



DIY Adaptive Game Controllers

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<https://learn.adafruit.com/diy-adaptive-game-controllers>

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Overview



It's never been easier to create adaptive controls to play video games. For gamers with particular needs not met by standard gaming controllers, the [Microsoft Xbox Adaptive Controller \(\)](#) (XAC) is a fantastic option for managing alternative inputs.

In this guide, we'll learn how to build our own interconnections between large buttons, foot pedals, analog joysticks, and limit switches and the XAC's button inputs.

XAC is designed to work with the Xbox One series of consoles and Windows 10. However, many people have successfully used it on other systems by adding a wireless controller adapter to translate between standards.

The basic switch inputs in this guide do not require any soldering, but as you build more complex XAC projects, some soldering skills can come in handy!

Assistive Technology Resources

There are many great resources out there for people to learn more about AT for gamers. Here are a few:

- [Able Gamers \(\)](#)
- [Cerebral Palsy Foundation \(\)](#)
- [Special Effect \(\)](#)

- [Warfighter Engaged \(\)](#)

If you're interested in helping build adaptive controllers, [AT Makers \(\)](#) can help you get connected with people in your areas. They've also got great guides on [building adaptive connectors \(\)](#) and [switch testers \(\)](#).

The support of Bill Binko of AT Makers, and Bryce Johnson of Microsoft Devices have been incredibly helpful in creating this guide! Thanks guys!

If you're just learning about XAC, here are a couple of good videos to watch:

Parts

You'll need a Microsoft Xbox Adaptive Controller as well as an Xbox One or Window's 10 PC to use this guide. Additionally, here are some of the switches, buttons, joysticks, pedals, wiring, connectors, and supplies you can use to create your own inputs:

1 x Massive Arcade Button with LED 100mm Red	https://www.adafruit.com/product/1185
1 x Large Arcade Button with LED 60mm White	https://www.adafruit.com/product/1192
1 x Mini Analog Joystick 10K Potentiometers	https://www.adafruit.com/product/3102
1 x Foot switch momentary button, bare wires	https://www.adafruit.com/product/423
1 x Small Arcade Joystick with four switches	https://www.adafruit.com/product/480
1 x Magnetic contact switch door sensor/reed switch	https://www.adafruit.com/product/375
1 x Micro Switch w/Wire Three Terminals	https://www.adafruit.com/product/820
1 x Hefty On-Off Pushbutton Power Switch It's hefty	https://www.adafruit.com/product/3991

TRS
TRS

1 x [3.5mm \(1/8"\) Stereo Audio Jack Terminal Block](https://www.adafruit.com/product/2791) <https://www.adafruit.com/product/2791>
TRS

1 x [3.5mm \(1/8"\) Stereo Audio Plug Terminal Block](https://www.adafruit.com/product/2790) <https://www.adafruit.com/product/2790>
TRS

1 x [3.5mm \(1/8"\) 4-Pole \(TRRS\) Audio Plug Terminal Block](https://www.adafruit.com/product/2914) <https://www.adafruit.com/product/2914>
TRRS

1 x [Right-Angle 3.5mm Stereo Plug to Pigtail Cable](https://www.adafruit.com/product/1700) <https://www.adafruit.com/product/1700>
TRS

1 x [Arcade Button and Switch Quick-Connect Wires - 0.187"](https://www.adafruit.com/product/3838) <https://www.adafruit.com/product/3838>
10 pack

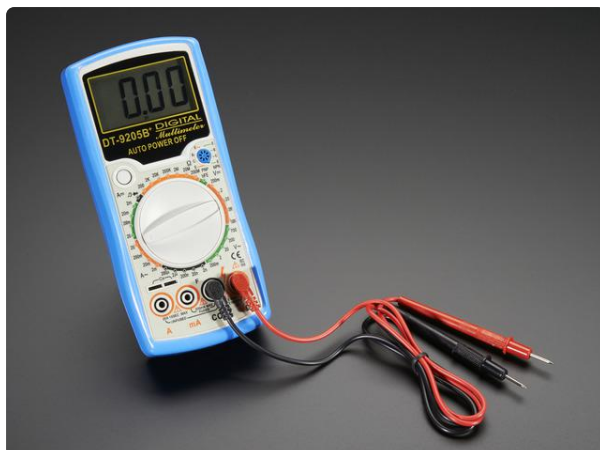
1 x [Arcade Button and Switch Quick-Connect Wires - 0.25" \(10-pack\)](https://www.adafruit.com/product/3838) <https://www.adafruit.com/product/3838>
10 pack

1 x [Arcade Button Quick-Connect Wire Pairs - 0.11" \(10 pack\)](https://www.adafruit.com/product/1152) <https://www.adafruit.com/product/1152>
10 pack

You can also have a look at our [many, many other buttons \(\)](#)!

Tools

Here are some useful tools for use when making adaptive tech inputs:



[Digital Multimeter - Model 9205B+](https://www.adafruit.com/product/2034)

This massive multimeter has everything but the kitchen sink included. It's a great addition to any workbench or toolbox. It's low cost, simple to use, and has a big clear...

<https://www.adafruit.com/product/2034>



Precision screwdriver set (6 pieces)

Break seals! Void warranties! With this handy screwdriver set at your hands, all hardware you touch will open up and reveal their secret innards. This set contains 6...

<https://www.adafruit.com/product/424>



Hakko Professional Quality 20-30 AWG Wire Strippers

These are the finest wire strippers we have used, and if you have to do a lot of wiring, you will agree! They have soft rounded grips - very comfortable to use, and precision ground...

<https://www.adafruit.com/product/527>

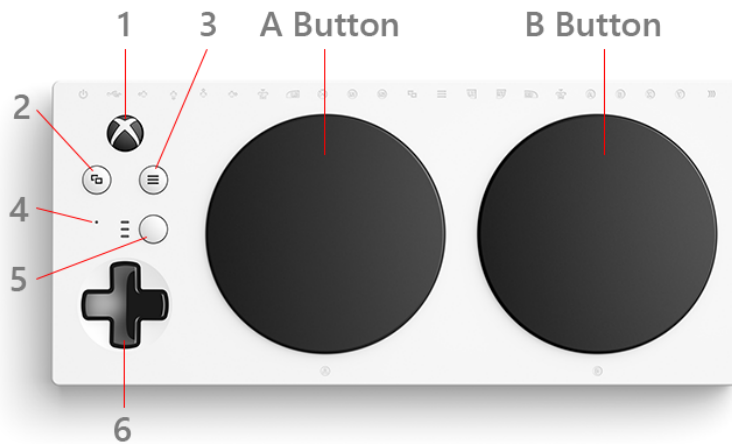
XAC Standards

If you're new to the Xbox Adaptive Controller, have a look at these resources:

- [All about the Xbox Adaptive Controller \(\)](#)
- [Getting to know the Xbox Adaptive Controller \(\)](#)
- [External devices with XAC \(\)](#)
- [FAQ \(\)](#)

If you need to dive into deeper details, check out these [Xbox Adaptive Controller Input Specifications \(\)](#). These are incredibly helpful in detailing the pinouts and voltages for all of the ports, particularly the analog ports for joystick control.

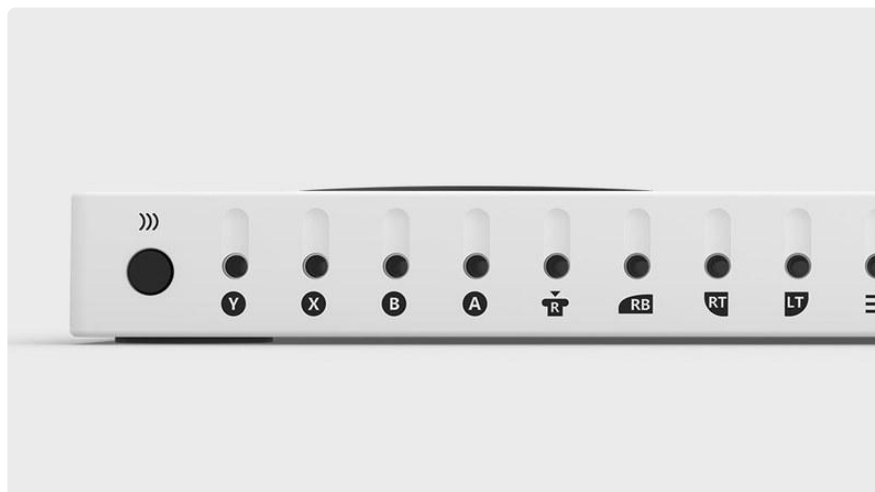
The XAC works just like a standard Xbox controller in terms of wireless connection with the Xbox, however it only sports a few of the typical buttons -- D-pad (6) , A button, B button, menu (3), Xbox button (1), menu button (3), and view button (2).



