

# Altair-Duino 2.0

## Experimenter 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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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 (round toggles included with 8800, flat toggles with 8800b)

#### Bag #4

- 36 x 5mm Red LEDs

#### Bag #5

- 5 x ULN2803APG
- 1 x SP3232

#### Bag #6

- 4 x 15mm Male-Female Standoffs (12mm with the 8800b version)
- 4 x 10mm M3 Nylon Bolts
- 4 x 28mm Female-Female Standoffs
- 8 x 8mm M3 Bolts
- 2 x M3 Nuts
- 6 x Jumpers

#### Bag #7

- 1 x Expansion Circuit Board
- 1 x DB9 Connector
- 1 x 3.5mm Audio Jack
- 1 x Power Jack
- 7 x 100nF (104) Capacitor
- 1 x 1kΩ Resistor
- 1 x 14-pin Right Angle Header

#### Bag #8

- 1 x 2x4 Female Header
- 1 x ESP-01s Module

#### 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
- 1 x 26-pin Male Header

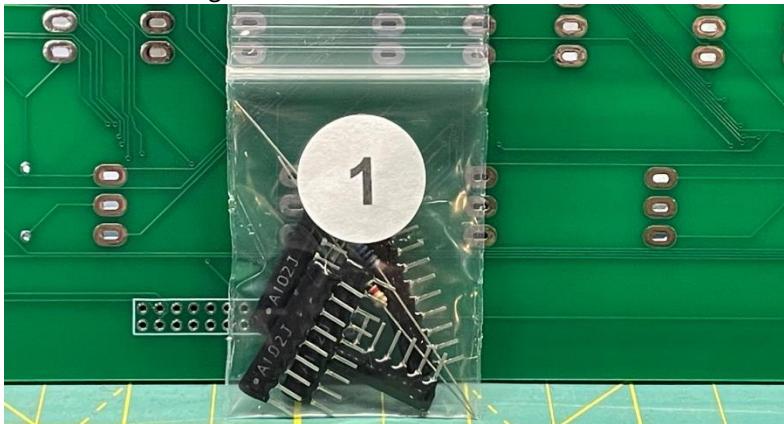
- 4 x 28mm F-F Standoffs
  - 4 x 6mm M3 Nylon Bolts
  - 2 x #4-40 ½" Bolts
  - 2 x #4-40 ¼" Bolts
  - 2 x L-Brackets
- Bag #10:
- LED Output Circuit Board
  - 8 x 150Ω Resistors
  - 8 x 5mm LEDs
  - 3 x 100nF (104) Capacitors
  - 1 x 470pF (471) Capacitors
  - 2 x 14-pin DIP Sockets
  - 1 x 18-pin DIP 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 Bus Circuit Board
  - 1 x Altair Metallic Sticker (included with 8800 version)
  - 1 x Main Circuit Board
  - 1 x Arduino Due
  - 1 x USB Extension
  - 1 x Micro USB Cable
  - 1 x 9v Power Supply
  - 1 x Micro SD Module
  - 1 x Micro SD Card
  - 1 x Acrylic Spacer (included with 8800b version)

## 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:

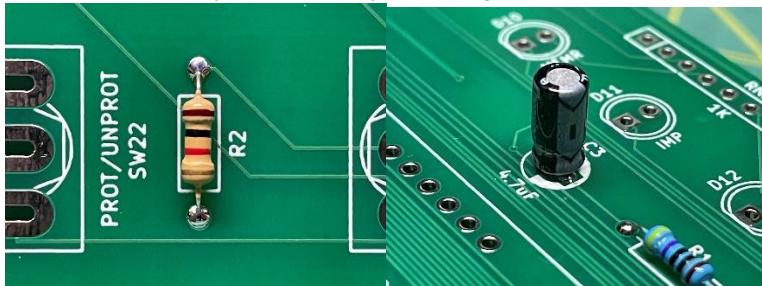
1k (Brown-Black-Red)



470 ohm (Yellow-Violet-Black-Black)



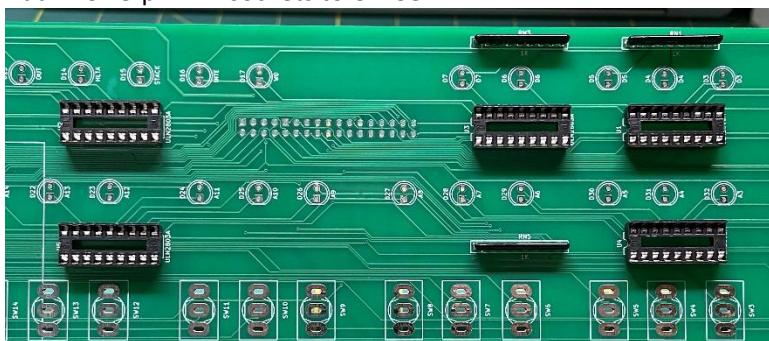
Add the 47uF Capacitor and the 470 ohm and 1k ohm resistors in C3, R1 and R2. (If your board says 4.7uF, ignore that – it is 47uF.)



