DIY Vectrex Controller with Arcade components

By Mountain Goat

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The motivation behind this project was double-fold, the original Vectrex controller is very expensive to replace (also very difficult to get an extra one for two player games). In addition, proper arcade control components – joysticks and buttons – are superior to most other components of the same type. These arcade components are also fairly inexpensive online.

The goal was to create a joystick + four button control box that can be connected to the Vectrex and used in place of the original controller. One limitation of this new box is that it is purely digital (on / off) so games that require the analog feature of the original Vectrex joystick will not work.

There are resources on the web that describe the electronic parts of DIY Vectrex controllers. While they are great for people who have some good understanding of electronics they can be difficult for beginners to build. I have seen some questions asked about DIY controllers and also some incorrect advise given. So I decided to document building of this control box.

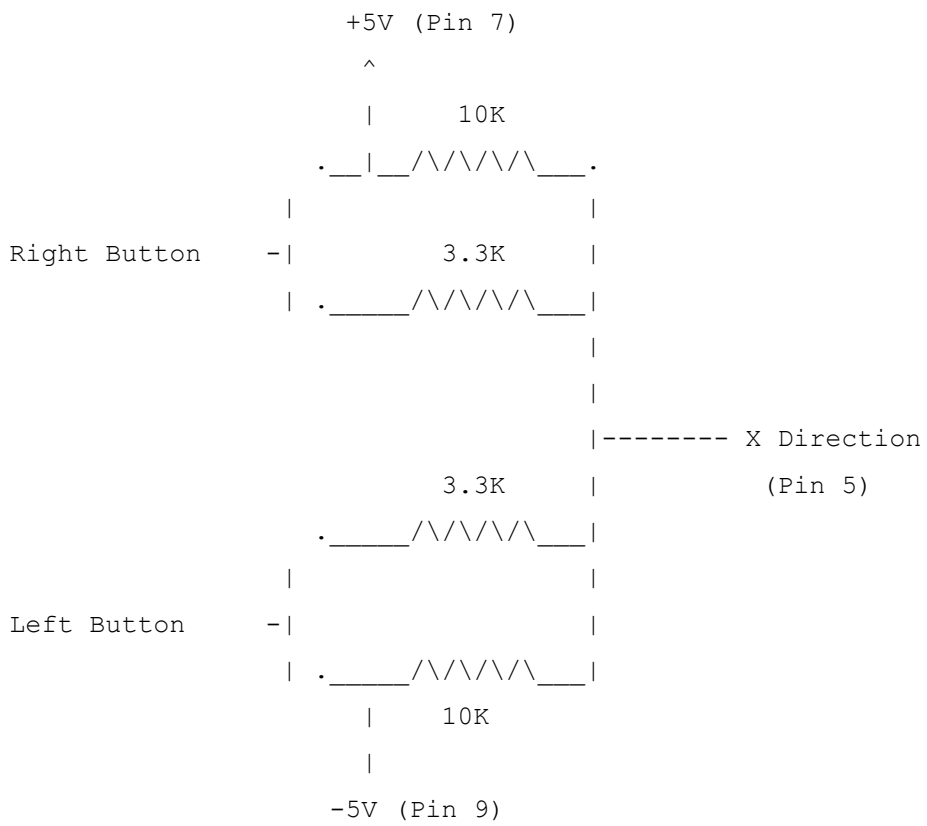
1. Electronics

1.1 The Joystick

The Vectrex joystick does not work like most arcade joysticks, it is analog and actually measures voltage using two sensors, one for Up/Down and one for Left/Right. This means that we cannot just replace the joystick with 4 simple switches that connect to ground on movement.

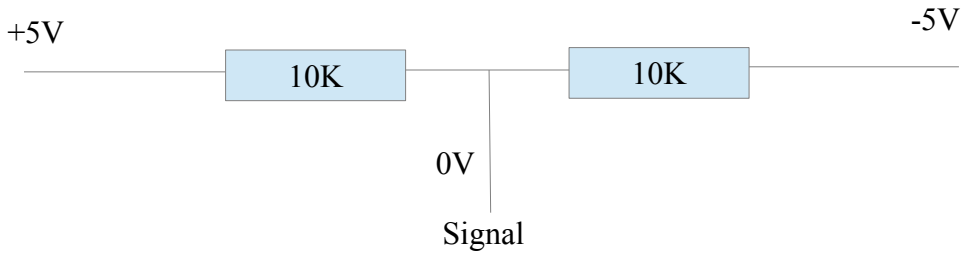
There is a very good document online from 1995 by Brian Holscher that shows how a circuit can be built to satisfy the voltage requirements of the Vectrex system. Link:
http://www.playvectrex.com/vectech/controller.txt