All of the missing inputs, along with the ones already physically present, can be controlled by external devices plugged into the 3.5mm jacks along the back of the XAC.



For example, you can see here that the Y, X, B, and A buttons are all represented as 3.5mm jacks, where you can plug in four larger buttons if needed.



Thanks to the Copilot Mode, you can use a standard Xbox controller in tandem with the XAC, so two users can work together as a single player, or one user can use both if that suits their needs.

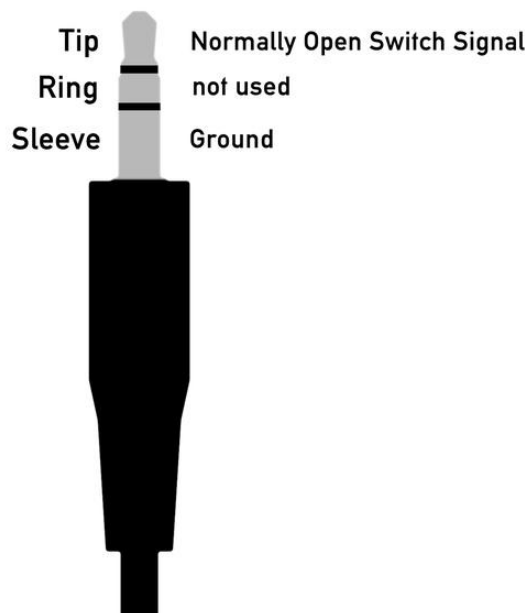
Next, we'll look at the standards used with these jacks so you can interface your own digital buttons, switches, and analog devices with them.

The XAC can also use HID joystick devices plugged into the USB ports on either side -- we won't be covering this in this guide.

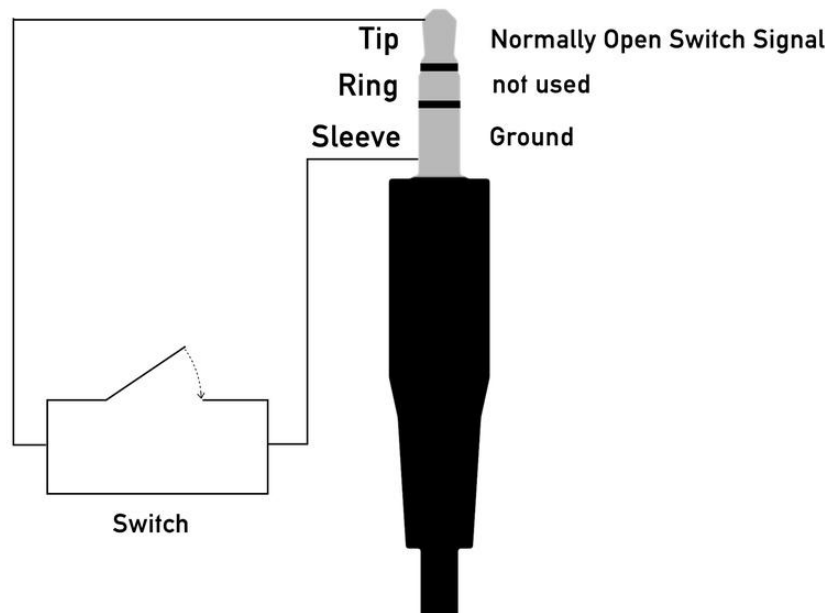
Digital Input Standard

The 3.5mm inputs jacks on the XAC allow you to connect any type of switch that can open and close a circuit between the internal Ground and a 1.8V pin that is internally read on the device. These pins have internal-pull up resistors, so you can think of them just like you do any switch used in a microcontroller project.

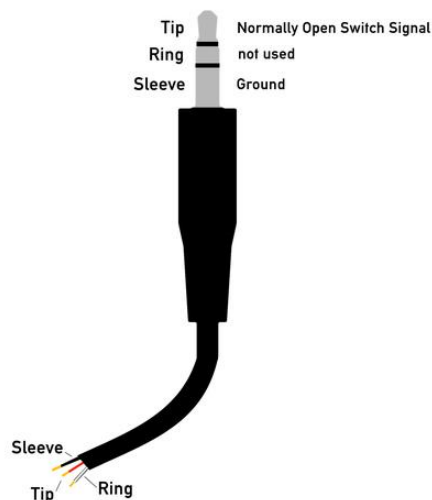
These jacks are a standard stereo audio-type jack, and have Tip, Ring, Sleeve (TRS) connections. However, only Tip and Sleeve contacts are used.



So, in order to press a button on a digital input port, we simply need to ground the tip to the sleeve.



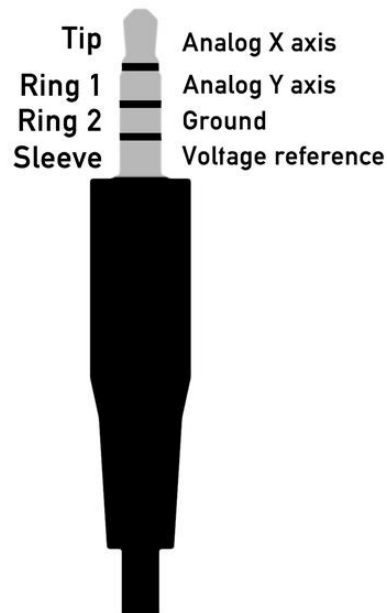
Represented another way, we can see that the Tip and Sleeve wires coming from a typical stereo cable can be shorted via a switch or button to create the connection that signal a button press.



Analog Input Standard

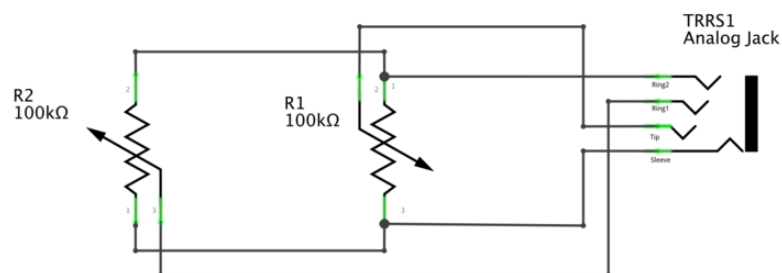
There are four jacks on the XAC that can accept variable resistance analog inputs, such as potentiometers -- X1, X2, LT, and RT. These map to the left thumb stick, right thumb stick, left trigger, and right trigger.

In order to read dual potentiometers and provide ground and reference voltages, these ports require the use of a four-pole TRRS plug. This is what is commonly found on mobile phone earbuds that include a microphone.



This is how the connections are used:

- Tip = wiper output from potentiometer 1 for X axis
- Ring 1 = wiper output from potentiometer 2 for Y axis
- Ring 2 = Ground
- Sleeve = 3.3V reference voltage



Here you can see two potentiometers from a typical analog joystick connected to the proper poles of the TRRS jack. Note, one potentiometer is inverted to provide the proper orientation of signal values as used on most joysticks. This isn't of too much

concern however, as values can be remapped in software configuration on the game console.

