Altair-Duino 2.5 Experimenter Assembly & Operations

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

https://github.com/dhansel/Altair8800/raw/master/Documentation.pdf

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 1kΩ Resistor Array
- 1 x 47uF Capacitor
- 1 x 470Ω Resistor
- 1 x 1kΩ Resistor

Bag #2

- 1 x 2x3 Female Header
- 2 x 40-pin Single Male Header
- 1 x 40-pin Double Male Header
- 5 x 18-pin DIP Socket
- 1 x 16-pin DIP Socket
- 1 x 26-pin Female Header
- 1 x 14-pin Female Header

Bag #3

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

Bag #4

- 36 x 5mm Red LEDs

Bag #5

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

Bag #6

- 4 x 15mm Male-Female Standoffs
- 8 x 10mm M3 Nylon Bolts
- 4 x 8mm Male-Female Standoffs
- 4 x 20mm Female-Female Standoffs
- 4 x 8mm M3 Bolts
- 2 x M3 Nylon Nuts
- 4 x 12mm M4 Bolts
- 4 x M4 Nuts
- 4 x M4 Lock Washers
- 4 x Rubber Feet

Bag #7

- 1 x VT100 Circuit Board
- 1 x 8MHz Crystal
- 2 x 27pF Capacitors
- 1 x VGA Connector
- 1 x USB-A Jack
- 1 x 3mm LED
- 1 x 10uF Capacitor
- 2 x 100nF (104) Capacitor
- 1 x 100kΩ Resistor
- 1 x 4.7kΩ Resistor
- 1 x 220kΩ Resistor
- 1 x 150Ω Resistor
- 4 x 8mm Male-Female Standoffs
- 4 x 6mm M3 Nylon Bolts
- 4 x M3 Nylon Nuts
- 3 x Jumpers
- 1 x 6-Pin IDC Cable

Bag #8

- 1 x Expansion Circuit Board
- 7 x 100nF (104) Capacitors
- 1 x 1kΩ Resistor
- 1 x DB9 Connector
- 1 x Power Jack
- 1 x Audio Jack
- 1 x SD Card Module
- 1 x SD Card
- 1 x 14 –Pin Male Header

Bag #9 (Optional)

- 1 x Backplane Circuit Board
- 5 x 26 Pin Female Header
- 1 x 26-pin Male Header
- 1 x 100nF (104) Capacitor
- 1 x 0.33uF (334) Capacitor
- 1 x L7805 Regulator
- 1 x TO-220 Heatsink Set
- 2 x 40mm F-F Standoffs
- 2 x 6mm M3 Nylon Bolts
- 4 x 6mm M3 SS Bolts
- 2 x L-Brackets

Bag #10 (Optional)

- LED Output Circuit Board
- 8 x 150Ω Resistors
- 8 x 5mm LEDs
- 3 x 100nF (104) Capacitors
- 1 x 470pF (471) Capacitors
- 2 x 14-pin DIP Sockets
- 1 x 18-pin DIP Socket
- 1 x 20-pin DIP Socket
- 1 x UDN2981A
- 1 x 74HC273AN
- 1 x 74HC00
- 1 x CD4068BE
- 1 x 26-pin Male Header

Unbagged Parts:

- 1 x Altair Front Panel
- 1 x Altair Metallic Sticker
- 1 x Clear Acrylic Rear Panel
- 1 x Port Panel
- 1 x Main Circuit Board
- 1 x Arduino Due
- 1 x 30mm USB Extension
- 1 x Micro USB Cable
- 1 x 9v Power Supply

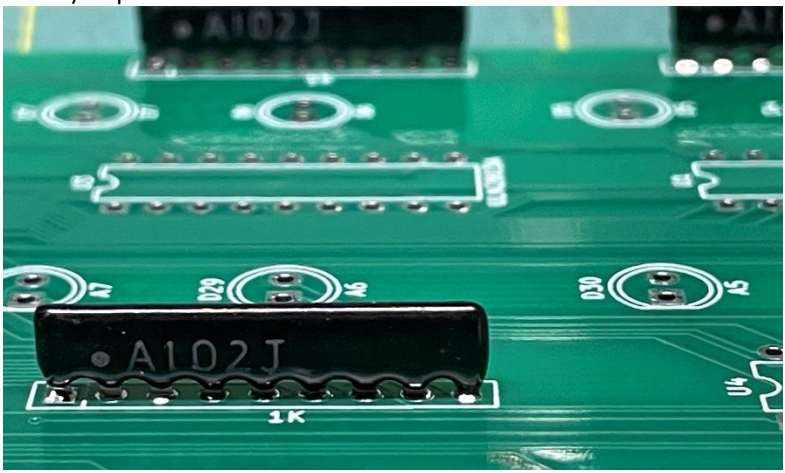
OTHER PARTS YOU MAY NEED

- 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)
- 7mm Nut Driver (or socket)

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.

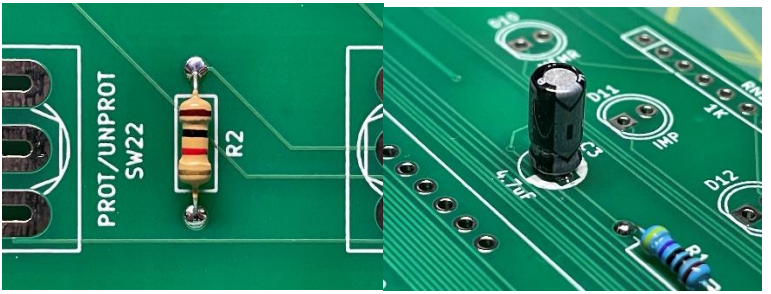


Resistor color codes for next step:

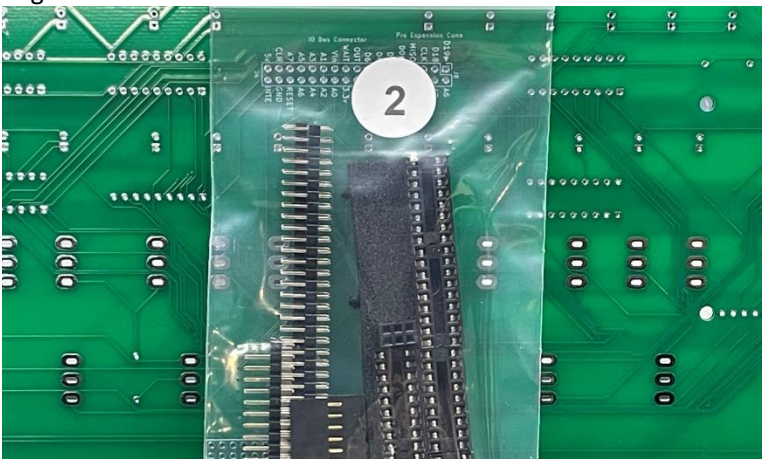
1k (Brown-Black-Black-Brown)

470 ohm (Yellow-Violet-Black-Black)

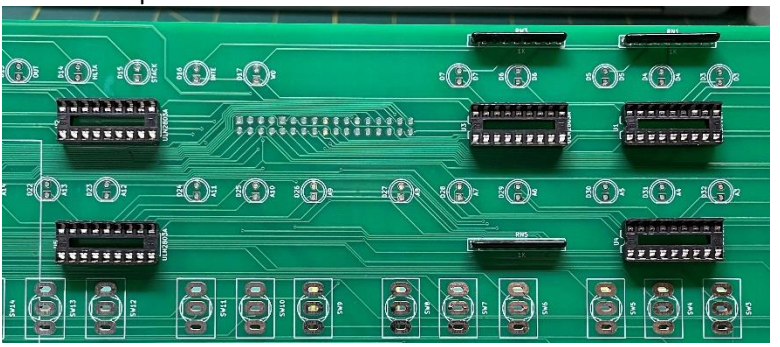
Add the 47uF Capacitor and the 470 ohm and 1k ohm resistors in C3, R1 and R2.



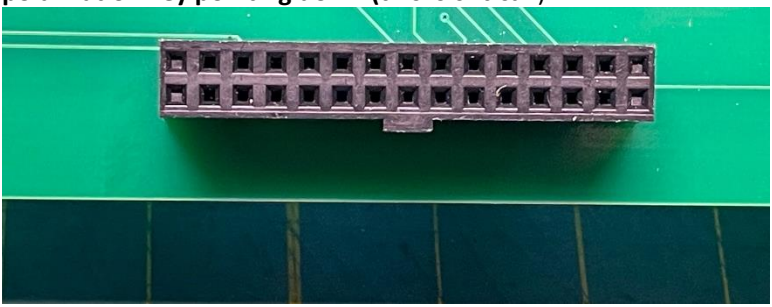
Bag number 2 is next.



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



Add the 26-pin female header to the “Experimenter IO Bus Connector” (J6) area in the middle of the bottom of the circuit board. Be sure to install the header on the **back** with the **polarization key pointing down (this is critical**.)

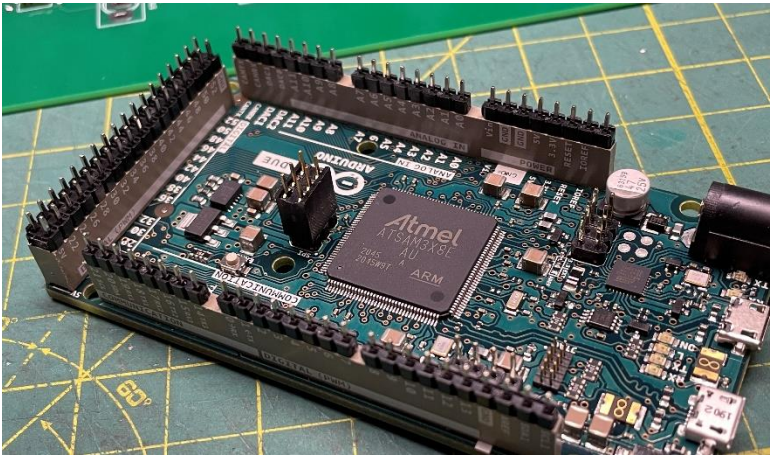


Add the 14-pin female header to the “Standard Exp Conn” (J1) area on the right side of the circuit board. This is installed on the **back** of the circuit board.