Bag number 2 is next.



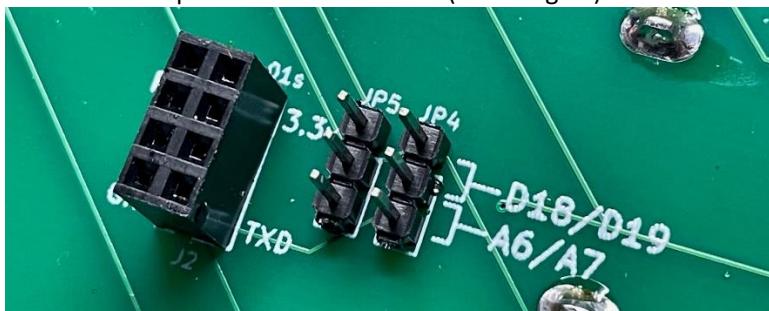
Add five 18-pin DIP sockets to U1-U5.



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



Add two 3-pin segments to the rear of the board in JP4 and JP5. Also add the 8-pin female header in J2 (from bag #8).



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.

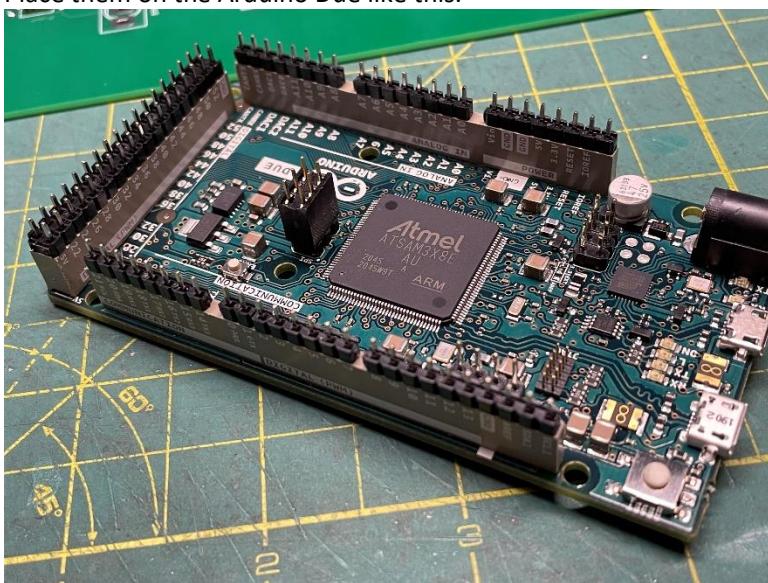


We’re going to use the Arduino Due to hold the pin headers temporarily while we solder them to the main circuit board. Cut (or locate) the following segments:

- 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



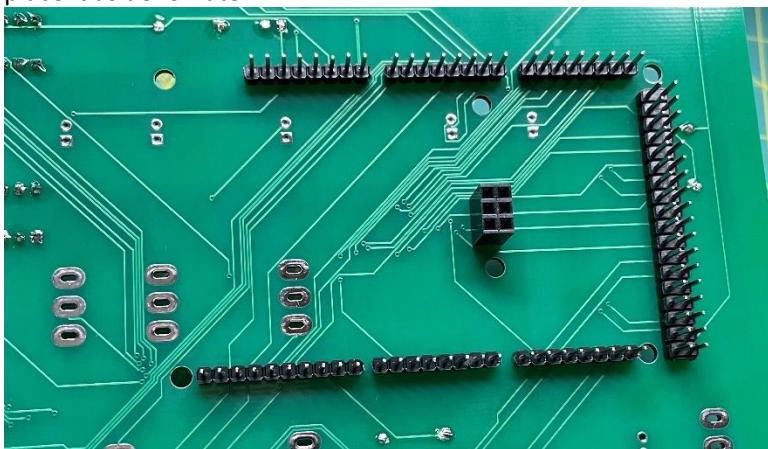
Place them on the Arduino Due like this:



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.



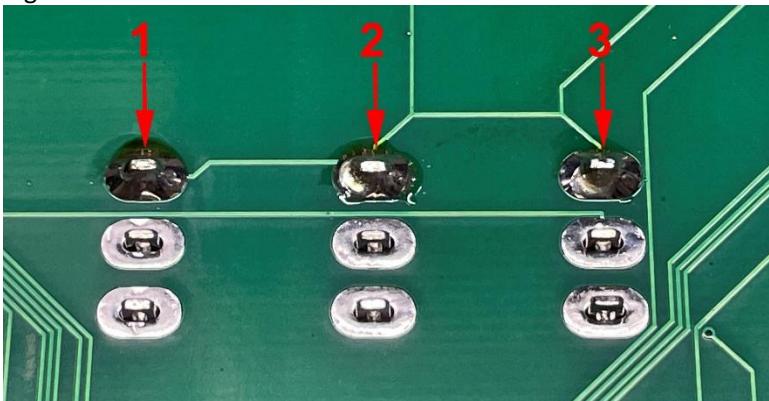
Next, we'll add the toggle switches from bag number 3.



