

# Altair-Duino 2.0 Assembly & Operations



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Up-to-date instructions are always available at [www.adwaterandstir.com/instructions](http://www.adwaterandstir.com/instructions). **Be sure to check this page before starting construction for addendums.**

**Altair 8800 Simulator - Copyright (C) 2017 David Hansel**

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**VT100 Terminal – Copyright (C) 2014 Geoff Graham**

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I would strongly suggest comparing the parts you received with the list below. Let me know if you are missing anything and I will send a replacement. (It will not be unusual to have a few extra minor parts.)

Bag #1

- 5 x 1k $\Omega$  Resistor Array
- 1 x 47 $\mu$ F Capacitor
- 1 x 470 $\Omega$  Resistor
- 1 x 1k $\Omega$  Resistor

Bag #2

- 1 x 2x3 Female Header
- 2 x 40-pin Single Male Header
- 2 x 40-pin Double Male Header
- 5 x 18-pin DIP Socket
- 1 x 28-pin DIP Socket
- 1 x 16-pin DIP Socket
- 2 x 18 Gauge Power Cables

Bag #3

- 17 x MTS-102 Toggle Switch
- 8 x MTS-123 Toggle Switch

Bag #4

- 37 x 5mm Red LEDs

Bag #5

- 5 x ULN2803APG
- 1 x PIC32
- 1 x SP3232

Bag #6

- 8 x 8mm Male-Female Standoffs
- 2 x 8mm Female-Female Standoffs
- 4 x 15mm Male-Female Standoffs
- 8 x M3 Nylon Nuts
- 6 x 6mm M3 Nylon Bolts
- 4 x 10mm M3 Nylon Bolts
- 4 x Rubber Adhesive Feet
- 8 x Jumpers

Bag #7

- 1 x VGA Connector
- 1 x DB9 Connector
- 1 x USB-A Connector
- 1 x 3.5mm Audio Jack
- 1 x Power Jack

Bag #8

- 1 x 10 $\mu$ F Capacitor
- 9 x 100nF (104) Capacitor
- 2 x 27pF Capacitor
- 1 x 1k $\Omega$  Resistor
- 1 x 100k $\Omega$  Resistor
- 1 x 220 $\Omega$  Resistor
- 1 x 150 $\Omega$  Resistor
- 1 x 4.7k $\Omega$  Resistor
- 1 x 8MHz Crystal

### Bag #9

- 5 x 26 Pin Female Header
- 1 x 100nF (104) Capacitor
- 1 x 0.33uF (334) Capacitor
- 1 x L7805 Regulator
- 1 x TO-220 Heatsink Set

### Bag #10

- 11 x 14mm M3 Bolts
- 11 x Square M3 Nuts
- 19 x 8mm M3 Bolts
- 19 x M3 Nuts

### Unbagged Parts:

- 1 x Altair Front Panel
- 1 x Altair Metallic Sticker
- 1 x Main Circuit Board
- 1 x Expansion Circuit Board
- 1 x Arduino Due
- 1 x USB Extension
- 1 x Micro USB Cable
- 1 x 34 Pin Ribbon Cable
- 1 x 9v Power Supply
- 1 x Micro SD Module
- 1 x Micro SD Card
- 12 x Acrylic Pieces

## OTHER PARTS YOU MAY NEED

- Soldering Iron with a good tip
- Good Solder (I recommend Alpha Fry or Kester Rosin Core 0.032")
- De-soldering Iron (optional)
- Phillips Screwdriver
- Needle-nose Pliers
- Side Cutters (Nippers)

A word about soldering: Do not underestimate the need for good solder and a good soldering iron. Most problems I've seen people have with this kit are caused by cold joints or insufficient wetting. I strongly advise you to get quality 60/40 Rosin core .032" diameter solder (I use Alpha Fry or Kester). The spools I buy are only \$10 and well worth it. I set my iron to 400 degrees (750 Fahrenheit) and use the fine point tip.

Let's start with bag number 1.



Add the five resistor arrays in RN1-RN5, making sure the dot indicator faces to the left side (where the square is on the circuit board) as pictured.



Resistor color codes for next step:

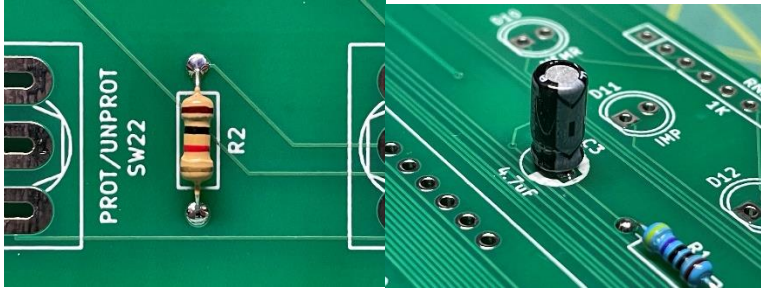
1k (Brown-Black-Red)



470 ohm (Yellow-Violet-Black-Black)



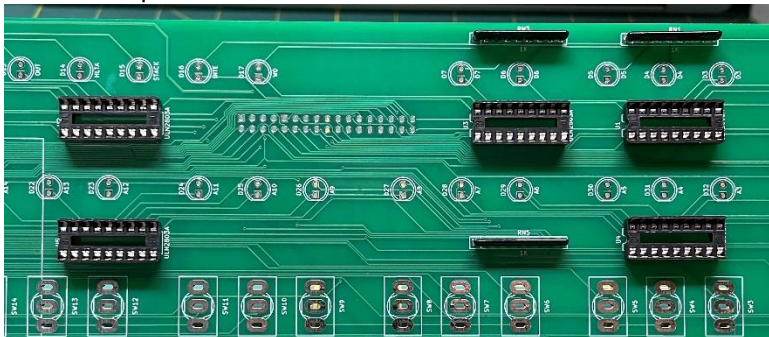
Add the 47uF Capacitor and the 470 ohm and 1k ohm resistors in C3, R1 and R2. (If your board says 4.7uF, ignore that – it is 47uF.)



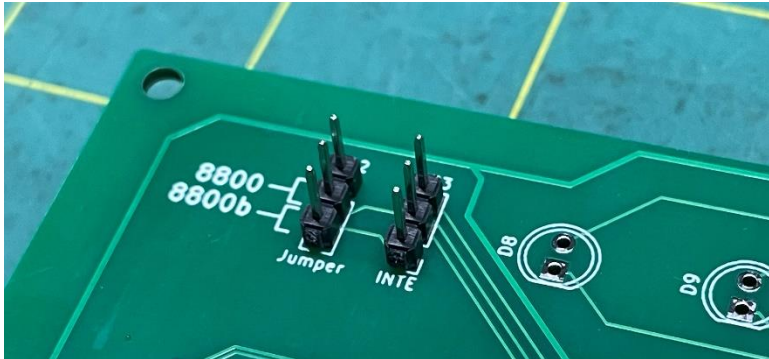
Bag number 2 is next.



