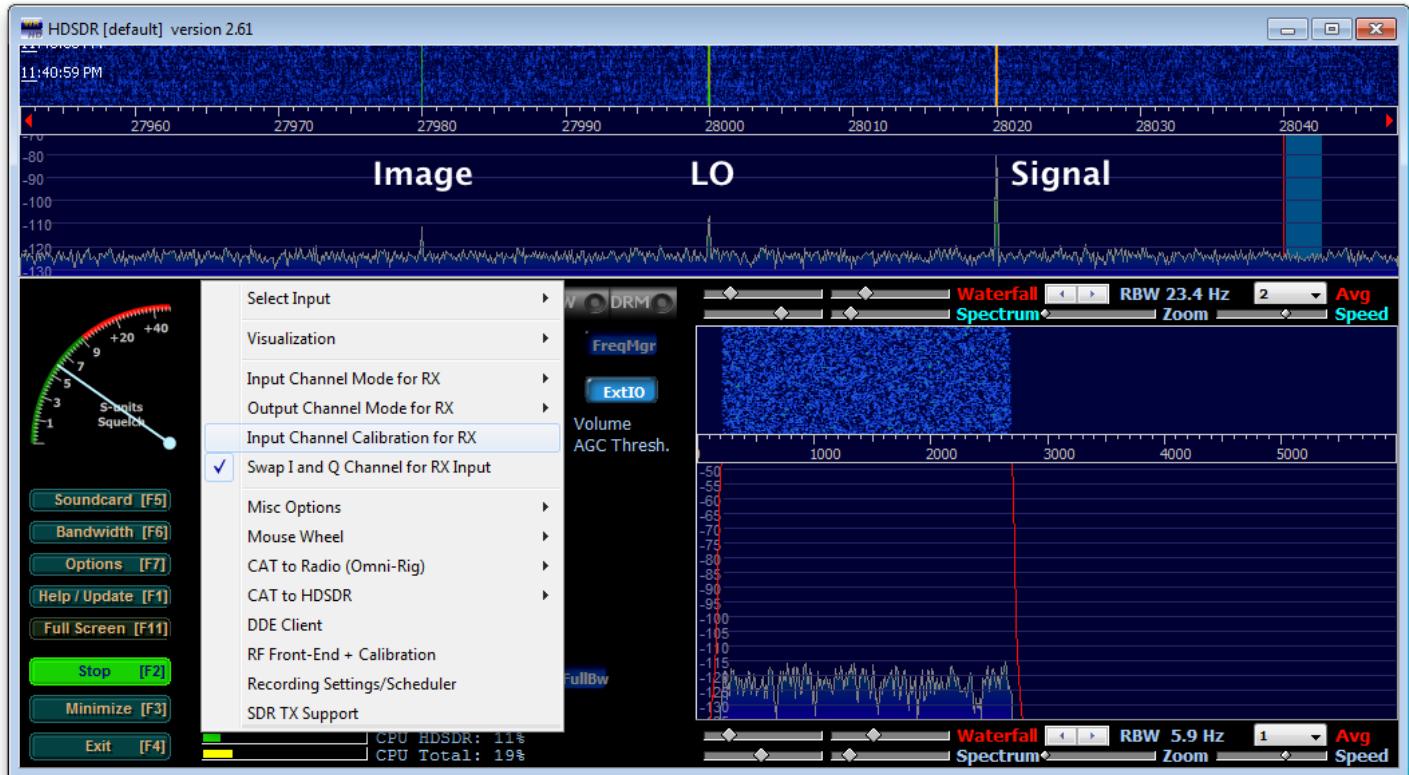
Zero-IF radios like the Peaberry SDR must have the I/Q data adjusted to compensate for hardware variances. Some software attempts to do this automatically with varying degrees of success. HDSDR is adjusted manually with perfect results.

In HDSDR, click “Options [F7]” then select “Input Channel Calibration for RX”. A dialog with sliders and some help text will appear. Ignore the settings about sample delays.



You will need a strong signal to make the adjustment. A signal generator is easiest, but a strong CW or AM station can also be used. Adjust the sliders until the image is completely gone. HDSDR does not save this per-band so you will have to make the adjustment every time you change bands.

Newer versions of HDSDR can remove the DC spike that appears at the LO frequency. Changing the mode to “Auto” is all you need.