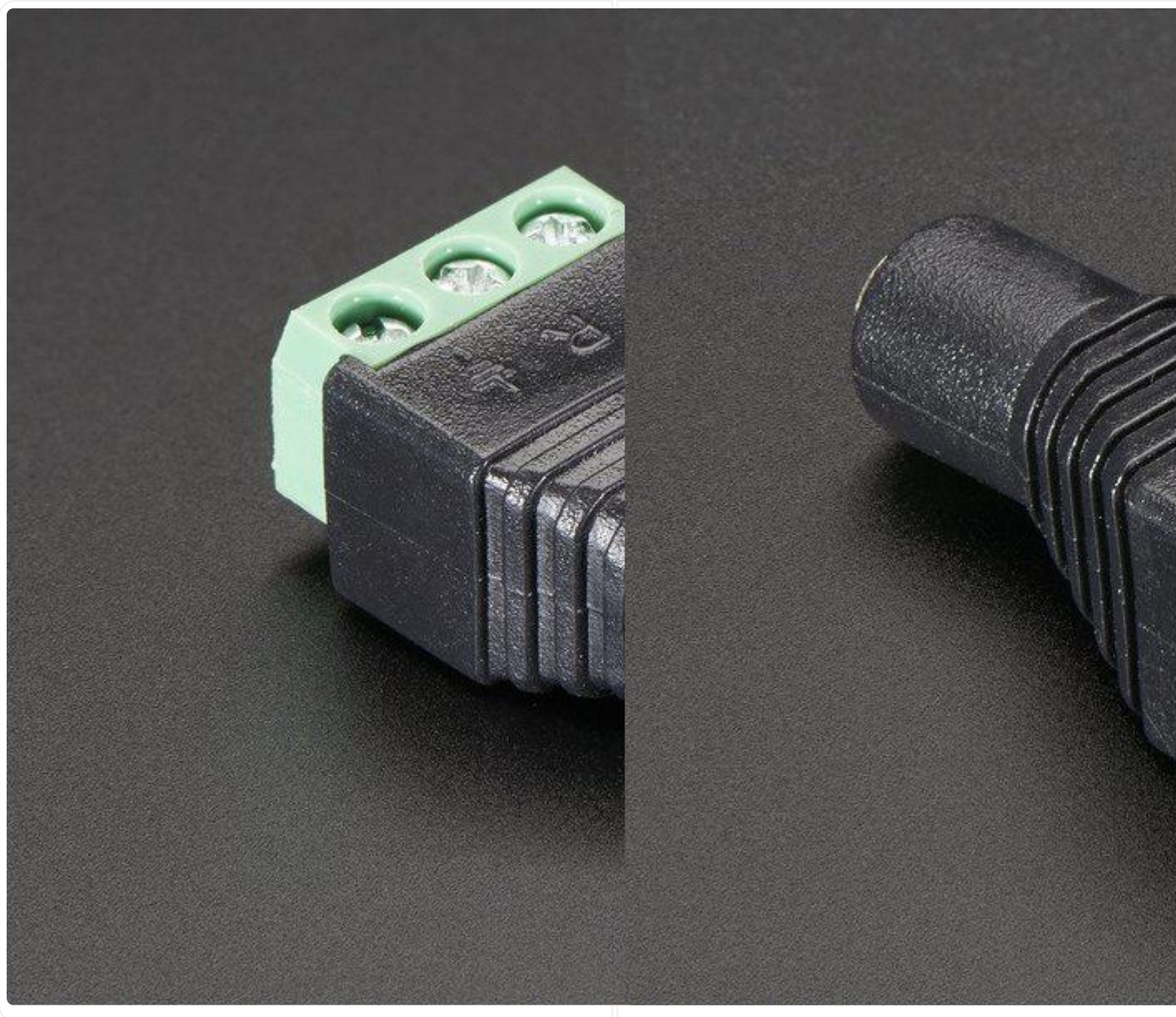
Now that we understand how the inputs work, let's wire up some components!

Interfacing Buttons and Switches

Interfacing buttons and switches to the XAC's 3.5mm digital input jacks is incredibly easy to do! We only need a way to connect a given button or switch to a 3.5mm mono or stereo cable.

Terminal Block Jack to Cable Plug

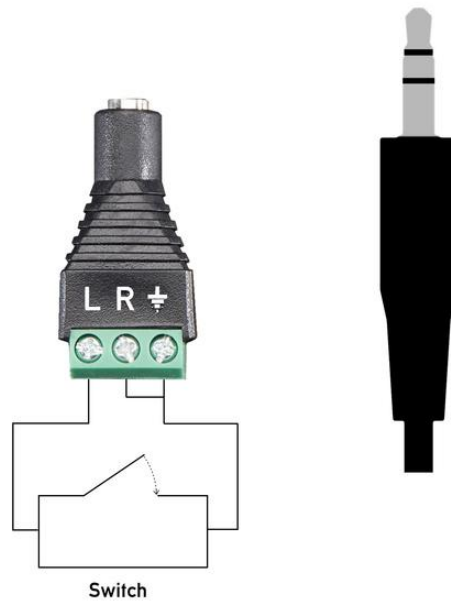
The simplest way to connect most buttons and switches is through a 3.5mm stereo audio jack terminal block. Once you connect it to your button, then you can simply run any 3.5mm stereo cable between it and the chosen port on the XAC.



Here we see the connections needed:

- N.O. switch to Adapter L (which will contact plug Tip)
- Common switch to Adapter Gnd (which will contact plug Sleeve)

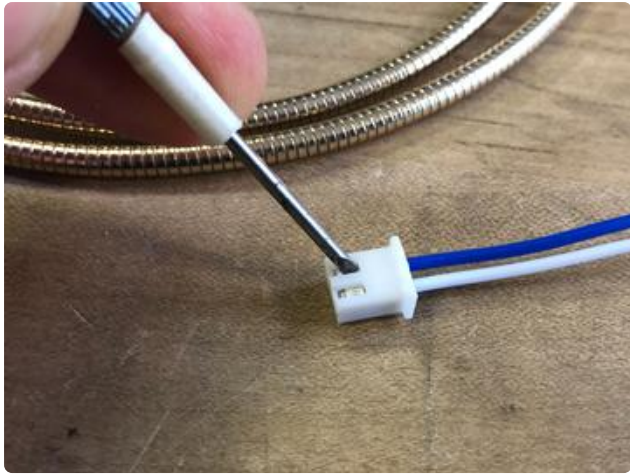
Optionally, to keep compliance with other adaptive technology devices other than the XAC that use 3.5mm TR mono jacks, it's a good idea to short the Adapter R contact to GND. This isn't necessary for the XAC, but good practice.



Switch to Terminal Block

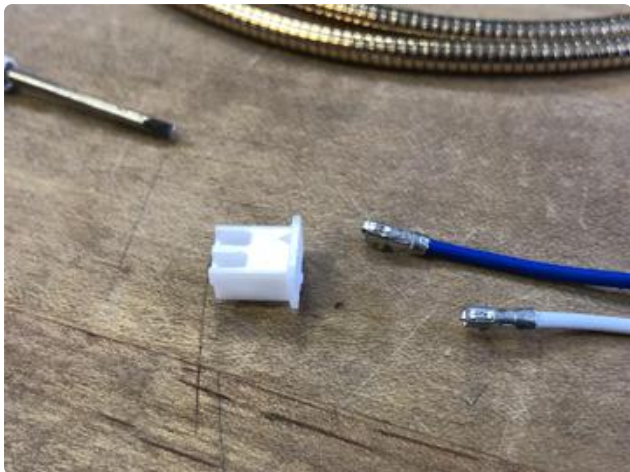
Here's an example of connecting a large arcade button to the terminal block, using quick connect wires. This is a nice, secure connection that requires no soldering.





Quick Connect Wire to Terminal

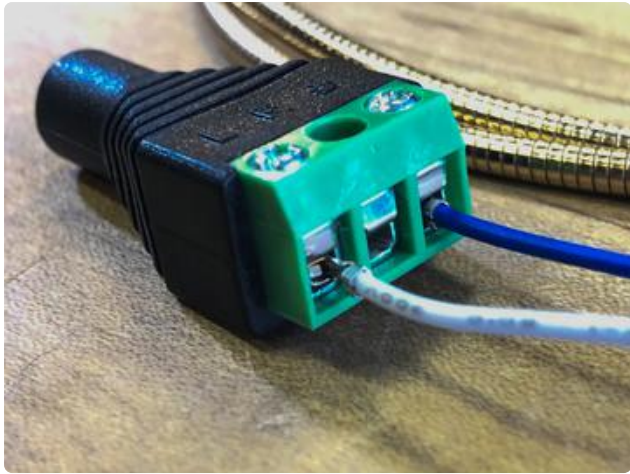
Use a small screwdriver to bend in the two metal crimp ends a little bit so they can be pulled from the plastic connector housing, we won't be using it.

