

# CTR2-Mini I/O Multiplexer Operation & Construction Manual v1.0



CTR2-Mini I/O Multiplexer

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Updated to firmware v1.0.0

Revised sections are highlighted in yellow

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## Introduction

The CTR2-Mini I/O Multiplexer is a small, purpose built four-port switch for the CTR2-Mini ecosystem that automatically selects the one of four ports based on the **Radio Port** selected in the Mini. Two common ports are provided on the front panel. The first serves as the connection to the Mini's RJ45 **Radio I/O** jack (or the CTR2-Mini Audio Controller's **Audio I/O** jack) and the second is used to daisy-chain to another I/O Multiplexer to expand the number of ports that can be routed. These ports are wired in parallel so it makes no difference which port you use. Up to three additional multiplexers can be added to the system bringing the total number of radio ports under the Mini's control to 16.

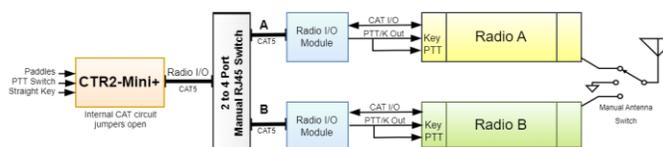
The multiplexer(s) are powered by the cable from the Mini or audio controller so no additional power connections are required. There are no user controls on the multiplexer so it can be located in any location in your station. The four status LED show which port is selected. If the multiplexer is not within sight range you can verify it is working correctly by changing the frequency on the Mini. The frequency of the selected radio should move with the Mini.

These photos show the front and rear panels of the multiplexer.

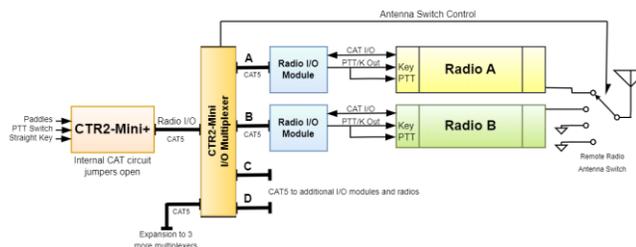


## Typical Usage

The multiplexer can be thought of as a smart cable splitter. It allows you to split the single **Radio I/O** port on the Mini (or **Audio I/O** port on the **Audio Controller**) into as many as 16 different connections. The first diagram on the right shows the basic Mini configuration for controlling two radios using a manually operated RJ45 switch. The second diagram shows how the multiplexer replaces the manual switch. The **Expansion** port allows you to easily expand the system and the **Antenna Switch** port allow the multiplexer to control a remote antenna switch to route your antenna to the selected radio.



One Mini with 2 to 4 Radios using a Manual RJ45 Switch



One Mini with 2 to 16 Radios using CTR2-Mini I/O Multiplexers

In either configuration an external [CTR2-Mini Radio I/O](#) or [CTR2-Mini Audio I/O](#) module is required on each radio. The **Radio I/O** module interfaces the CAT, PTT, and Key signals from the Mini to the radio

while the **Audio I/O** module does the same and adds Line-In and Line Out audio capability. The **Audio I/O** module requires either the [CTR2-Mini Audio Controller](#) or [CTR2-Mini SO2R Controller](#) to add the audio to the I/O cable.

## Theory of Operation

The multiplexer uses a relay matrix to select the desired port. All eight wires in the rear RJ45 I/O ports are switched. Each port has four DPDT relays that are activated when that port is selected.

The multiplexer uses a small Seeed Studios Xiao SAMD21 development board that monitors the serial traffic on the CAT Tx data line. Commands from the Mini are sent to the multiplexer at 300 baud so it doesn't confuse radio CAT traffic with multiplexer commands. When the user selects a Radio Port on the Mini the normal (higher speed) CAT traffic is paused and the Mini changes its CAT port's baud rate to 300 baud. It then sends out the port select command. The multiplexer(s) decode this command and selects the correct relay bank from the matrix. The Mini then sets the CAT port and baud rate for the newly selected radio port and proceeds to initialize the radio on the selected port.