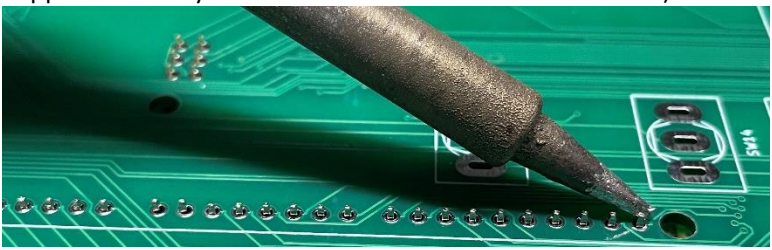
We’re going to use the Arduino Due to hold the pin headers temporarily while we solder them to the main circuit board. Cut (or locate) the following segments:

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

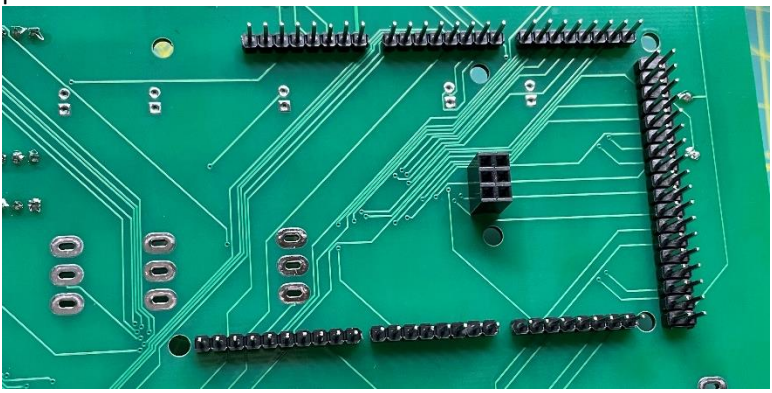
Place them on the Arduino Due like this:



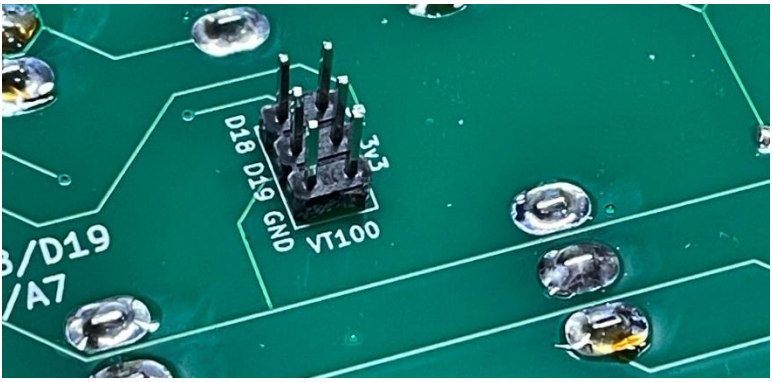
Insert the Arduino into the **back** of the main circuit board and solder all header pins in place (note: this is where most errors happen – it's easy to miss one or two header connections.)



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



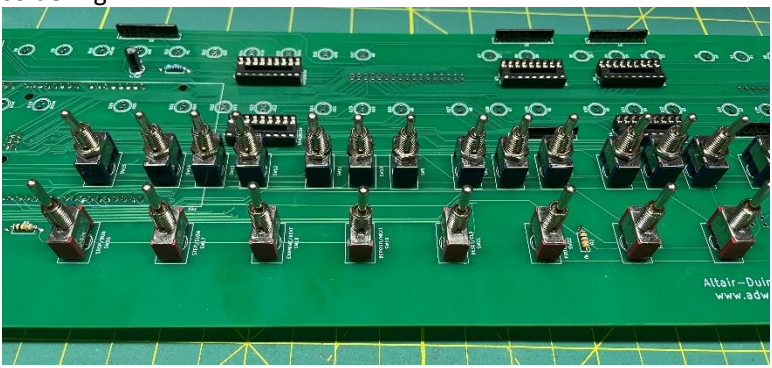
Add a 2x3 (six pin) male header to the rear side of the circuit board for the VT100 emulator connector.



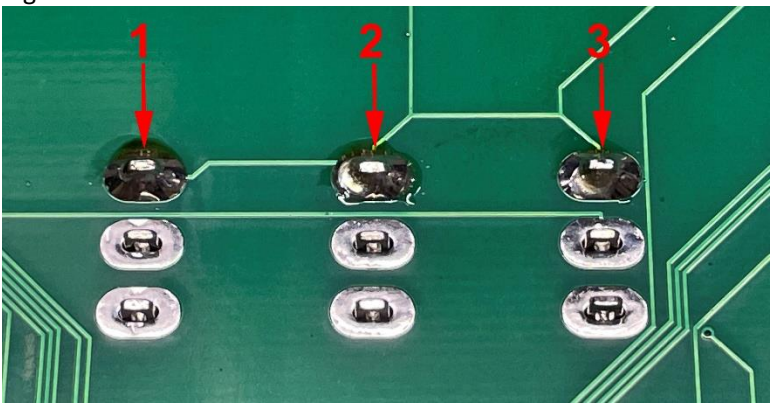
Next, we'll add the toggle switches from bag number 3.

Remove **all** of the nuts and washers from the switches (if there are any).

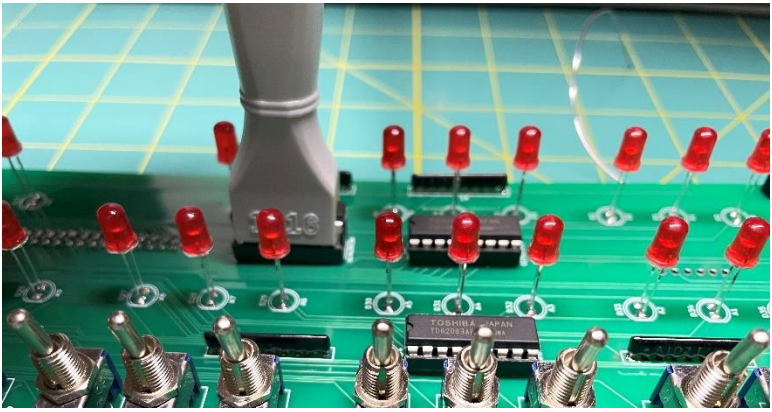
I like to first add the 17 on-off toggles and hold them in place with the front panel while soldering. This ensures the toggles switches remain in alignment with the front panel. Next, add the 8 on-off-on toggles and again hold them in place with the front panel while soldering.



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:

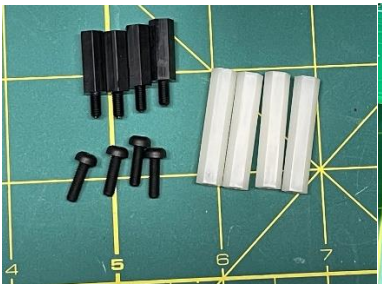


Insert five ULN2803 chips in the five 20-pin DIP sockets on the main circuit board.



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

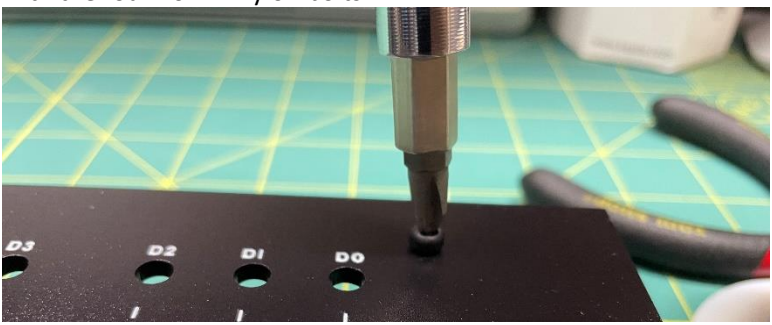
From bag number 6, get four 15mm and four 8mm standoffs, and four 10mm bolts.



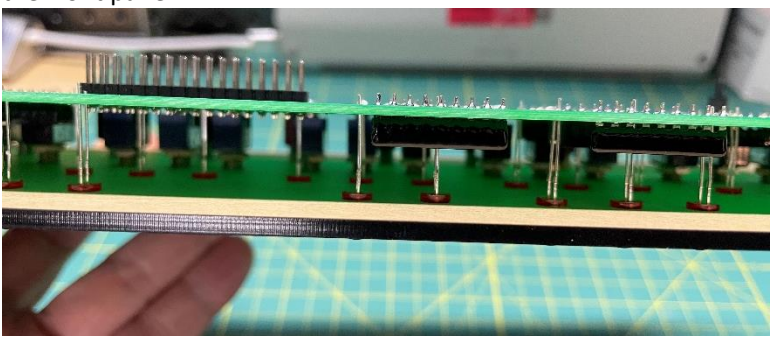
We’re going to temporarily add the standoffs to the main circuit board with the 15mm on top and 20mm on the bottom (temporarily).

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):

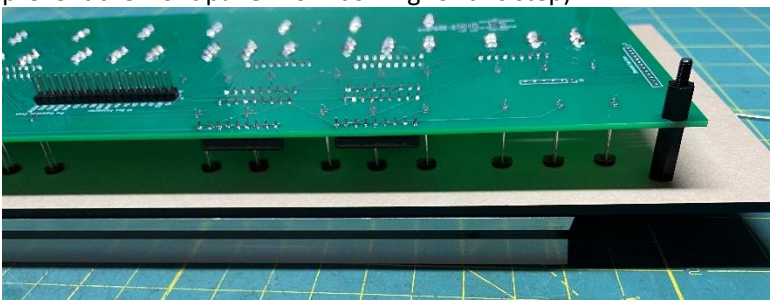
After all LEDs are in place, put the front panel in place and secure it with the four 10mm nylon bolts.



