

# CTR2-Mini+ Assembly Manual



Version 1.1

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## Introduction

CTR2-Mini+ is an expanded version of CTR2-Mini. Like CTR2-Mini, the CTR2-Mini+ is a small radio controller based on the Wio Terminal from Seeed Studios. The Wio contains the processor, a 2.4" color LCD display, three user buttons, a 5-way switch, a micro-SD slot, and a 40-pin GPIO bus. The GPIO bus is compatible with many Raspberry Pi accessories.

CTR2-Mini+, herein referred to as the Mini+, shares the same DNA as the Mini. It is named Mini+ because of the extras included that are not standard or available on the Mini. These include:

- A built-in function keypad
- A built-in radio I/O circuit that eliminates the external Radio I/O module used on the Mini if you are only controlling one radio. The Mini+ still supports the RJ45/CAT5 connection to a manual RJ45 switch and external Radio I/O modules if you have two or more radios you wish to control.
- A built-in 12 volt power supply that allows you to power the Mini+ from your station's 12 volt system or from the USB-C connector on the bottom of the Wio Terminal.
- A new sidetone amplifier with built-in volume control with On/Off switch
- Several different enclosure options including the PacTec KEU-5 shown in the lead photo, a custom acrylic enclosure similar to the Mini, and panel mount.

The basic layout of the Mini+ is similar to the Mini. The photo below shows the Mini+ connected to an FTdx101. The straight key and PC are optional.



Basic Mini System

As we'll see in this manual, the Mini+ only requires two circuit boards (and a back panel board) so it is easier to build and slightly less expensive to construct if you are controlling a single radio.

The Mini+ is available as a bare PCB kit (with SMT components installed and mounting hardware included). I've created a [Bill-of-Material \(BOM\)](#) on Mouser.com for you to order the necessary components with just a few clicks. It is also available as a complete, fully assembled unit complete with an updated and pre-programmed Wio Terminal through my blog, <https://ctr2.lynovation.com>

## Tools You Will Need

This manual assumes you will be installing the Mini+ in the PacTec KEU-5 enclosure. To build this kit you will need basic hand tools like a Phillips screwdriver, diagonal cutters, needle nose pliers, a small wrench to tighten the nuts on the control shafts, and a temperature controlled soldering iron. I prefer a beveled tip but you can use what you like. You'll also need a coping saw or a Dremel tool to grub out the top of the KEU-5 enclosure so the front panel PCB will mount flush with the top. You'll also need solder and possibly solder braid if you create any solder bridges. The boards are manufactured using leaded solder so consider that before purchasing.

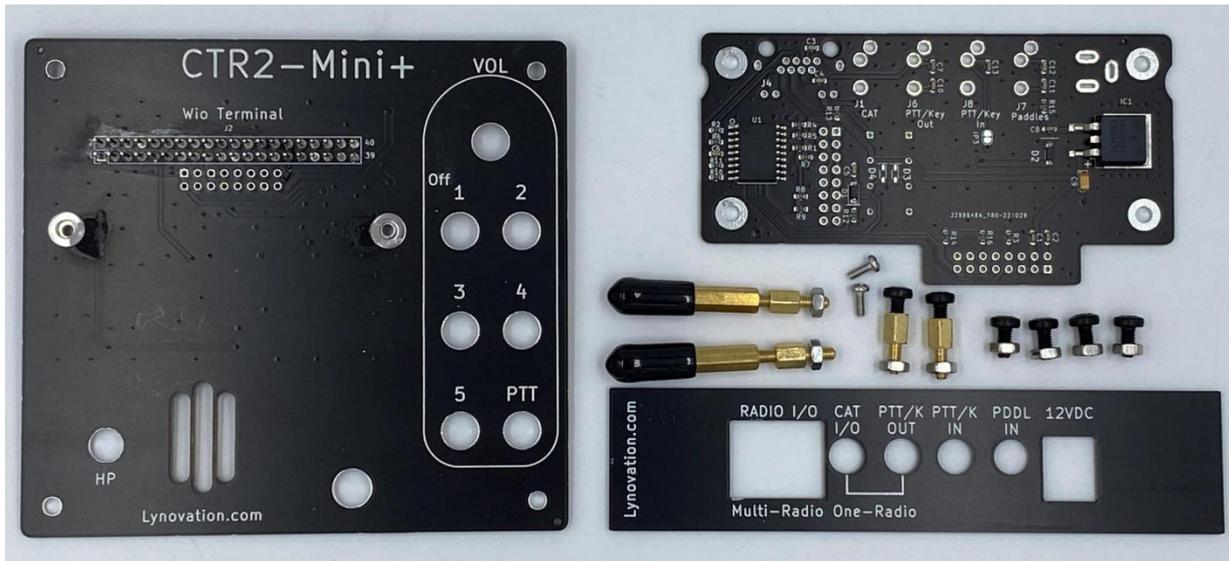
## Bill Of Material (BOM)

As mentioned above, I've created a BOM on Mouser.com that includes everything you'll need to build the Mini+, except the boards. I can supply the boards for a minimal cost. The link to the Mouser BOM is

<https://www.mouser.com/ProjectManager/ProjectDetail.aspx?AccessID=22e0705943>

## PCB Kit

The Mini+ PCB Kit consists of two PCBs, a back panel, and mounting hardware. All the SMT components are preinstalled at the PCB factory. You only need to install the through-hole components and build a ribbon cable. The front panel, shown on the left in the photo below, mounts flush in the recess in the KEU-5 enclosure. The base board, shown on the top-right mounts in the lower half of the enclosure. The PCB kit includes the back panel board and the mounting hardware as shown below.



Printed Circuit Board Kit with Mounting Hardware

## Pre-Cut Enclosure

I can supply a CNC cut PacTec KEU-5 enclosure if you don't want to cut your own. If you purchase an enclosure from me be sure to delete it from your Mouser order.



Pre-cut PacTec KEU-5 Enclosure

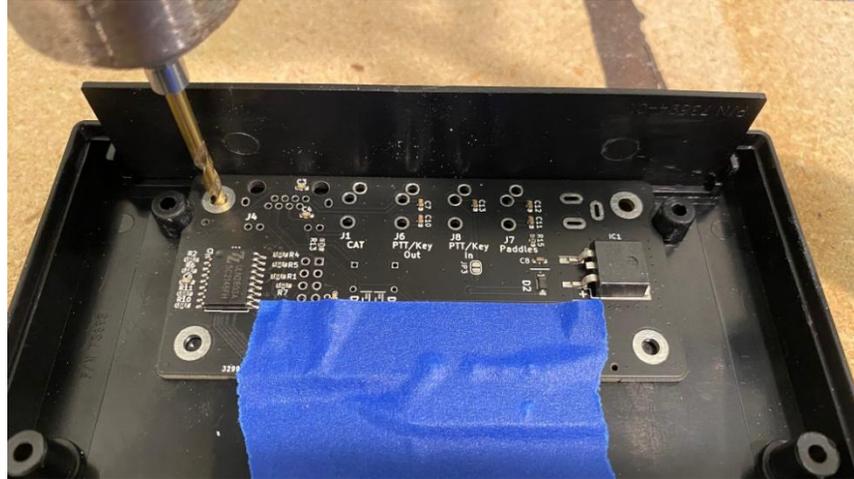
You can order PCB and the pre-cut enclosure on the [order form](#) on my [blog](#).

## Cutting your Own Enclosure

If you choose to purchase the KEU-5 enclosure from the Mouser BOM you'll need to prepare it for mounting the circuit boards.

### Drill Mounting Holes

The first task is to drill the mounting holes in the bottom and top sections of the KEU-5 enclosure. Take the Base PCB and lay it bottom up (with the ICs on top) in the bottom half of the enclosure as shown in the photo to the right. The concave notches on the board should fit next to the original mounting bosses in the box.



