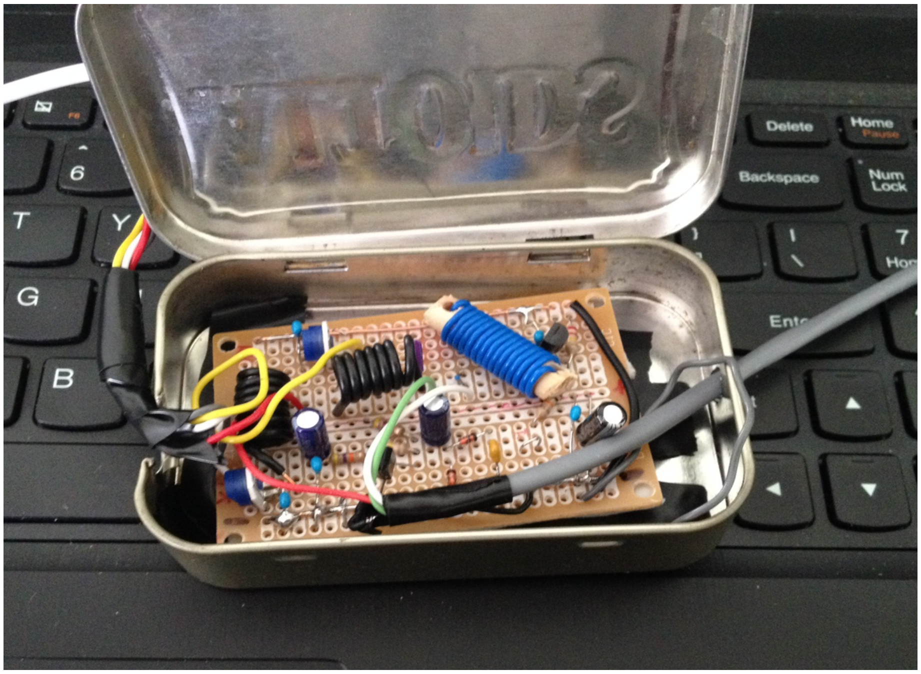
CONSTRUCTION PLANS FOR $10 TNC
(PART ONE)



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NOV 16 NOTE: *This construction project is a work in progress --- so the inexperienced reader is advised to read through both this document and the companion "Part Two" to decide exactly which output circuitry and where to position them. A beginning builder may prefer to use the two-board solution exhibited in "Part Two".*

To make a packet TNC, or to send PSK31 or any of several popular digital-over-audio modes, all you need is a sound card that generates the audio tones, a volume control to match those to the transceiver mic input; a volume control to match the transceiver audio output to the sound card mic input, and a way to activate the push-to-talk circuity fast enough to follow the ARQ handshaking of modes like packet. Add free software such as UZ7HO soundmodem.exe, or FLDIG, and start having digital fun!

This is a simple push-to-talk vox-type circuit that combines with an Adafruit Audio Adapter to make a complete sound-card-based TNC using freely available software. This circuit approximates the functions of the vox circuitry within the very popular Signalink-USB. The circuit is not original with me; I found the idea on a British ham's web page.   It can be built compact enough to fit into an Altoid tin -- or the entire thing including the Adafruit Audio Adapter can bit within a tea tin; or even easier, taped to the insides of a small cardboard box (e.g., granola bars box) and covered with aluminum foil.