I am copying his circuit schematic here for the directional control (he holds the copyright for this):



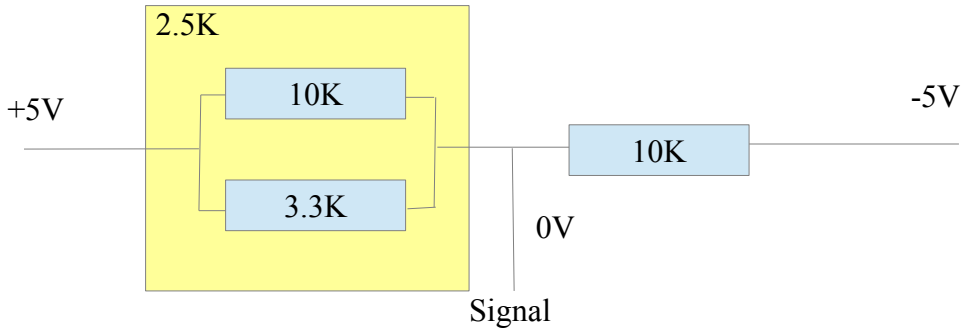
A few observations, notice how *nothing* is connected to ground here. The purpose of this circuit is to change the voltage from 0V when the right of left button is pressed. (The up/down is the exact same circuit.)

The circuit works the following way, when no button is pressed there is basically two 10K Ohm resistors in series with the Vectrex taking the voltage right in between them. Naturally with the +5, -5 voltages it will be 0V. (Other than it being obvious just by looking at the circuit, you can use I = U / R to see that the current flowing through will be 10 V / 20,000 Ohm = 0.5 milliAmp. On the left side the voltage drop U1 = I * 10,000 = 5 V.)



Once the left button is pressed, we “replace” the single 10K Ohm resistor with a parallel 10K + 3.3K resistor set. The resistance of the parallel 10K, 3.3K pair is ~2.5K Ohm. The voltage will drop less on that side of the circuit.

Using the same calculation the current flowing through is going to be I = U / R = 10V / 12,500 Ohm = 0.8 milliAmp. The left side drop is 0.0008 A * 2,5000 Ohm = 2V. So the signal will be 5 – 2 = 3V when the left button is pressed.



Similarly, if the right hand side button is pressed, Signal will “see” -3V. (In the unlikely event of both left and right being pressed simultaneously, they would again equal so Signal would be 0V – just with more current flowing between +5 and -5.)

1.2 The buttons

The buttons are actually very simple – just like “normal” arcade buttons, they connect to GND when pressed. There is no need to add extra resistors, looking at the Vectrex schematic they already have 680 Ohm resistors on all those pins so nothing gets shorted out.

1.3 Pinout

The pinout for the controller is also listed in the Vectrex schematics (and Brian Holscher's document), it is as follows:

Pin	Function
1	Button 1
2	Button 2
3	Button 3
4	Button 4
5	Left / Right (X) signal
6	Up / Down (Y) signal
7	+5 V
8	GND
9	-5V

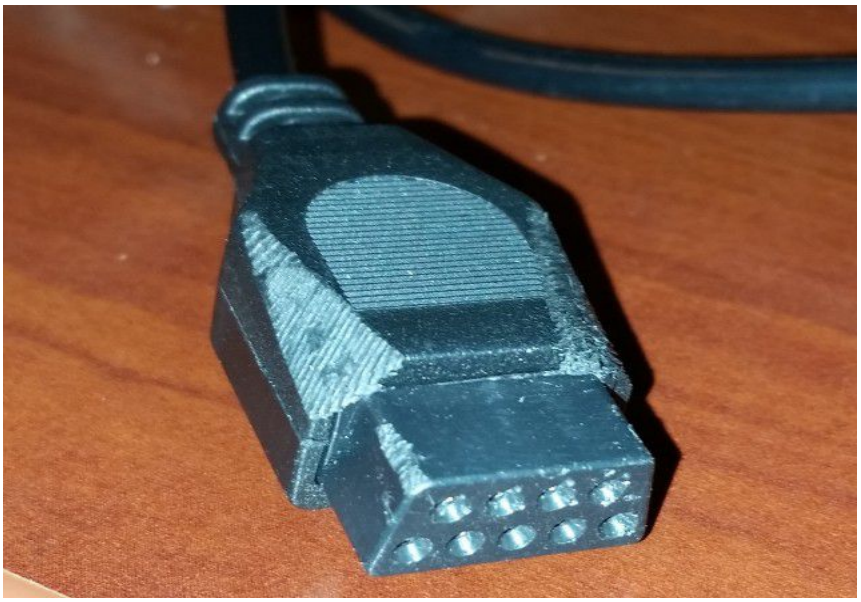
For the directional signals, Right and Up are assumed to be on the +5 side of the voltage and Left and Down are on the negative side. This matters because the Vectrex will interpret +3V as Right, not as Left and we want to move the correct way (not backwards).