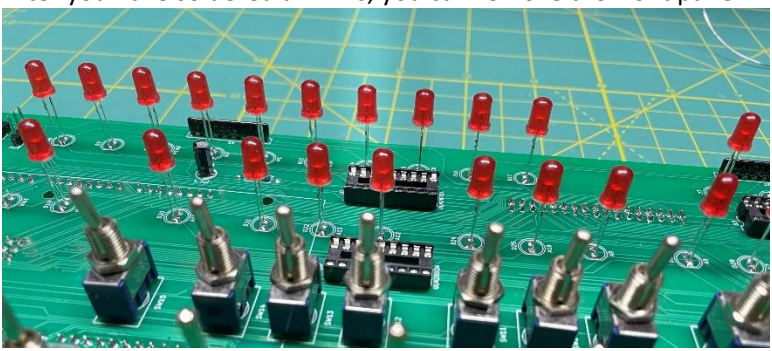
Flip the entire assembly over and allow the LEDs to fall into place in the front panel.



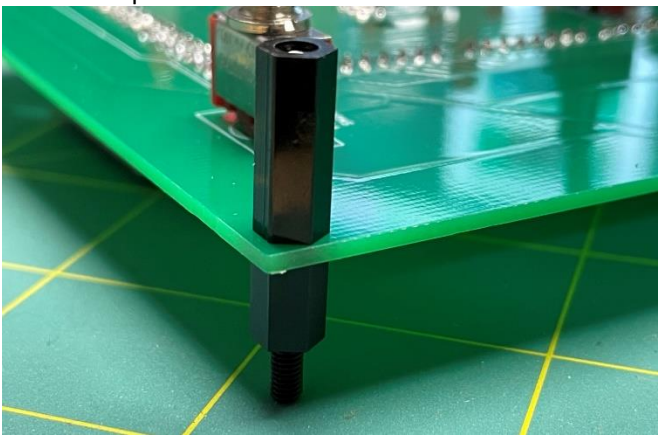
Then support the front panel while you solder the LEDs in place (to prevent the front panel from bowing for this step).



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

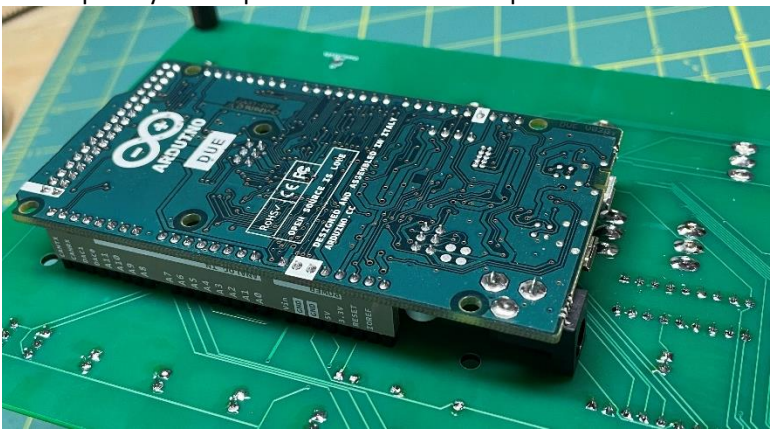


When you are done adding the LEDs, you can remove the 20mm standoffs and replace them with 8mm standoffs.



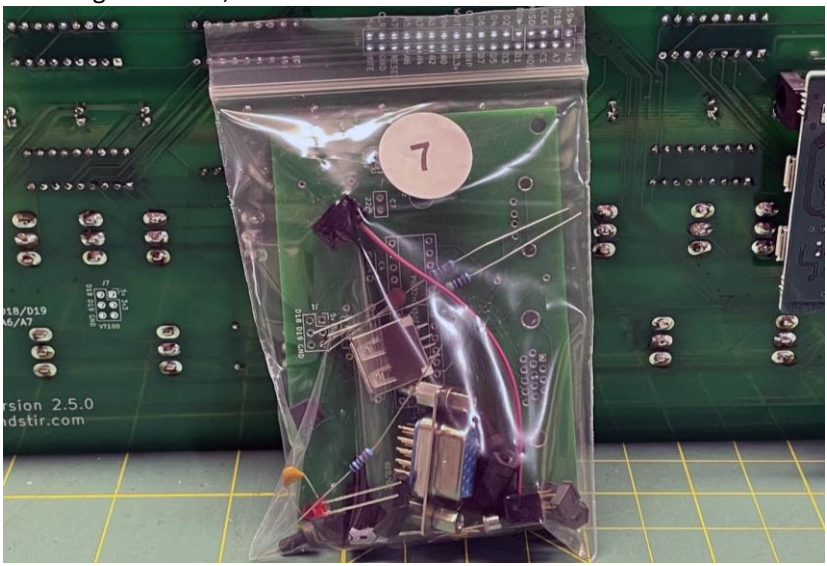
Bag number 5 is next.

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 lower AUX1 as seen in this video: 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.

With bag number 7, we will assemble the VT100 emulator.



All of the components are clearly marked on the circuit board. You will need to identify the following resistors:

100k (Brown-Black-Black-Orange)

4.7k (Yellow-Violet-Black-Brown)

220 ohm (Red-Red-Black-Black)

150 ohm (Brown-Green-Brown)

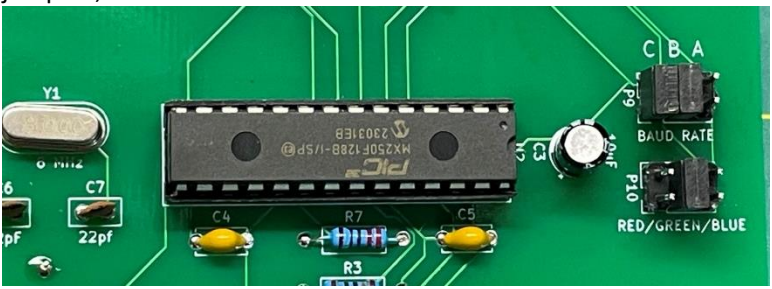
The following components are mounted to the rear of the circuit board:

- 8MHz Crystal
- 27pf Capacitors (2)
- 100nf Capacitors (2)
- 10uF Capacitor
- 100k Resistor
- 220 ohm Resistor
- 28-Pin Socket
- 2x3 pin Male Headers (2)

Turn the board over and mount the following components on the front:

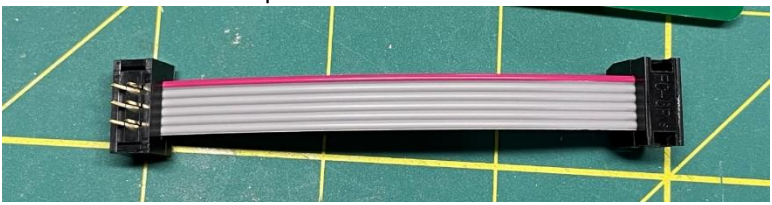
- 150 ohm Resistor
- 4.7k Resistor
- 3mm LED (with orientation as indicated on the board)
- USB-A Connector
- VGA Connector

Turn the board over, and add the PIC32 microprocessor and jumpers, as shown:

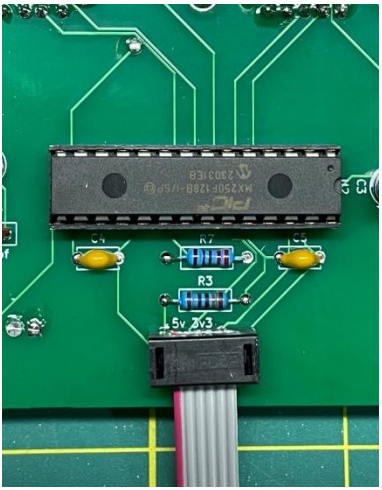


Baud rate jumpers are placed vertically over C and B (for 9600 baud) leaving A unjumpered. Place a monitor color jumper vertically, I prefer green.

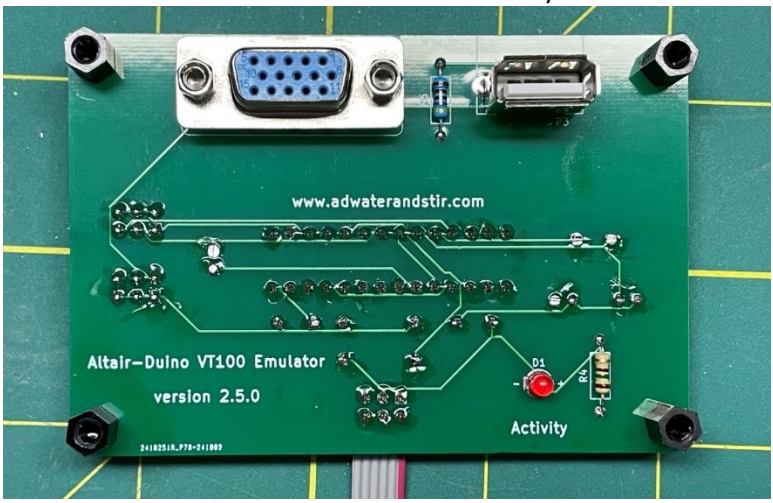
Next we will add the 6-pin IDC cable.



The male end is mounted on the back of the VT100 emulator circuit board as shown.

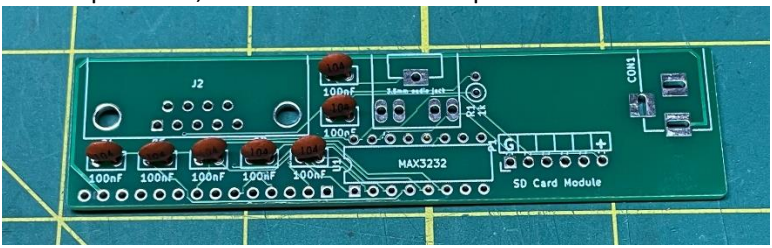


Add four 8mm standoffs and secure with four nylon nuts as shown.



Next we will work on the serial/audio/power board. Get bag number 8.

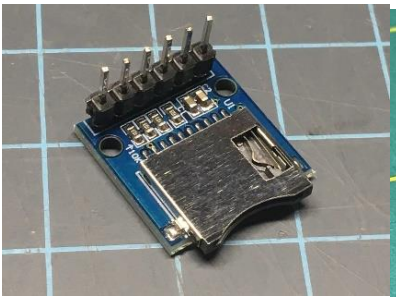
Start by installing the seven capacitors. These ceramic capacitors are not polarized, so orientation is not important.