Materials

Adafruit Audio Adapter ($5 from Adafruit, more expensive from Amazon): https://www.adafruit.com/products/1475?gclid=Cj0KEQjwg8i_BRCT9dHt5ZSGi90BEiQAItdjpJNq5fA6CG03Ky7dnef3t-H_QqTrcHCX21SXpH8PFisaAu1u8P8HAQ

Protyping Printed Circuit Board
Small board -- http://www.mcmelectronics.com/product/DISTRIBUTED-BY-MCM-21-113-/21-4590

Resistors -- 1/4 or 1/2 watt (not wirewound)

R1 --   Not used in my prototype, but I had to turn the TX GAIN almost down to the bottom and the adjustment was tricky. Suggest using a 4.7 - 10K ohm. https://www.digikey.com/product-detail/en/vishay-bc-components/PR01000101001JR500/PPC1.0KW-1CT-ND/597199

500 ohm potentiometer, R2, R6 https://www.digikey.com/product-detail/en/bourns-inc/3306K-1-501/3306K-501-ND/84791
47K, R3 https://www.digikey.com/product-detail/en/stackpole-electronics-inc/CF14JT47K0/CF14JT47K0CT-ND/1830391
220K R4, R8 (red, red, yellow) https://www.digikey.com/product-detail/en/stackpole-electronics-inc/CF12JT220K/CF12JT220KCT-ND/1830532
10K, R7, R9, R11 (brown, black, orange)   https://www.digikey.com/product-detail/en/stackpole-electronics-inc/CFM12JT10K0/S10KHCT-ND/2617547
4.7K (4700 ohms) (yellow, purple, red) R5   https://www.digikey.com/product-detail/en/yageo/FMP200JR-52-4K7/4.7KZCT-ND/2059014

Capacitors
Ceramic 0.01 microfarads (10,000 pf) C1,C2, C5, C8, C9. Ceramic, any voltage 25 or greater. https://www.digikey.com/product-detail/en/murata-electronics-north-america/RCER71H103K0K1H03B/490-11884-ND/4277785
Ceramic 0.1 microfarad C7.   https://www.digikey.com/product-detail/en/vishay-bc-components/K104Z15Y5VF5TL2/BC1160CT-ND/286782
Electrolytic (polarity important)   1 microfarad C3, C6, any voltage >15 volts
47 microfarads, C4, any voltage >15 volts https://www.digikey.com/product-

detail/en/panasonic-electronic-components/ECA-1EHG470/P5539-ND/245138

Transistors

All transistors can be 2N3904 or almost any general purpose NPN transistor, including the 2N2222. Note you must idenfify which lead is the emitter, base and collector. In the drawings of the schematic, the emitter is the one with the arrow, and goes to ground. The Collector is the highest terminal. The base is the lead that goes to the LEFT. Different transistors can have their leads placed differently on their case. https://www.digikey.com/product-detail/en/fairchild-semiconductor/2N3904BU/2N3904FS-ND/1413

2N3904 pinout: http://www.futurlec.com/Transistors/2N3904.shtml

Diodes

D1,D2 can be any kind of diode, including small signal diodes. The BAND on the physical diode corresponds to the vertical thin line side. A 1N4148 or 1N4448 will work. https://www.digikey.com/product-detail/en/fairchild-semiconductor/1N4448TR/1N4448CT-ND/458915 http://www.vishay.com/docs/81857/1n4148.pdf However, it is ABSOLUTELY NON CRITICAL. Any of the 1N400X series (1N4001, 4002, 4003, 4004, 4007) will also work.

D3: This diode shorts out the reverse voltage that an inductor creates when the current is rapidly stopped (when the PTT circuitry stops pushing to talk) -- I would use one of the 1N400X series for this diode. https://www.digikey.com/product-detail/en/fairchild-semiconductor/1N4007/1N4007FSCT-ND/965481

Inductors

L1,L2,L3: Approximately 0.5 microhenries, easily made by wrapping about 8-10 turns of solid hookup wire around a pencil or phillips screwdriver and then removing the pencil or screwdriver and the inductor should keep its form. If you are planning to use this for HF,, you might consider using a toroid with 6 turns or so. The purpose of this is to create impedance to stop incoming radio frequency interference.