Drilling the base board's mounting holes

Insert the enclosure's back panel in the slot on the back of the bottom half and push the PCB toward the back panel until it touches it. This is where the base PCB is to be mounted. A piece of tape will help hold it in place. Drill 1/8" holes into the enclosure bottom at the four mounting holes on the PCB. The base will mount to these holes using M3-6mm standoffs supplied with the PCB kit.

**CAUTION:** Be careful when drilling these holes so that the drill bit doesn't cut into the through-hole plating on the board's mounting pads.

Next, lay the blank front panel PCB face-down (IC-1 on top) in the recess on the top section of the enclosure as shown here. Drill a 1/8" hole at each corner mounting pad.

**NOTE:** Drill these holes before grubbing out the center so you can leave plenty of material around the holes for the mounting screws.



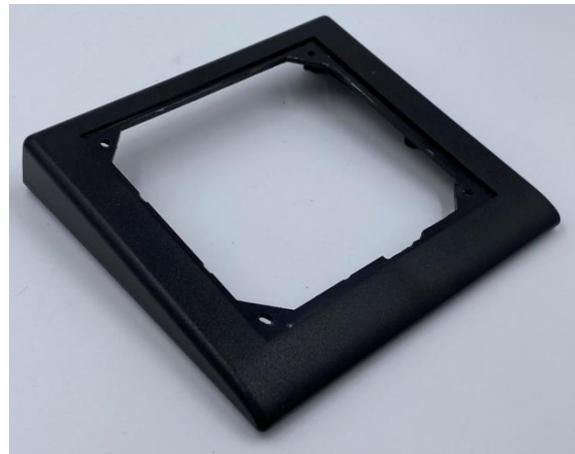
Drilling Front Panel PCB Mounting Holes

Next, print out the template in [Appendix B](#) and cut it out. Lay it in the recess in the top panel and mark the cut lines as shown the left photo below. Use a fine-tooth coping saw or a Dremel tool to grub out the inside of the recess. It doesn't have to be pretty. Just make sure you leave about 1/8" of the recessed portion for the board to sit on and be sure to leave flanges in each corner where the mounting holes are located. Once complete the top section should look like the photo on the right. The front panel PCB should fit into this void.

**NOTE:** The notch for the encoder is on the bottom (narrow end) of the top section of the enclosure.



Grub Template

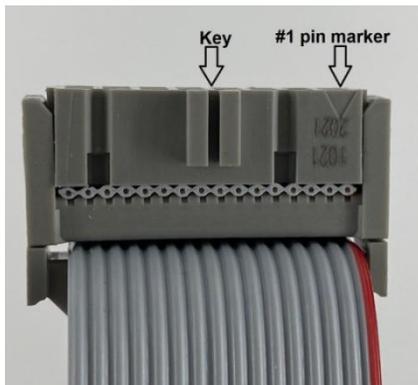


Grubbing Complete

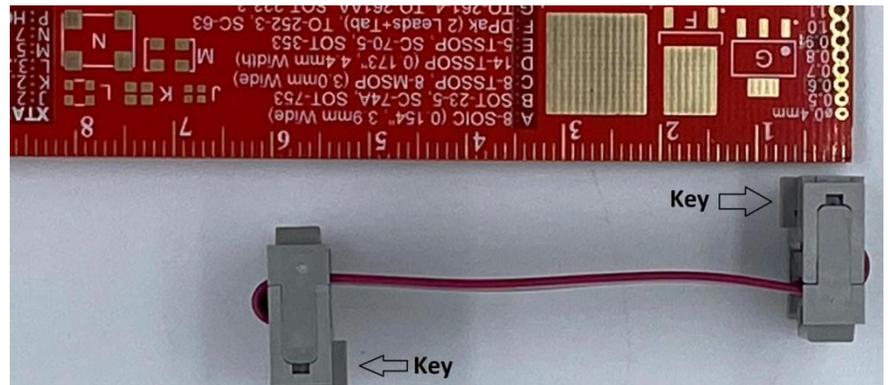
## Interconnect Ribbon Cable

A 60mm 16-conductor ribbon cable connects the front panel PCB to the base PCB. To build this cable, cut an 80mm length of 16-conductor ribbon cable then install the ribbon cable connectors on each end as shown below. The finish length after the strain-reliefs are installed should be around 60mm. You can build this cable longer if you want more space between the board when you assemble or disassemble the enclosure but I find 60mm to be about right.

**NOTE:** When building the cable, make sure that the #1 pin of both connectors is on the same conductor (indicated by the red stripe). The #1 pin is marked by a small triangle on side of the connector as shown in the photo on the left. When the connectors are properly installed the cable should look like the cable in the photo on the right with the key for each connector facing toward the ribbon cable.

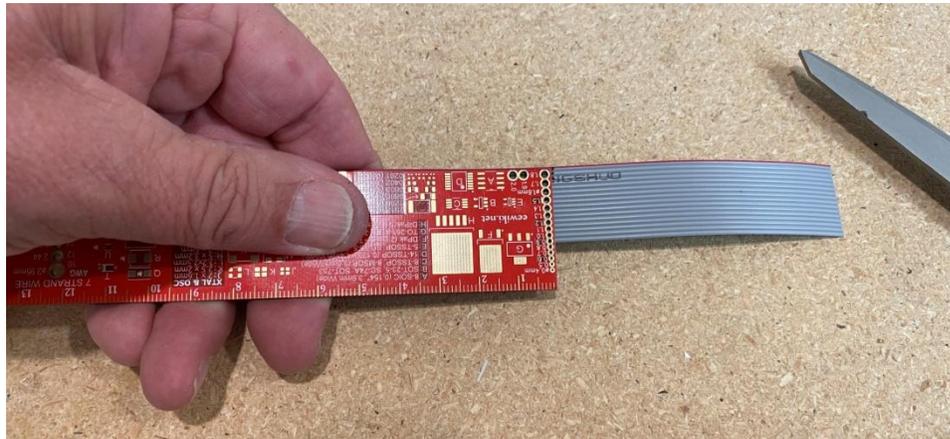


Pin 1 Marker



Finished ribbon cable

When building the ribbon cable be very careful that you cut the ends square. I use a ruler as a straight-edge. Hold the cable under it flush to the upper edge then use a pair of *sharp* scissors to cut the end square as shown in the photo below.



Cutting the ribbon cable

## Installing the Components

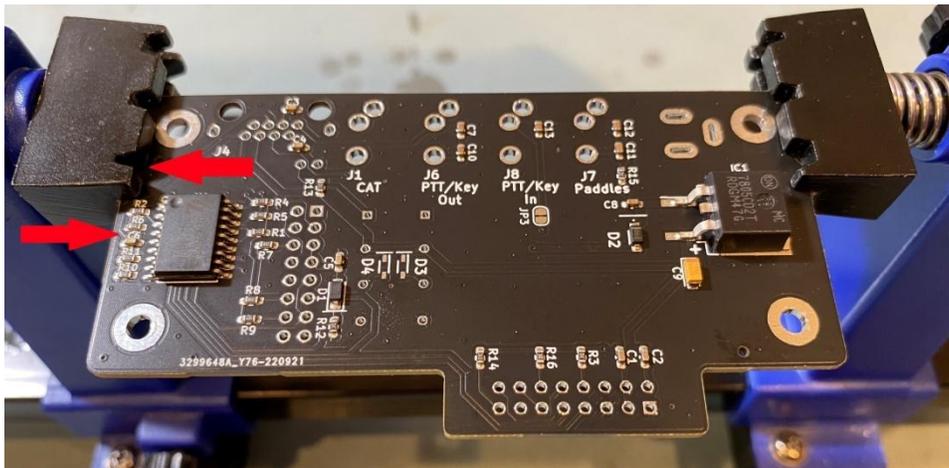
I find it's much easier to install components if the board is installed in a PCB vise. Working with the bottom of the board facing up I insert each connector into its holes from under the board. I hold the solder with my left thumb and index finger and use my left middle finger to hold the connector in position. Once I have soldered one or two pins, I remove the board and check to make sure the connector is positioned properly and laying flat against the board. It's easy to reposition it with only a couple of the pins soldered. Once I'm happy with its placement I solder the rest of the pins. You'll see me using this technique throughout this manual.