2. Cable

One problem that home controller makers usually face is that the actual socket on the face of the Vectrex is pretty deep and has a strange hexagonal shape to it. So a generic DB9 connector will not fit even though the pins are of the right dimension.

I have seen people just taking the inner plastic part of the female DB9 connector or one can buy a controller with a connector that is almost right. Almost right because the two bottom corners still need to be removed a little.

Here you can see the face of the 9 pin connector after I filed the corners down:



Like a lot of people I have purchased a Sega Genesis controller as it had a cable that I could use. I did not plan on using the controller itself at all though, just the cable with the 9 wires. Please keep in mind that even though most Atari controllers look like that their cable would fit the Vectrex just fine, they typically only have 6 wires connected inside their plug. This is because the Atari only needed 4 directional, 1 fire and 1 Ground wire. So do not disassemble your old Atari joystick as it won't work in the Vectrex.

Why not just buy a joystick extension cable? It is possible and would work, however at the time of this writing a Sega controller was way cheaper than an extension cable.

Here is the one I got:

After dis-assembly I was unpleasantly surprised that the colors of the wires were completely different compared to the document.

A little testing with a multimeter revealed the color – pin matches:

Pin	Function	Color
1	Button 1	Yellow
2	Button 2	Orange
3	Button 3	Red
4	Button 4	Brown
5	Left / Right signal	Black
6	Up / Down signal	Green
7	+5 V	Blue
8	GND	Gray
9	-5V	White

Please keep in mind that if you build one of these, your colors will most likely be different yet again so you will have to check them.

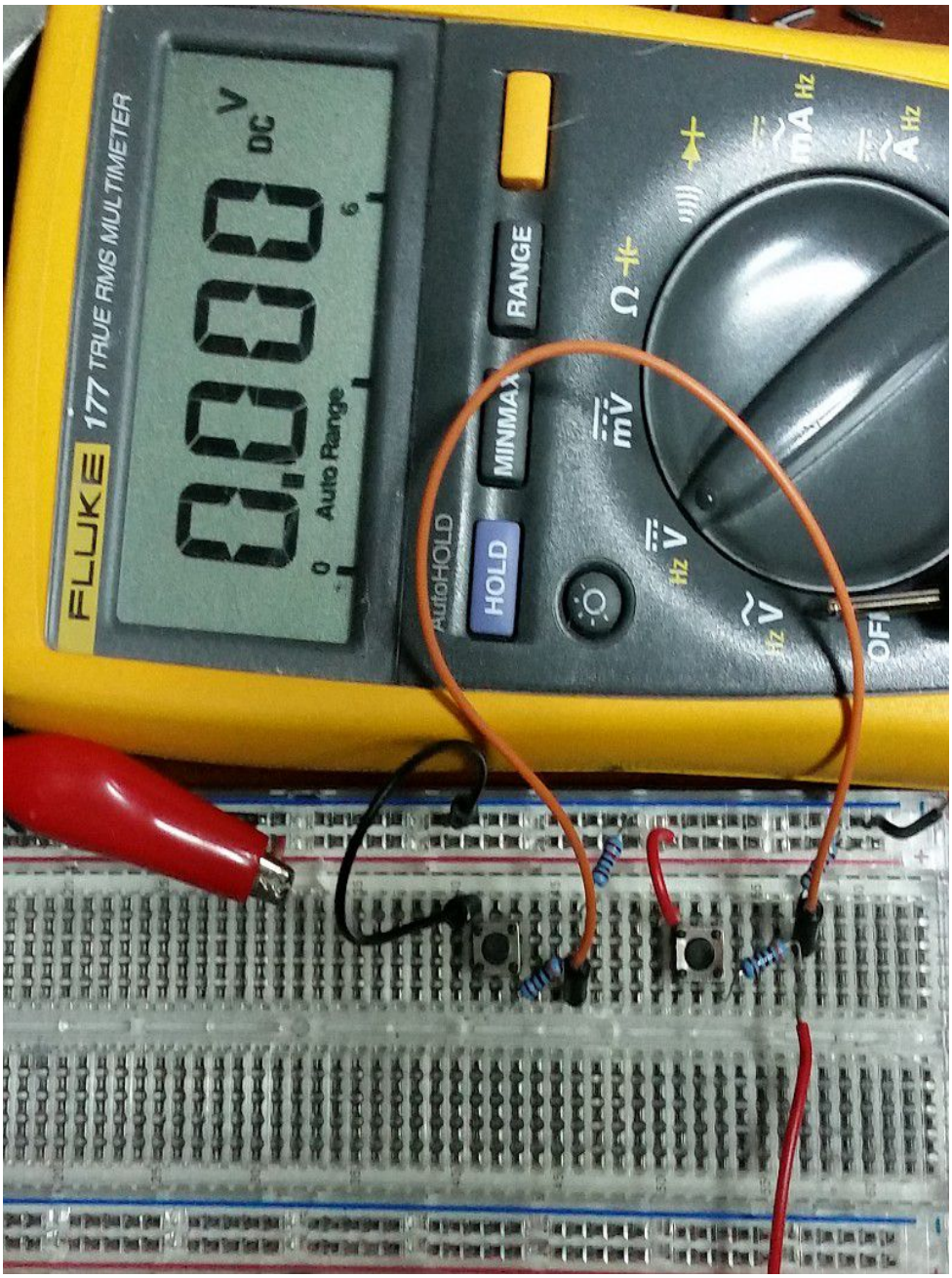
Here I am double-checking the pinout – making sure that the +5V / GND / -5V are where I think they should be. (They are, bottom row rightmost 3 pins for blue – gray – white.)