Relay (optional)--but highly recommended as the relay output has had far less trouble with RFI problems than the open collector version

RL1 5volt, reed relay, low current draw (<20 mA) e.g. https://www.digikey.com/product-detail/en/coto-technology/9007-05-00/306-1062-ND/301696 (10mA coil current)

Ferrite Core for transceiver cable:
Example: https://www.digikey.com/product-detail/en/laird-signal-integrity-products/28A2025-0A0/240-2074-ND/242802

LED (indicator) optional
https://www.digikey.com/product-detail/en/tt-electronics-optek-technology/OVLBR4C7/365-1175-ND/827111

Tools

- small needle nosed pliers
- small diagonal cutter (“dikes”)
- low-wattage soldering iron (e.g., 25-40 watts) Here's an example from Walmart: https://www.walmart.com/ip/Nippon-America-71B30KT-30W-Soldering-Iron-Pen-Kit/49016054 for under $10. It is almost impossible to build this circuit with a big soldering gun -- a nice pencil point gets into tight spaces and doesn't create “solder bridges”
- something safe to set the hot iron on, that will cradle it to some extent. metal, ceramic or brick. I use good sized electric junction box.
- rosin core (electrical) solder, lead alloy preferred (lower melting temperature). You won't need a lot. I prefer the 60/40 lead tin (lowest melting point) but it is getting harder. It is a lot easier to build small circuits if you have THIN (small diameter) solder
- Optional: alligator clip parts holding “third hand”
- Optional: magnifying glass
- Voltmeter ($5 Harbor freight digital multimeter works fine)
- You may want to have a “solder sucker” or “solder wick” to absorb mis-placed solder that creates an unwanted solder bridge.

CONSTRUCTION

The circuit consists first, of a circuit that turns the transmitted audio into an ON-OFF dc voltage that is used to drive any of several optional output circuits:
- An open collector transistor switch that can short to ground a positive voltage from a transceiver push to talk circuit of up to about 20 mA (more prone to RFI however, if there is any RF around your station.)
- An optional LED indicator that will light up during transmit (helpful if you are having problems with circuitry or RFI).
- An optional relay output that can drive higher current push to talk, provide more isolation of the circuitry to reduce RFI problems, or switch a negative voltage, should your transceiver's push to talk be negative (most aren't).

You can use any or all of the output circuits.

The audio signal from the USB audio device is a low voltage audio signal, less than 1 volt. Q1 is a simple transistor amplifier that develops roughly a 4 volt peak-to-peak AC signal from the low voltage audio input signal. Diodes D1 and D2 rectify this to create a positive DC voltage. C7 provides a very small delay to keep the transmitter ON. The turn-off delay constant of this circuit is at a minimum the result of 0.1 microfarads and 3.3kohms (if all three output circuits are built) or 0.3 milliseconds, but probably 2 time constants have to expire before the PTT stops. This is long enough to keep the push to talk energized throughout the audio signals.

Building the PTT input circuit.

There are multiple building techniques, even including “dead bug” construction in mid-air. Most small circuits are more easily built on perforated board which provides mechanical support. Using perf board with copper lands (“printed circuit board”) makes it even easier because connections can be made by using lands that connect multiple holes.

Most simple circuits that are not at radio frequency, can be built by laying out the components somewhat as they appear on the schematic. I generally prefer to write schematics and build circuits from left to right.

The board chosen for this project has two “bus bars” running across the board, however these are really CLOSE to each other to use one as the plus voltage and one as the negative....too close for possible soldering errors. So I use one of them as the positive bus bar and run a bit of hook up wire along the periphery of the board (both top and bottom) as the “ground”. Although I put it on the component side, I think it would actually be better to put the ground bus on theprinted side. Either can be done.