## Base PCB Assembly

The base PCB is the easiest to build. All the components are through-hole and mount to the top of the board. There are silkscreen outlines for each component.

### A WORD OF CAUTION

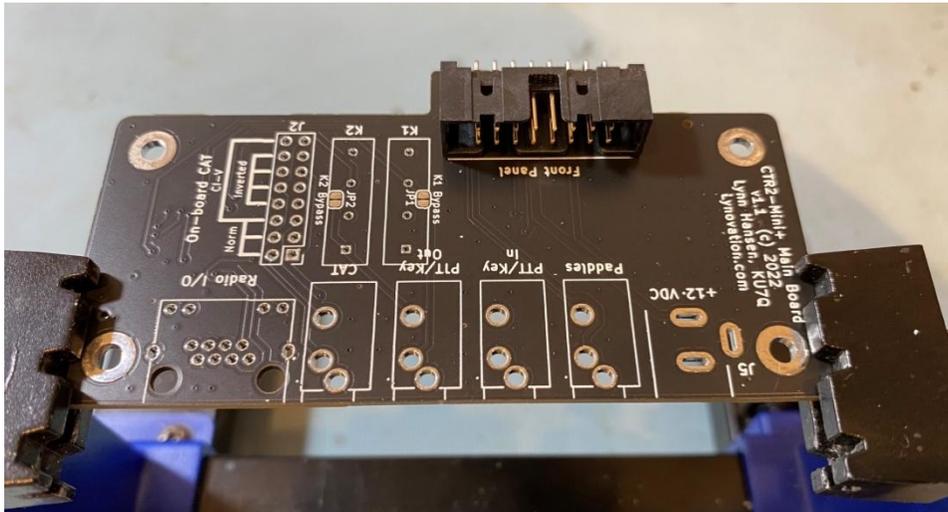
If you use a PCB vise like I do be *extremely* careful when installing the base PCB into the vice. There's a row of SMT resistors and capacitors next to the ULN2803A Darlington driver chip on the bottom of the board. If your vice has slots to hold the PCB it may break these components when you tighten it. I recommend clamping the board as shown in the photo below to eliminate this problem.



Watch out for these components!

## 16-Pin Ribbon Connector – J3

Let's start by installing J3, the 16-pin ribbon cable connector. As shown in the photo below this connector mounts on the top of the PCB and the pins face backwards toward the connectors on the rear of the board. Place it in position then use one finger to hold it to the board while you solder it. While it is hard to do, be careful that you don't form solder bridges between the pins. If you do, use some copper braid (SolderWick or equivalent) to remove the bridge.

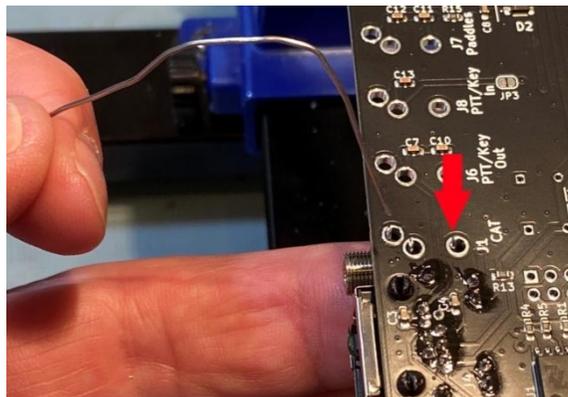


Installing J3

## Jacks

Next, mount the RJ45 jack, the four 1/8" stereo jacks, and the barrel connector for the power.

When mounting these jacks, place your finger on the jack to hold it in place and gently pull the jack toward the rear edge of the board. The pins on the jack should touch the rear edge of the holes they're in, as shown the photo at the left. This will insure that the jacks are all lined up across the back of the board and their barrels extend past the back edge of the rear panel.

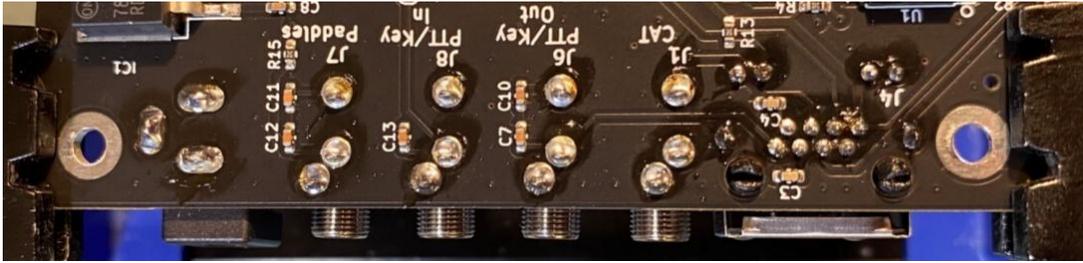


Install connector with pins close to the edge

Make sure the power connector is square to the board. Once it's soldered in it is very difficult to reposition.

Be very careful when soldering the pins on the RJ45 jack. They are close together and you can easily form solder bridges between them. Also, don't forget to solder the four leads for the LEDs on this connector.

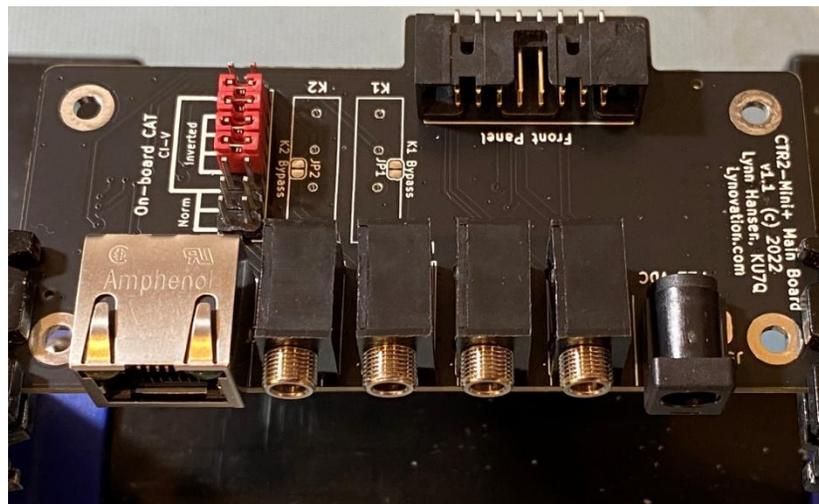
Once you're done the board should look like the photo below. You'll want to use some flux remover to clean off the flux.



Jacks installed

### Dual-Row 8-Pin Header

The final task of populating the base PCB is to install the dual-row 8-pin header for the internal radio I/O circuit. The photo to the right shows the completed base PCB with jumpers installed on the 8-pin header.



Completed base PCB

### Internal or External Radio I/O

The Mini+ has an internal radio I/O circuit. If you don't plan on using the internal radio I/O circuit (i.e. you're going to use the external Radio I/O module instead) you don't need to install the dual-row 8 pin header or J1 and J6, the CAT I/O and PTT/Key Out 1/8" jacks.

Conversely, if you're not planning on using external Radio I/O modules you don't need to install J4, the RJ45 jack.

I recommend you install all of the jacks so you have flexibility in the future. When using the internal radio I/O circuit install the appropriate jumpers on the dual-row 8-pin header. When using the external radio I/O module, remove all of the internal jumpers. I place each one of them on a single pin for storage so I have them when needed again.

## Isolated PTT and Key Output Relays

If your radio is older and uses keying voltage greater than +50 volts, or uses negative voltage for grid-block keying you will need to install the PTT/Key Relay modification. This modification adds two reed relays to the Mini+ that allows you to key radios using voltages up to +/- 200 volts.

This modification requires you to cut JP1 and JP2 on the top of the board, install the reed relays on top, and add flyback diodes D3 and D4 on the bottom of the board.