3. The final circuit

I did not have any 3.3K resistors at hand but had 3K ones, I figured they should work just fine. The Vectrex should recognize any voltage difference above 2V easily. And the current still should be very small even with the slightly smaller resistor.

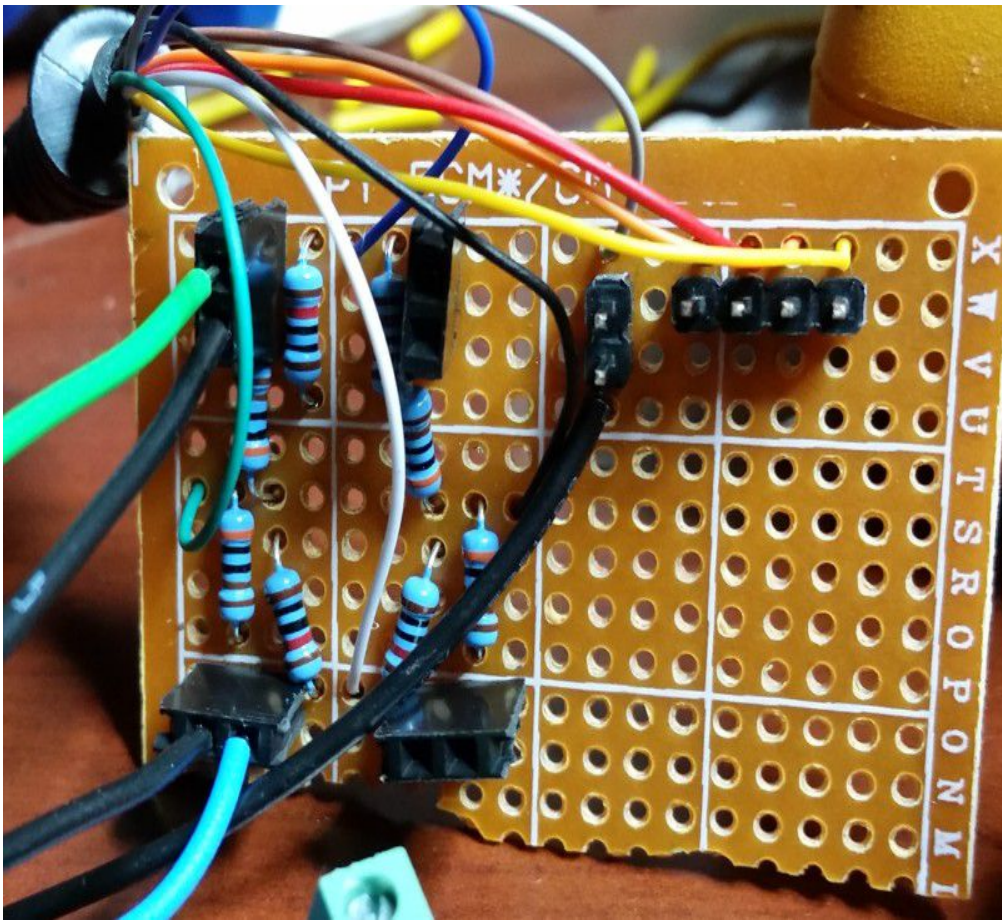
Looking at the drawing above, using the 3K instead of the 3.3K will yield 2.3K when the button is pressed (instead of the 2.5K). This will only increase the current to 8.1 milliAmp. Pretty safe to ignore the difference. The voltages expected at the signal (using the calculations from above) would be +3.1V / -3.1 V