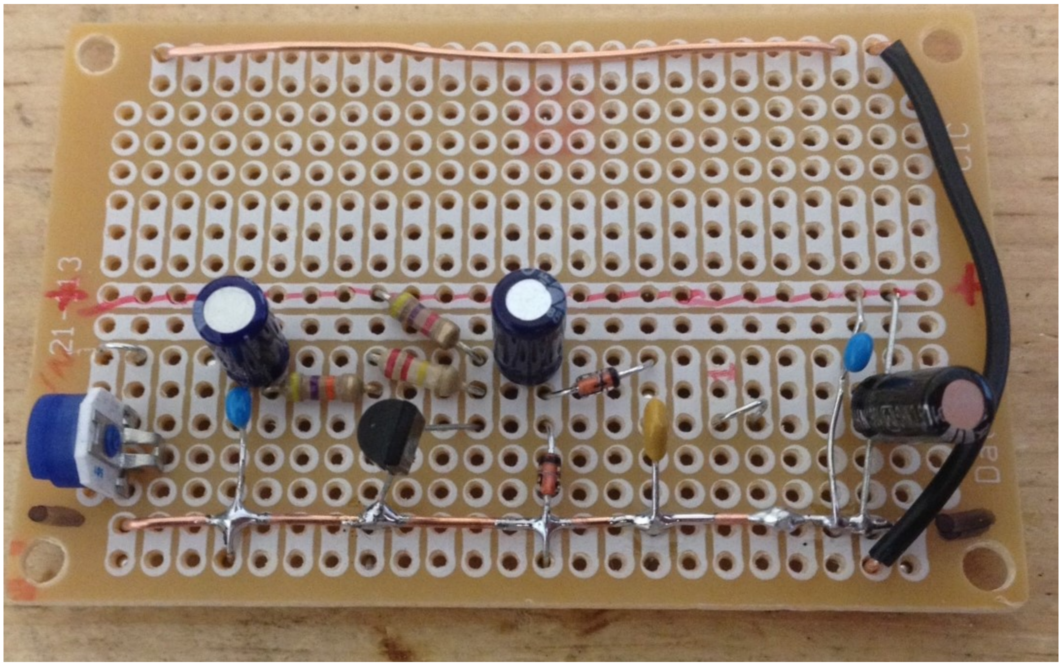
In this case, I build the input circuit on the “bottom” of the board, and then rotate the board 180 degrees and build one nor more output circuits on the “top” of the board.

The photo above shows the completed “input” circuitry, all the way to the development of the filtered DC voltage.

I over-crowded the input portion of the circuit, R2, C1, C3. That made it hard to fit in L1 and C2 later on. Give yourself just a little more room and move R2 a couple of holes further to the right on the board.

NOTE: FOR BEGINNING CIRCUIT BUILDERS, IT IS PROBABLY A BETTER IDEA NOT TO PLACE THE TRIMMER POTENTIOMETER HERE AT ALL, BUT INSTEAD TO BUILD IT ON A SEPARATE BOARD. THAT ALLOWS THIS BOARD TO HANDLE ONLY PUSH TO TALK, AND A SECOND, SMALLER BOARD TO HANDLE THE AUDIO INPUT/OUTPUT. SEE THE COMPANION DOCUMENT (“PART TWO”) FOR MORE DETAILS.