You can order the relays and diodes from [Mouser using this BOM](#).

## Front Panel PCB Assembly

The front panel uses a fairly unique construction technique that results in a professional looking control panel at a very inexpensive cost. The PCB is actually the front panel. While this is not unique, many kit manufacturers do this, the method of mounting and connecting the controls from the front panel to the Base PCB is uncommon. I've written an article for QEX describing the method of creating the PCB for the front panel. It's scheduled for publication in the January/February 2023 issue.

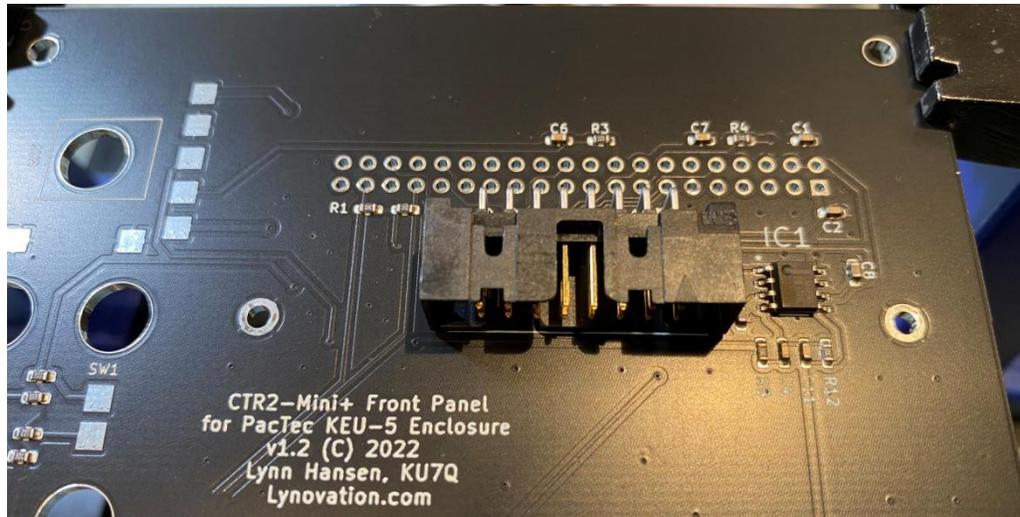
All of the controls mount on the bottom of the front panel PCB and connect to the board using short jumper wires landing on large pads near each control. These pads route the control signals to J1, the 16-pin ribbon connector. A 16-conductor ribbon cable connects to J3 on the base PCB. This technique greatly simplifies and declutters the Mini+ assembly.

## GPIO Connector

The good news about this connector is that you don't have to install it! In order to have the Wio Terminal mount as low as possible on the front panel the dual-row 20-pin header must be slightly modified, installed, and then the plastic retainer needs to be removed. I found this was probably more difficult than a typical build would want to do so [I install these headers on all PCB kits](#). I also glue a couple of M3 washers on the M2 holes on the front panel for the Wio Terminal to rest on so the PCB doesn't warp when these screws are tightened.

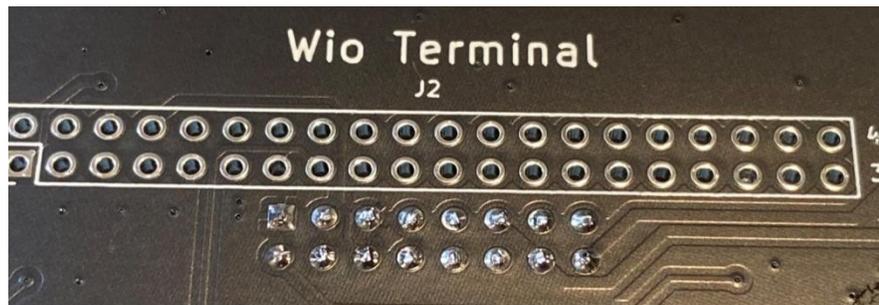
## 16-Pin Ribbon Connector - J1

The first connector you should install is J1, the 16-pin header connector. It mounts on the bottom of the board as shown here. Solder it from the top side of the board.



J1 installed next to IC1

Once completed, trim the leads protruding on top with flush-cutters so the Wio Terminal doesn't rest on them.



Flush cut J1's pins on top

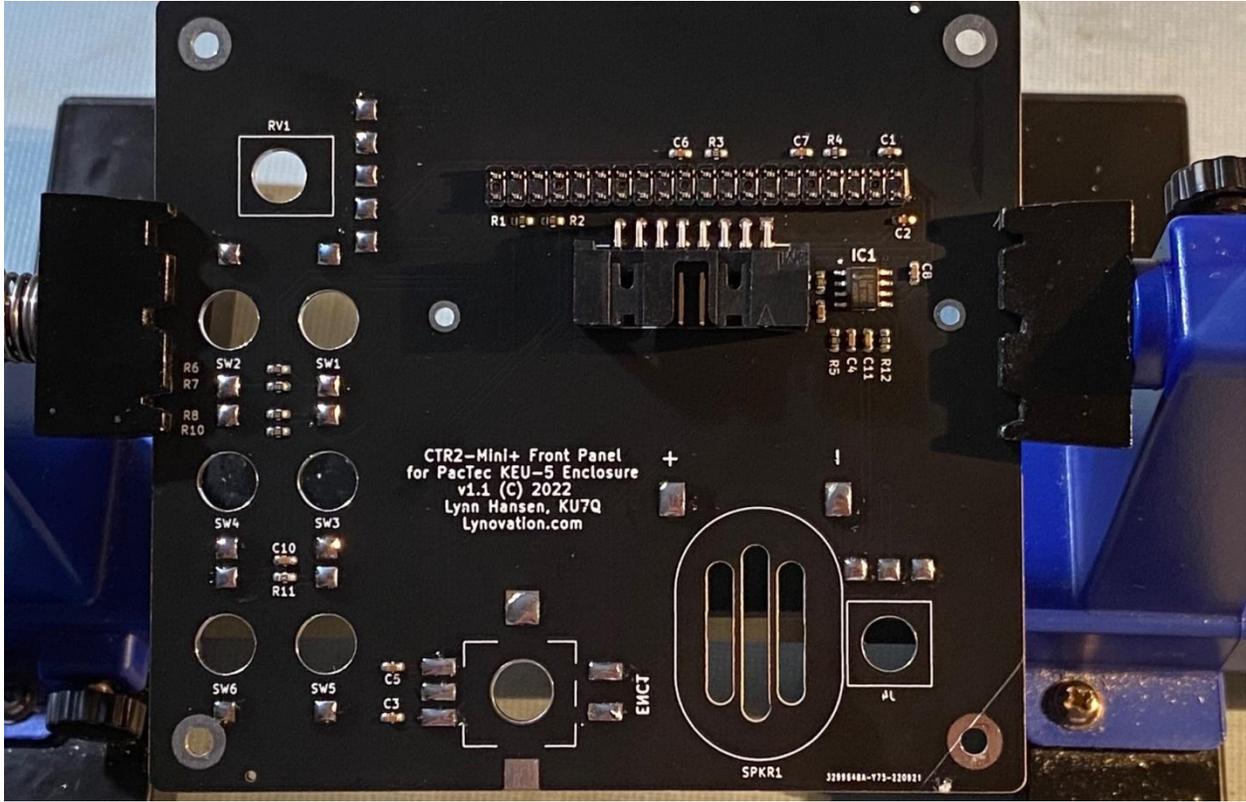
## Installing the Controls

The next step in assembling the front panel is mounting the controls. Everything mounts on the bottom of the board.

**NOTE: Install the speaker after all other controls have been mounted and the flux removed. The flux solvent will melt the foam pad use to stick the speaker to the board.**

Before you start installing controls, add a blob of solder to every pad **except the center pad on the headphone jack** as shown in the next photo. Don't hold the soldering iron on the pad too long or you'll burn all the rosin off. You'll be tacking wires to these pads so a little extra rosin helps.