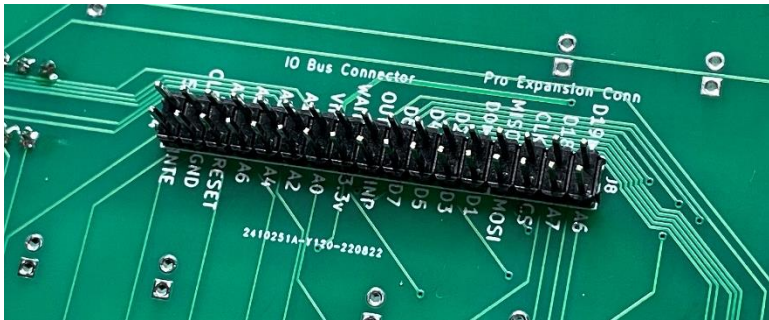
Add five 18-pin DIP sockets to U1-U5.



Cut three 3-pin segments from a single-row male header and place those segments in JP1 (lower left) and JP2-JP3 (upper right).



Cut a 34-pin segment from a double-row male header and solder that to the **back** of the circuit board in the “IO Bus Connector” location.

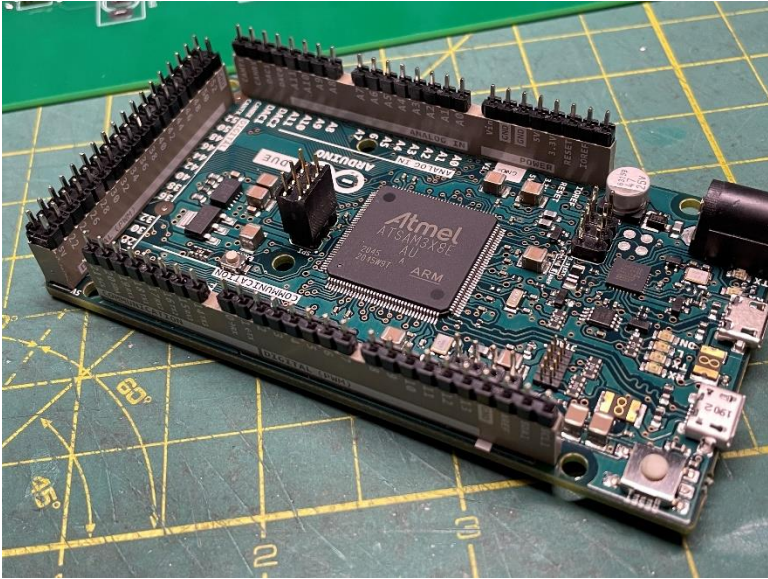


We’re going to use the Arduino Due to hold the pin headers temporarily while we solder them to the main circuit board. Cut (or locate) the following segments:

- 5 x 8-pin single-row male header
- 1 x 10-pin single-row male header
- 1 x 36-pin double-row male header
- 1 x 6-pin double-row female header



Place them on the Arduino Due like this:

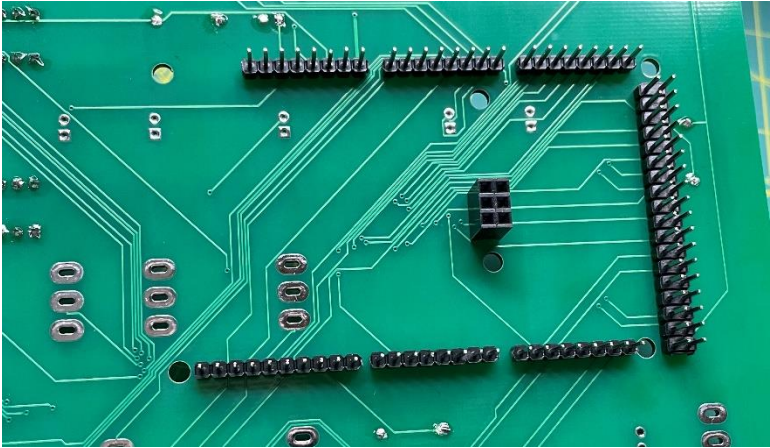


Insert the Arduino into the **back** of the main circuit board and solder all header pins in place (note: this is where most errors happen – it's easy to miss one or two header connections.)



After all header pins have been soldered, remove the Arduino and place it aside for later.

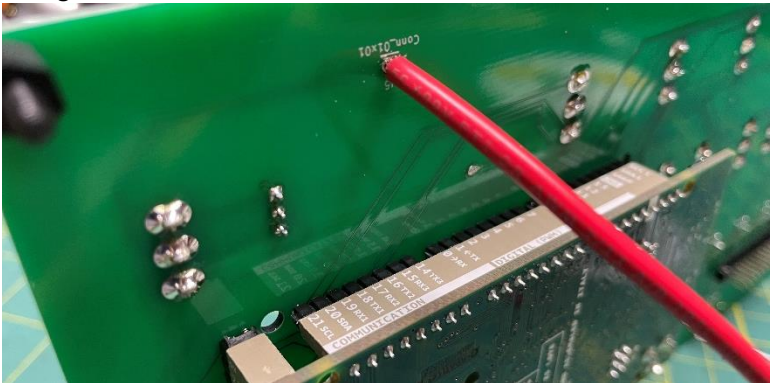




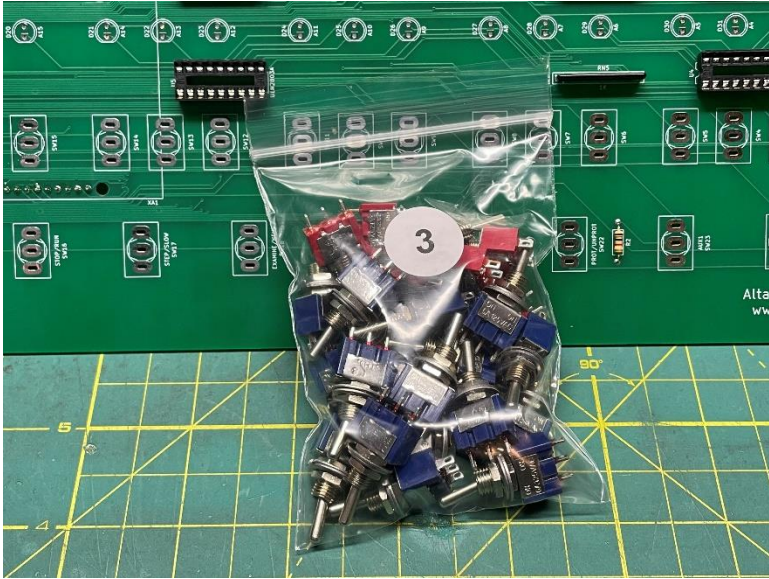
Also in bag 2 you will find two segments of a power cable. These connect the two circuit boards and provide power.