When two or more multiplexers are used each unit must be assigned to a range of four ports. This is done through two address jumpers near the processor. The table below shows the jumper and port range relationship. On power up the yellow LED on the **Radio I/O** RJ45 jack will flash the assigned port range in Morse code.

Jumpers	Port Range	Start Up LED Flash Morse Code
Both jumpers OUT	Port 1 to 4	1
ADRO IN & ADR1 OUT	Port 5 to 8	2
ADRS0 OUT & ADRS1 IN	Port 9 to 12	3
Both jumpers IN	Port 13 to 16	4

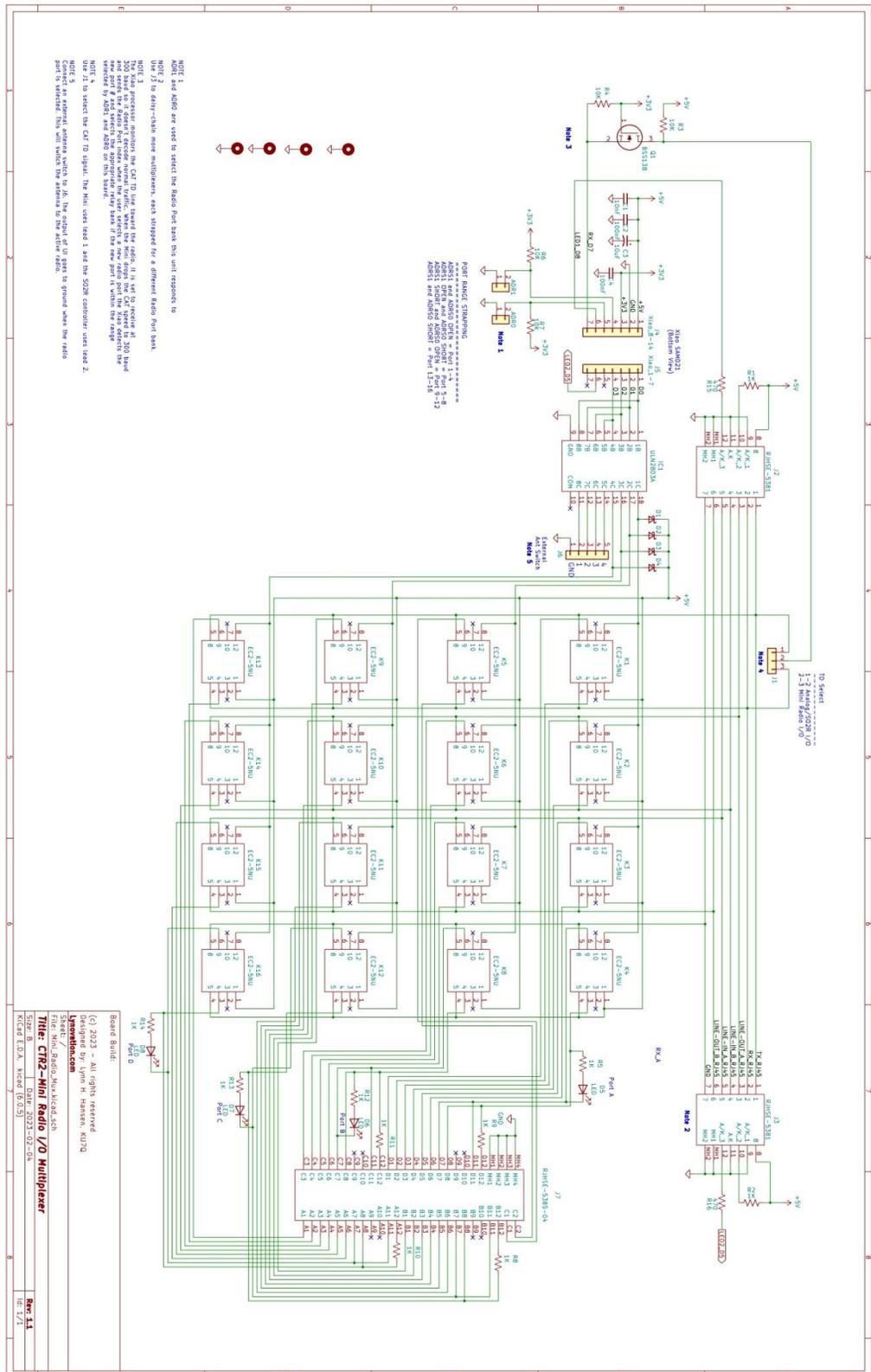
When the multiplexer receives the port select code from the Mini it checks to see if that port is within its port range. If it is the multiplexer enables the four relays on that port to route it to the common ports. If the port is not in this multiplexer it opens all of its relays. Only one LED on the multiplexer the selected port resides in will be illuminated.