I built the prototype circuit on a breadboard first just to test things out. You can see the four resistors and the two mini buttons emulating the joystick (only one pair instead of two):



I do not have a power supply that could generate (+5, -5) V. (Actually that means I only had one power supply to test with.) However I do have one that can be adjusted to to 10V. Calculating the “real” voltages on the Vectrex can be done by just subtracting 5 from the measurements. (If you do not have an appropriate power supply, you could check everything with a simple 9V battery and just remember that the actual voltages on the Vectrex will be slightly higher.)

Things worked as expected so I built the real circuit on a solder board – this time with both sets of resistors:



The right hand side has the male connectors to the four buttons – arcade controllers frequently come with wired connectors and I had a 4 female cable left over. The two vertical pins to their left are Ground pins – I ended up no using them but too many times I do not have enough grounds so I added them. The black wire just below is the ground connector wire for the arcade buttons.

The left side of the circuit is the 4 resistor network (twice over). Blue +5V connects to the top and white -5V is on the bottom. You can see the four 2-pin female connectors where the joystick buttons would connect. (Two are plugged in on the picture.) These are female because I ran out of my nice arcade cables and had to use 22ga hookup wire for the joystick buttons. They just simply plug into these female connectors.

Re-measured all the of the voltages on both circuits – using simple push buttons to emulate the joystick for now. (So these are NOT the button buttons but just testing ones to see how the joystick would work in terms of voltages.)

Button press	**Side 1 voltage**	**Side 2 voltage**
No button	5.02 V	5.04 V
Button 1	8.18 V	8.18 V
Button 2	1.88 V	1.89 V

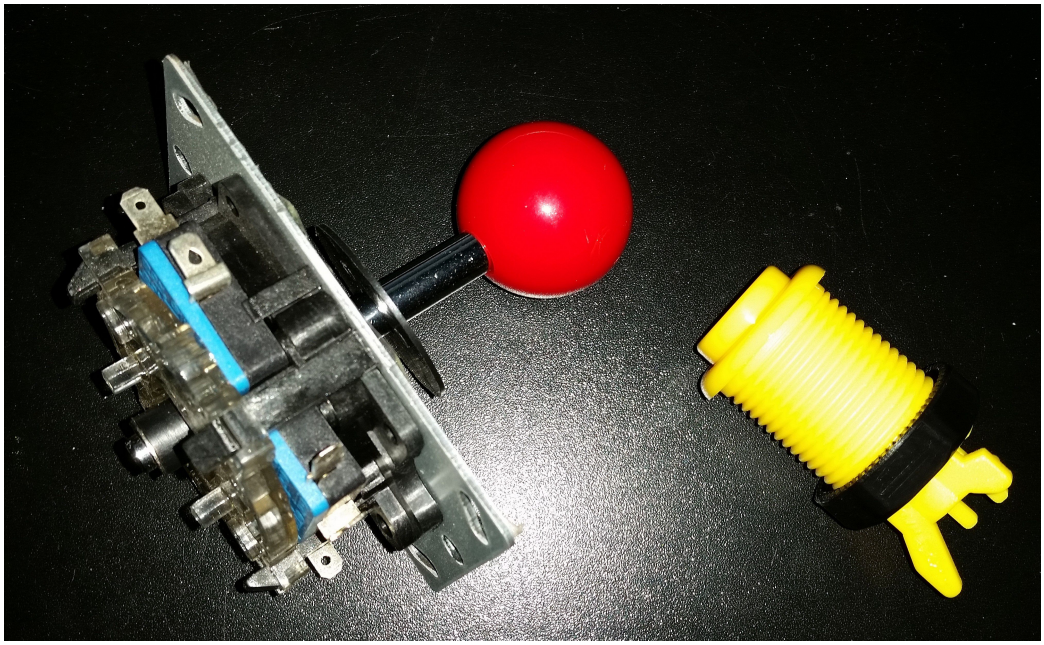
Subtracting 5 and all values look good : 0.04V, 3.18V and -3.11 V. (The reason things don't come up perfect is because the resistors themselves are not exact. There are different types, the typical resistor is only accurate to 5% of the value. The ones I had on hand were 1% ones but there is still some inaccuracy. I also doubt that my multimeter is accurate down to 0.01V.)