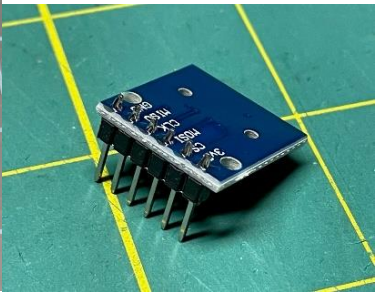


The 1k resistor mounts vertically. Resistor code: 1k (Brown-Black-Black-Brown)

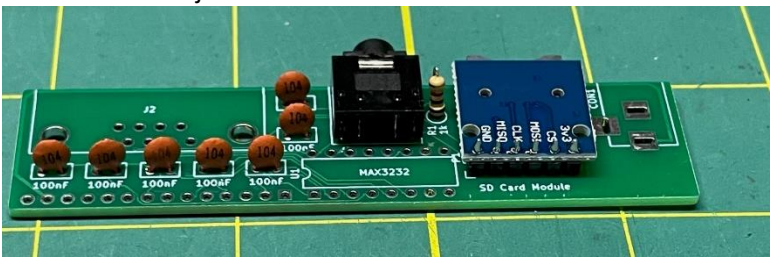
Next, we'll add the SD card module.

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:

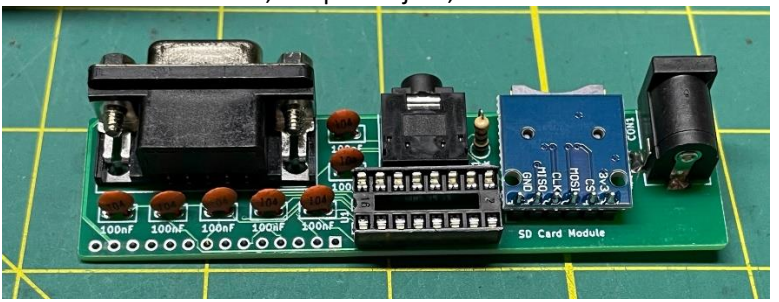




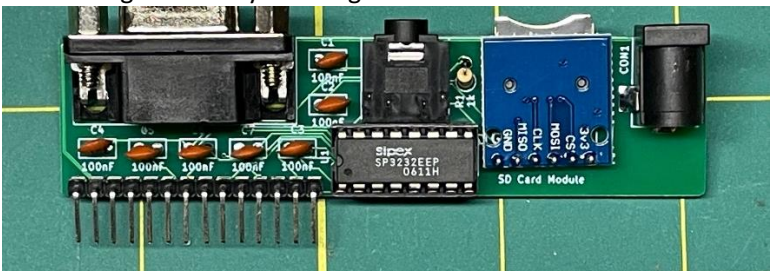
Solder the audio jack and SD module to the circuit board.



Add the DE9 connector, the power jack, and the DIP socket.

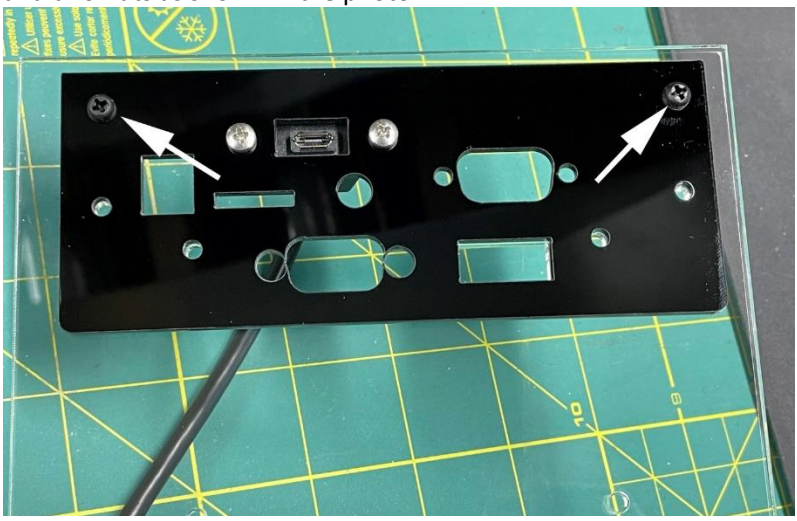


Finally, you can add the 14-pin right angle header and the SP3232 IC from bag #5. Now your daughter board is finished.

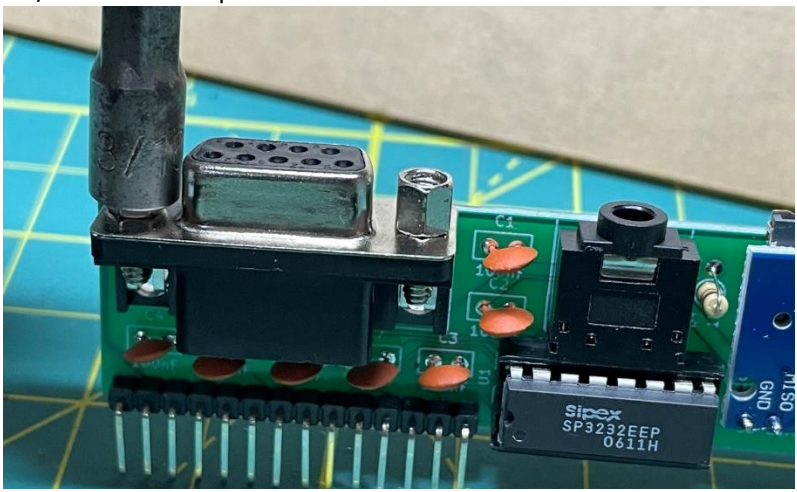


Get the rear port panel, remove the protective plastic, and attach the USB extension with the included M3 bolts as shown.

Take the clear acrylic pane and peel the protective plastic from both sides. Attach the rear ports panel with two 10mm M3 bolts and two nuts as shown in the photo.

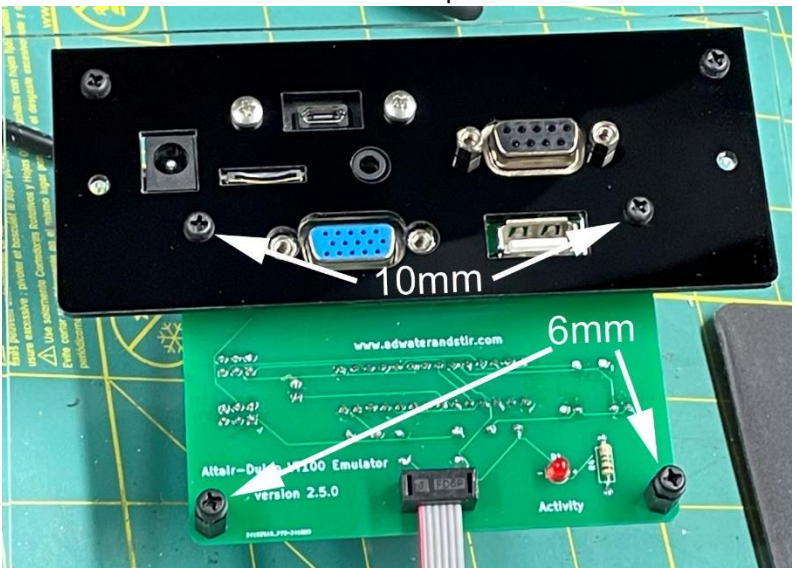


Remove the jack nuts from the DE9 connector. You can do this with a 3/16” driver or a pliers.



Attach the daughter board assembly to the rear port panel and secure with the jack nuts.

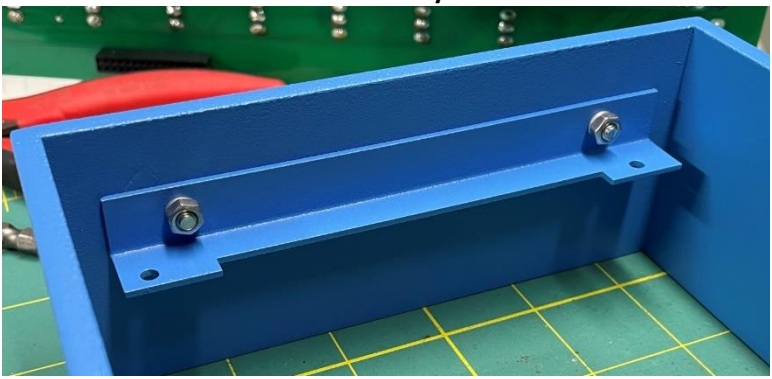
Attach the VT100 emulator to the rear panel as shown:



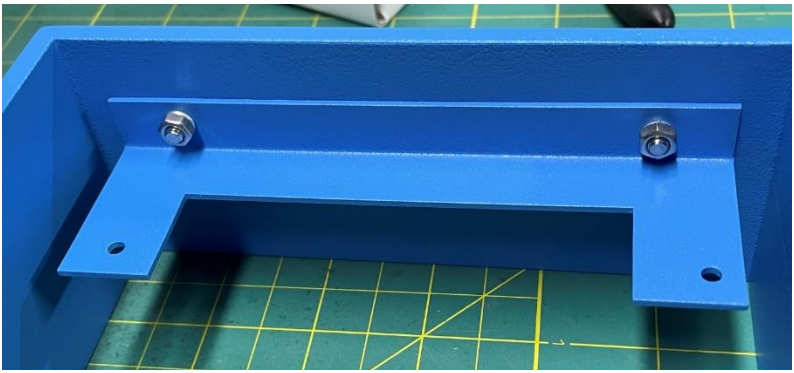
Secure it with two 6mm nylon bolts on the bottom and two 10mm nylon bolts at the top.

Now we will assemble the aluminum frame. Get the frame, two blue mounting brackets, four 12mm M4 bolts, four M4 lock washers, and four M4 nuts.