Separate open collector Darlington drivers are connected to the four relay bank select lines. These are wired to the External Antenna Switch connector on the side of the multiplexer. When a relay bank is activated its corresponding antenna switch driver goes low. This can be used to pull in an antenna relay. Each driver is cable of sinking 500 milliamps at 50 volts.

As noted in the [Typical Usage](#) section the multiplexer supports both the **CTR2-Mini Radio I/O** and the new **CTR2-Mini Audio I/O** modules. The CAT Transmit Data line is on a different pin on these two modules so the **CAT TD SELECT** jumper option on the multiplexer allows you to select the correct pin to monitor depending on the I/O module you're using.

# Schematic Diagram

The schematic for v1.1 of the multiplexer is shown below. To save money you only need to populate the relays for the number of ports you currently need. You can always add the additional relays later if you expand the number of radios you're controlling.



## Bill of Material

The parts required to complete the CTR2-Mini I/O Multiplexer PCB kit are listed in the spreadsheet below. I've also created a shopping cart on Mouser.com so you can conveniently order these parts with just a couple of clicks. The link to the Mouser BOM is

<https://www.mouser.com/ProjectManager/ProjectDetail.aspx?AccessID=a7b82760bc>

You can reduce the cost of your multiplexer by only installing the number of relays you need. If you only plan on controlling two radios, only 8 relays (K1 to K8) are required.

A spreadsheet with the Mouser links can be found on my blog at

[https://ctr2.lynovation.com/category/products/radio\\_mux](https://ctr2.lynovation.com/category/products/radio_mux)

## Building the Multiplexer

The multiplexer is an easy project to build, but it will take some time and you should be comfortable soldering tightly packed pins because there are a lot of connector pins to solder. Make sure you get them all soldered with no solder bridges. Use solder braid to clean up anything that looks suspicious. I find a chisel soldering iron tip works good for me.

## Enclosure Preparation

The PCB mounting bosses on the enclosure will not be used. Remove the bosses on the top and bottom covers with diagonal cutters. There are also two extrusions on each side of the bottom cover. Trim these off too.

The mounting holes on the PCB don't line up with the mounting bosses on the enclosure so before populating the PCB use it as a drilling template. Insert the end panels into the enclosure then lay the PCB inside. Slide the PCB so it just touches the rear panel and use tape to secure it in position. Use a 3.5mm (1/8") drill bit to drill the board's mounting holes. The board mounts to the enclosure using the 5mm brass standoffs, nuts, and bolts supplied with the PCB kit. Secure the standoffs to the PCB using the nuts and use the bolts to attach the PCB to the bottom cover.

If you're going to install the 5-pin Molex antenna switch header you'll need to cut a 12mm H x 20mm W rectangular hole in the side of the enclosure. This hole is on the right front of the enclosure. It starts 35mm back from the front edge and 6mm up from the bottom.