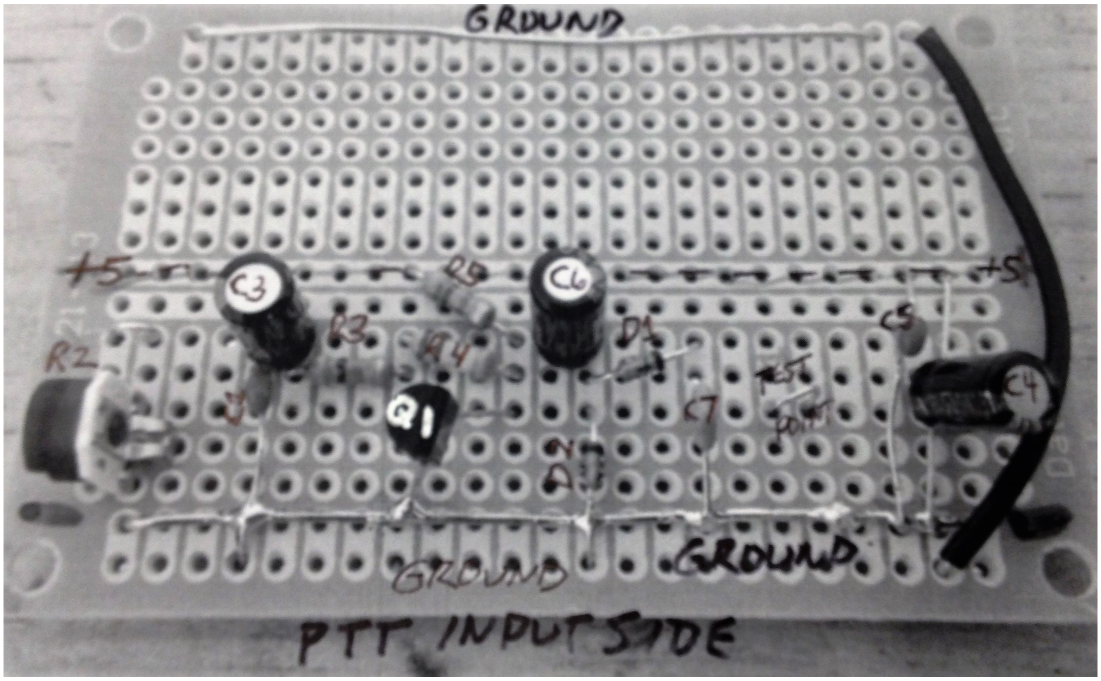
COMPONENT LAYOUT: The photo below shows the component names:



Leave a bit of room to get at the wiper (center pin) of R2 as you'll have to connect to it later.

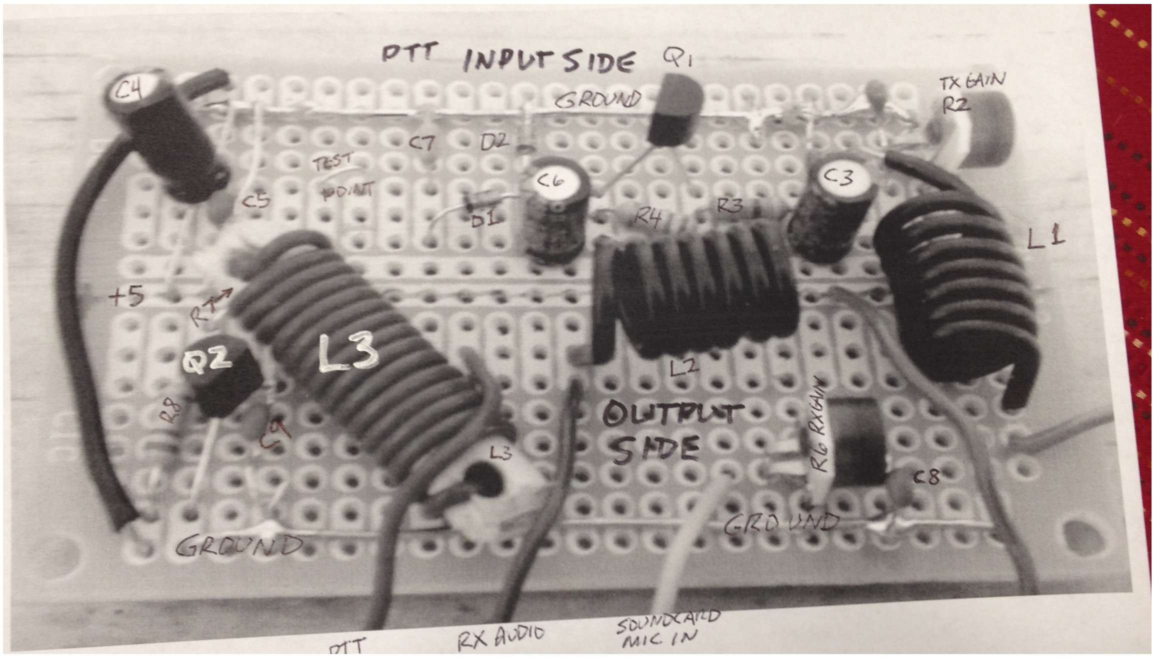
Be sure to get the polarity of C3 and C6 -- the plus side is closest to Q1, and the negative side away.