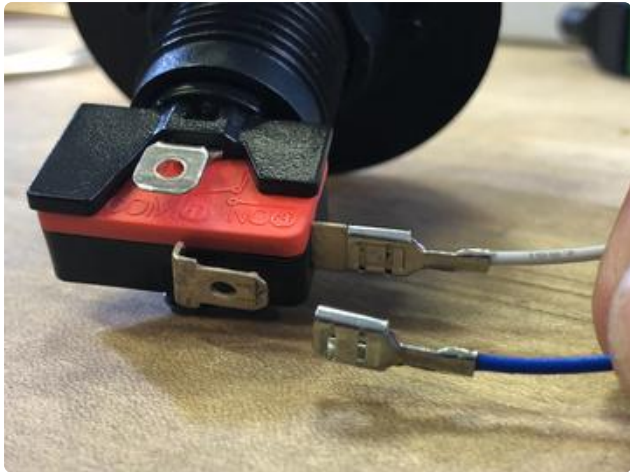


Unscrew the terminal block screws to open the terminals fully, then insert the blue wire into the GND terminal and the white wire into the L terminal.



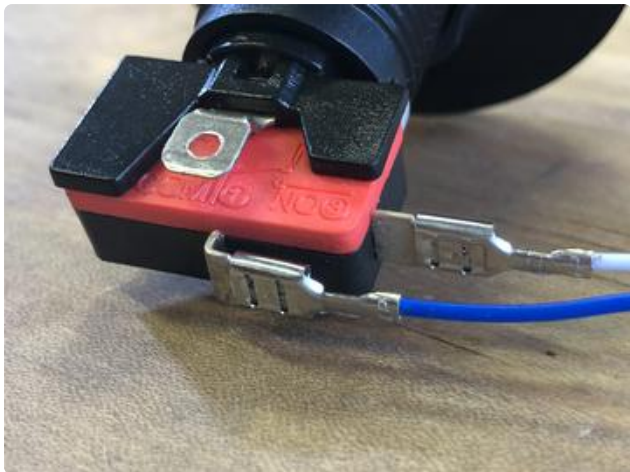
Screw down the terminal screws moderately tight.



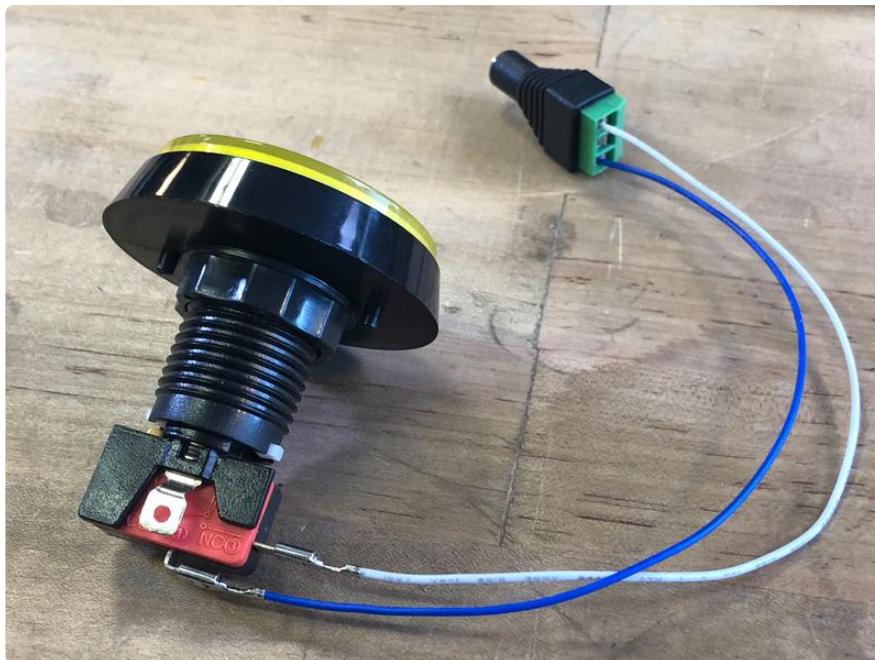


Quick Connect Crimp Connectors to Switch

Now, slide the white wire crimp terminal connector to the N.O. spade terminal of the switch.



Connect the blue wire to the Common connector





3.5mm Cable

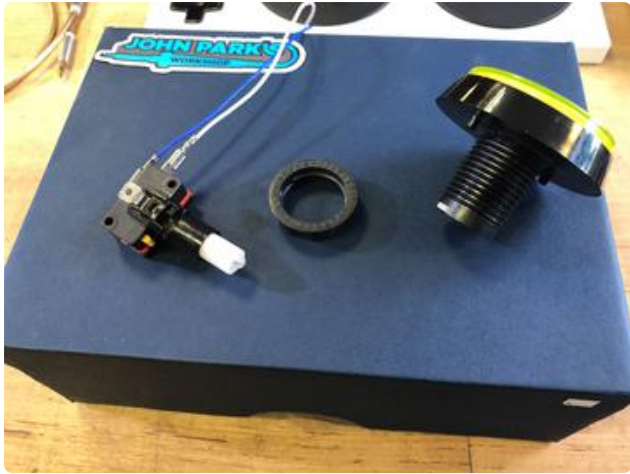
Plug one end of a TRS 3.5mm stereo cable into the adapter



This button is now ready to be plugged into any of the digital input ports on the XAC and used just like any Xbox controller button!

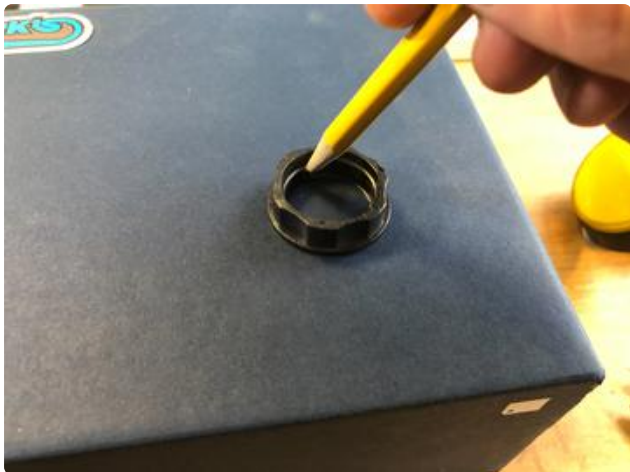
We'll give it a nice home by re-using a cardboard box as a button housing.





Box Prep

Decide where the button will go, then trace the inside of the plastic button shaft nut.



Cut out the hole with a hobby knife.

Insert the button and push down a bit to make marks with the registration shafts, then poke those holes out with a small screwdriver.



Insert the button, then thread on the nut from the inside of the box.





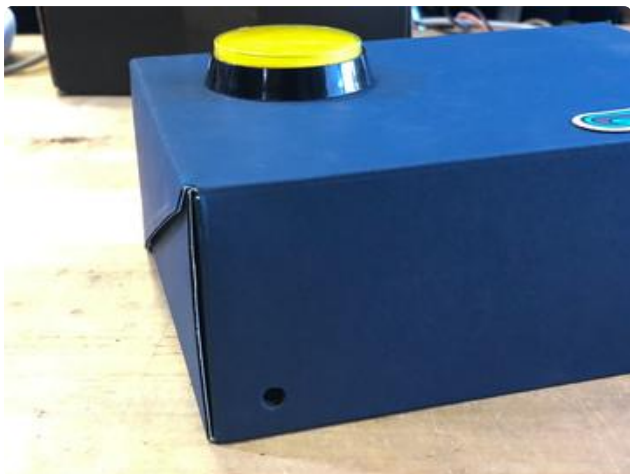
Add Switch and Wire

Place the switch into the shaft and twist to lock into place.