## Populate the PCB

Start populating the PCB by installing the pin headers first. There are three of them, two 2-pin and one 3-pin. Next, install the two 7-pin header sockets for the Xiao development board. Make sure they are installed vertically. I find it's easier to plug them into the Xiao board and use it to keep them straight while I solder a couple of pins on each socket. Then remove the Xiao board and finish soldering the rest.

You can solder the Xiao board directly to the PCB but that makes it difficult to remove if it fails down the road.

Install the relays next. They are grouped in sets of four. Relays K1 to K4 go to Port A, K5 to K8 go to Port B, K9 to K12 go to Port C, and K13 to K16 go to Port D. You only need to install the relays for the number of ports you want to use. For instance, if you only have two radios to control you only need to install K1 to K8. You can always add the other relays later if you add more radios.

Install the four LEDs, even if you aren't populating all the relays (they plug the holes in the front panel ☺). The cathode (short lead) goes into the square pad and the anode (long lead) goes into the round pad. Bend leads at a 90 degree angle just at the start of the flattened area on the leads. The LED lens should extend past the edge of the board about 2mm. Make sure they are aligned, horizontal, and just touching the board before you solder them. I found that soldering them from the top of the board aids in keeping them aligned.

Finally install the RJ45 jacks and the 5-pin header for the antenna switch. The pins on the 4-port jack on the back can be difficult to align with the holes. It helps to make sure the pins are all straight before inserting the jack. Also, check to make sure every hole has a pin in it. Do not force the jack into the board! Soldering everything down and finding a bend pin will ruin your day!

Insert the Xiao SAMD21 into the 7-pin header sockets with the USB-C port facing toward the front panel as shown in this photo.

Once you're done the board should look like this...