You can see that I put C4 and C5 to the far right side of the board.   These are easy to install and are probably the first two components to install to get some practice soldering.



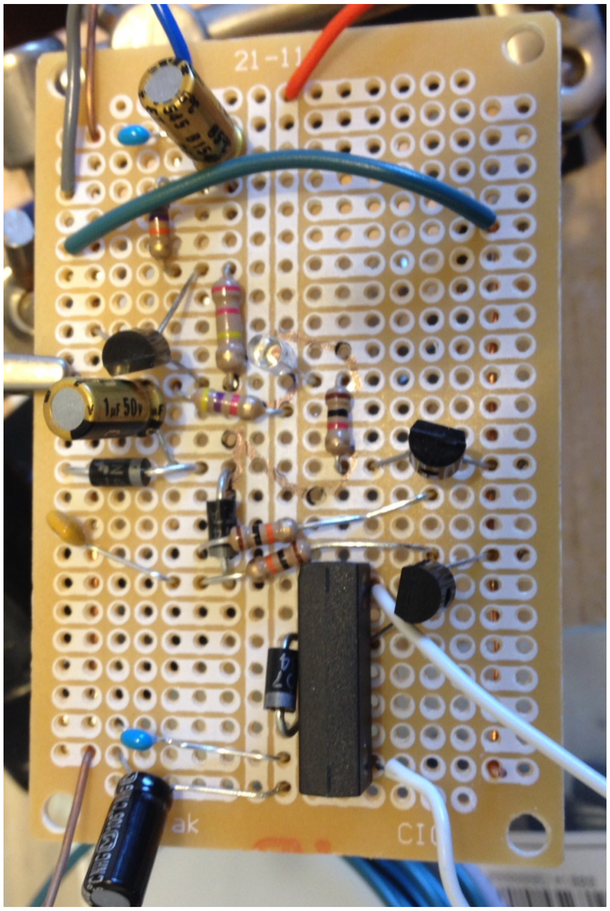
Building the output circuits

I originally chose only to build the open collector PTT on this model (I did the LED on my previous build). Flip the board around and pick a spot on which to work. I started to the far left, which left plenty of room for the inductors that would be added later.



RELAY OUTPUT: In subsequent builds I preferred to build the relay output. It seems more immune to RFI. You must remember the diode 'backwards" across the relay coil or you may fry the switching transistor.