At this point the circuit needed to get tested. I had a dual arcade button setup left over from another project so I went on to test the circuit with the actual Vectrex. I used the two push buttons for joystick left / right. (The red semi-box has the two arcade buttons.)

You can actually play Mine Storm with this setup – not easy as you kind of need two hands to operate the little push buttons to turn. Plus there is no escape jump as there are only two active buttons.

4. Arcade enclosure and assembly

I had a black plastic enclosure that I wanted to use for the control box. The arcade joystick and a button (without its micro switch) is pictured here:



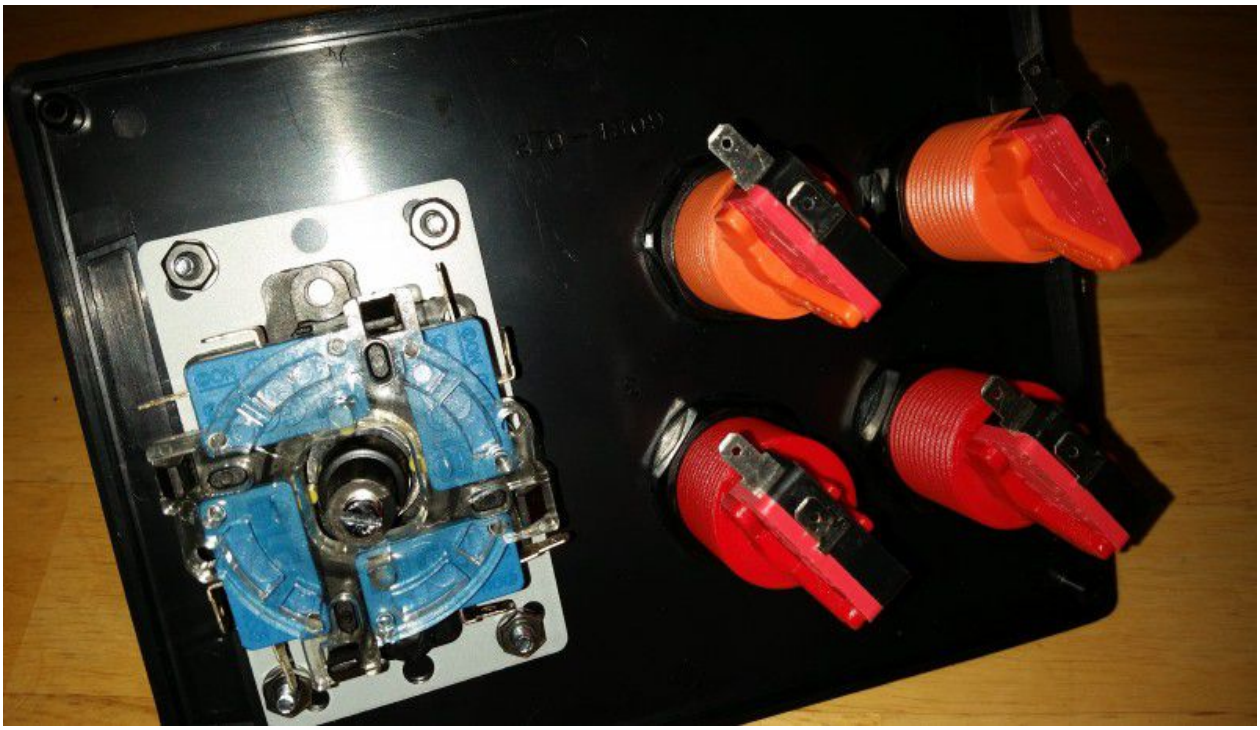
The faceplate of the joystick can be used as a template to drill the holes into the enclosure top. Here is a picture of the top with the faceplate and also three of the four buttons already inserted.