I use 26 gauge solid copper wire from indoor CAT5 wiring cable to make the connections from the controls to the board. I strip the insulation from the wire since it's not needed in this application. If you use stranded wire, tin the ends before soldering them.



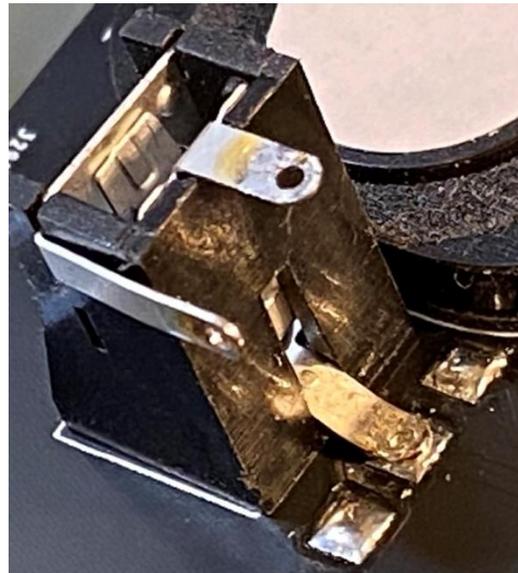
Add a solder blob to each pad before installing components

### Headphone Jack, J4

Mount the headphone jack next.

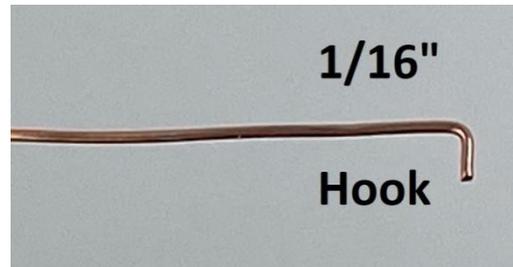
Add a slight bend to the center terminal on the barrel end to bring it down to the board before tightening it down. It should touch the pad when you tighten the mounting nut. It helps if you don't add a blob of solder to this pad as noted above.

Solder the center terminal to the pad on the PCB as shown in the photo to the right.

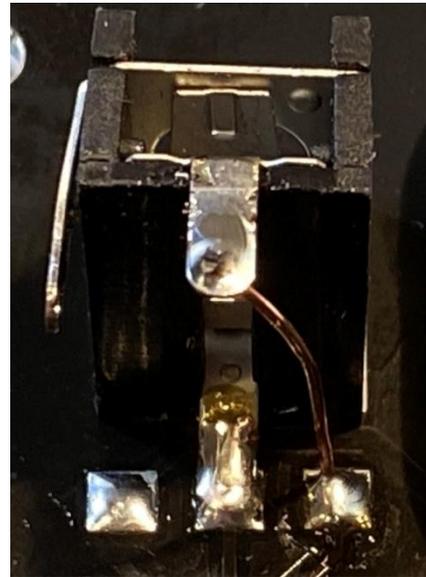


Headphone jack installation

Next, take a short length of wire and put a 1/16" bend on one end to form a hook. This end will be set into the solder blob.



Insert this wire through the top-center terminal and melt the hook into the solder blob on the right hand pad as shown in the photo on the right. Just heat the pad with your soldering iron and push the wire into the blob. This will hold the wire in place while you solder the other end of the wire to the top-center terminal.



Jumper installed

Next, solder the wire to the top-center terminal and clip it off as shown here. Go back and touch-up the solder blob on the pad to make sure the hook end of the wire is completely covered in solder. A slight curve in the wire acts as a strain relief.



Headphone jack completed

Next, add a wire to the terminal on the top-left side using the same technique.

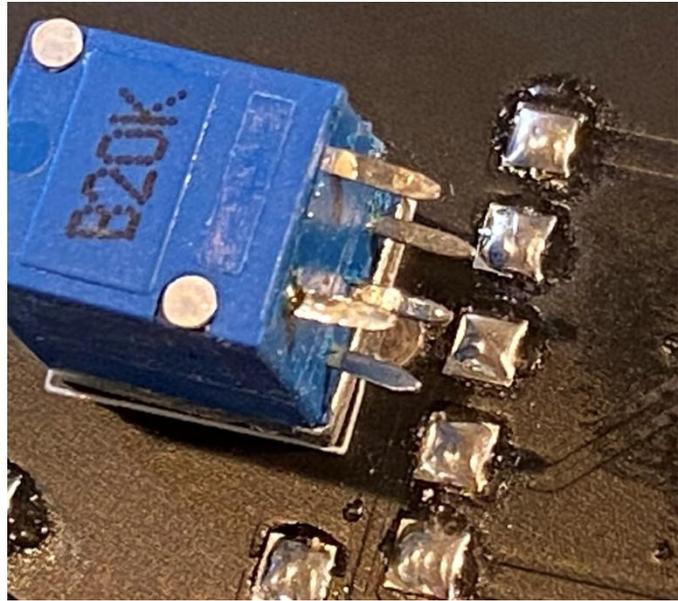
Make sure all connections are solid and that solder flows onto both the terminal and the wire.

## Volume Control

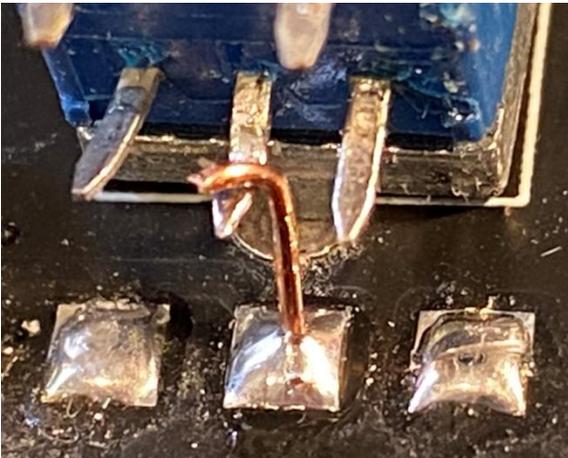
The volume control is a little harder to connect because it just has small pins without holes.

Start by mounting the control to the bottom of the board. The anti-twist tab should drop into the small hole drilled partially through the PCB. This hole can be seen in the photo to the right just below the center pin. This keeps the control from rotating when you reach the stops.

**NOTE:** You may need to trim off a small amount of the tab for the pot to sit flush to the board.



Volume control installation

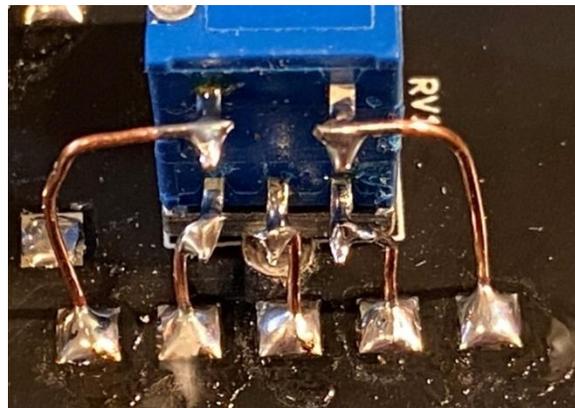


Center pin jumper

Start with the center pin. Solder the hook into the solder blob then clip the wire slightly above the center pin. Use a pair of needle nose pliers to bend another small hook on the top of the wire. This hook should be touching the center pin on the pot as shown in the photo to the left.

Solder the hook to the center pin of the pot. Be careful because this wire is short and has a tendency to melt the solder on the pad too.

Add jumpers using the same technique to the other four pads for the volume control. When you're finished the volume control should the photo on the right.