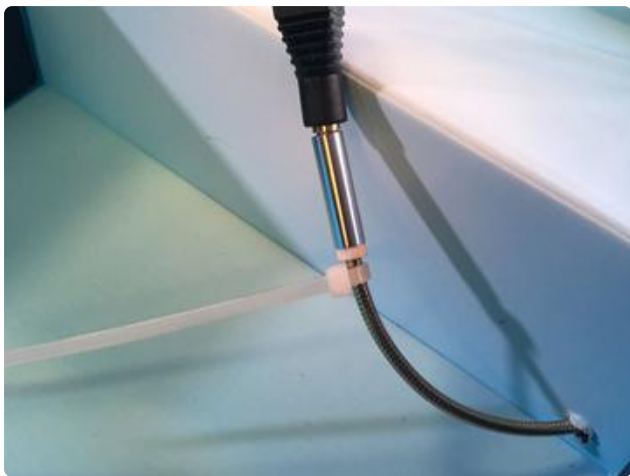


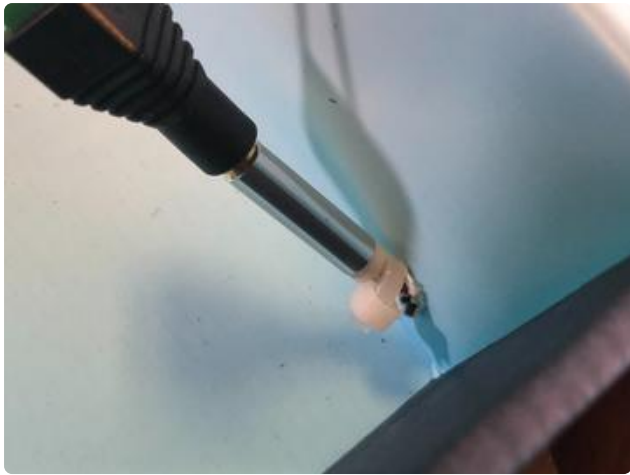
Add a small hole in the back of the box for the cable.

Plug the cable in through the box and into the adapter.



Add strain relief with a zip tie.





The button and box are ready to go, time to plug it in and test it out!

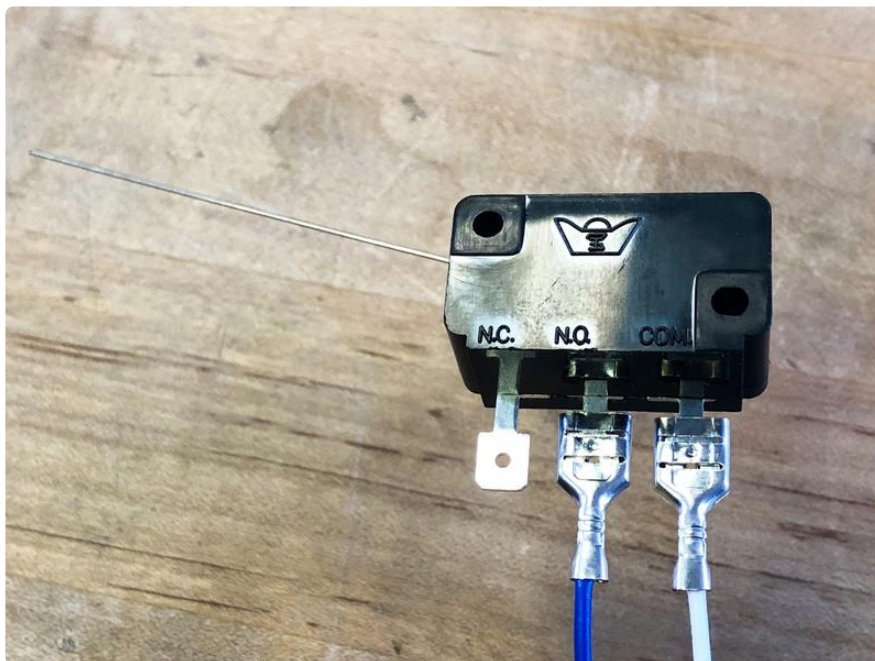
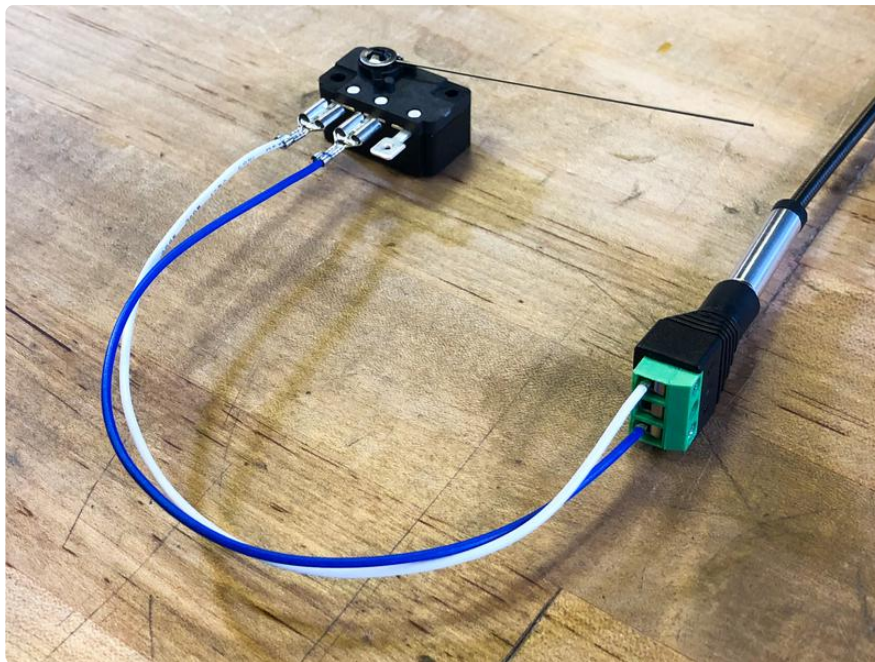
Here, we're plugging it in to the X button jack on the XAC.



You can use this method with any type of switch or button. Here are a few other examples.

Light Touch Limit Switch

The switch shown takes very little pressure to activate, which may make it good for adapting to chin or mouth activation (with appropriate adaptation) as well as light pressure activation from other sources.



Foot Pedal

The Adafruit foot pedal has a good activation switch inside and can be easily wired to a TRS plug.

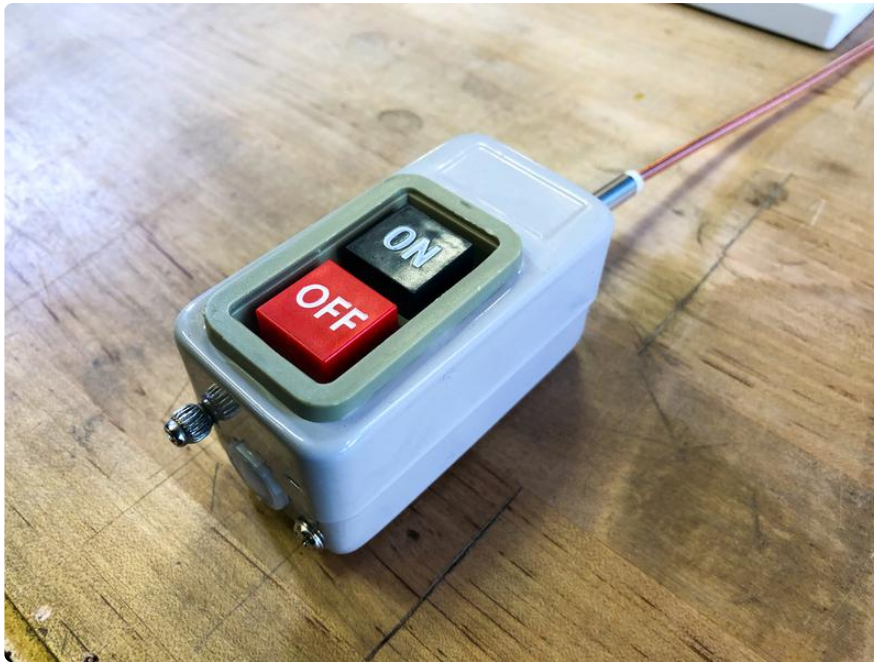


To use the footswitch as a normally open, momentary switch, simply connect the white wire to the Adapter GND terminal and the red wire to Adapter L. You can leave the black wire unconnected.