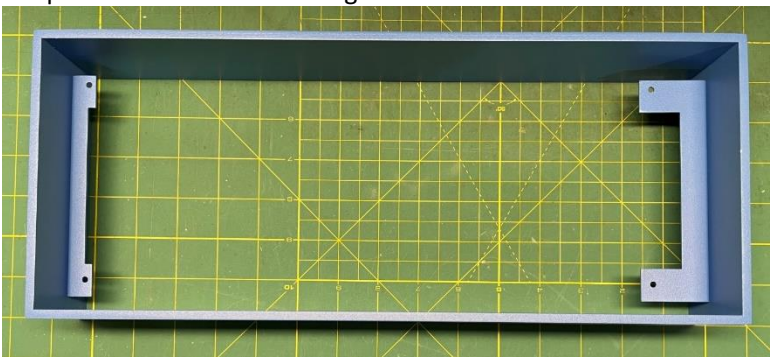
Place the aluminum frame with the holes closest to the top, and mount the smaller side bracket **exactly as shown**:



Turn the bracket and do the same to the other side:

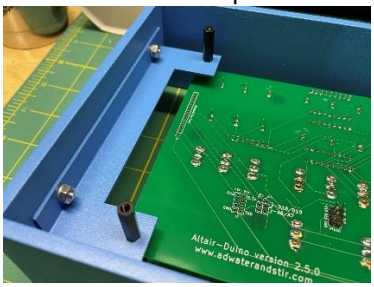


Turn the assembly over and it should look exactly like this. Note the placement of the mounting holes.



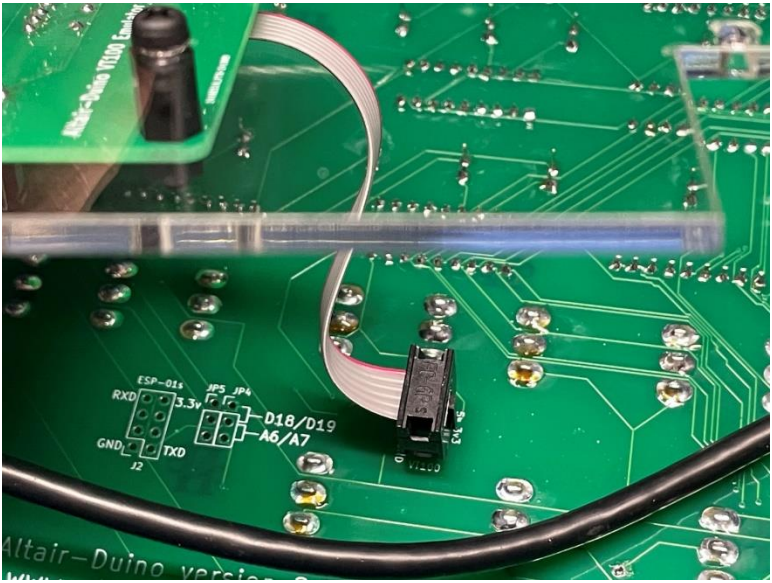
Place the assembled main circuit board in place, directing the 8mm standoffs into the mounting holes.

Secure the board in place with four 20mm nylon standoffs:

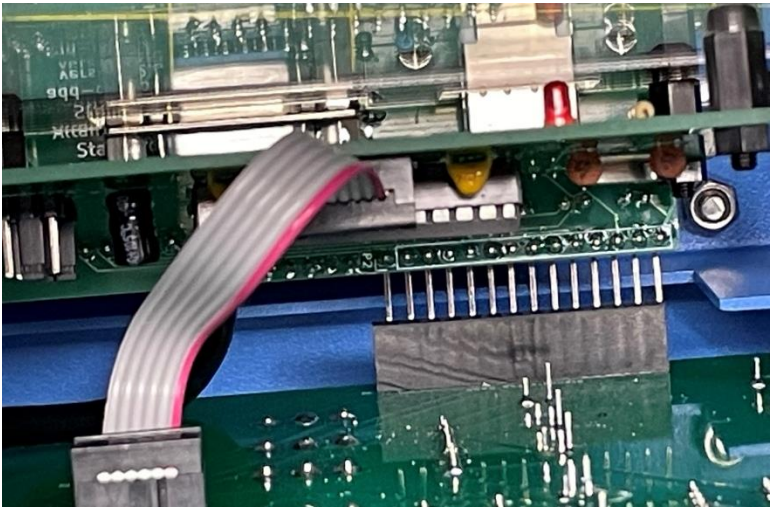


Plug the USB extension cable into the Programming Port on the Arduino Due (the port closest to the power jack.)

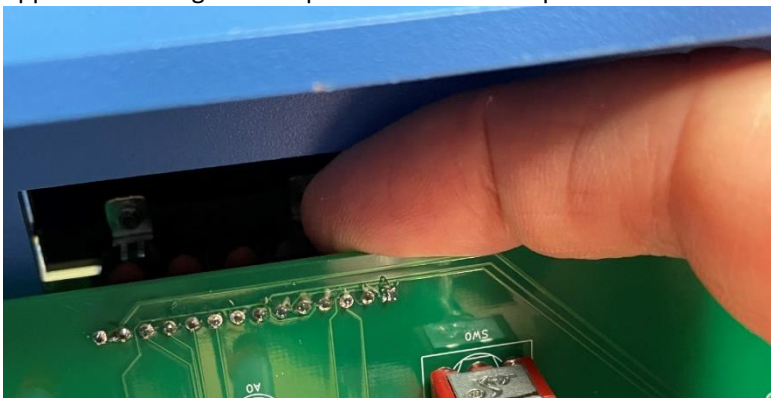
Plug the six-pin IDC cable from the VT100 emulator into the headers on the back of the main circuit board.



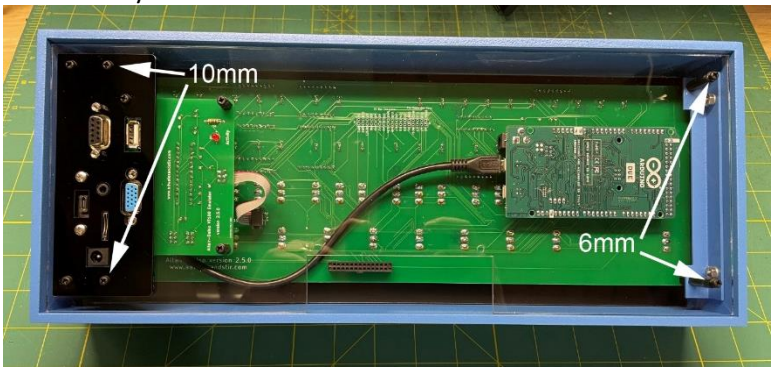
The next part can be somewhat tricky. You need to insert the 14-pin male header from the expansion circuit board into the 14-pin female header on the main circuit board.



One thing I have found that can help is to use your finger from the opposite side to guide the pins into the correct position.

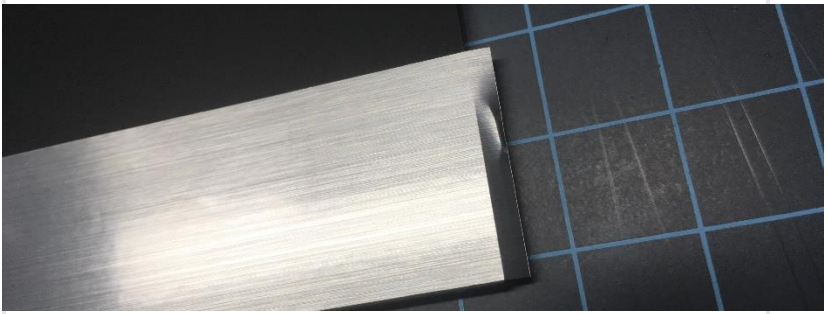


Secure the rear panel in place with two 10mm nylon bolts and two 6mm nylon bolts.



Apply the Altair 8800 sticker to the front panel. 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.



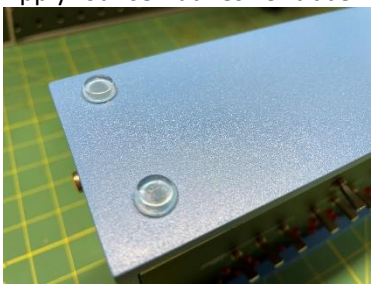
You may wrap the excess around the edge of the panel or trim it with a sharp razor.

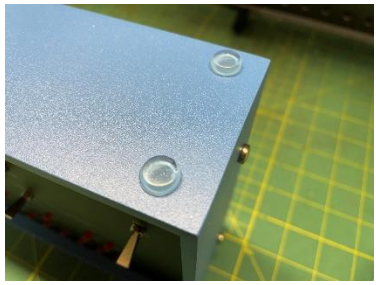
Turn the case over and put the front panel in place.

You may have to push a few of the toggles to the side to get the panel in place. When it is in correctly, the toggles will stick out like this:

Secure the front panel in place with two 10mm nylon bolts for the top of the panel and two 8mm stainless steel bolts for the bottom.

Apply four self-adhesive rubber feet to the bottom of the case.



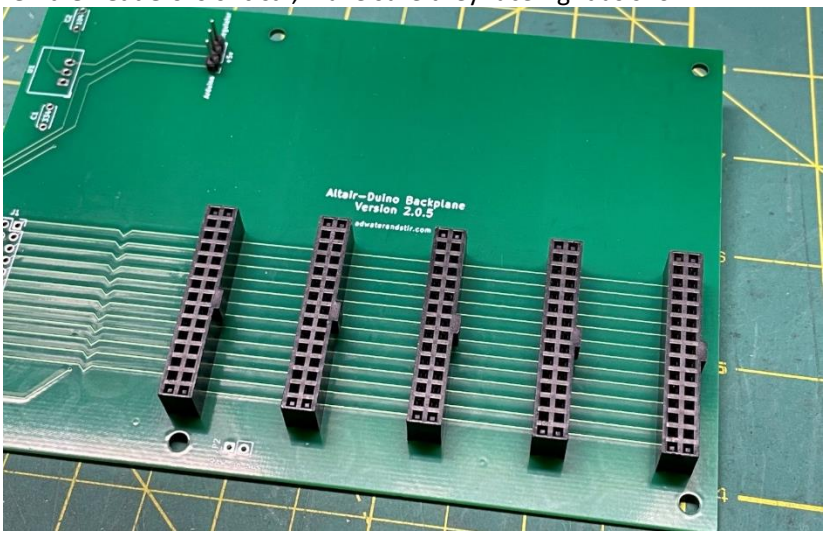


The main body of your Altair-Duino Experimenter is complete.