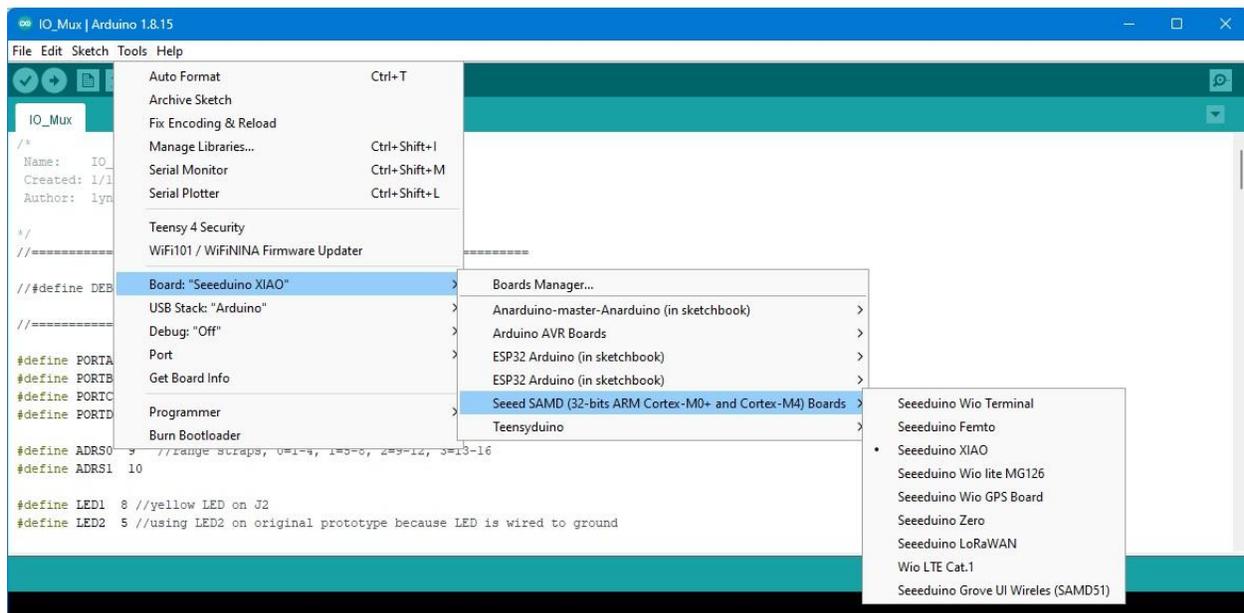


## Programming the Xiao SAMD21

If you purchased the Xiao SAMD21 from Seeed Studios or Mouser you'll need to compile the program and install it. To do this you'll need to install the Arduino IDE (Integrated Development Environment) on your PC if you don't already have it. You'll also need a USB-C cable to connect the Xiao to your PC.

Load the source code you downloaded from my blog and copy the **IO\_Mux.ino** file to a new folder named **IO\_Mux**.

Next, open the IO\_Mux.ino file in the IDE. Once you have it opened, use the Board Manager to load the **Seeeduo XIAO** board profile. This file tells the IDE how to manage the Xiao SAMD21 board.



Once you have everything set up plug the Xiao into your PC. A virtual serial port should be created for it. It will show as the **Seeed Xiao** port in the **Tools->Port** menu. Select this port.

Finally, click the **Sketch->Upload** option to compile and upload the file to your Xiao board.

This is the process you'll need to follow if I release future updates to the program.

## Connecting it up

The multiplexer is designed to be easy to install. Once you have set the strapping options in the [Theory of Operation](#) section just plug it in. Use CAT5 cable to plug the front **I/O** port on the first multiplexer (if you're using more than one) into the Mini's **Radio I/O** port (or the **Audio I/O** port on the **Audio Controller** or **SO2R** controller and connect the **Expansion** port to the next multiplexer (again, if you're using more than one) using a short CAT5 cable. Plug the CAT5 cables from the **Radio I/O** or **Audio I/O** modules on the radios into the ports on the back of the multiplexer as they appear in the Mini's **Radio Port** menu. That's it! The multiplexer draws power from the I/O port on the controller it's plugged into and requires no other user intervention. Configurations can be found in [Appendix A](#).

When first powered up the multiplexer has all of its ports disabled. The yellow LEDs on the **I/O** and **Expansion** ports flash while the multiplexer is waiting for a port selection command from the Mini. The Mini only sends the port selection command on boot up or when you select a **Radio Port**. Since the multiplexer is powered by the controller it's plugged into it will be initialized when the Mini boots up and loads the radio configuration. If you unplug the CAT5 between the controller and multiplexer then reinsert it you will need to reselect a **Radio Port** in the Mini to reinitialize the multiplexer.

## Troubleshooting

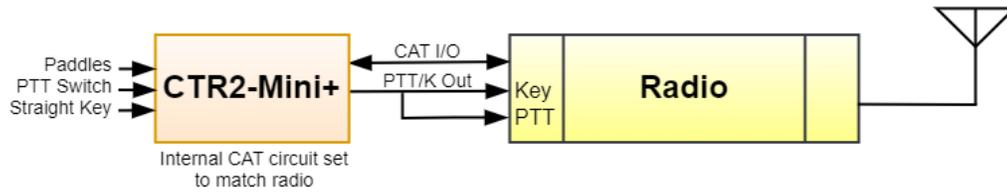
There's not a lot to go wrong with the multiplexer. Once you plug it in and turn the Mini's power on the yellow LED on the **Radio I/O** RJ45 jack will flash the relay bank assigned to this multiplexer as shown in the table in the [Theory of Operation](#) section. This multiplexer will only respond when you select a **Radio Port** in the Mini in this port range.

The table below list possible issues and their resolution.