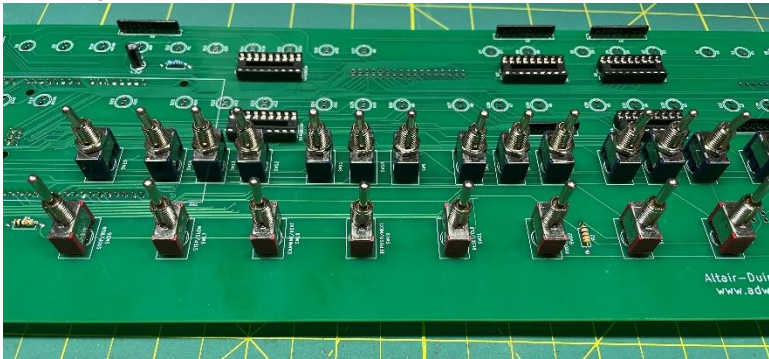
Solder one of the segments to the lower left of the circuit board, facing out the **back**:



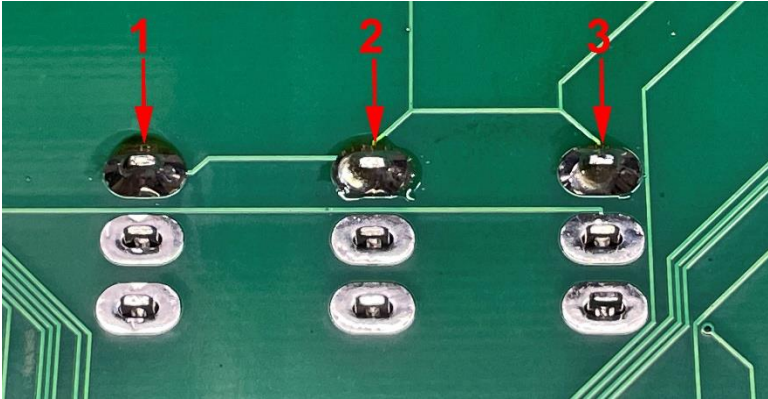
Next, we'll add the toggle switches from bag number 3.



I like to first add the 17 on-off toggles and hold them in place with the front panel while soldering. This ensures the toggles switches remain in alignment with the front panel. Next, add the 8 on-off-on toggles and again hold them in place with the front panel while soldering.



Be careful that you don't over-heat the toggle switches while soldering. This can damage the switch mechanism. Instead of soldering all three lugs on the toggle one after the other, I solder the top lugs on all switches, then the center lugs, then the bottom lugs like this:



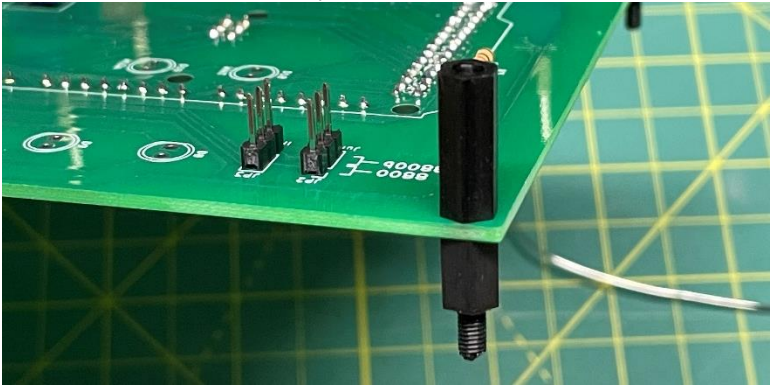
For the next few steps, we will need parts from both 4 and 6.



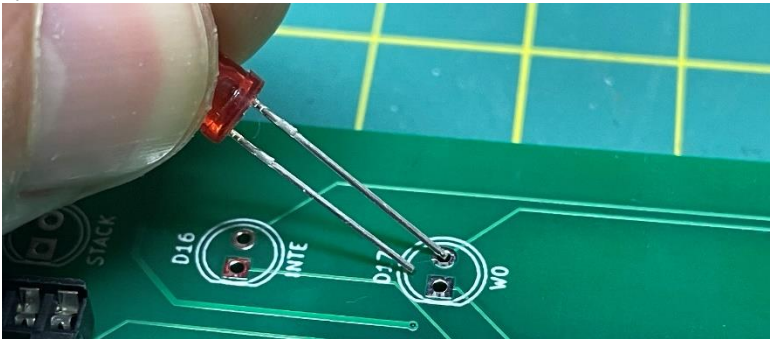
From bag number 6, get four 15mm and four 8mm standoffs, and four 10mm bolts.



We're going to temporarily add the standoffs to the main circuit board with the 15mm on top and 8mm on the bottom.



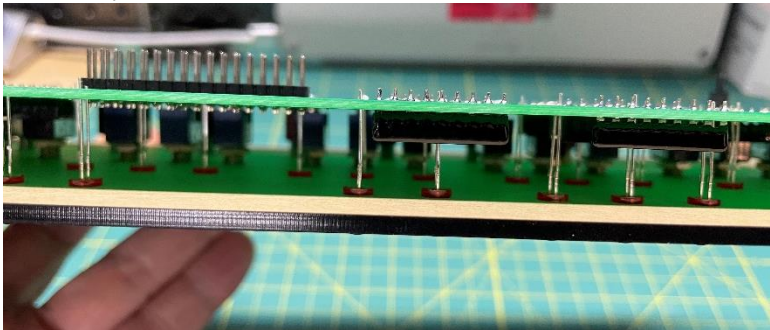
Insert 36 LEDs with the long leg toward the top of the board and the short leg in the square hole (near the flat part of the LED symbol):



After all LEDs are in place, put the front panel in place and secure it with the four 10mm nylon bolts.



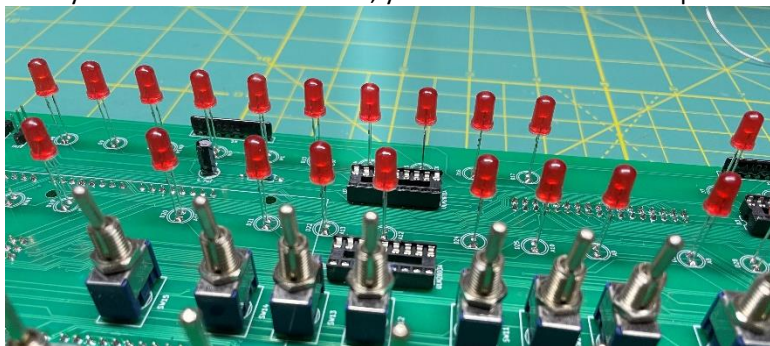
Flip the entire assembly over and allow the LEDs to fall into place in the front panel.



Then support the front panel while you solder the LEDs in place.



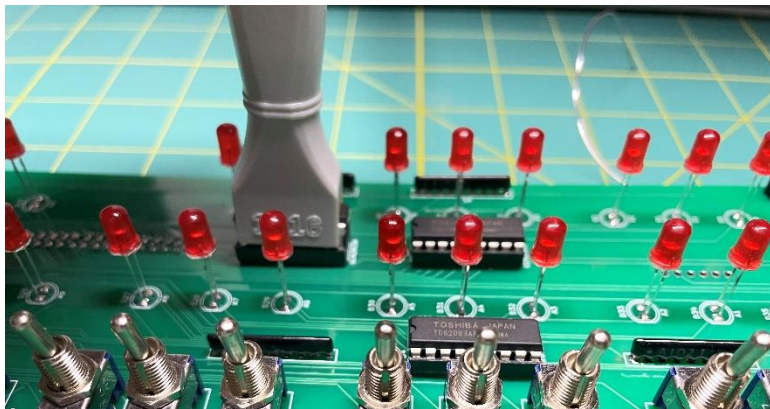
After you have soldered all LEDs, you can remove the front panel.