TX Driver and Mixer

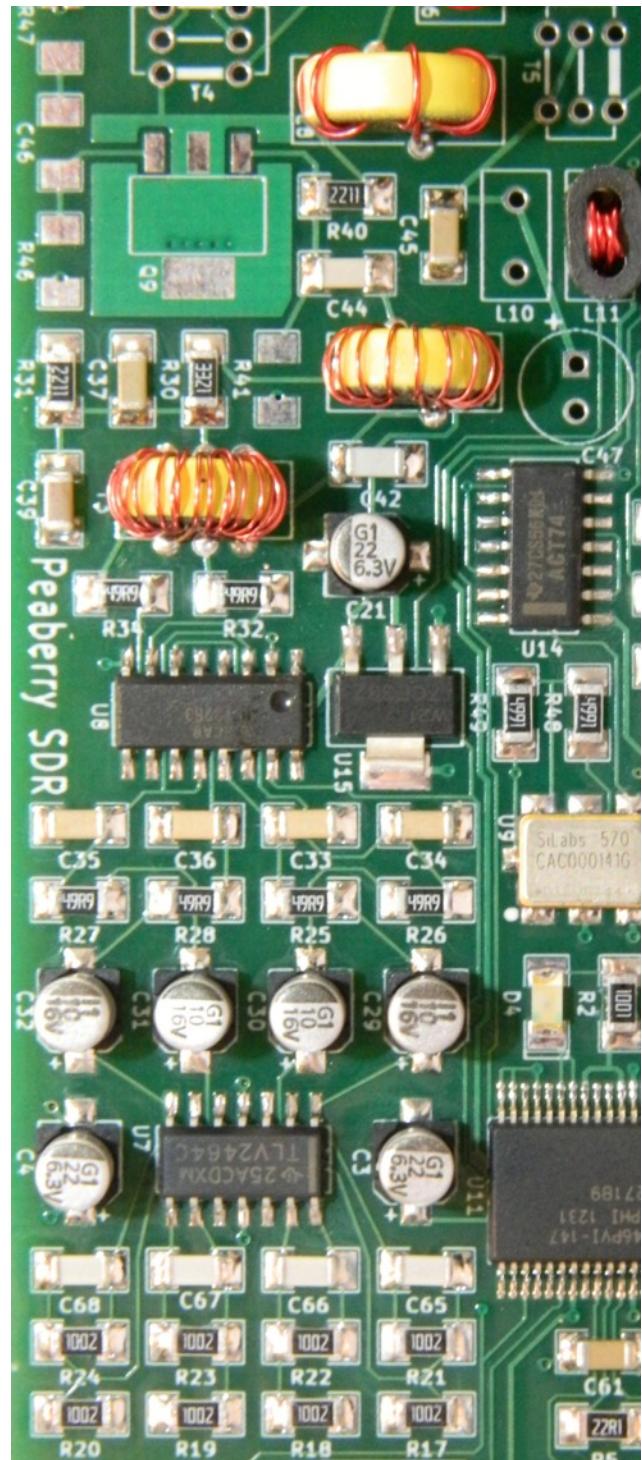
- C65-C68 - 100pF
 - U7 - TLV2464C
 - C29-C32 - 10 μ F
 - C33-C36 - 0.022 μ F
 - R30 - 3.32k
 - T3 - see schematic
 - L9 - see schematic
 - C42, C44 - see schematic

Testing

Launch HDSDR and set it to AM mode. Tune to a frequency in one of the bands you built. Activate the transmitter so we have an AM carrier. If you disconnect or mute any microphone the signal will look a bit cleaner.

- J2 - 200-230mA
 - R17-R20 - AM carrier at | Tune - LO | frequency
 - C29-C32 - AM carrier at | Tune - LO | frequency
 - C44 - AM carrier at Tune frequency

The amplitude is controlled by HDSDR and does not matter for testing. There is no gain on the transmitter yet so all signals in these tests should be close to the same level.