If you have a reason to use it as normally closed, so that a button is pressed constantly unless you tap the switch, use the black wire in the L terminal and ignore the red wire.

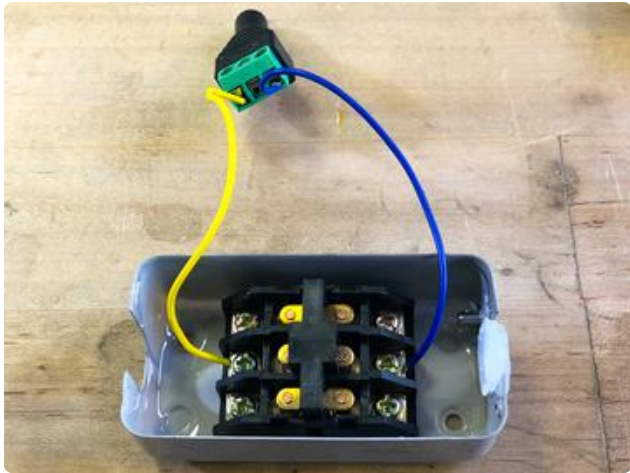
Hefty On Off Switch

This one is unique in that it is not a momentary switch, but instead latches in the on or off position. This may be useful for cases where the player wants to "hold" a button for long periods of time, such as an accelerator pedal in a driving game, and doesn't plan to "feather" the throttle too much.



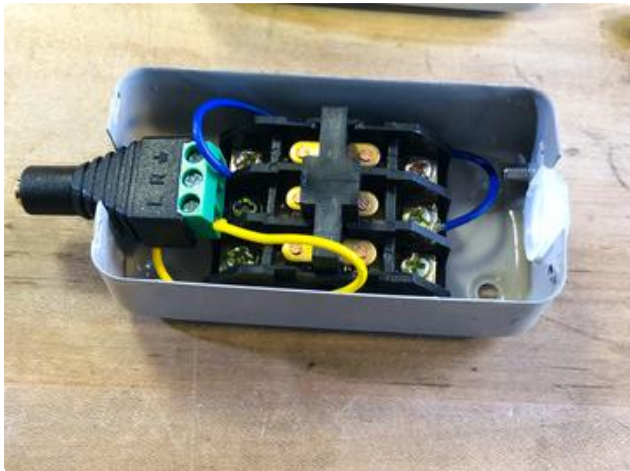


Open the case with the thumb screw and remove the top.



Wire from the Adapter L and GND positions to two terminals across each other in the switch.

Tuck in the wires neatly so they don't impede the button mechanisms, and place the adapter in the case cutout (remove plastic plug first).



Close the case and replace the thumb screw.

Plug in a 3.5mm stereo cable.



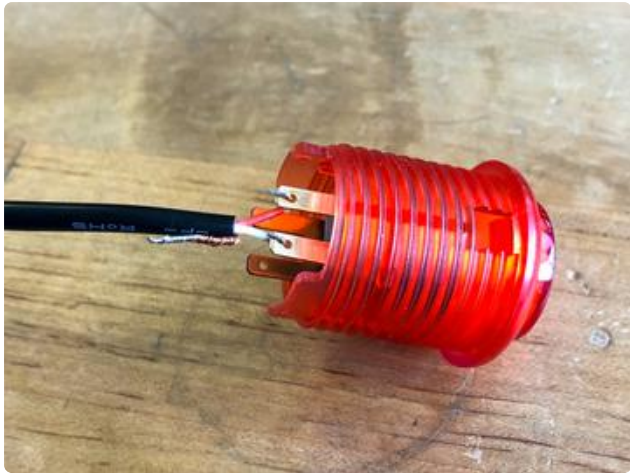
Soldered Wire Connections

In cases where you want a soldered connection, you can use the 3.5mm stereo pigtail cable instead. It has pre-tinned wires to solder to your buttons and switches.

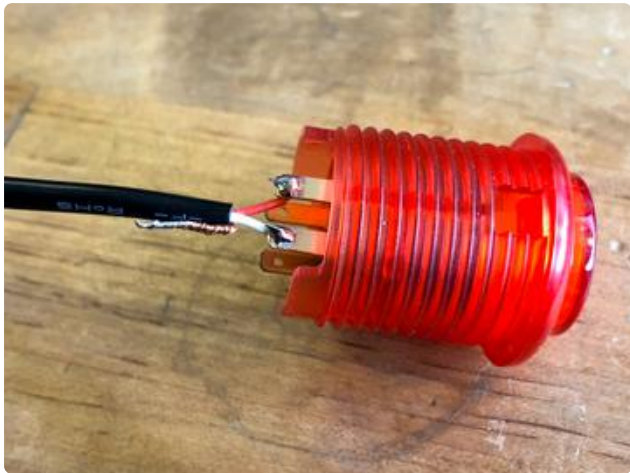




Use a multimeter in continuity mode to determine which wires are tip and sleeve, then solder those two the NO and GND of your button or switch.

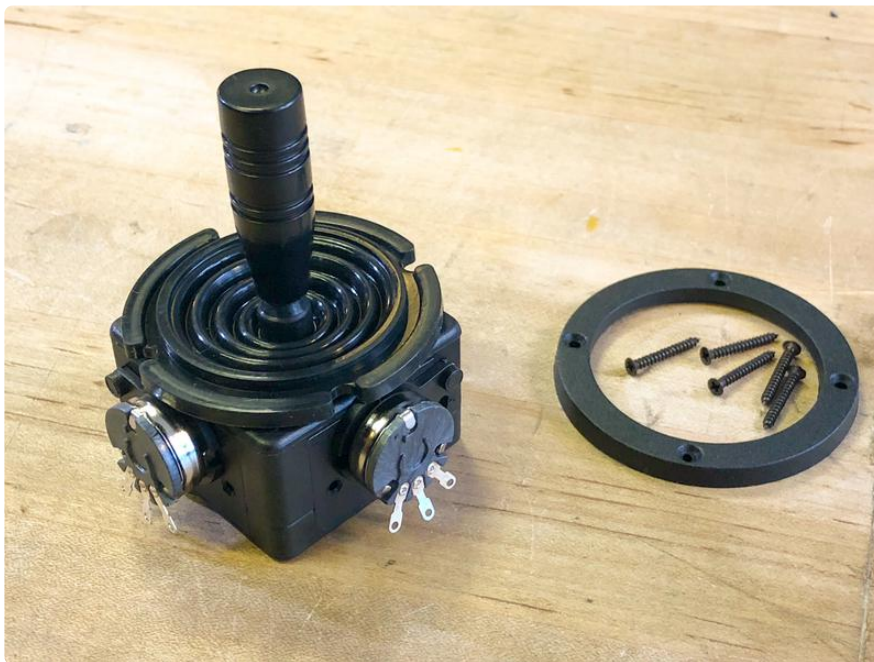


In this case, the red and white wires are tip and sleeve, and we'll ignore the copper non-insulated wire (it can be trimmed or bridged to sleeve).





Analog Inputs

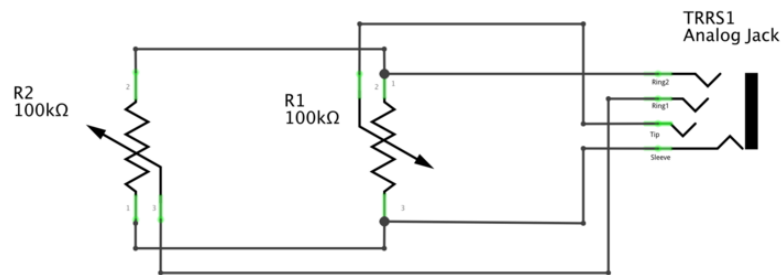


Analog inputs are a bit more complex than digital. They require either one or two variable resistors to be used as triggers or thumb sticks, respectively.