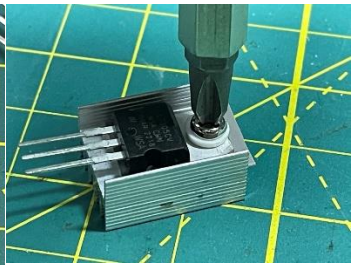
Next we will build the bus board (if purchased). Get bag #9.

Examine your 26-pin female headers and make sure no pins fell out in shipping. If they did, look in the bag and reinsert them.

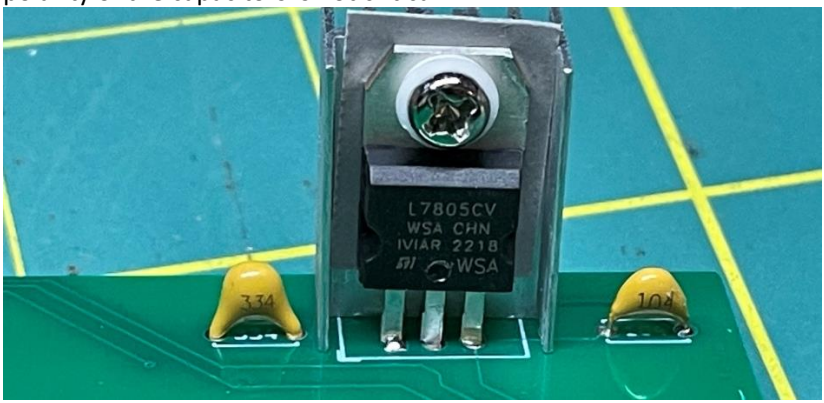
Solder all five 26-pin female headers and a three pin male header to the circuit board. **The orientation of the polarizing key on the female headers is critical**, make sure they face right as shown.



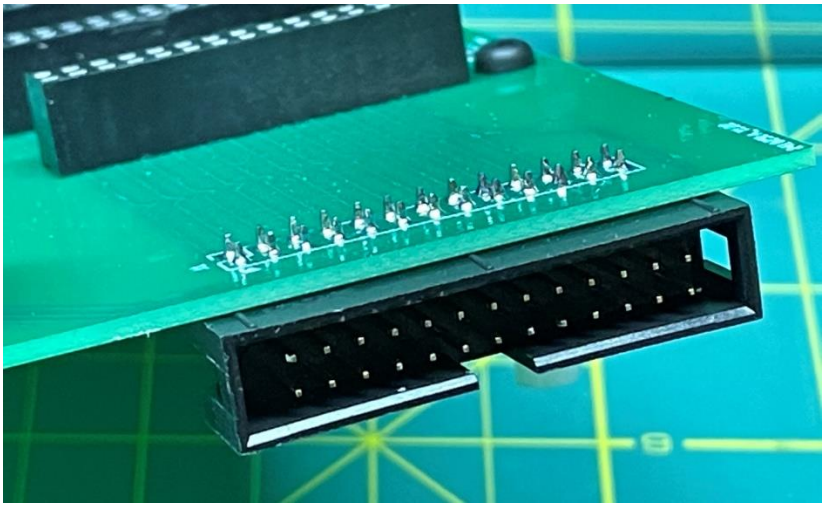
Assemble the heat sink to the voltage regulator. First, put the thermal pad in place then attach the regulator with the included washer and bolt.



Solder the regulator to the PCB as shown, and add a 0.33uF (334) capacitor on the left and a 0.1uF (104) capacitor on the right. The polarity of the capacitors is not critical.

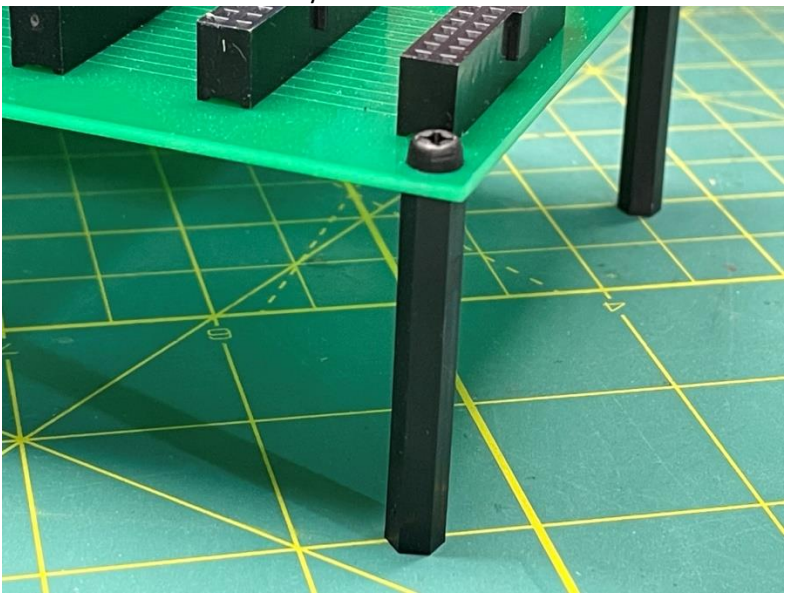


Solder the 26-pin male shrouded header to the bottom of the circuit board. **NOTE: I cannot overemphasize placing the shrouded connector at the BOTTOM of the circuit board as shown.**

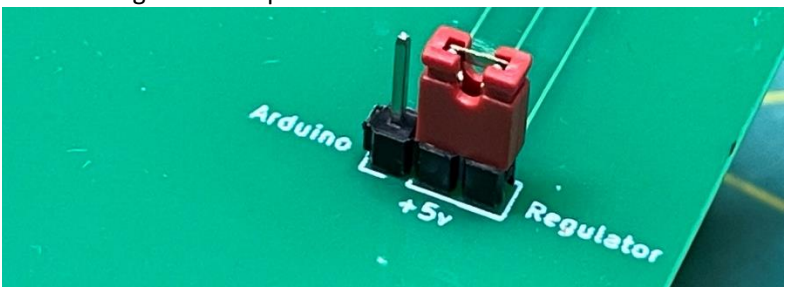


You may be tempted to place it on top (like the other components) – I know I have made this mistake…

Attach the 40mm nylon standoffs at the outside edge of the circuit board with two 6mm M3 nylon bolts.



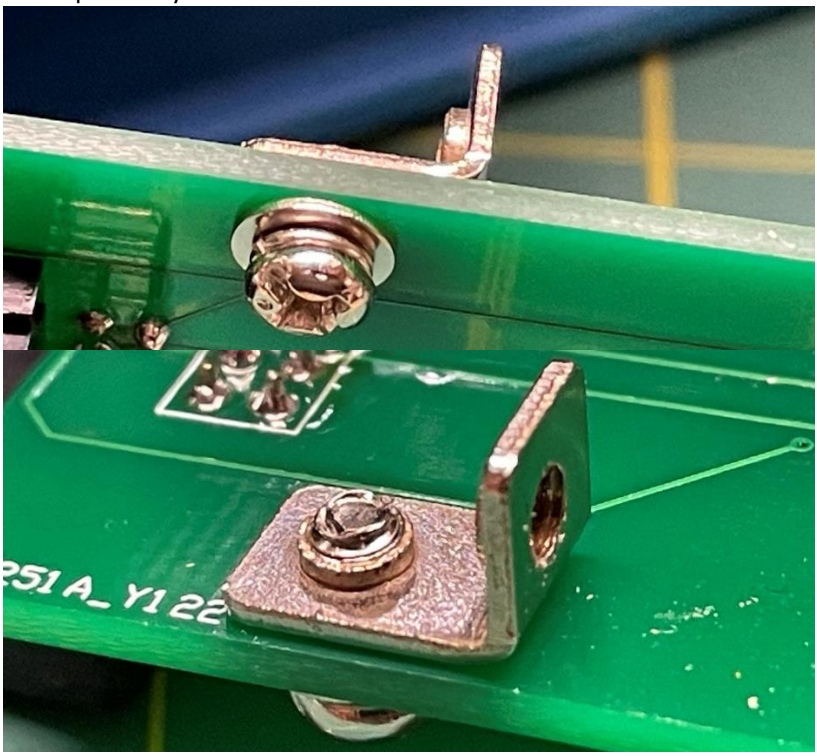
Add a jumper to the “+5v” power selector. This selects the source of the voltage to the expansions cards.



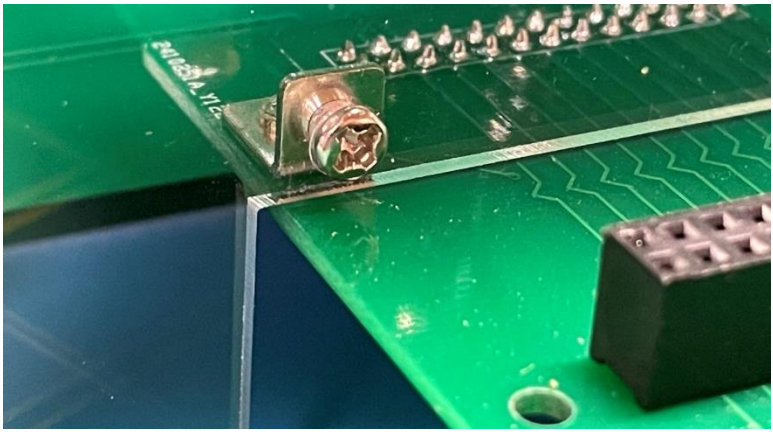
In general, you should select “Regulator” which provides power from the L7805CV regulator, but this will only provide power when the kit is powered from a plug-in 9-12v power adapter (included.) Selecting “Arduino” will power the cards from the Arduino’s internal regulator. That means power will be available when the kit is powered from a USB connection, but this power supply is limited and may not be sufficient for multiple expansion cards.

Install the two L-brackets with 6mm M3 bolts to hold your expansion bus securely in place.