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.



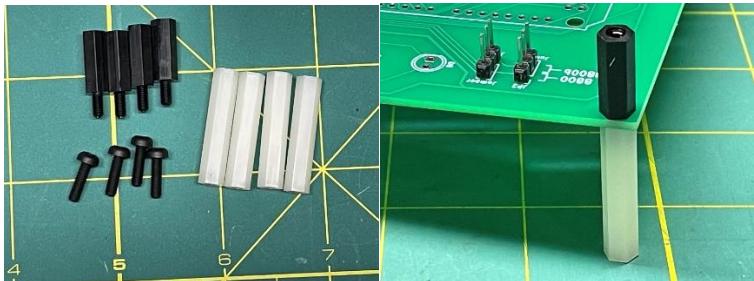
Be careful that you don't over-heat the toggle switches while soldering. This can damage the switch mechanism. Instead of soldering all three lugs on the toggle one after the other, I solder the top lugs on all switches, then the center lugs, then the bottom lugs like this:



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

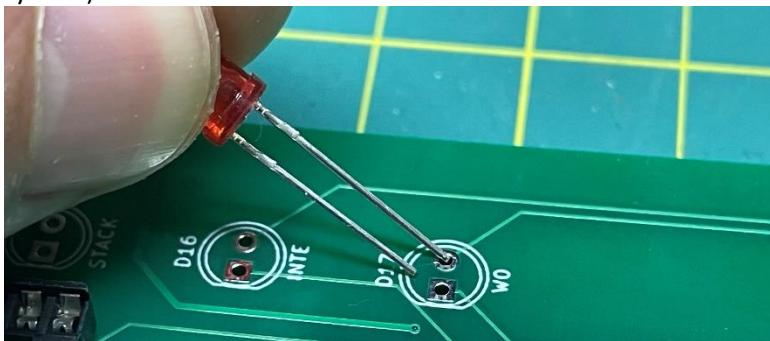


From bag number 6, get four 15mm and four 28mm standoffs, and four 10mm bolts.



We're going to temporarily add the standoffs to the main circuit board with the 15mm on top and 28mm on the bottom. If you have the 8800b variation, you have 12mm standoffs instead of 15mm.

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):



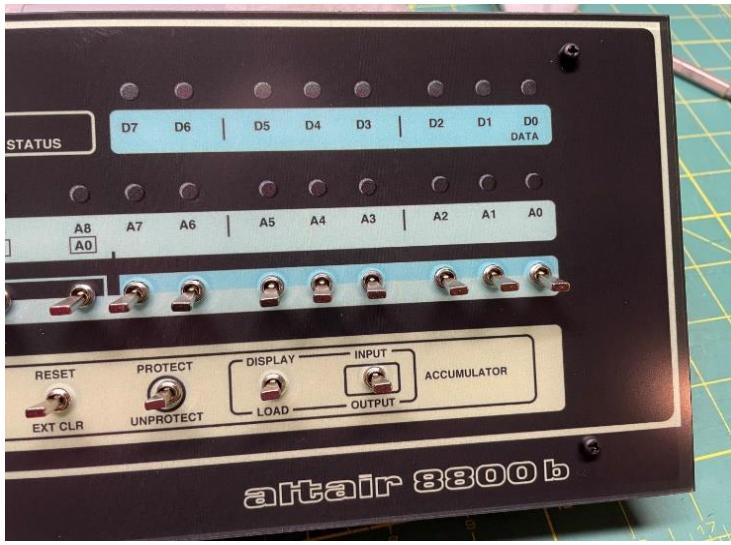
If you have the 8800b variation:

Place the acrylic spacer over the front.



If there is printing on the front mask, remove that. However, leave the mask on the rear, as it will lessen light leakage.

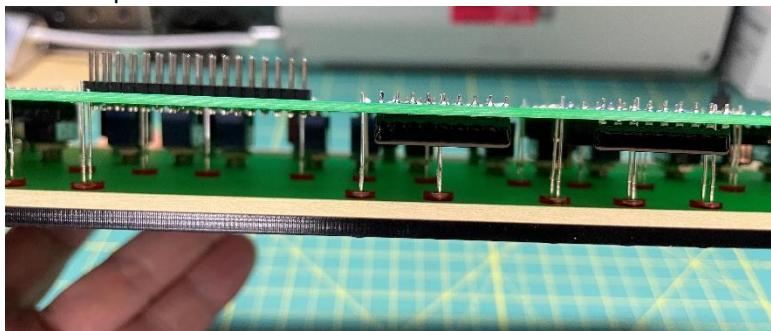
Place the front panel over the spacer and secure with 10mm nylon bolts.