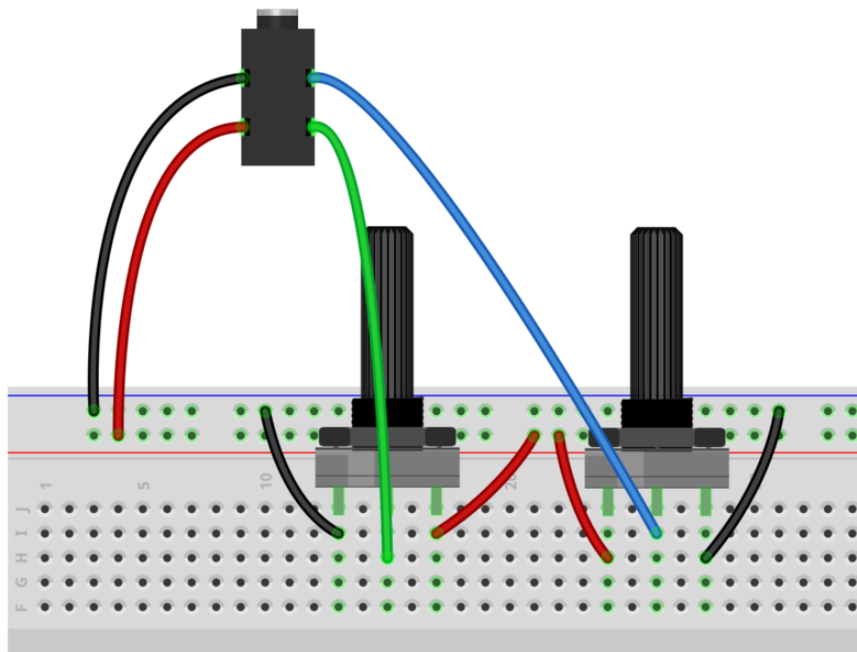
Let's add a joystick to the X1 or X2 ports, which can control the two thumb sticks. This joystick is really just a pair of potentiometers, one for the X-axis that is controlled by horizontal movement of the stick, and the other for Y-axis motion achieved through vertical motion of the stick. It's capable of mixing those motions to partial values of

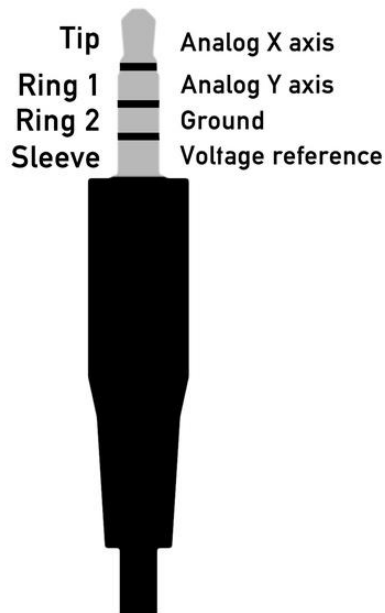
both potentiometers simultaneously for smooth motion, and has a spring return to bring it to center when you let go.

From our previous look at the XAC Standards we saw that we'll use this following connection schematic:



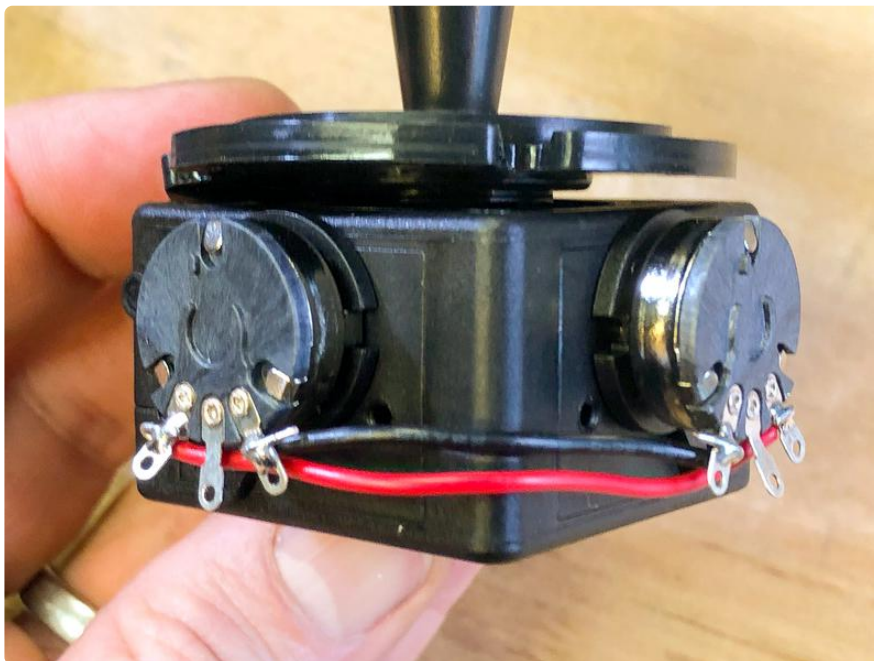
Again, note how we're reversing the direction of the second potentiometer to mimic the value behavior of a typical joystick.



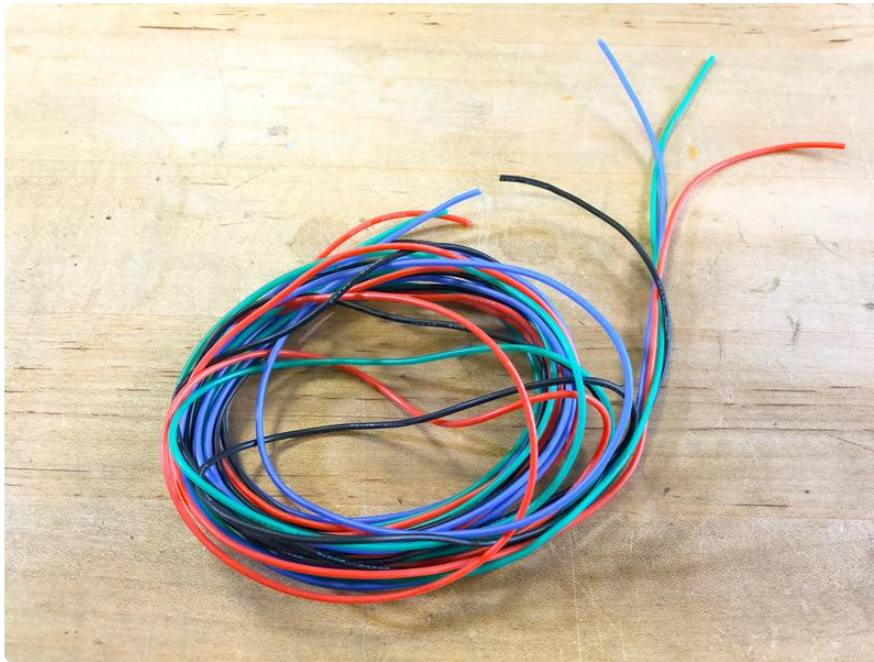


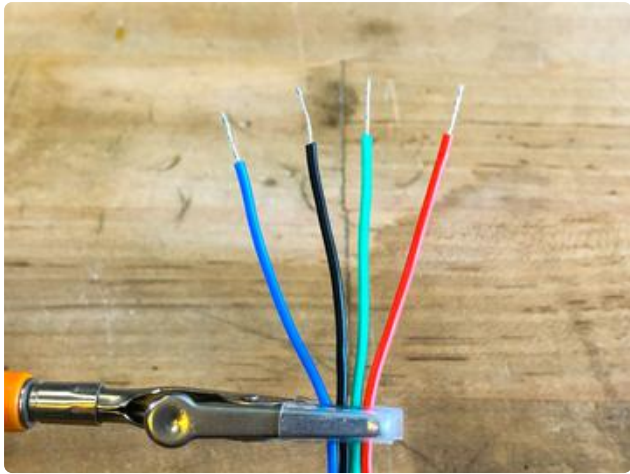
Wiring

We'll first connect the ground and reference voltage tabs of the pots so we only need four, not six wires.