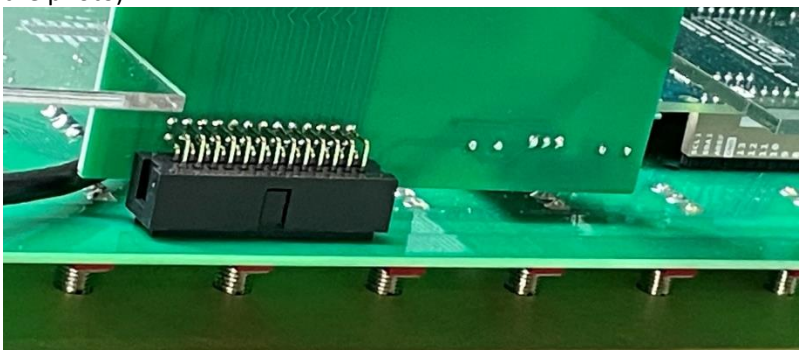
The two side of the L-bracket are slightly different. Attach the longer side to the bus circuit board with an M3 bolt, trying to make it as square as you can.



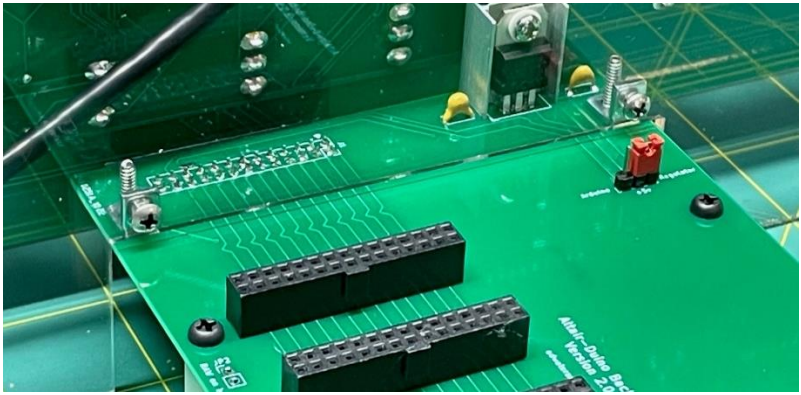
Your expansion bus circuit board is complete and may be plugged into the main unit. Be sure to have the brackets sit behind the clear acrylic back. Wiggle the expansion board back and forth to get it to sit firmly in the shrouded male header. Secure it in place with two 6mm M3 bolts



Here is a view from below (with the aluminum frame removed for the photo):

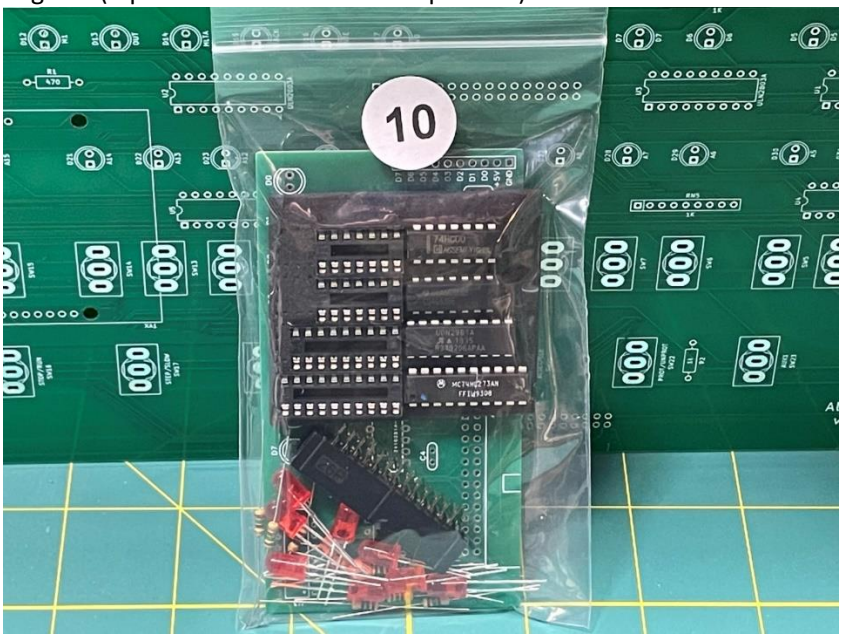


And here is a view from above:

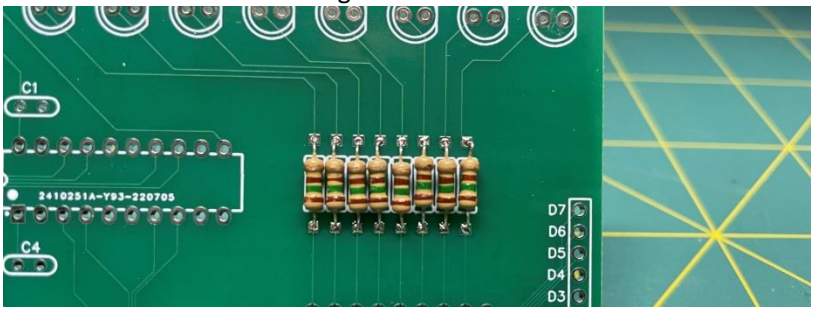


Your Altair-Duino Experimenter kit is complete and can be powered up and tested.

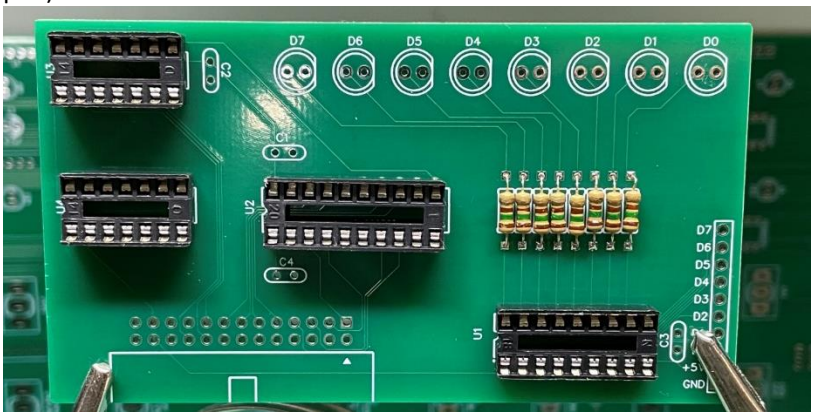
But as long as the soldering iron is still hot, you may want to continue and build your first expansion card with the contents of bag #10 (if purchased with the bus expansion).



Start with the resistors. All eight resistors are 150Ω.

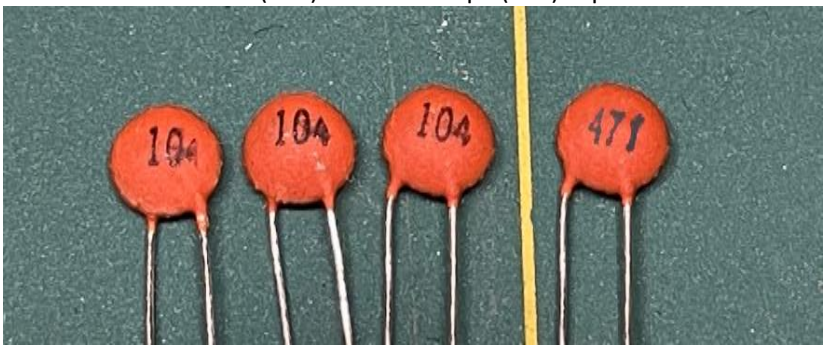


Next add the four DIP sockets (two 14-pin, one 18-pin, and one 20-pin.)

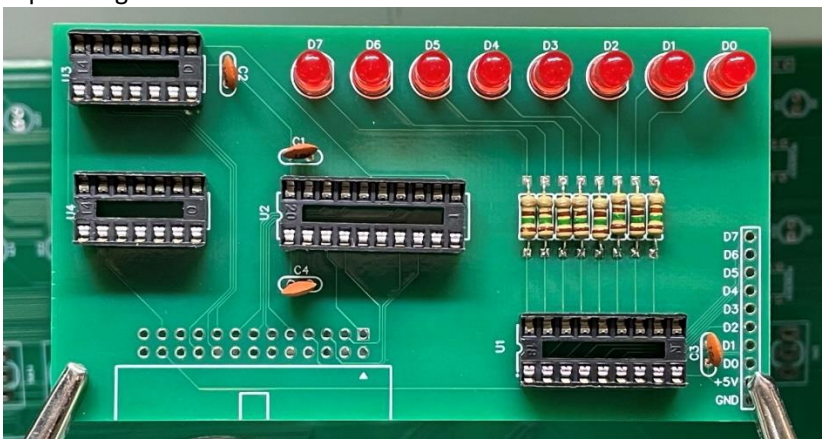


Add the eight LEDs next, with the long lead in the left hole and the flat part of the LED to the right.

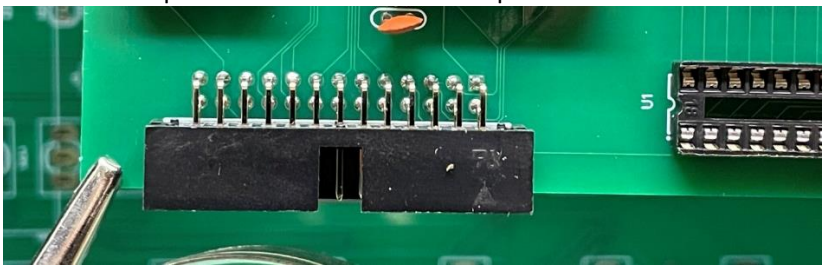
Next we'll add the four capacitors. Look at the capacitors carefully, there are three 100nF (104) and one 470pF (471) capacitors.



The 104 capacitors go in locations C1, C2, and C3. The 471 capacitor goes in location C4.