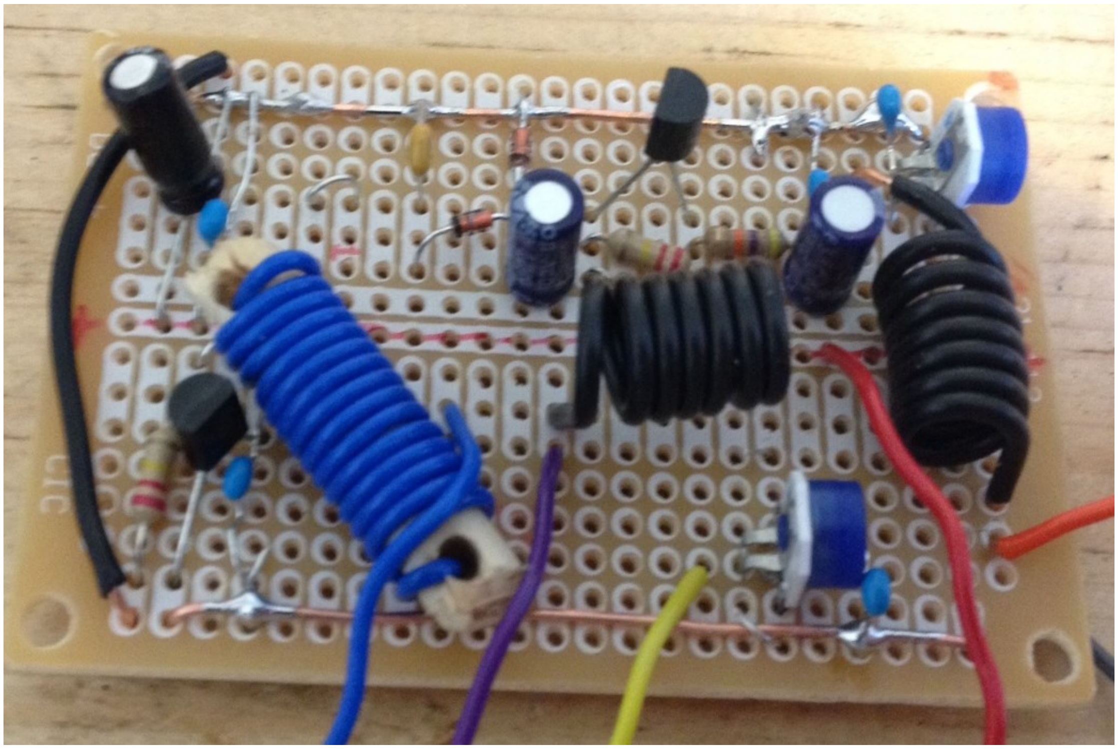
The photo below shows the reed relay positioned on the opposite side of the board, the switching transistor. A separate transistor drives an LED. If you want a dim LED, put 4.7K in series with it, if you want a very bright LED, put 1000 ohms in series with it. **The longer lead on the LED goes to the +V side.**



Final Completion

I think the open air construction that I used for L1, L2 is easier than the dowel-rod that I used for L3, so I suggest it for all of them, but I would shoot for about 8 turns.

Add in the R6 potentiometer for the RX gain control.

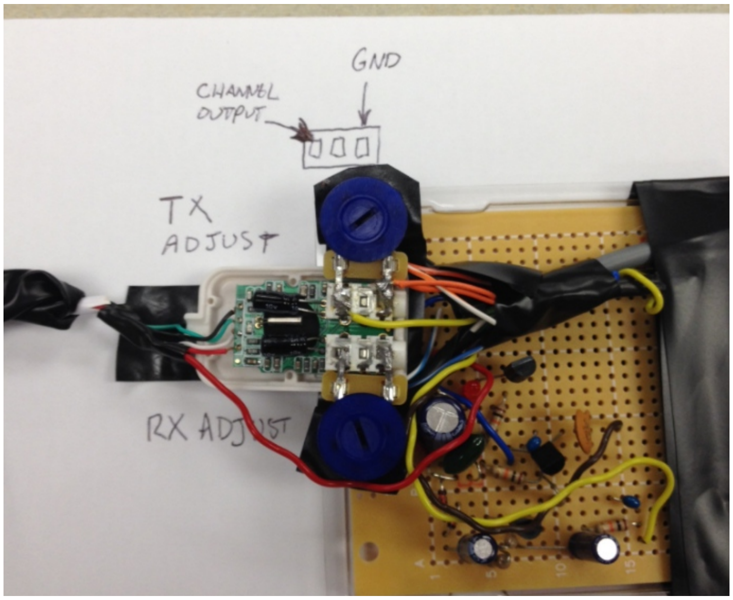


Wiring to the USB audio dongle:

There are four signals you need to connect to.. Using tiny very flexible stranded wire will make this a lot easier. After you get all the connections done and have tested the circuity, I recommend a bit of 5 minute epoxy to glue the USB circuit board back into the bottom half of its clamshell, and a dab on the white cable coming fromthe computer to strain relief it.