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 if you are building an 8800 replica, or at the bottom if you are building an 8800b.



On the back place two jumpers in J4 and J5 in the top positions. Also place the ESP-01s module from bag #8 in place facing left (as shown).



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

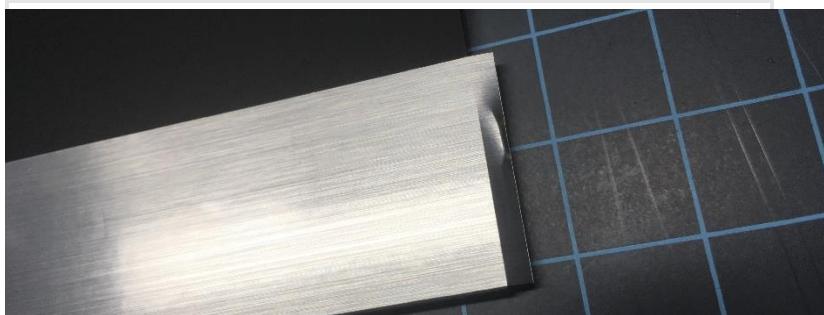


This is a good time to test your Altair-Duino. Plug a micro USB cable into your Arduino and connect it to a computer (or other USB power supply.) Try launching Kill-the-Bit by setting SW1 up and lower AUX1 as seen in this video: [adwaterandstir.com/FirstTest](http://adwaterandstir.com/FirstTest). Next,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

You may attach the front panel to your Altair-Duino, but first you need to add the metallic sticker. 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.

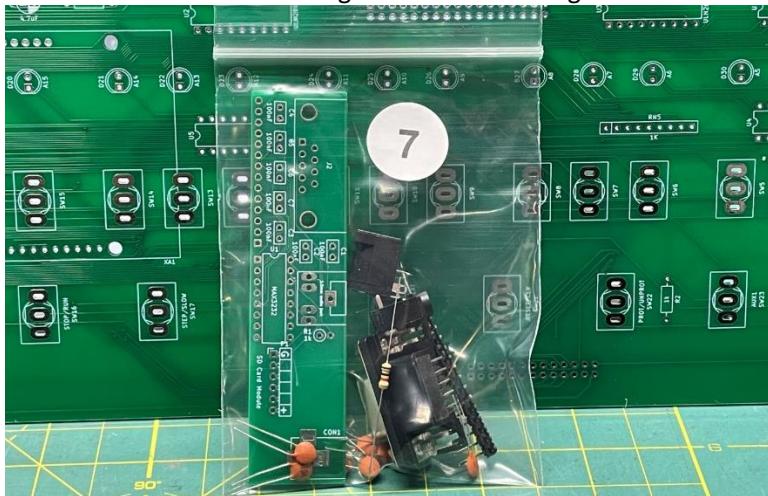


Your label will be a little bit longer than the front panel.

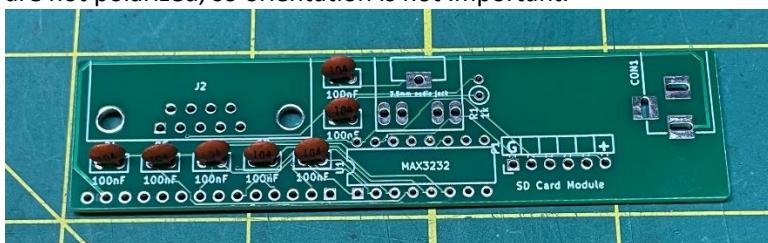


You may wrap the excess around the edge of the panel or trim it with a sharp razor.

Next we will work on the daughter board. Get bag number 7.



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



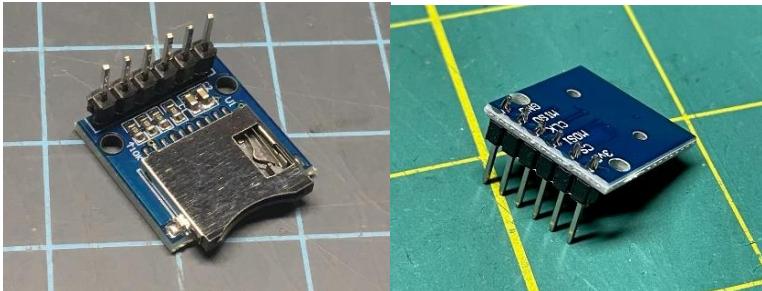
The 1k resistor mounts vertically.  
Resistor code: 1k (Brown-Black-Red)



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:



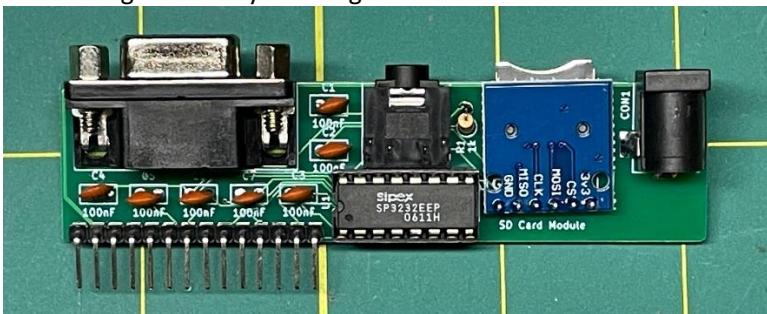
Solder the audio jack and SD module to the circuit board.