Completed volume control wiring

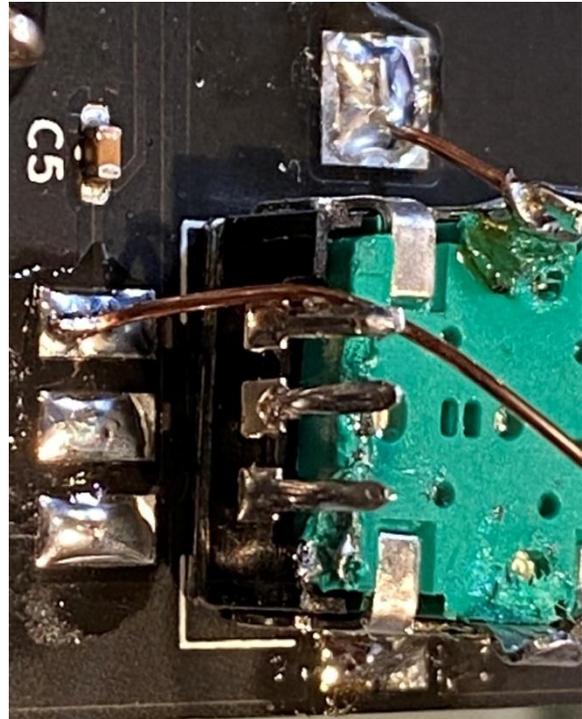
## Encoder

Mount the encoder so the pins align with the pads on the board and tighten its mounting nut. There is no anti-rotation tab on the encoder (since it has no stops).

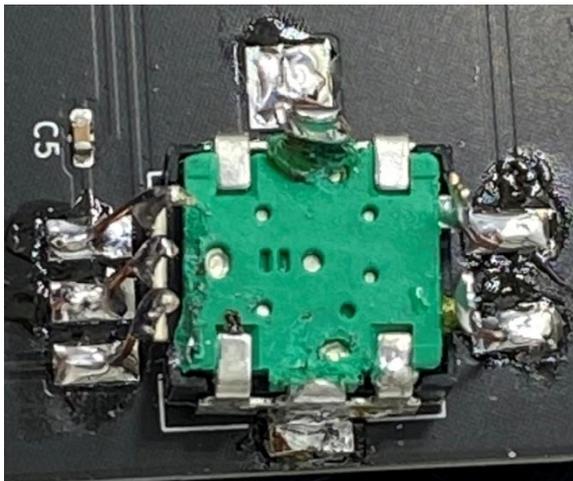
Solder the two ground lugs to the board. Use a hook wire to solder the top lug to the pad as shown in photo to the right. Solder the case of the encoder directly to the lower pad as shown in the next photo.

To solder the pins on the encoder, solder a hook wire to the solder blob on the board then bring it up next to the pin. Make a slight twist around the pin as shown in the photo to the right. Solder the wire to the pin and cut off the excess wire then touch up the solder on the pad. Do this on all 5 pins on the encoder.

**NOTE:** Make sure the wires don't touch each other!



Encoder wiring



Finished encoder wiring

When you're done the encoder should look like photo on the left.

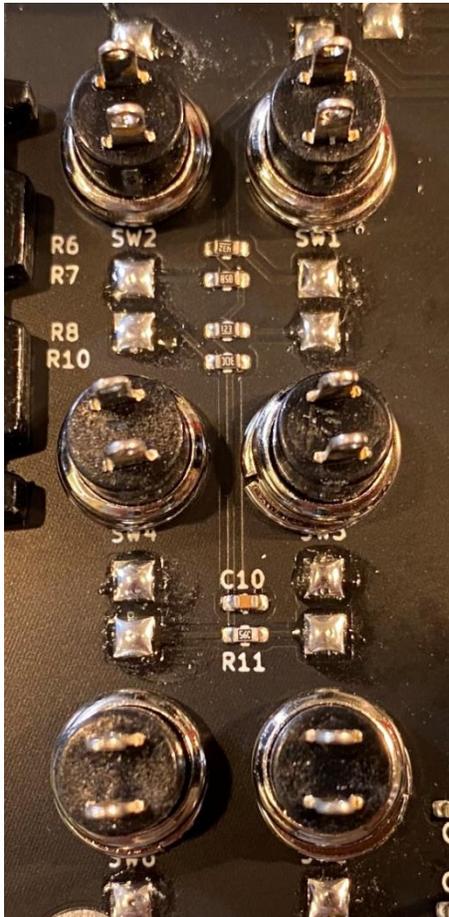
## Pushbuttons

Install the pushbuttons last. Mount them to the bottom of the PCB. I put the washers on top, under the nut so I don't scratch the panel when tightening the nuts. I like colored buttons but you can use any color you want. I recommend using a red pushbutton for PTT (SW6).

Align the nuts on the buttons so they are symmetrical as shown in photo to the right. It's OK if the terminals on the back are slightly out of alignment with the pads.



Installed pushbuttons



Before wiring jumpers

← Before adding wires

Wiring completed →

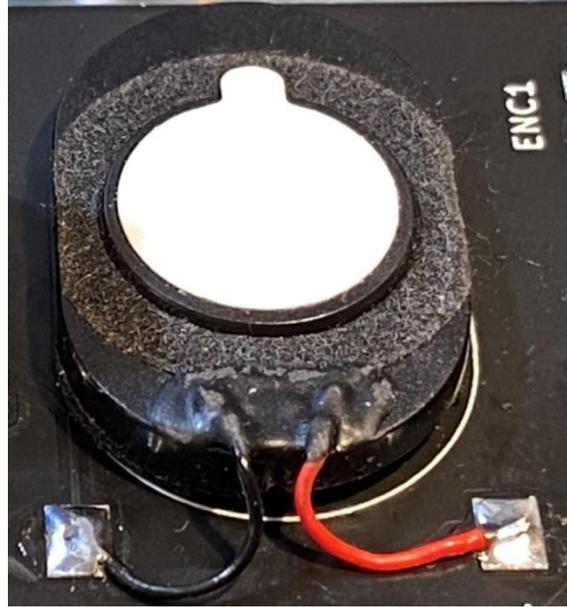


After wiring jumpers

## Speaker

The speaker should be installed **after you have installed all the other components and cleaned the rosin off the board**. The solvent will melt the foam and glue that attaches the speaker to the board.

To install the speaker remove the paper on the speaker's face and stick the speaker down to the back of the PCB using the silkscreened oval as your guide. Cut the connector off the speaker wires leaving enough wire to reach the pads on the board. Tin the ends of the black and red wire and solder them to the – and + pads. The photo on the right shows the completed speaker connections.



Installed speaker

## Assembly

To assemble the unit simply install the front panel in the recess on the top section of the KEU-5 enclosure and secure it with the supplied M3x6mm screws and nuts. It should sit flush with the top of the enclosure.

Carefully align the dual-row 20 pin header on the top of the front panel with the Wio Terminal's GPIO connector and push the two together. Use the supplied M2x5mm screws to secure the Wio to the front panel.

**WARNING: Make sure the M3 washers that I glued to the top panel are still installed. They provide a stop to support the Wio and keep it from warping the PCB when you tighten the mounting screws. Insert the M2 screws from the bottom of the PCB and lightly tighten them.**

Install the four M3x6mm standoffs on the base board using the supplied M3 nuts. Place the base board into the bottom section of the enclosure. Next, place the back panel over the jacks on the board and slide it into the groove on the back of the enclosure. Use the M3x25mm standoffs to secure the back two mounting holes and place the rubber boots on the standoffs as shown to the right. Use the remaining M3x6mm screws to secure the front mounting holes.



Connect the ribbon cable to J3 connector on the base board. Hold the top section over the bottom section and connect the other end of the ribbon cable to the J1 connector on the front panel. Secure the two enclosure halves using the provided screws and install the rubber feet (screws and feet are supplied with the enclosure).

**NOTE:** Before you button up your Mini+, decide if you're going to use the internal radio I/O circuit or use an external Radio I/O module. If using the internal circuit, install the jumpers on the dual-row 8-pin header to match your radio's CAT interface polarity. If you're going to use a Radio I/O module, remove all of the jumpers from this header. (The red jumpers shown in photo 36 configure the internal radio I/O for RS232 operation.)



Your new Mini+ ready to button up!

## Quick Start Guide

Now that you have your Mini+ assembled you're almost ready to start using it. There are just a couple of things that you need to do first...