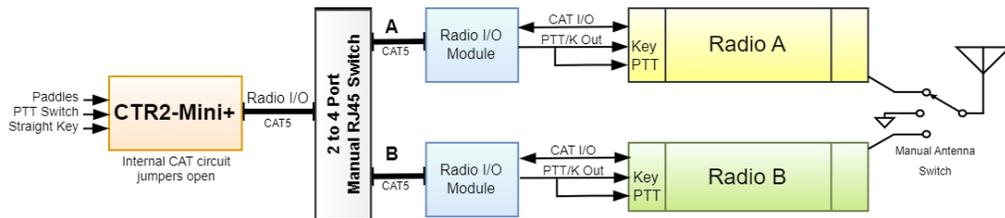
Issue	Resolution
The yellow LED on the Radio I/O RJ45 doesn't flash when I turn on the Mini	<ol style="list-style-type: none"> <li>1. Verify you have the <b>Radio I/O</b> port on the Mini connected to the front <b>I/O</b> port on the multiplexer.</li> <li>2. The program in the Xiao may be corrupt. Reflash it using the procedure in the <a href="#">Programming the Xiao SAMD21</a> section.</li> </ol>
The yellow LEDs on the <b>I/O</b> and <b>Expansion</b> jacks flash continually	The multiplexer is not initialized and all output ports are open. This may happen if the multiplexer initializes after the Mini boots or if power has been removed from the multiplex after the Mini boots. Reselect a <b>Radio Port</b> on the Mini.
The yellow LED flashes the wrong bank #	Verify the ADR1 and ADR0 strapping matches the table in the <a href="#">Theory of Operation</a> section
The multiplexer doesn't select a relay when I select a port on the Mini in its port range	Verify that the multiplexer is power up (yellow LEDs on the front ports are flashing) and that the CAT TD SELECT strapping is correct for the I/O modules being used on the radios.
I'm using two multiplexers and they both select the same port when I select a <b>Radio Port</b> on the Mini	Verify the port bank strapping address is correct (and different) on each multiplexer and that each multiplexer flashes the correct relay bank on power up.
I have both <b>Radio I/O</b> and <b>Audio I/O</b> modules for my radios. Can I use them in the same system?	Yes, but you'll need to use two multiplexers. The one connected to the <b>Radio I/O</b> modules should be connected to the Mini and the second one connected to the <b>Audio I/O</b> modules should be located after the <b>Audio Controller</b> . There is a diagram showing this configuration in <a href="#">Appendix A</a> .

## Appendix A – System Configurations

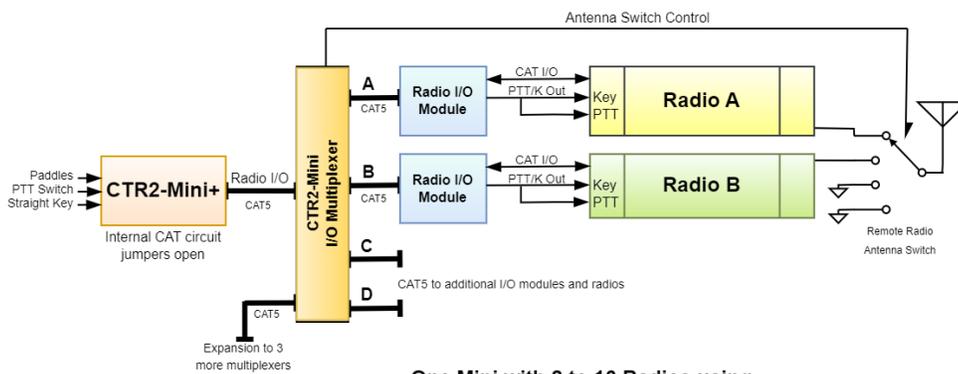
The following diagrams show the various system configurations with the CTR2-Mini ecosystem. Choose the configuration that works for your station today and expand it with easy to build modules in the future.