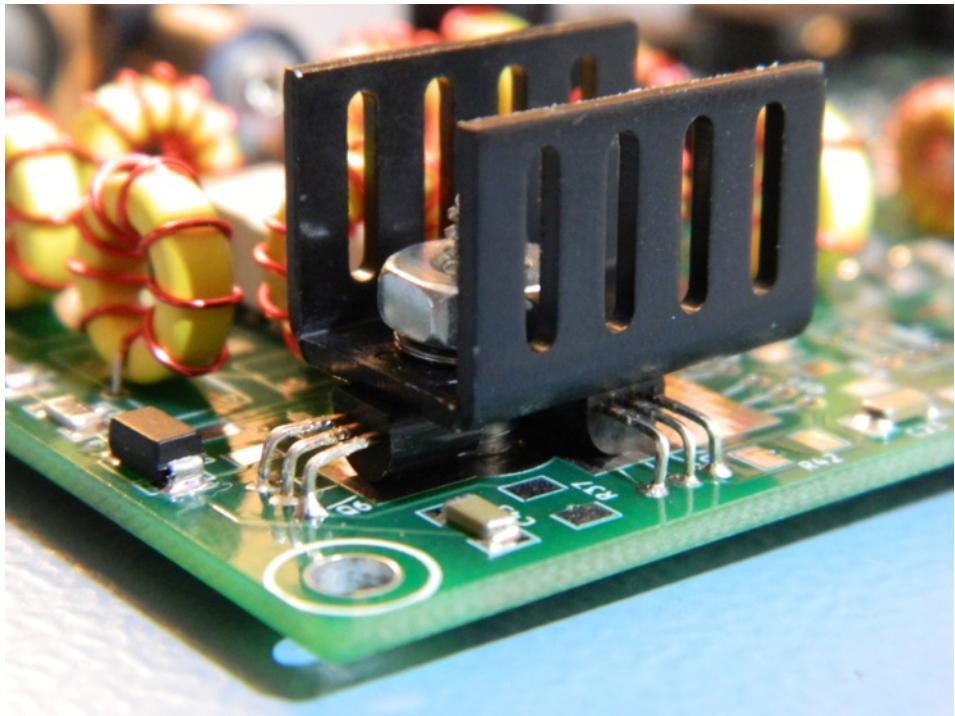


TX MOSFETs

Prepare three BS170 transistors by bending the leads so they may be installed as in the picture. Use the heatsink and #6 mounting hardware to temporarily hold all three transistors in place while soldering. Remove the heatsink to inspect your work and leave it off for now.

- Q6, Q7, Q8 - BS170

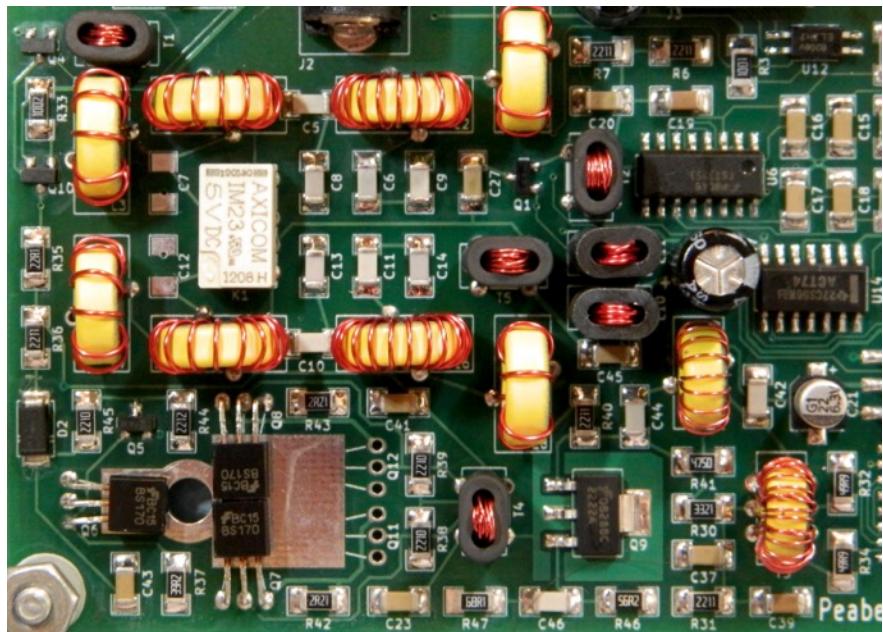
The MOSFETs will be destroyed if you transmit significant power out of band or into a poorly matched antenna system. Replace all three if this happens.



Q11 and Q12 are for advanced experimentation. Do not install anything here. The engineering for this has not been done. It is possible that you will end up with a radio that is not FCC part 97 compliant or has excessive IMD if you try to simply add parts here without doing the engineering.