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 paper. I'm going to leave it on so it shows up more plainly in a few photos. Attach the rear ports panel with two 8mm 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.



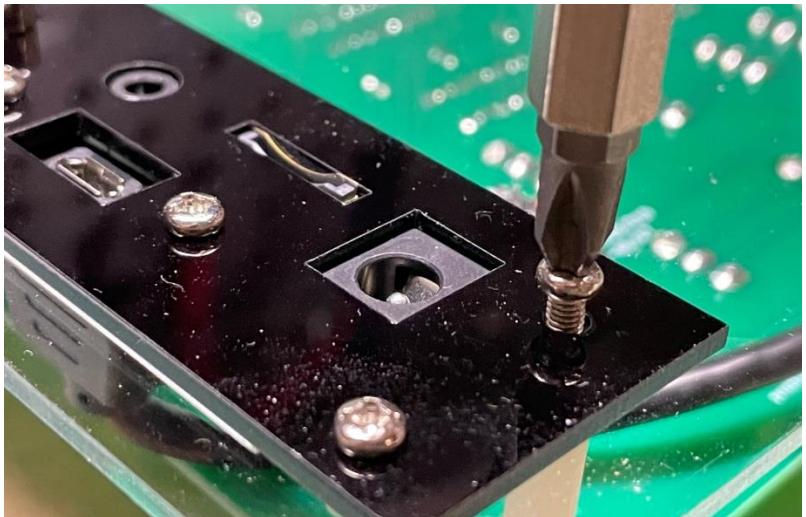
Plug the USB extension cable into the Programming Port on the Arduino Due (the port closest to the power jack.)



Insert the 14-pin male header into the 14-pin female header, and route the USB extension cable as shown.



Secure the clear panel to the 28mm standoffs with four 8mm M3 bolts.



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



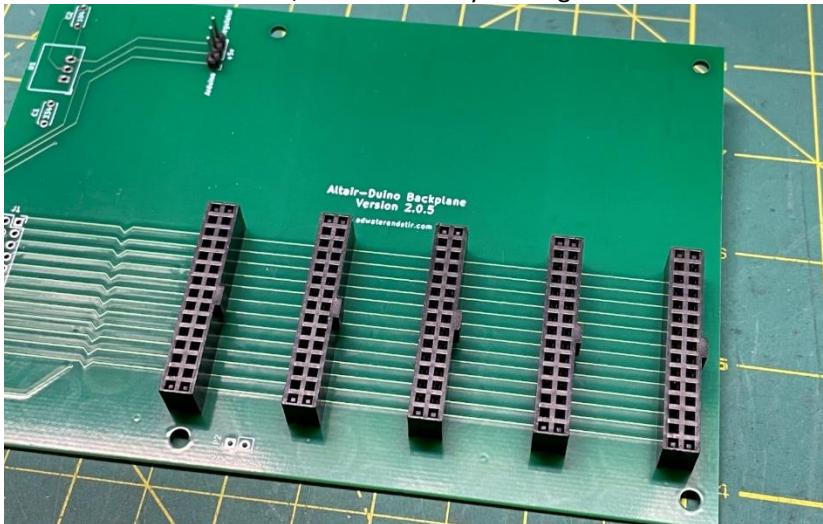
Next we will build the bus board. Get the PCB and bag #9.



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.



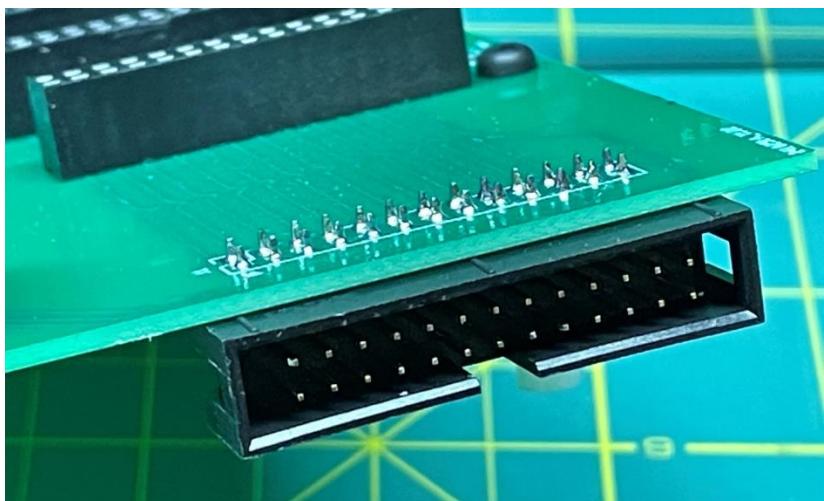
Assemble the heat sink to the voltage regulator. First, put the thermal pad in place then attach the regulator with the included washer and bolt.