Bag number 5 is next.



Insert five ULN2803 chips in the five 20-pin DIP sockets on the main circuit board.



Get three jumpers from bag number 6 and place them in the appropriate locations on JP1-JP3 - at the top since you are building an 8800 replica.



At this point you can put the Arduino Due in place.



This is a good time to test your Altair-Duino. Plug a micro USB cable into your Arduino and connect it to a computer (or other USB power supply.) Try launching Kill-the-Bit by setting SW1 up and raise AUX1 as seen in this video: [adwaterandstir.com/FirstTest](http://adwaterandstir.com/FirstTest). Next, set SW0 through SW15 up and lower EXAMINE and see if all address LEDs illuminate. If not, check your solder connections.

You can remove the standoffs and set the main circuit board aside. Next we will work on the expansion board. Get parts bags number 7 and 8.



Resistor color codes:

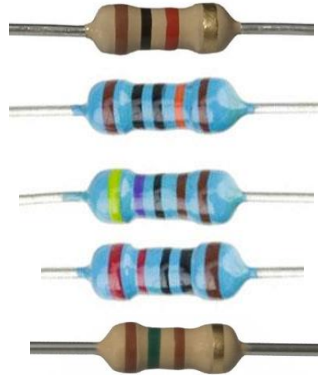
1k (Brown-Black-Red)

100k (Brown-Black-Black-Orange)

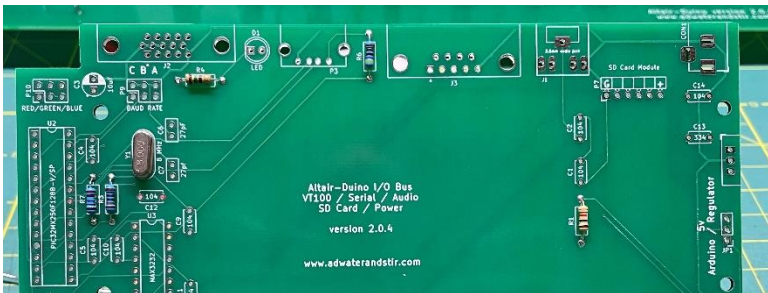
4.7k (Yellow-Violet-Black-Brown)

220 ohm (Red-Red-Black-Black)

150 ohm (Brown-Green-Brown)



Start by installing the five resistors and crystal in their locations as indicated on the circuit board.

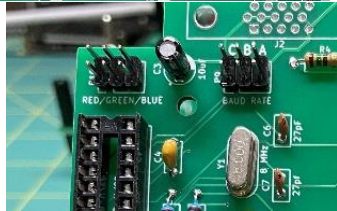




Add the DIP sockets and capacitors.



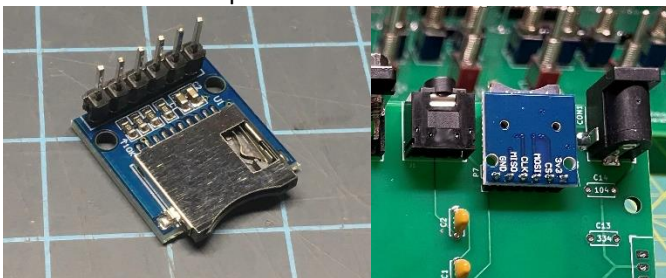
Cut two six-pin male headers and solder those to the upper left of the circuit board. Also add the 34-pin double header to the left side.



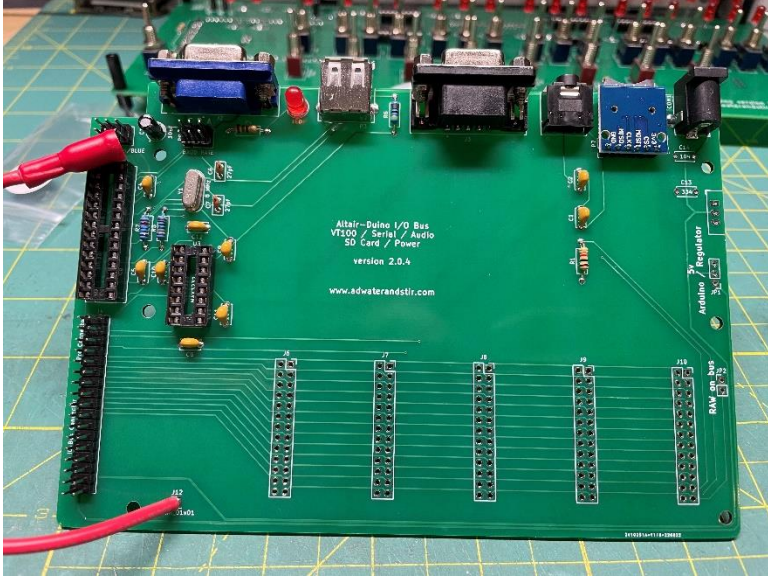
Next, we'll add the SD card module.



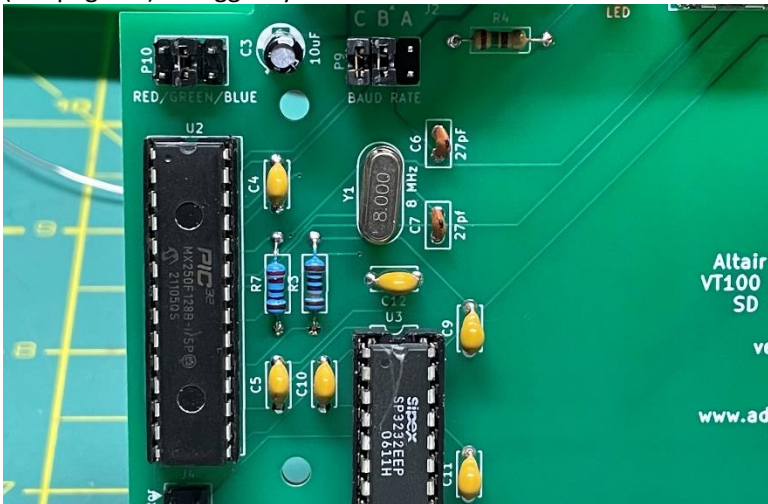
You will need to solder the male header to the SD card module. It is very important you install the header as pictured, and solder it to the circuit board as pictured:



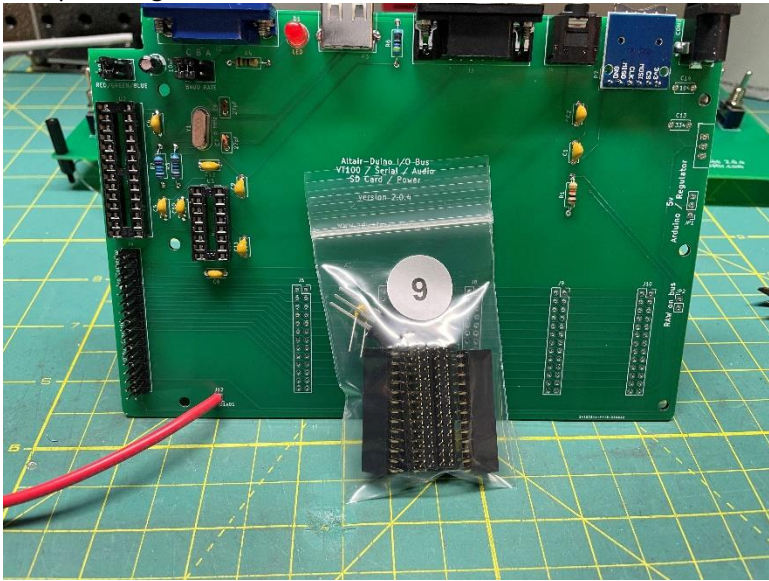
Add the other connectors from bag number 7 (VGA, DE9, audio jack, power jack, USB), an LED from bag number 4, and the other half of the power cable from bag number 5. Also add a 34-pin male header in the lower left from bag number 2.