TX Amplifier Circuit

- Q4, Q5 - [K1N] MMBT3904
- Q10 - [SP] BSS84
- Q9 - [2222] PZT2222A
- R37 - 33.2Ω
- R38, R39, R45 - 221Ω
- R41 - 475Ω
- R42, R43 - 2.21Ω
- R44 - 22.1k
- R46 - 56.2Ω
- R47 - see schematic
- C46 - see schematic
- T4, T5 - see schematic
- L10 - see schematic
- C47 - 47μF



Reinstall the heatsink and silicone pad using the #6 screw, nut, and lock-washer. The lock-washer goes under the nut. This heatsink will get very hot while transmitting.

Testing

Use a 50Ω dummy load and HDSDR on one of the bands your build covers. Power requirements and output will vary depending on the mode, band, and application. The 20m band output with HDSDR will be very close to 1 watt.

- J2 - 300-750mA
- J1 - 0.5-2.0W

Q4 and Q10 switch the 12V transmitter power on and off. Q9 is a class-A amplifier with a fixed bias. Q7 and Q8 is a class-AB amplifier with automatic bias set using Q6 as a reference and Q5 for current detection. This part of the circuit is difficult to test because of the transitions between single-ended and balanced circuits. Also, the normal variations in transistor manufacturing will cause different amounts of gain.

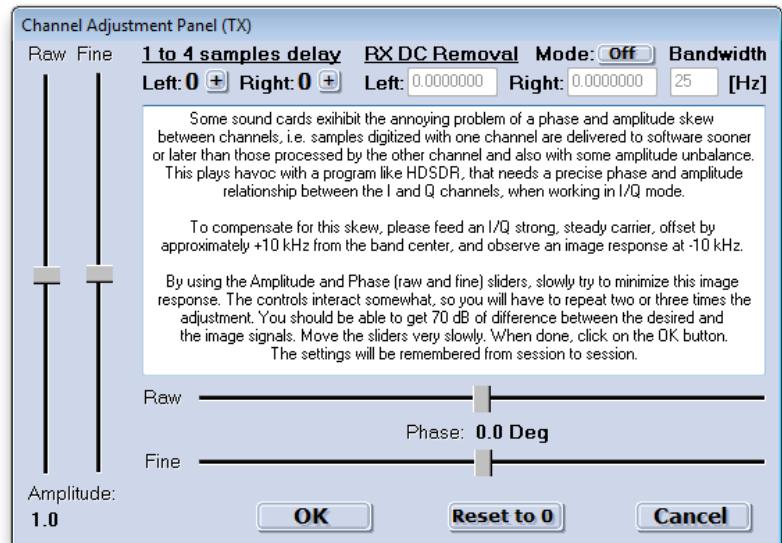
BOOT and DEBUG

Install the three pin jumper block as BOOT and the ten pin connector as DEBUG. The shorter side of both parts goes through the PCB. For normal operation, the BOOT jumper should be on the side nearest DEBUG. The appendix has information about using these to upgrade firmware.

□ TX Adjustment

The transmitter must have the I/Q data adjusted just like the receiver. If you fail to do so then your image will not be suppressed enough.

In HDSDR, while transmitting, click “Options [F7]” then select “Output Channel Calibration for TX”. A dialog with sliders and some help text will appear. Ignore the settings about sample delays and DC removal. The help text here is for the receiver and not very helpful.

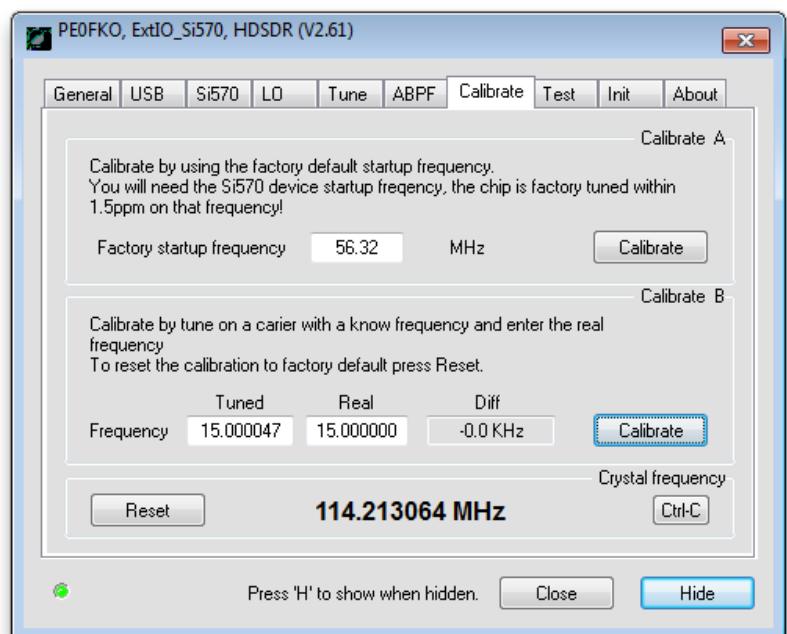


For example on 10m: Set mode to AM, LO to 28.400, tune to 28.380, and begin transmitting into a 50Ω dummy load. Use another SSB or CW receiver to monitor the AM carrier on 28.420. Adjust the sliders to minimize the strength of the received signal.