To drill holes for the arcade buttons one needs a very specific size bit: 1 1/8” (28 mm). I used a forstner bit. For the faceplate center hole, I used the same size bit but a smaller hole would also work. It only needs to be big enough for the stick to be able to move around.

To mount the faceplate to the box I decided to use #8-32 screws, they fit nicely (this is around 4.1mm diameter.) Slightly bigger would also fit.

The one issue with these types of plastic boxes and the forstner bit is that it tends to drill and melt at the same time. This means that there is always a little bit of cleanup job left around the edge of the holes.

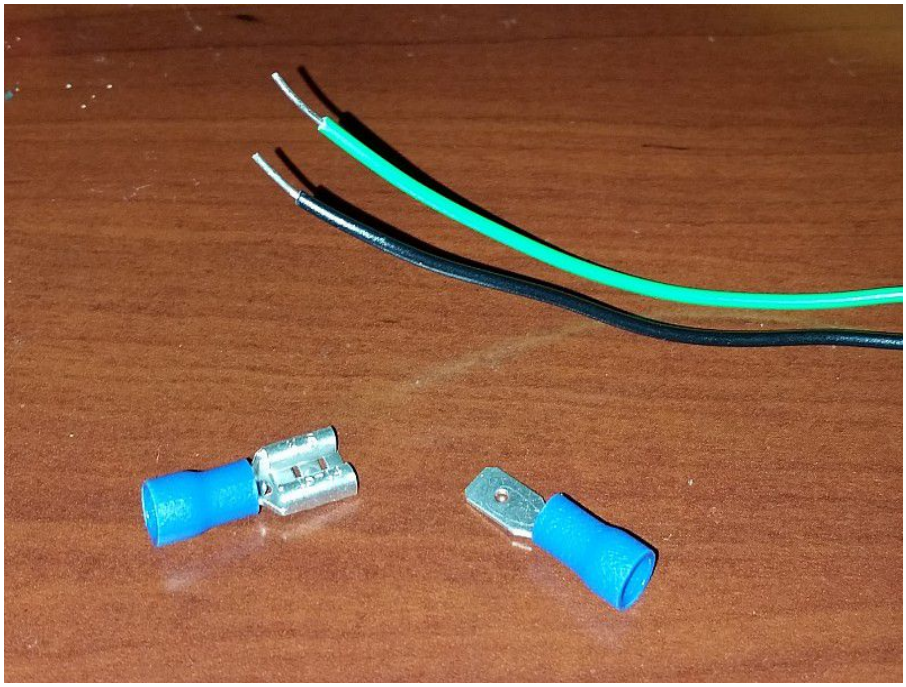
Here is the assembled box top:



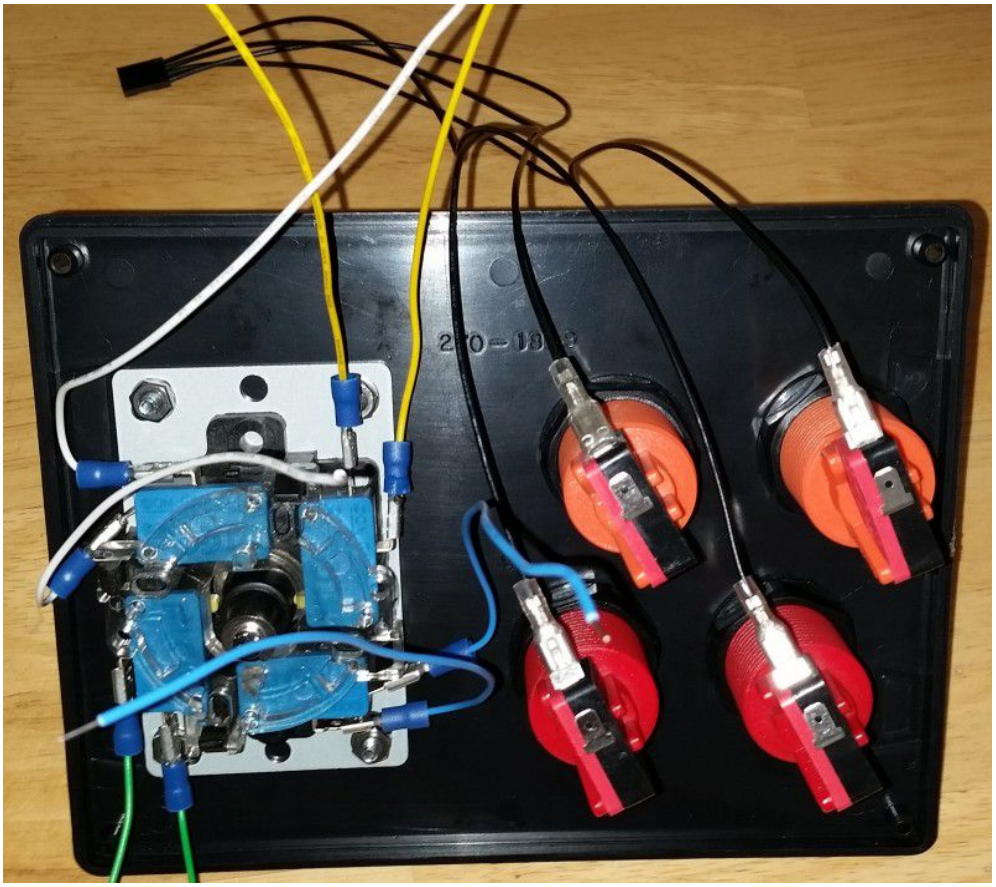
The buttons have their switches installed and you can see the nuts securing the joystick.