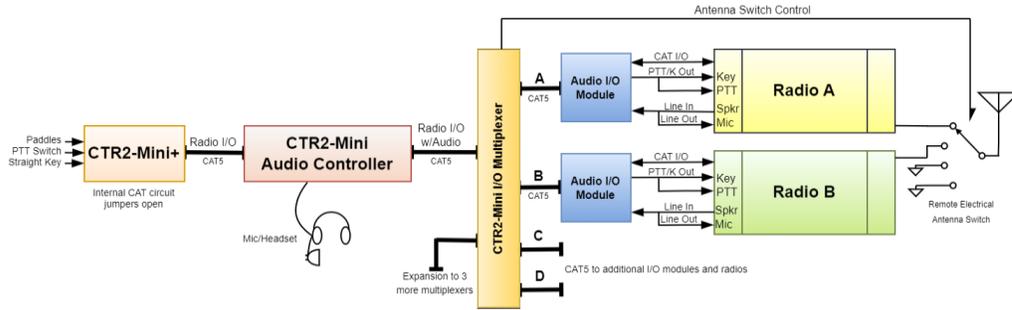
**One Mini / One Radio Configuration**



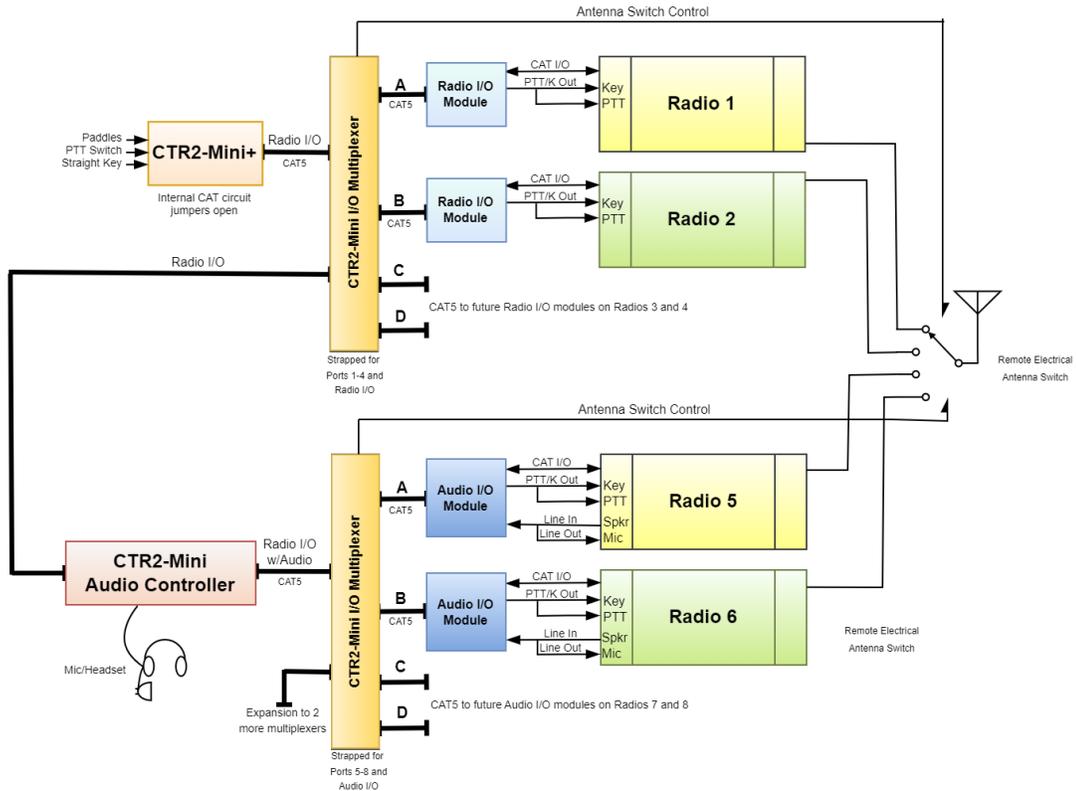
**One Mini with 2 to 4 Radios using a Manual RJ45 Switch**