Install the PIC32 and SP3232 chips, and install a jumper for your desired monitor color on P10, and jumpers for the baud rate on P9 (see page 34). I suggest you set it to the default 9600 baud.



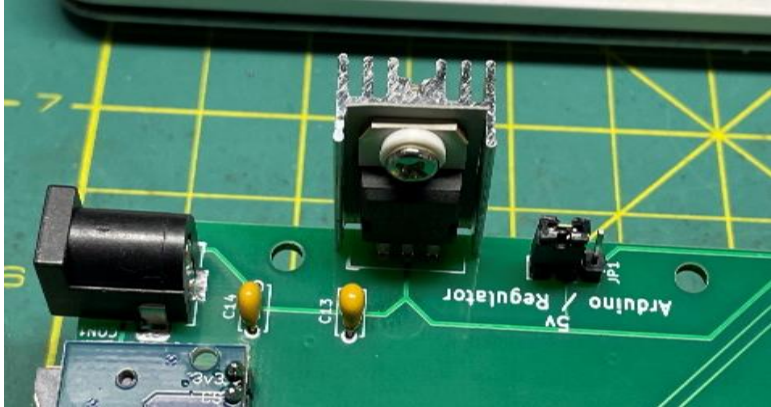
Find parts bag number 9.



Install the 26-pin female headers with the polarity key facing right (the orientation is very important.)



Add the L7805 voltage regulator, heatsink, and capacitors to the appropriate locations on the circuit board as pictured.

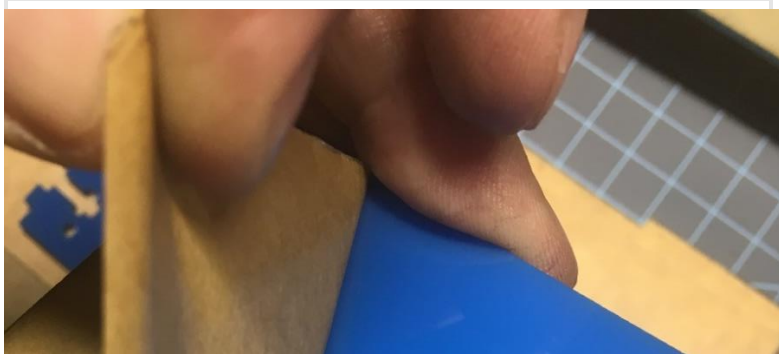


The bus can be powered from the Arduino, but I would recommend that only with one expansion card. Otherwise the bus should be powered from the regulator, so place the jumper accordingly.

Get the acrylic pieces and bag number 10 with nuts and bolts.



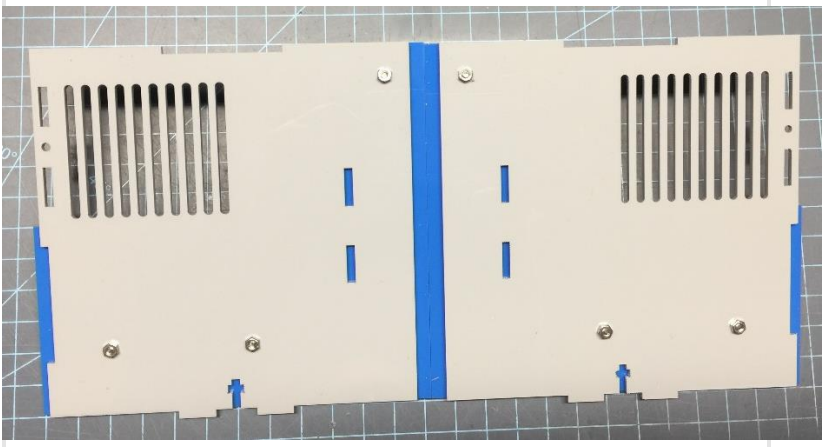
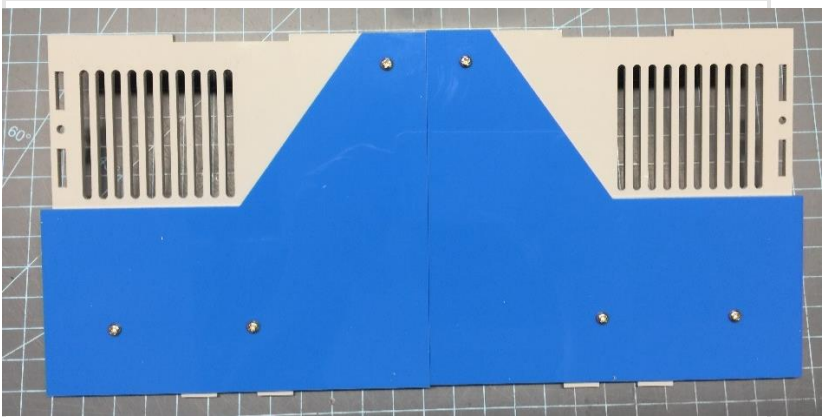
Start removing the masking paper (or plastic) from the acrylic pieces.



Take the two smaller acrylic pieces with the word “Top” engraved. Add four 8mm nylon standoffs to the side that says “Top” and secure each with a nylon nut. (These pieces may be blue or gray.)



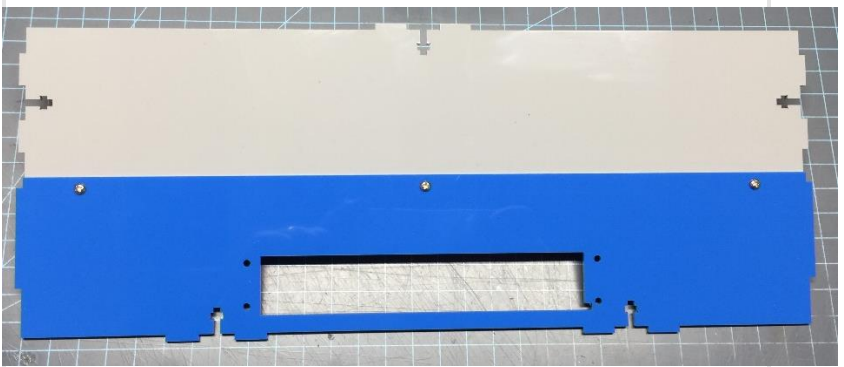
Next take the two gray side pieces (with “ventilation holes” and attach the blue side pieces with three 8mm bolts each.