□ Si570 Calibration

You can perform a manual calibration to improve frequency accuracy of the Si570.

Use the “Calibrate” tab in the ExtIO utility. “Calibrate B” is used to make a manual adjustment. “Calibrate A” will restore the factory calibration.



□ Get on the air!

Your Peaberry SDR V2 is complete. Get on the air and enjoy it. HDSDR is only one of many applications that can be used. You may prefer a different one.

Digital modes are typically done with “virtual” audio cables connecting a SSB application like HDSDR with a digital mode application like fldigi. Digital mode configurations are beyond the scope of this documentation.

73 David AE9RB

Appendix A: LED Status

A power-on self-test function is included in the Peaberry SDR V2. The status LED sends error messages in morse code at 5 WPM.

Status	Information
Off	PSoC not initialized (or LED failure)
Steady On	Normal operation.
Rapid Blinking	Transmitter active.
"BOOT"	Bootloader active. Ready to receive new firmware over USB.
"XTAL"	24 MHz crystal X1 failure.
"I2C"	I2C bus failure. Both PCM3060 and Si570 are unreachable.
"SI570"	Si570 U9 not responding.
"PCM3060"	PCM3060 U10 not responding.

By default, the included LED D4 is driven at 5mA with current limiting by R2. You may prefer to install the LED on your enclosure and increase the power. Pretty much any LED can be used so long as you don't exceed 16mA. Be careful if you select a complete assembly as some will include a resistor which you do not need. A recommended part is the Dialight 5592201007F (Digi-Key 350-2422-ND).

Appendix B: Channel Reversal

The "Peaberry Radio" sound card that shows up on your computer carries the I/Q radio signal. This will appear as regular stereo device with, for example, the left channel containing the I data and the right channel containing the Q data. There is no standard for which channel carries which data. Most applications will let you configure this but some do not. Tune the LO to one of these magic frequencies and the channel reversal will immediately take effect and be saved to EEPROM.

LO Frequency	Effect
33.333333	Normal. The HDSDR configuration in this guide assumes this setting.
33.444444	Receive is reversed.
33.555555	Transmit is reversed.
33.666666	Both are reversed.

Appendix C: USB Commands

The USB command set that was developed by DG8SAQ and PE0FKO for the Atmel AVR has been re-implemented for the PSoC. This makes the Peaberry SDR V2 extremely compatible with free and open source software for homebrew radios.

Command - Direction	Function
0x00 - IN size: 2	Returns version number. Most significant byte is major version. Always returns V0.0.
0x02 - IN size: 1	Deprecated. Read pin status.
0x20 - IN valueHi: register index: value	Write a byte value to a Si570 register. Only value 0x01 can be written to register 0x87 to request a reset of the Si570. The Si570 is not actually reset, but command 0x3D will return the factory setting after issuing.
0x30 - OUT size: 6	Deprecated. Set LO frequency by Si570 register. If your software still uses this command, tell it to use a crystal frequency of 114.285 MHz.
0x32 - OUT size: 4	Set current LO frequency. Coded as fixed point in 11.21 bits. The Si570 operates at 4 times the tuning frequency. For example: <code>(float)frequency * 4 * (1<<21)</code>
0x33 - OUT size: 4	Set Si570 crystal frequency. 8.24 bits format. This is changed to calibrate your radio.
0x3A - IN size: 4	Get current LO frequency.
0x3C - IN size: 4	Get Si570 startup frequency. 11.21 bits format. Always 56.32 MHz.
0x3D - IN size: 4	Get Si570 crystal frequency. 8.24 bits format. Returns current setting. Use command 0x20 first to obtain factory setting.
0x3F - IN size: 6	Get Si570 control registers 7:12.
0x50 - IN valueLo: PTT size: 1	Set PTT and read CW paddle status. Bit 0x01 is high to transmit.
0x51 - IN size: 1	Read CW paddle status. Bit 0x20 is KEY_0 and 0x02 is KEY_1.