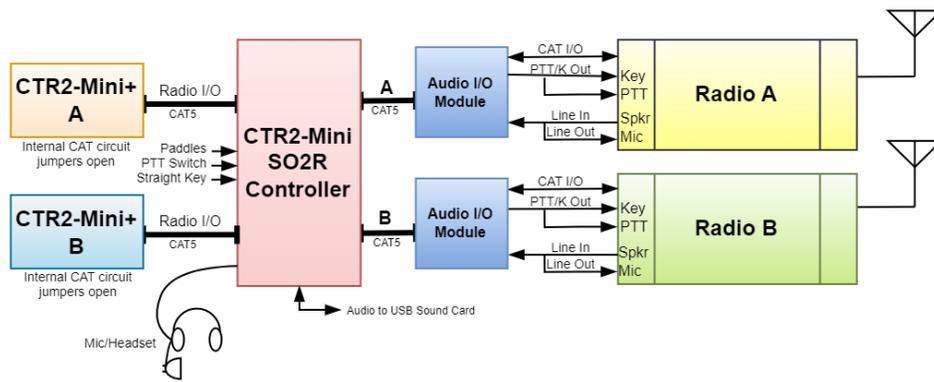
**One Mini with 2 to 16 Radios using CTR2-Mini I/O Multiplexers**



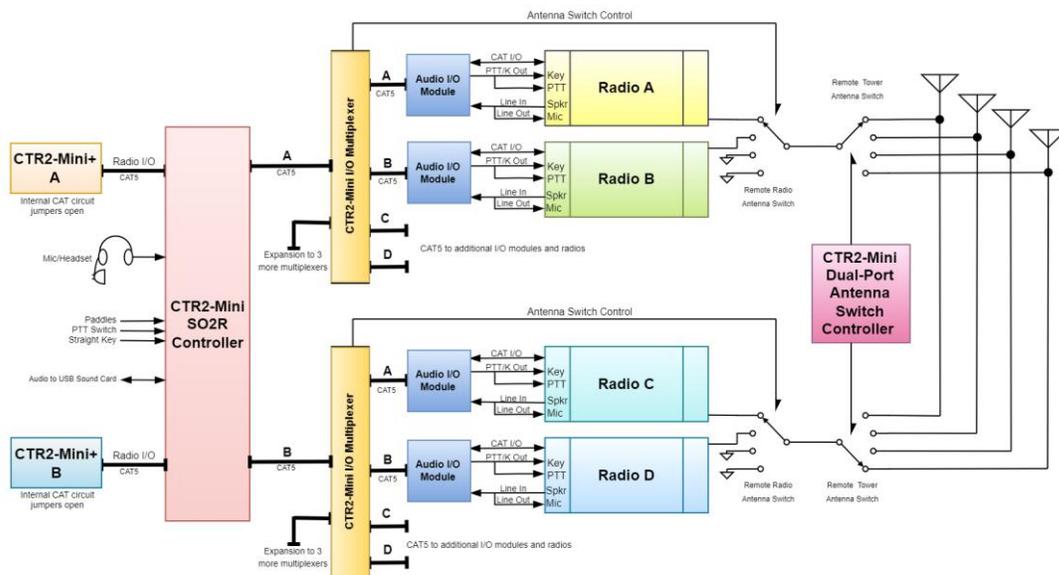
**One Mini controlling 2 to 16 Radios with Common Audio using the CTR2-Mini Audio Controller and up to four CTR2-Mini I/O Multiplexers**



**One Mini using two I/O Multiplexers to control two radios with Radio I/O modules and two radios using Audio I/O modules with the CTR2-Mini Audio Controller**



Two Minis Operating in SO2R Mode with Two Radios



Two Minis controlling two Radios with backup Radios in SO2R Mode with two CTR2-Mini I/O Multiplexers and a CTR2-Mini Remote Antenna Switch Controller