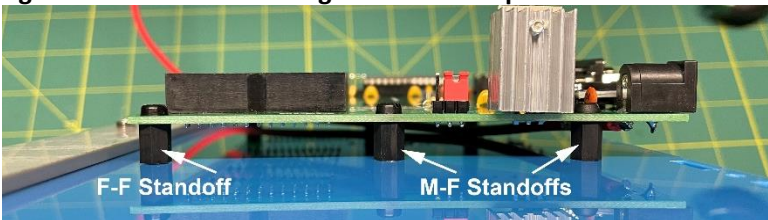
Attach the blue top piece to the gray top piece as shown with 8mm bolts. Make sure the blue piece extends 6mm over each side (turn it over if it doesn't.)



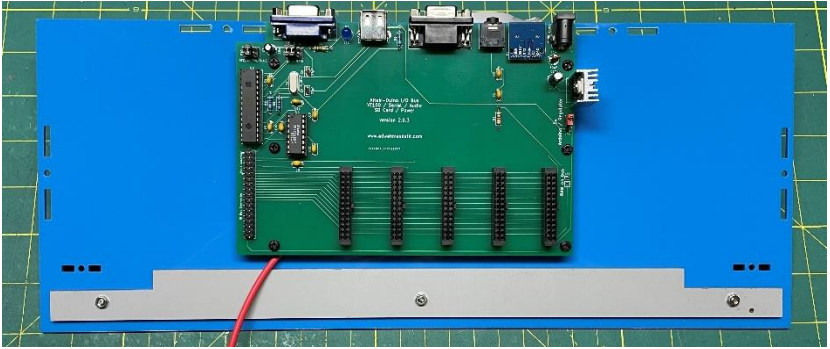
Attach the two back pieces together with 8mm bolts. Note the position of the notch in the lower right.



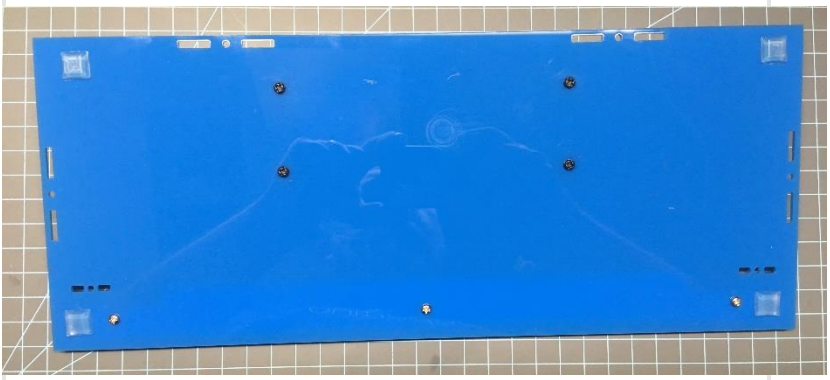
Attach the I/O circuit board to the blue bottom piece with six 8mm standoffs (four male-female, two female-female toward the rear), nylon nuts and nylon bolts. **Leave them a little loose, you will tighten them after attaching the small rear panel.**



Attach the gray piece (as shown) to the bottom with 8mm bolts.

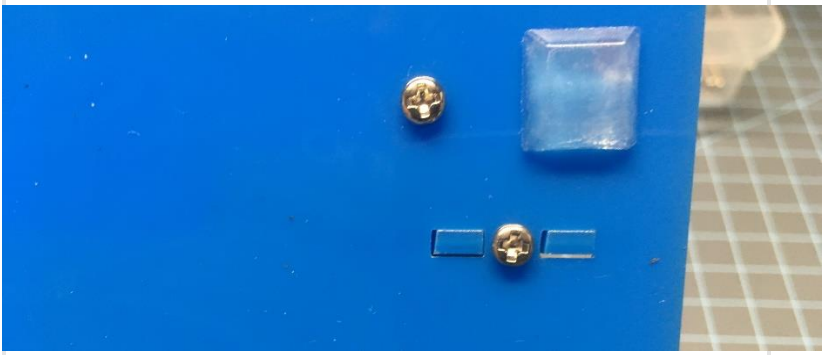


This would also be a good time to apply the rubber feet to the bottom piece.

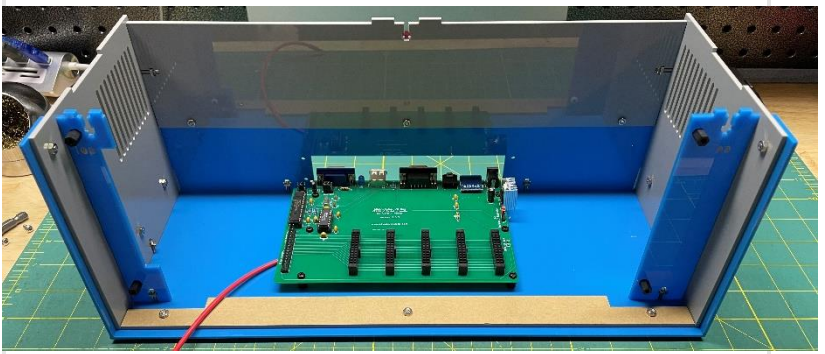


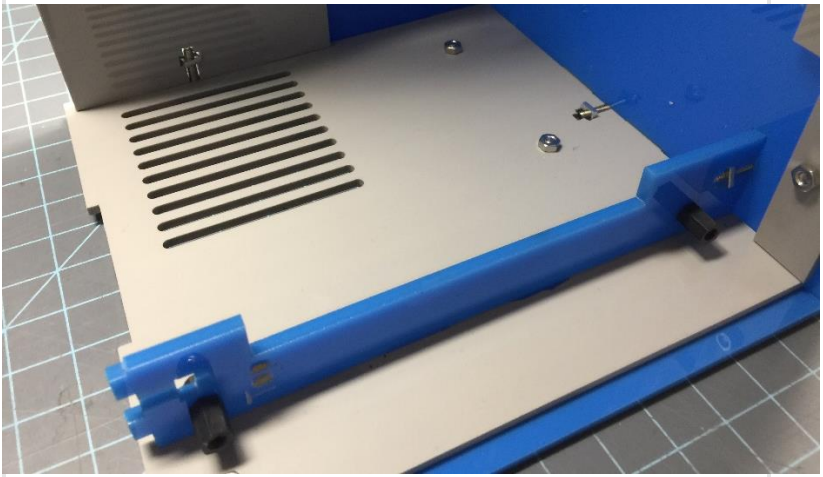
Next we're going to start joining acrylic pieces with a t-slot joint. Start with the uprights where we will eventually mount the main circuit board. Attach them to the bottom piece with 14mm bolts and square nuts. Tighten firmly, but not too tight – acrylic can crack.





Add the back piece and side pieces and bolt in place with four 14mm bolts.