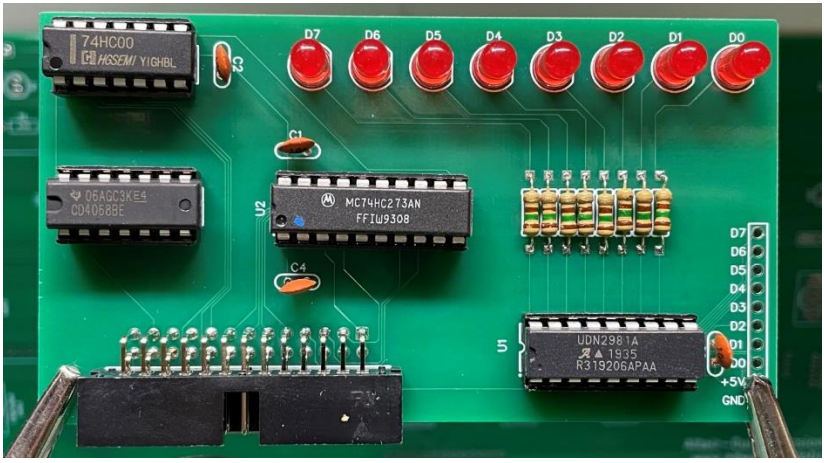


Solder the 26-pin shrouded male header in place.

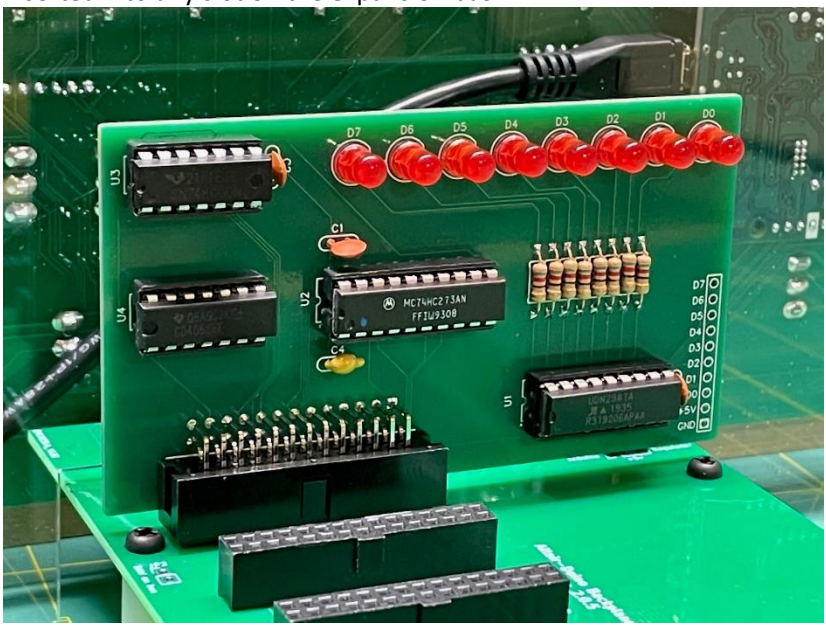


Insert the ICs as follows:

U1 - UDN2981A
U2 - 74HC273AN
U3 - 74HC00
U4 - CD4068BE



Your LED Output Register expansion card is complete and may be inserted into any slot on the expansion bus.



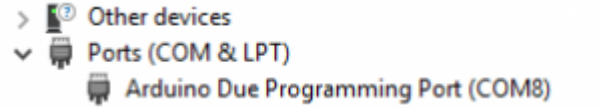
CONGRATULATIONS! YOUR ALTAIR 8800 IS COMPLETE!

See the web page www.adwaterandstir.com/operation for full documentation and easy step-by-step things to do.

Here are a few easy things to try:

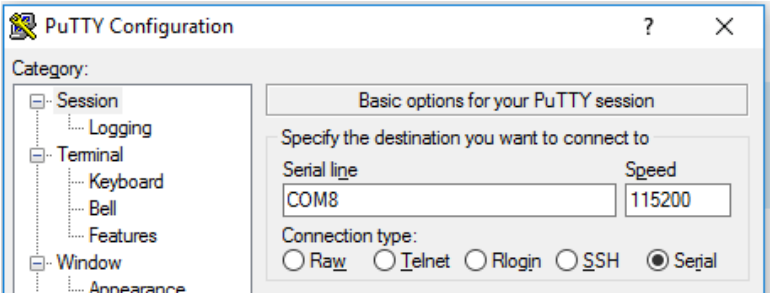
By default, your Altair-Duino is set up to communicate through the USB port.

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

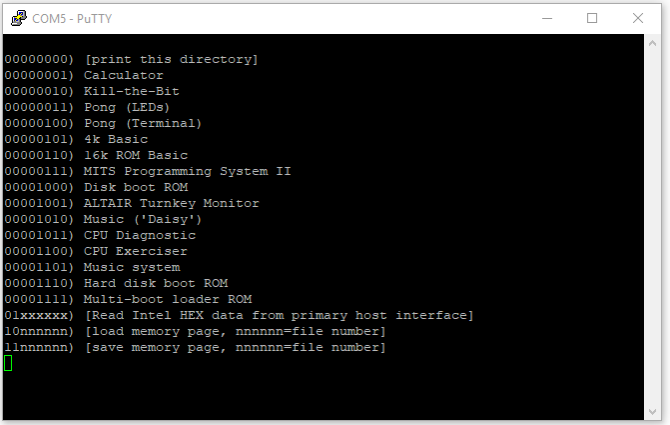


(COM8 is an example, your port may be different.)

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.



NOTE: When connected to a computer via USB, the power switch on the front panel is bypassed and the kit is always in a powered-on status.

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 want to communicate at different serial port settings, you will need to adjust the setting for

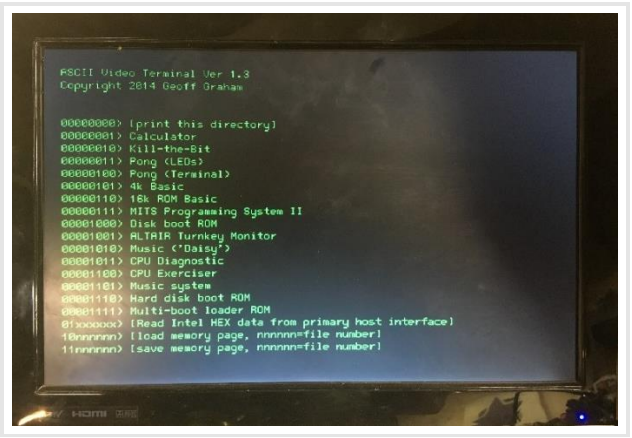
configuration 2 (or create your own configuration). See David Hansel's official project documentation for this information.

https://github.com/dhansel/Altair8800/raw/master/Documentation.pdf

Geoff Graham's VT-100 emulator is available on serial port 1 (using the I/O expansion board):

1. Plug a VGA monitor and USB 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.

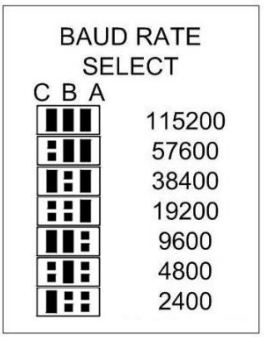
You should see "ASCII Video Terminal Version 1.3 Copyright 2013 Geoff Graham" on the VGA monitor. With all switches down, press AUX1 down. On the monitor, you should see a directory of options for front panel switches.



If you do not see a list of options, most likely configuration 1 did not load from the SD card. Verify the card is inserted, and that you

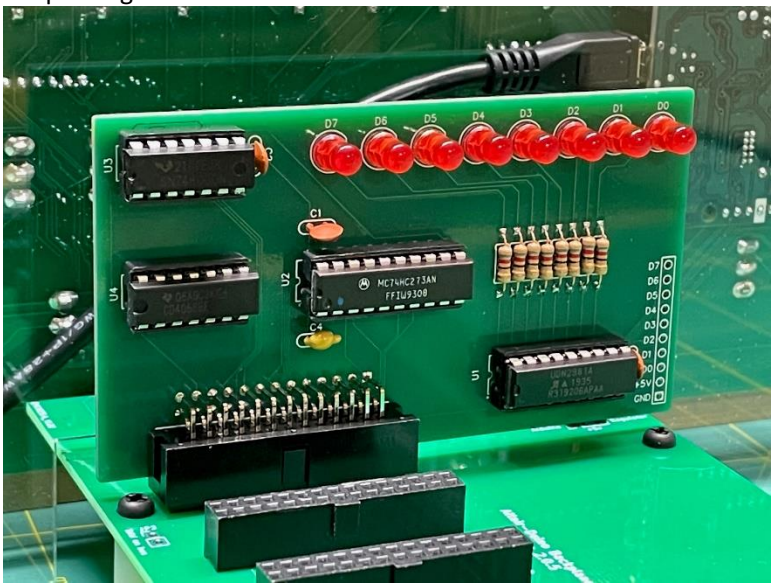
can read from the SD card (try this while connected via USB to your laptop/desktop computer).

Baud rates for the VT100 emulator (only):
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:



The baud rate jumpers MUST match the baud rate set in the configuration menu for pin 18/19. I would encourage you to leave it set to the default 9600 baud. Other baud rates for the DE9 serial port (9600 default) and USB serial port (115200 default) are controlled in the configuration menu.

Now that you're connected to your Altair-Duino, let's try the LED Output Register.



You need to get into any version of BASIC - MBASIC, Altair BASIC, or the easiest way is to launch Microsoft 16k ROM BASIC by simply raising the AUX1 toggle.

You'll be prompted with "MEMORY SIZE?" Press Enter to accept the default. The next prompt is "LINE PRINTER?" Type an uppercase "O" (for Okidata) and press Enter.

You're now at a BASIC prompt.

Type "OUT 255, 45" and press Enter. If all works correctly, you'll see a binary representation of 45 on the LED register.

To output a value to the LEDs in BASIC just execute "OUT 255,x" where x is a byte value (0-255). The LEDs will display the binary representation of the given value.

Here's a simple BASIC program that will flash the LEDs repeatedly in a random pattern:

```
10 X = INT(RND(1) * 255)
20 OUT 255, X
30 FOR I = 1 TO 100
40 NEXT I
50 GOTO 10
```

Please see the website (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).

Visit David Hansel's Github page for his notes and designs for more expansion cards: github.com/dhansel/Altair8800-IOBus.