Appendix D: Firmware Updates

New firmware is distributed in a ZIP file containing two formats of the ROM. Two methods of updating the firmware are available.

USB Bootloader

When the BOOT jumper is in the position nearest the USB jack the LED will blink BOOT in morse code. In this mode the radio is ready to accept firmware. You will need the free PSoC Creator (2.1 or newer) from Cypress to use this method.

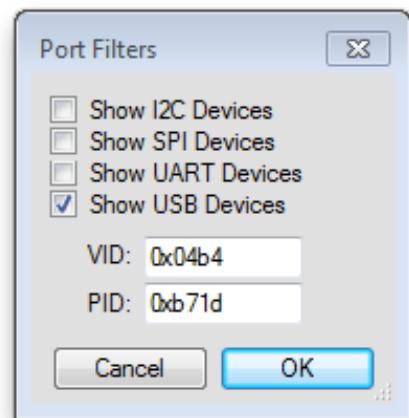
Get it here: <http://www.cypress.com/go/creator>

If Cypress asks for a company name, use “personal/hobbyist”.

Install the software as per the directions from Cypress. It's an ordinary Windows installer so you shouldn't have much trouble. Launch the PSoC Creator application after it's installed.

From the menu of PSoC Creator, choose “Tools” then “Bootloader Host...”. This will launch the Bootloader Host application.

Press the “Filters...” button in Bootloader Host. A dialog will pop up. Ensure that “Show USB Devices” is checked and the VID and PID are as shown here. The other checkboxes do not matter. Press “OK”.

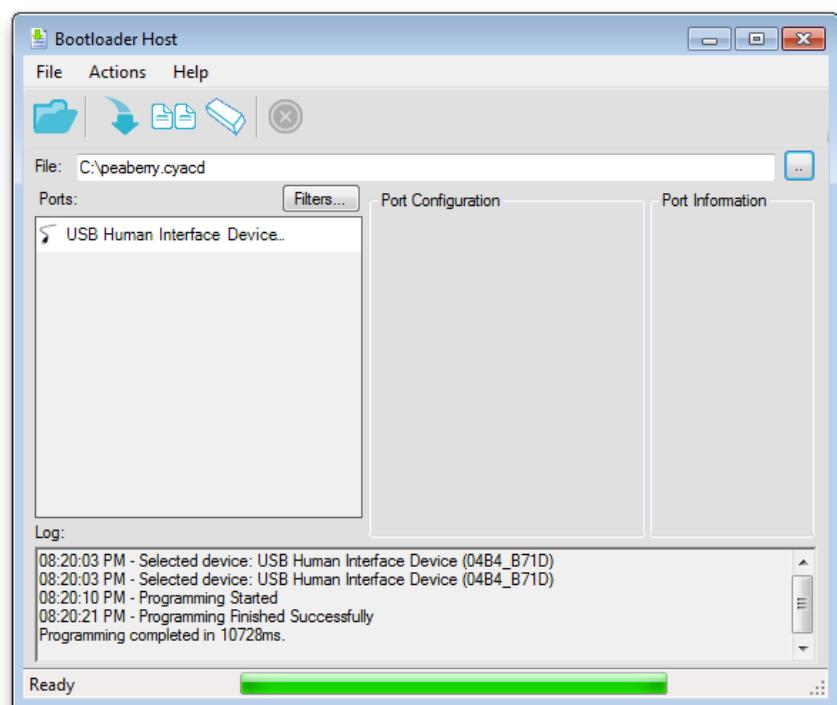


Make sure the BOOT jumper is on the USB jack side and the radio is powered and connected. You should see a “USB Human Interface Device” in the ports list.

Choose “File” then “Open...” from the menu. Select the .CYACD file for the firmware you wish to load.

Now choose “Actions” then “Program” from the menu. You may need to click the ports list or relaunch Bootloader Host to get this enabled.

In a few seconds the new firmware will be loaded and you'll get a success message. Move the jumper back and restart your radio by interrupting power.



SWD Programming

A 10-pin SWD connector is included with every radio for connecting a Cypress MiniProg3 or other programmer. The connector isn't keyed so please observe the PCB silkscreen when connecting your programmer. This method is for advanced users who should be familiar with the process. Here are the critical settings you need to know:

File Path: Choose the .HEX file

Programming Mode: Reset

Connector: 10p

Protocol: SWD

Voltage: 5.0V

Clear EEPROM: Disable (or Si570 calibration is reset)