Next, we'll use four long lengths of silicone sheathed stranded wire. These are color coded for ease of explanation in this guide, however, they are unruly and could get tangled easily, so you would want to use some wire loom to neaten them, or get some appropriate four-conductor wire for your own use. (Old USB cables can be a very good source for this once you cut off their ends!)





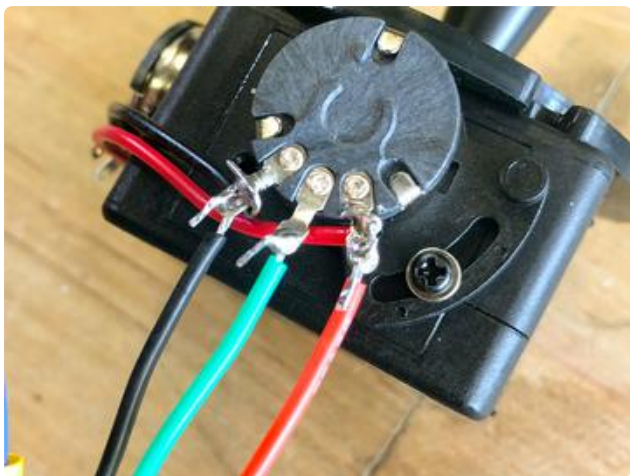
Strip some insulation from the four wires.



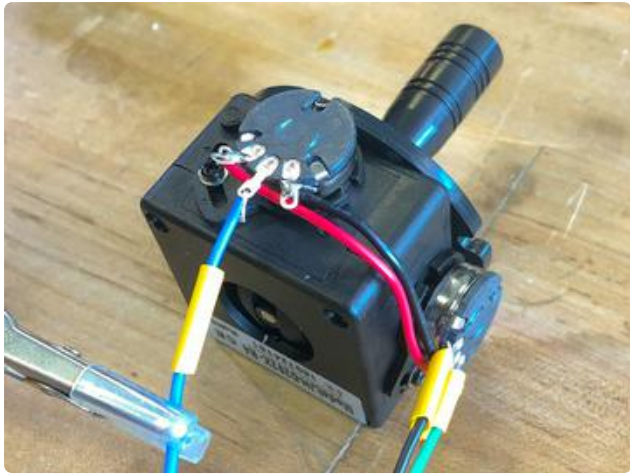
Add some heat shrink tubing to each wire.

Solder the black, green, and red wire's as shown.

Solder the blue wire only to the other potentiometer.

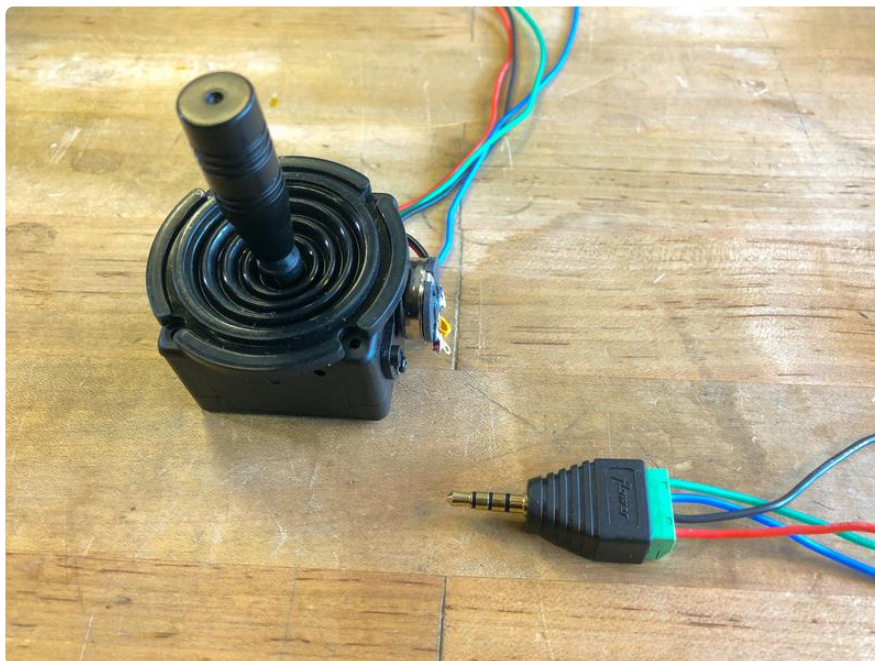


Heat the shrink tubing.

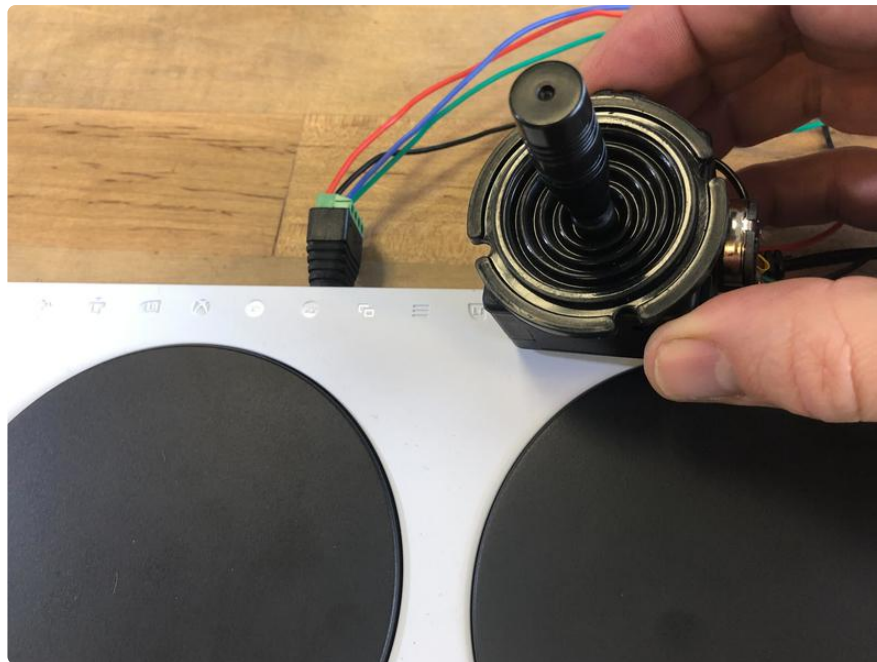


Add Terminal Adapter

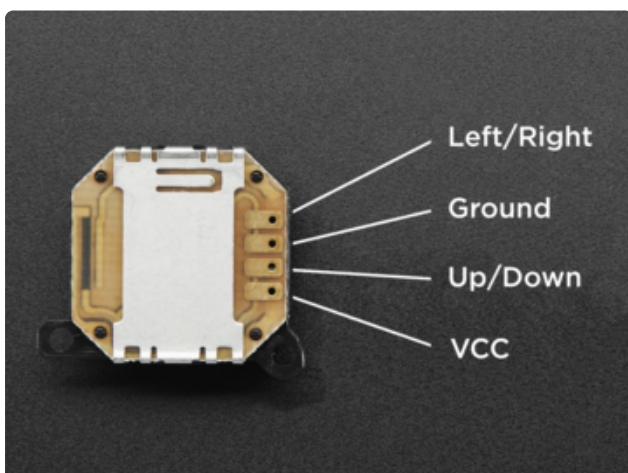
Now, screw in the four wires as shown. Ignore the markings on the adapter, those refer to the expected use as a stereo + microphone adapter, not a joystick for the XAC!



Plug in the joystick to X1 or X2 on your Xbox Adaptive Controller and you're ready to play!



Note, you should be able to use a similar wiring scheme to adapt a [PSP thumbstick like this one \(\)](#).



As you can imagine, every gamer with assistive tech needs will want potentially unique solutions, so this is just a small set of possible controls you can build, and some of the fundamental techniques for getting started.

USB Inputs

As mentioned previously, this guide does not go into USB HID joysticks, but there is some work being done by Bill at AT Makers and our own Dan Halbert to bring CircuitPython HID joystick drivers into use with the XAC and Circuit Playground Express boards. Stay tuned!