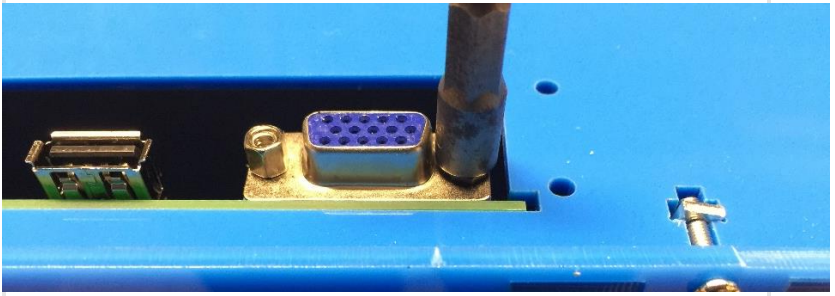




Get the small rear panel (for the ports) and add the USB extension with two 8mm bolts.



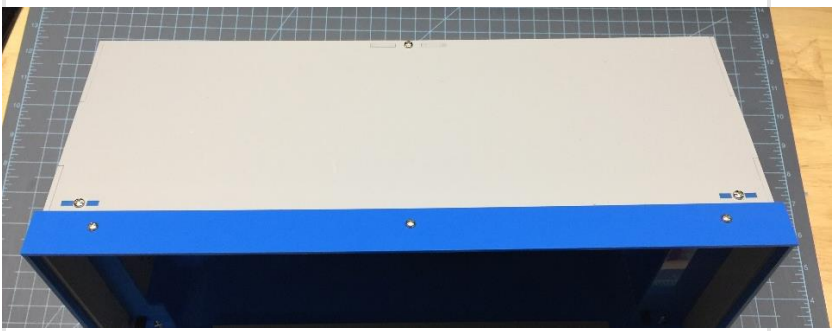
Remove the jack screws from the VGA and Serial connectors with a needle-nose pliers, or a 3/16" or 5mm socket.



Place the rear panel in place and secure it with the jack screws and four 8mm bolts. Tighten the connections, including the standoffs supporting the circuit board.



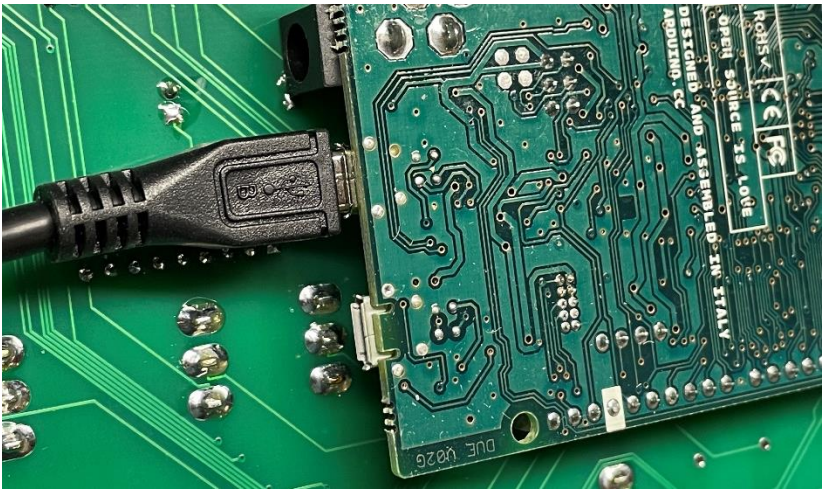
Add the top piece as shown and secure with three 14mm bolts.



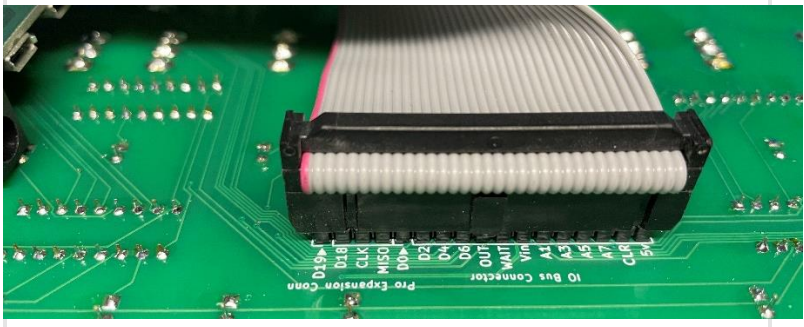
Connect the 34 pin IDC cable to the I/O board, with the red stripe toward the top (or if you have a rainbow colored cable, take note of the color of the top wire, and make sure it is oriented correctly in the following step).



Connect the USB connection cable to the Programming port on the Arduino Due (the port nearest the onboard power connector).



Plug the 34 pin IDC cable onto the rear of the main circuit board with the red stripe toward the left (or the color of the wire you previously noted).



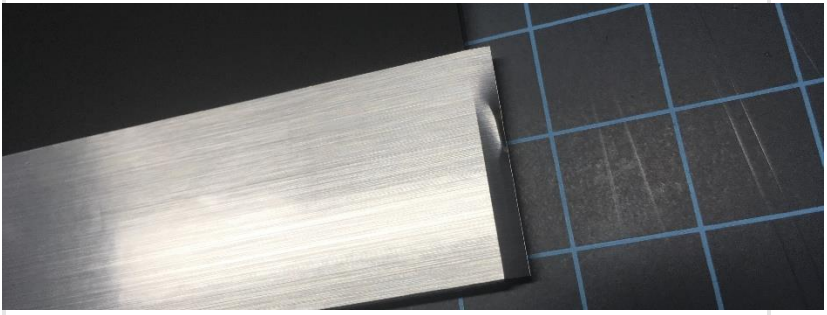
Attach the main circuit board to the case with 15mm M-F nylon standoffs.



Apply the Altair 8800 sticker to the front panel (not necessary with the 8800b variation). The adhesive is forgiving, so if you place it wrong, you can pull it up and put it in place again. Use a small Phillips screwdriver or awl to poke holes where the bolts will go.

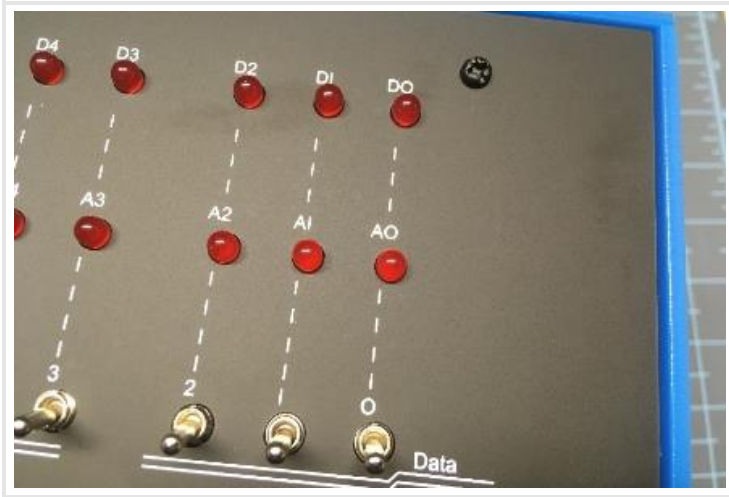


Your label will be a little bit longer than the front panel.



You may wrap the excess around the edge of the panel or trim it with a sharp razor.