As you can see all these arcade components can use slip-on type connectors, they are great if you ever need to service anything. Like I said I had the cables ready for the buttons but I had to make them for the joystick.

I had the crimp type connectors you can see both the male and female type here. For this build the male type is not used. You can also see some of the hookup wire:



The 22ga wire is thin enough that crimping usually does not work. I recommend soldering them into the connectors. You can see the wires connected – the “official” arcade wire for the buttons is seen on the top of the picture. (The ground wire(s) for the buttons is still missing):



I used four different colors for the joystick wires. When you connect these, make sure you wire them to the right directions – these joystick switches are quite confusing, they tend to give you the exact opposite direction when assembled. :-)

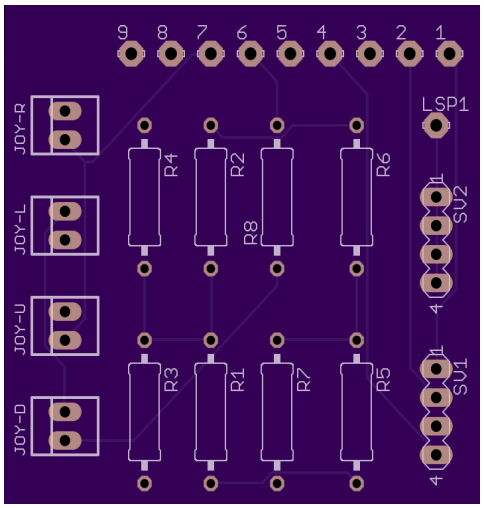
I also cut a hole in the back of the box where the cable can come through.

Finally everything is put together and we are ready for a good game of Scramble – with which we can test all buttons and all four directions:

The box is much bigger than the original controller box but fits comfortably in your lap and actually very nice to play. One positive difference is the familiar clicking of the micro switches.

5. Printed Circuit Board

After the initial success with the solderboard version I wanted to build another controller. I did not want to go through the process of making the solderboard so I designed a little PCB to make it easier. Ordered the prototypes and things are working just fine.



- R1, R2, R5, R6 are all 10 K Ohm,
- R3, R4, R7 and R8 are 3 K Ohm,
- The top row 9-1 are for the cable,
- LSP1 and SV2 are all ground connectors,
- SV1 are for the buttons, as labeled, 4 at the edge of the board.

If you want to order the board, follow this link:

https://oshpark.com/projects/9zhVWb4o

6. Parts

Here is where I got all the parts from:

- Resistors, breadboard, solder board, push buttons (for testing) – All from Ebay.
- Arcade joystick and buttons – All from Ebay.
- Sega controller (for cable) – Also from Ebay.
- Enclosure – Radio Shack.
- Screws, nuts, washers – Local hardware store.
- Hookup wire – Amazon.

I had very good luck with Chinese electronics sellers on Ebay. The one recommendation I would have is that if you are in the US, get your parts with “ePacket delivery” and not the standard post as ePacket seems to be significantly faster.

Hopefully this was somewhat useful and you will be able to build your own Vectrex arcade controller.

--Mountain Goat