1. Insert a micro SD card into the Wio Terminal. Any size from 128 MB to 16 GB will do. The card slot is just below the power switch on the left side. The Mini firmware uses this card to store all of its settings.  
**NOTE:** Insert the card upside down (the gold terminals facing up). It is spring loaded so push it in until the retainer clicks. You may need to use a small flat blade screwdriver to get it in all the way.
2. Download the CTR2-Mini firmware [here](#). Before installing the firmware, you must update the eRPC firmware on your Wio Terminal. The CTR2-Mini firmware will not function properly until this has been done. The [firmware download page](#) has instructions on doing this.
3. Build the appropriate radio I/O cable for your radio. Diagrams for many radios are shown in [Appendix C](#). I can supply custom built cables for many radios. Part #s and ordering information can be found with the schematics. If your radio isn't shown, use your radio's manual to determine the CAT, key, and PTT wiring.
4. If using the internal radio I/O circuit, set the jumpers on the dual-row 8-pin jumper on the base board to match the CAT signal polarity your radio uses. *If you're using the external Radio I/O module, do not install the jumpers on the base board, install them on the Radio I/O module instead.* Normal TTL, inverted (RS232) TTL, and Icom CI-V formats are supported. If your radio has an RS232 connector on it you'll use the inverted settings otherwise it's probably normal TTL.
5. Plug the Mini+ into a +12 VDC power supply (center pin is +). Move the power switch on the Wio Terminal to the ON position (center) and twist the Mini+ volume control to turn on the 12 to 5 volt DC power supply in the Mini+.
6. Connect the Wio Terminal on the Mini to your PC and copy the CTR2-Mini firmware downloaded in step 2 above to it using the Instructions on the [firmware download page](#).
7. It will take the Mini+ a few moments to boot the first time. It's setting up the default files for Radio Port #1. Once the Mini+ boots, perform the following operations:
  - a. If you installed an encoder with detents (the BOM lists a smooth encoder without detents), navigate to the **Config** menu, select **Encoder** and toggle it from **Slow** to **Fast**. This speeds up the encoder response.
  - b. Navigate to the **Config->Radio CAT** menu and select the CAT protocol for your radio.
  - c. If you're using a non-standard baud rate on your radio, navigate to the **Config-Radio Baud** menu and select the CAT baud rate your radio is using.
  - d. Connect the CAT adapter cable to the Mini+ and you should be able to control your radio.

- You will find it is easier to set up the Tx Message buffers, WiFi addresses, etc. if you connect your PC to the Wio's USB-C port then open a terminal program to connect to the Mini+. Select the COM port created by the Wio Terminal and set the baud rate to 115200. Once connected, press the [Enter] key on your keyboard to start Terminal Mode. You can control everything on the Mini+ from your PC using the cursor control keys shown on the startup menu to navigate the Mini+ menu system. In addition, you can use your keyboard as a keyboard keyer... just enter text and press [Enter] to send it. Press the [Enter] key to open the main menu and the [Tab] key to redisplay the Terminal Mode menu.

```

COM13 - Tera Term VT
File Edit Setup Control Window Help
CTR2-Mini Terminal Menu

-----FREQUENCY/MENU CONTROL-----
[Enter] Encoder Click - Next Menu          [Tab] Display this screen
[ESC] Return to Home page                  [\/] or [?] List Current Status
[Up Arrow] Increment Selection             [Down Arrow] Decrement Selection
[Left Arrow] Freq Step Up                 [Right Arrow] Freq Step Down
[Page Up] Open Frequency Menu             [Page Down] Open User Menu

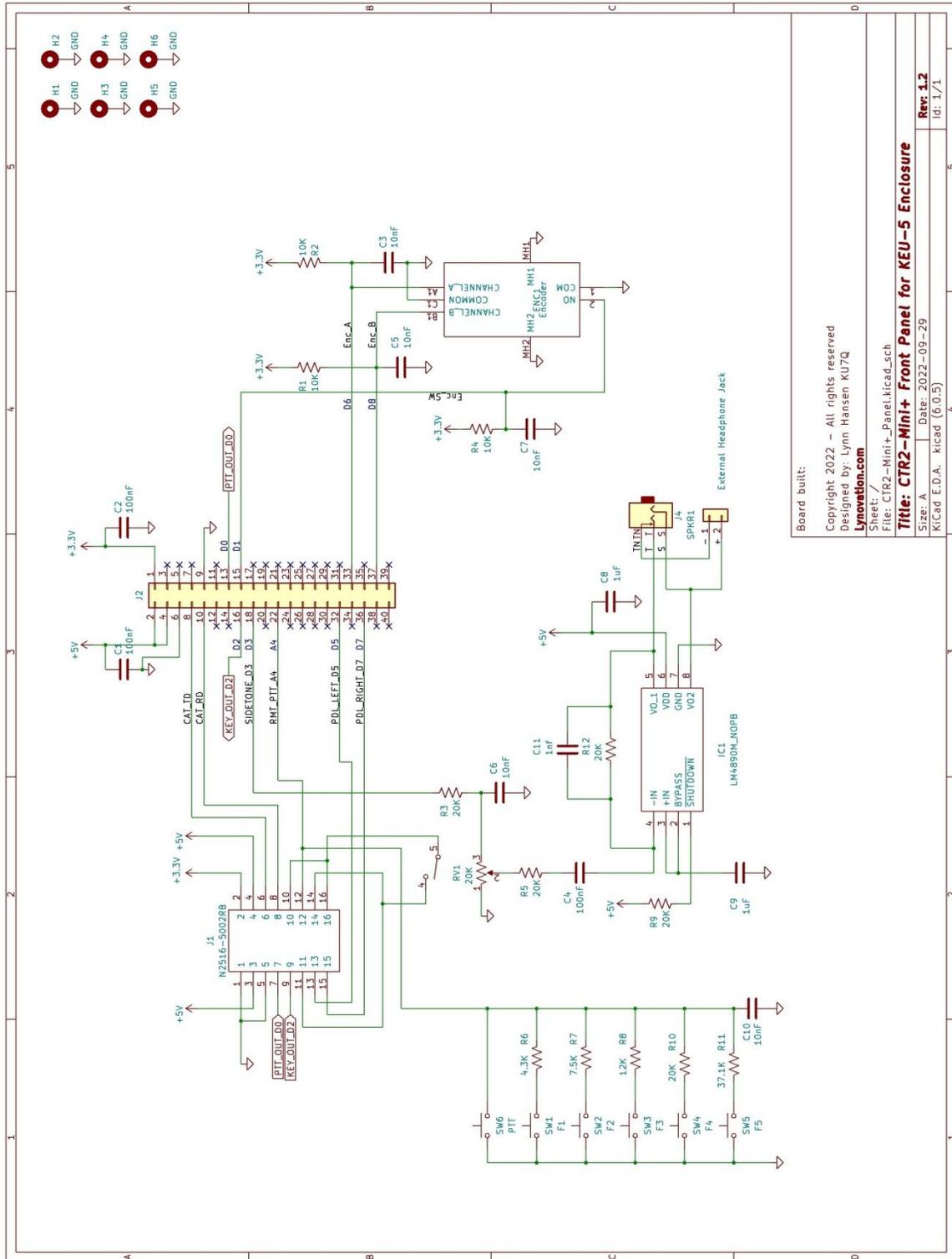
-----KEYER CONTROL-----
[F1] Repeat last message                   [F2] Contest Exchange
[F3] to [F9] Send Message 3-9             [F10] Send Call ^
Shift [F3] to [F7] Send Message 10-14    [F11] Send Contest SN #
Insert] Pause Tx Message                  [F12] Send Exchange %
[End] Delete Tx Message
[Home] Toggle Tx Enable/Disable           [Enter] Send Keybd Buffer

-----TX MSG PROSIGNS-----
[^] Call      [#] Contest SN      [%] Contest Exchange
["] RR      [$] SX      ['] WG      [(] KN      [)] KK      [+] AR      [-] DN      [\/] DN
[:] KN      [:] AA      [<] AR      [=] BT      [>] SK      [0] AC      [[] AS      []] KN

Type chrs then [Enter] to Tx. [Enter] opens Menu, [Tab] displays this screen