Add the front panel to the main circuit board, push down around the toggle switches, and secure it with four nylon bolts.



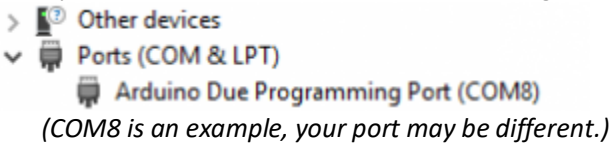
**CONGRATULATIONS!  
YOUR ALTAIR 8800 IS  
COMPLETE!**

See the web page [www.adwaterandstir.com/operation](http://www.adwaterandstir.com/operation) for full documentation and easy step-by-step things to do.

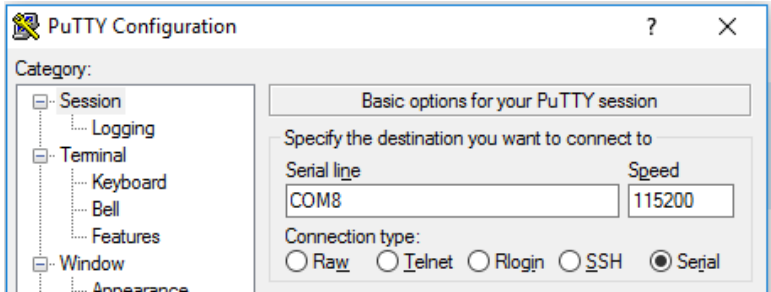
Here are a few easy things to try:

**By default, your Altair-Duino is set up to communicate through the USB port.**

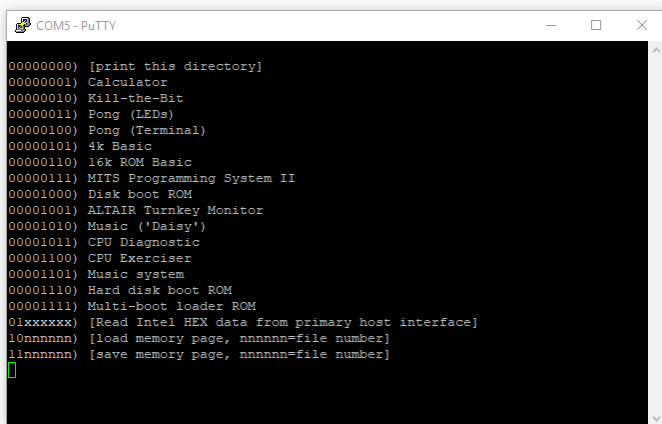
1. Plug USB cable into computer and the other end to your Altair-Duino.
2. Windows 10 should automatically recognize a new serial port. To check, launch “Device Manager”.
3. Expand “Ports (COM & LPT)” in Device Manager



4. Your port should be identified as “Arduino Due Programming Port”.
5. Launch PuTTY (or another terminal program if you choose.)
6. Connect to the indicated COM port at baud rate 115200.



7. The front panel lights will flash briefly while it connects.
8. With all switches down, press AUX1 down.
9. On the terminal, you should see a directory of options for front panel switches.



```
COM5 - PuTTY
00000000) [print this directory]
00000001) Calculator
00000010) Kill-the-Bit
00000011) Pong (LEDs)
00000100) Pong (Terminal)
00000101) 4k Basic
00000110) 16k ROM Basic
00000111) MITS Programming System II
00001000) Disk boot ROM
00001001) ALTAIR Turnkey Monitor
00001010) Music ('Daisy')
00001011) CPU Diagnostic
00001100) CPU Exerciser
00001101) Music system
00001110) Hard disk boot ROM
00001111) Multi-boot loader ROM
01xxxxxx) [Read Intel HEX data from primary host interface]
10nnnnnn) [load memory page, nnnnnn=file number]
11nnnnnn) [save memory page, nnnnnn=file number]
```

**If you have a serial device (such as a dumb terminal):**

1. Plug a serial cable from the Altair-Duino to your serial device.
2. Connect a power supply to the Altair-Duino.
3. **Make sure the SD card is inserted.**
4. Set front panel data switches to “2” (switch 1 up, all other switches down).
5. Raise (and hold) DEPOSIT up.
6. Turn on Altair-Duino.

This will cause the Altair-Duino to load configuration 2 on power up. This configuration has been saved to communicate on serial port 2 at 9600 baud.

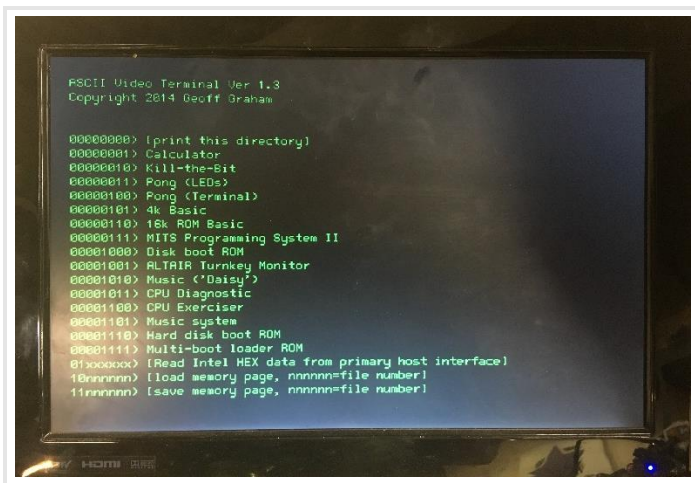
**If you have Geoff Graham’s VT-100 emulator on serial port 1 (using the I/O expansion board):**

1. Plug a VGA monitor and PS2 keyboard into the Altair-Duino. Power on the monitor.
2. Connect a power supply to the Altair-Duino.
3. **Make sure the SD card is inserted.**
4. Set front panel data switches to “1” (switch 0 up, all other switches down).



5. Raise (and hold) DEPOSIT up.
6. Turn on Altair-Duino.

You should see “ASCII Video Terminal Version 1.3 Copyright 2013 Geoff Graham” on the VGA monitor. With all switches down, press AUX1 down. On the monitor, you should see a directory of options for front panel switches.



**Baud rates for the VT100 emulator:**

The VT100 emulator and settings on the included SD card are set up for 9600 baud. Other baud rates are supported. Use the following jumper settings from this table.

Please see the website ([adwaterandstir.com/operation](http://adwaterandstir.com/operation)) for many other examples and walk-throughs for common functions. Also visit the online forum to discuss the Altair-Duino with other enthusiasts, or to ask questions ([adwaterandstir.com/forum](http://adwaterandstir.com/forum)).

| BAUD RATE<br>SELECT |   |   |        |
|---------------------|---|---|--------|
| C                   | B | A |        |
| ■                   | ■ | ■ | 115200 |
| ■                   | ■ | □ | 57600  |
| ■                   | ■ | ■ | 38400  |
| ■                   | ■ | □ | 19200  |
| ■                   | ■ | ■ | 9600   |
| ■                   | ■ | □ | 4800   |
| ■                   | ■ | ■ | 2400   |

If you have the 8800b variation, you may want to search the forums. There has been a user-contributed software revision specifically for the 8800b additional functionality.