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.

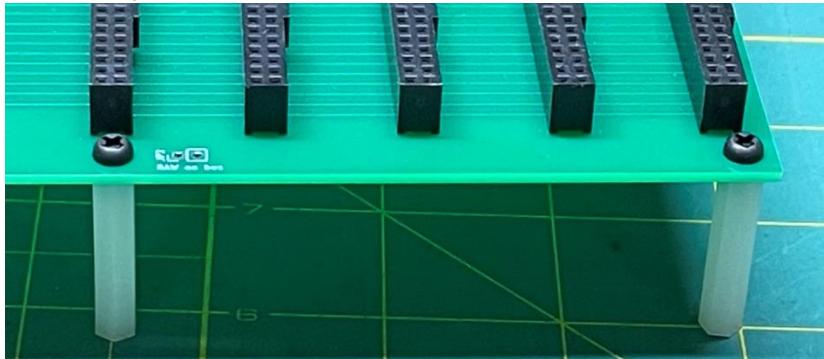


Solder the 26-pin male shrouded header to the bottom of the circuit board. **NOTE: I cannot overemphasize placing the shrouded connector at the BOTTOM of the circuit board as shown.**



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

Attach the 28mm nylon standoffs to the circuit board with four 6mm M3 nylon bolts.



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



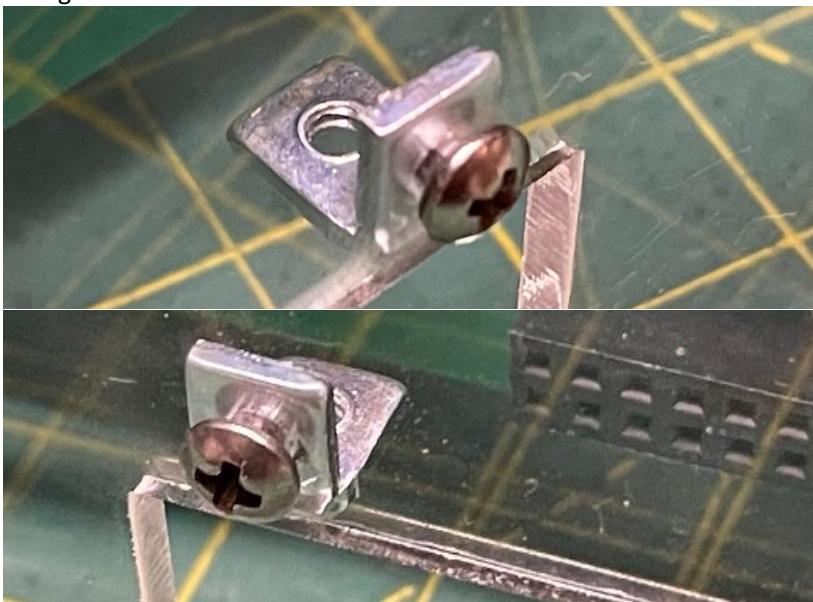
In general, you should select “Regulator” which provides power from the L7805CV regulator, but this will only provide power when the kit is powered from a plug-in 9-12v power adapter (included.) Selecting “Arduino” will power the cards from the Arduino’s internal regulator. That means power will be available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

The next part is optional but you may want to install the two L-brackets to hold your expansion bus securely in place.

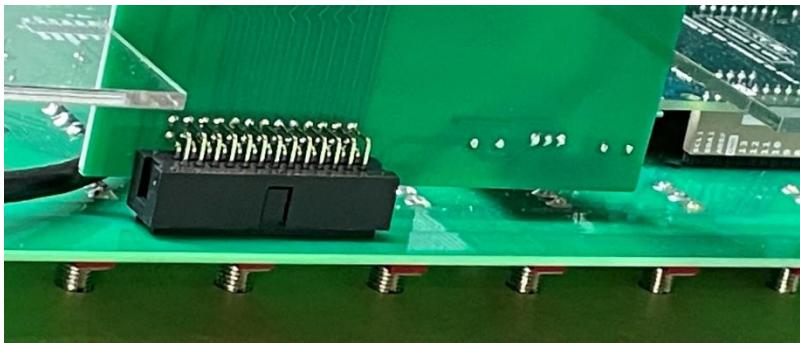


**Note:** these are #4-40 bolts, not M3 like in the rest of your kit.  
Don't get them mixed together.

The two sides of the L-bracket are slightly different. Attach the smaller side to the acrylic back with the  $\frac{1}{4}$ " bolt, with the other end facing down as shown.



Your expansion bus circuit board is complete and may be plugged into the main unit. Here is a view from below:



You can attach the expansion bus board to the L-brackets with the  $\frac{1}{2}$ " bolts from below.