```

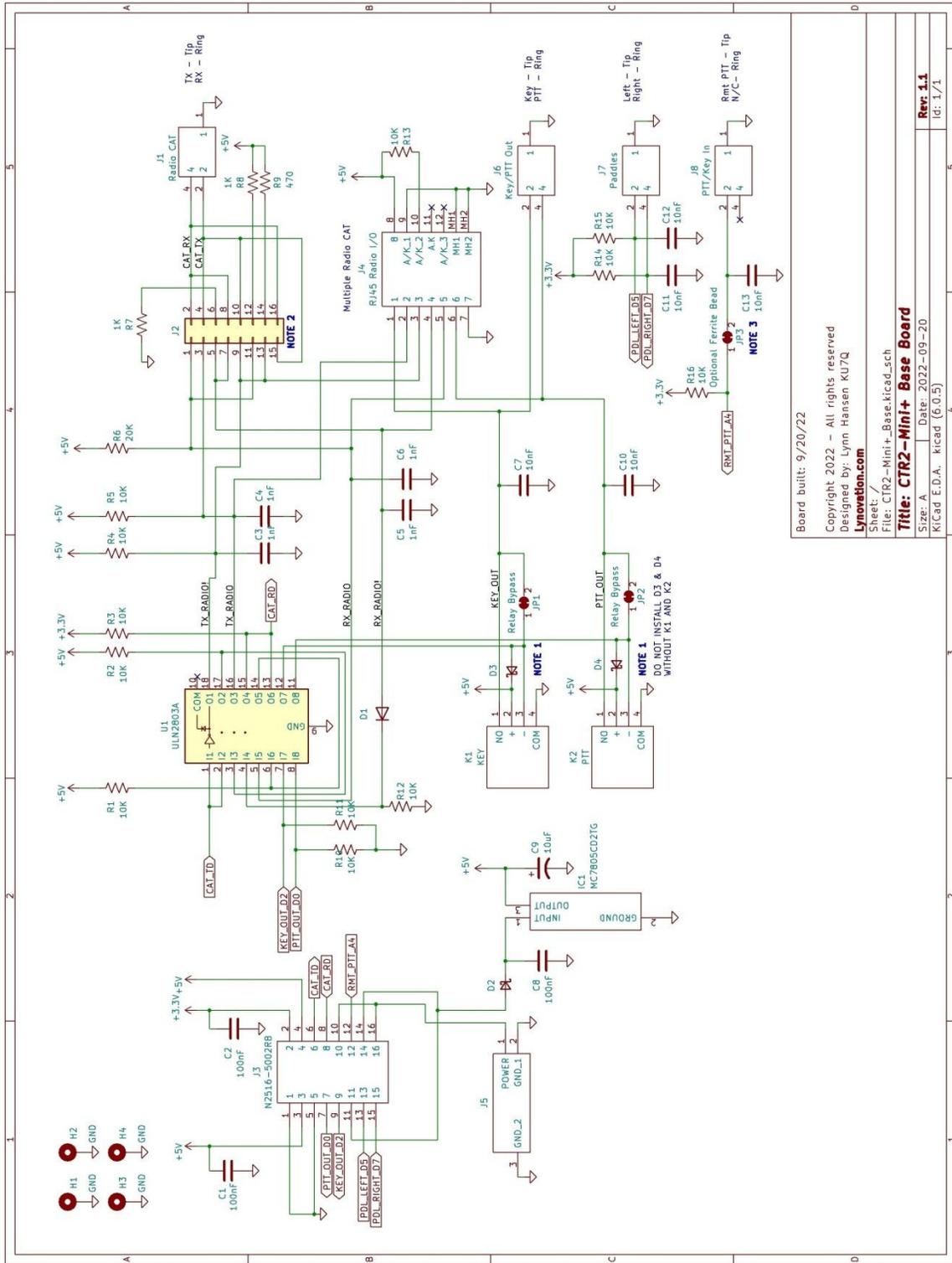
# Appendix A - Schematics



Front Panel Schematic v1.2

Board built:

Copyright 2022 - All rights reserved  
 Designed by: Lynn Hansen KU7Q  
**Lynovation.com**  
 Sheet: /  
**Title: CTR2-Mini+ Front Panel for KEU-5 Enclosure**  
 Size: A  
 Date: 2022-09-29  
 KICad E.D.A. kicad (6.0.5)  
**Rev: 1.2**  
 Id: 1/1



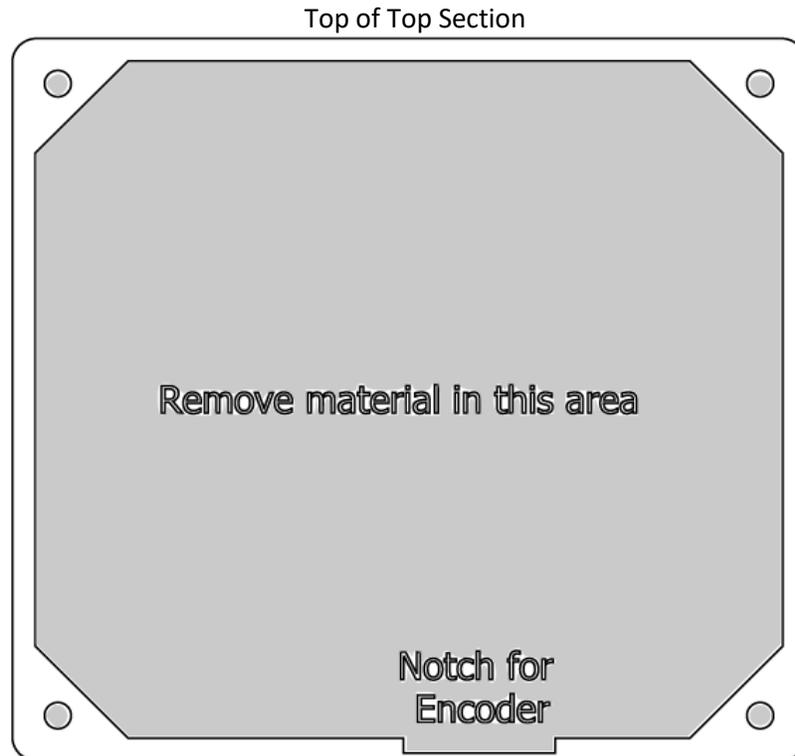
Base Schematic v1.1

Board built: 9/20/22  
 Copyright 2022 - All rights reserved  
 Designed by: Lynn Hansen KU7Q  
 Lynovation.com  
 Sheet: /  
 File: CTR2-Mini+-Base.kicad\_sch  
**Title: CTR2-Mini+ Base Board**  
 Size: A Date: 2022-09-20  
 Kicad E.D.A. Kicad (6.0.5)  
 Rev: 1.1  
 Id: 1/1

## Appendix B – Top Section Grubbing Template

The grubbing template for the top section of the KEU-5 enclosure is shown below full size. Print this page and cut the template out. Lay the template in the recess on the top section of the enclosure and use it to mark the cutout. Remove the material in the recess shown in the shaded area of the template.

You should have already [drilled the mounting holes](#) using the front panel PCB.



Grubbing Template



Completed Cutout

## Appendix C – Radio Wiring Diagrams

This section contains the wiring diagrams you'll need to connect the *Radio I/O* module to your radio. Many of them are simple mono or stereo 1/8" (3.5mm) to 1/8" cables. Others require a custom connector to be added to a factory built stereo to mono adapter such as a DB9, or a 6 or 8-pin mini-DIN. None of them are difficult to build. These can be found on the [Radio Interface Cable](#) page on my blog.

I can supply pre-built cables for your radios. The drawings below have cable part #s. Use these part #s on the [CTR2-Mini Order Form](#) to order the cables you need.