- +V (5V DC) which is on the little red wire coming from the USB. You are probably going to have to disconnect that tiny wire, connect to it, and then run a short jumper back to the board. This is tiny tiny soldering so be careful.
- Ground -- easiest picked off of the farthest tab on the audio connectors.
- Audio output from the computer --- from the channel closest to the computer
- Mic input to the Computer (will go to the speaker output from the transceiver) -- from the tab closest to the computer.

The photo below shows an earlier prototype where the audio potentiometer were mounted right on the jacks in the Adafruit Audio adapter, but it shows you where the terminals are that you need to connect to:



On both the audio output (top) and mic input (bottom), the farthest right termimal is ground, and the farthest left terminal is the signal you want.   Solder quickly so you don't melt the entire jack and it will work nicely!

Wiring to the Transceiver:

There are four signals you will need to connect to the transceiver:

- Mic input
- Speaker output
- Push To Talk control
- Ground

I recommend using shielded wire to run these signals to the transceiver, with the ground connected to the shield at the computer/circuitry side.   Leave enough room to put a 2.5” loop a couple of times in this cable to add common mode inductance, and crucially, put a ferrite bead close to the transceiver.

In my station, all cables coming from transceivers terminate in a RF45 wired in the way that would connect to a Signalink which has been configured for their Baofeng/Kenwood connector:

RJ45 Pin	Signal
1	Mic
2	Ground
3	Push to Talk
5	Speaker audio

I choose to wire the cables from my TNCs (the ones that don't have female jacks accepting

RJ45 like a Signalink) in the exact same way, and then use a female-female RJ45 compatible adapter to connect TNC to transceiver. This makes it a lot easier for me to “mix and match” different radios and TNCs when necessary.

SOFTWARE

I use UZ7HO soundmodem.exe (the 1200 version, not the high speed 9600 baud version) for packet. This wraps the sound card/ptt circuity and gives it both an AGWPE and KISS tcp interface. Version 0.95 is current as of this writing. http://uz7.ho.ua/packetradio.htm

You can also use MixW for multiple modes, including PSK31 and AX.25 packet. http://mixw.net/ (there may be a charge for purchase).

You can also use FLDIGI with this board for modes that have a continuous audio output such as PSK31 and RTTY. http://www.w1hkj.com/

If the ptt delay is too short, increase the value of C7.

This circuit works well with WINLINK, using UZ7HO software.
http://www.winlink.org/ClientSoftware (see WINLINK EXPRESS download link, lower down the page)

Setting the Volume Controls

If you're using a laptop, be sure to set the volume output to maximum. If you're using a Raspberry PI, see the section below to learn how to use alsamixer to set the volume levels of input and output.

1. Set the RX volume control in the middle of the range where your software properly decodes some normal-sounding beacon or packet station.
2. St the TX volume control (with your computer or Raspberry PI set to 100% output volume) by monitoring your transmitted signal, and setting the TX gain just below the point where the received audio no longer gets any louder.

Setting RASPBERRY PI Audio Gain (Volume) Levels

You'll need to set the mic gain and audio output levels if you're using a soundcard-based technology. If the audio output isn't at 100%, Signalink and similar devices (such as the $10 TNC) may not key the transmitter properly.

```
      alsamixer
```

will bring up a “somewhat graphical” volume control. Use Left/Right cursor keys to reach your sound-card device. Use the up/down arrow keys to adjust volume. You probably want the audio output at maximum and the mic gain at 50%.

Note that the `alsamixer` works perfectly with the Adafruit USB audio adapter.
(Unfortunately as of this writing, the popular Tigertronics Signalink doesn't interface well with alsamixer, making adjust of the Raspberry volume levels more problematic.)

After you get your signal levels the way you want them, you'll need to use this command to lock them into place so they remain after the next reboot:

```
      sudo alsactl store
```

If you're using a Windows computer, (e.g., with FLDIGI, MixW, BPQ, Outpost or other software) you can adjust the volume controls as with any other windows component.