And here is a view from above:

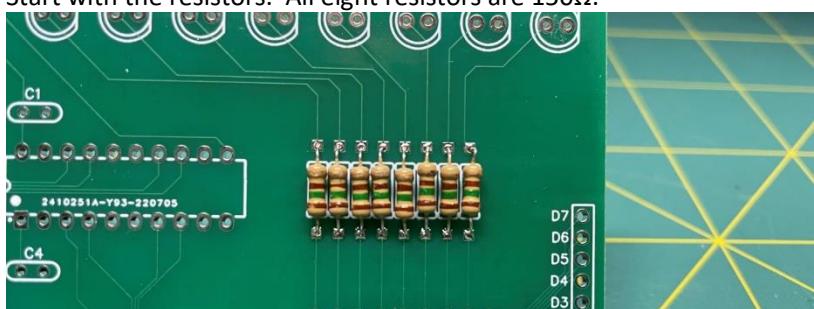


Your Altair-Duino Experimenter kit is complete and can be powered up and tested.

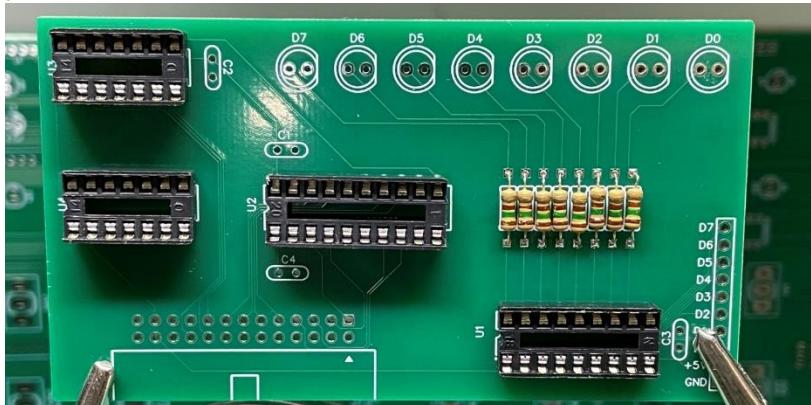
But as long as the soldering iron is still hot, you may want to continue and build your first expansion card with the contents of bag #10.



Start with the resistors. All eight resistors are  $150\Omega$ .



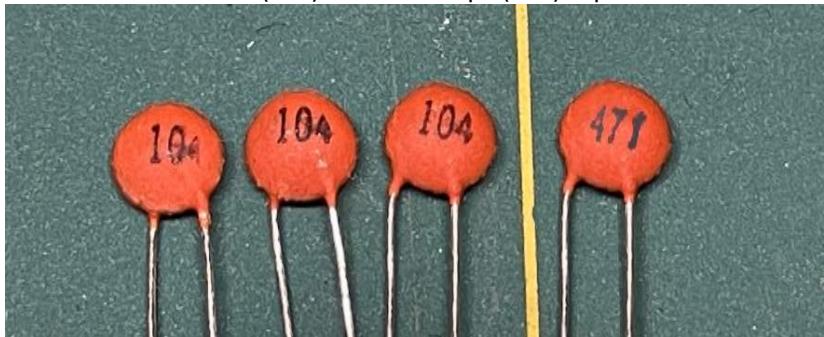
Next add the four DIP sockets (two 14-pin, one 18-pin, and one 20-pin.)



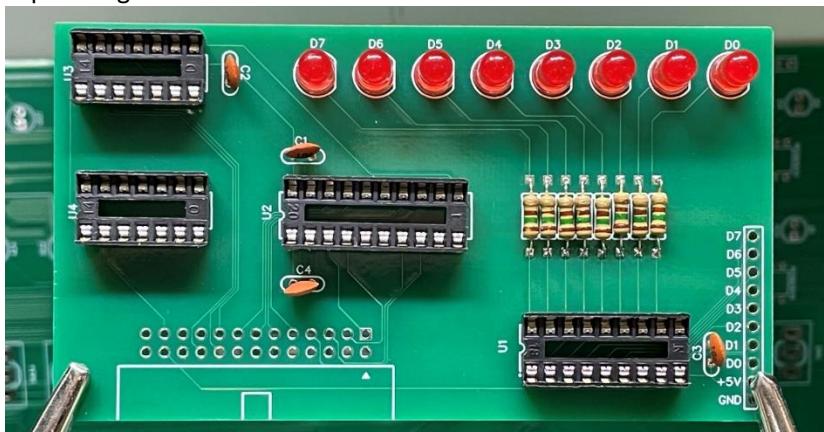
Add the eight LEDs next, with the long lead in the left hole and the flat part of the LED to the right.



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.



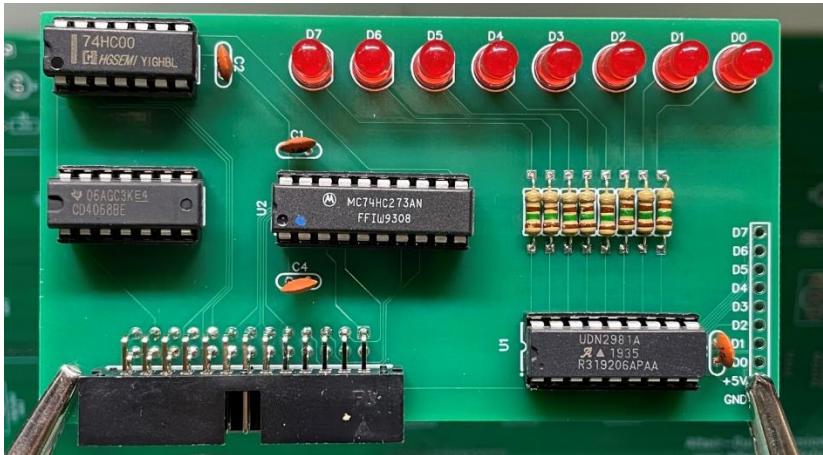
Insert the ICs as follows:

U1 - UDN2981A

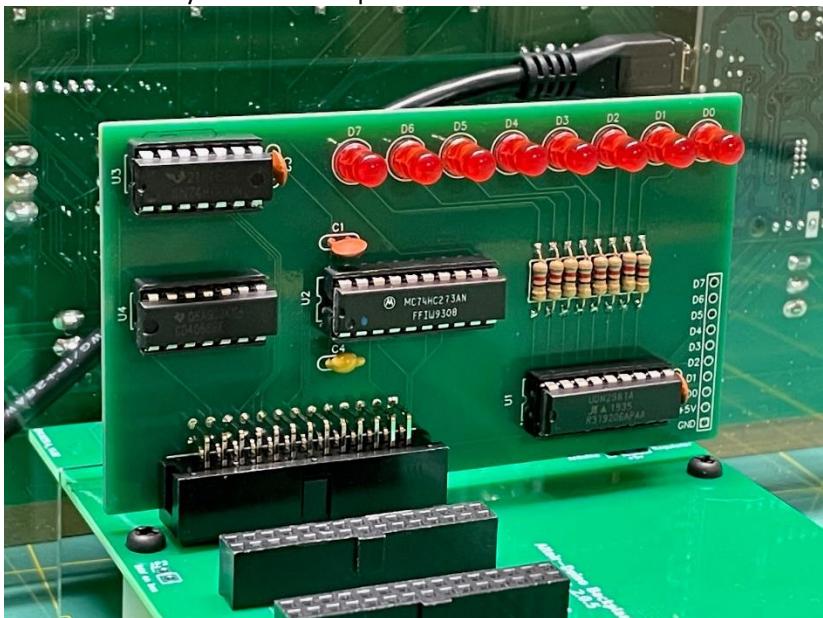
U3 - 74HC00

U2 - 74HC273AN

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!

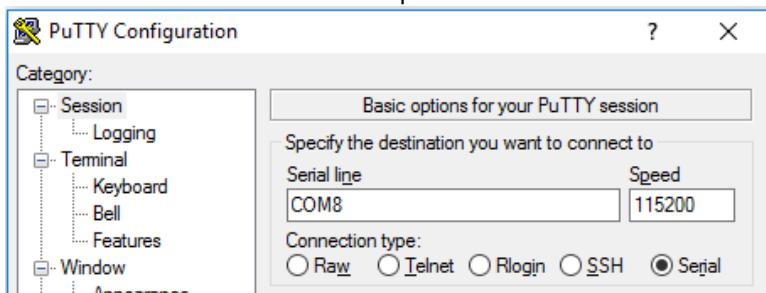
See the web page [www.adwaterandstir.com/operation](http://www.adwaterandstir.com/operation) for full documentation and easy step-by-step things to do.

Here are a few easy things to try:

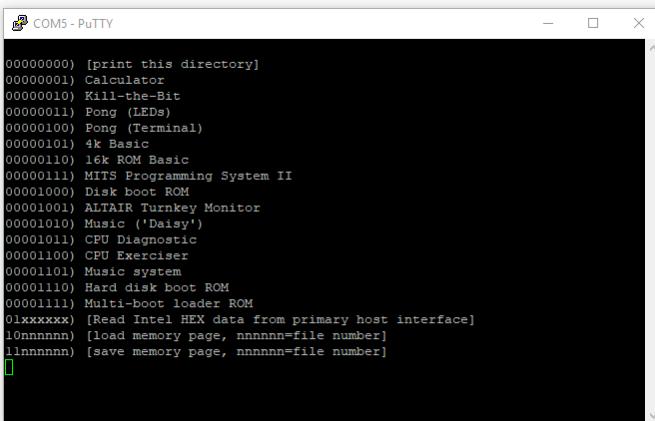
**By default, your Altair-Duino is set up to communicate through the USB port.**

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”.  


(COM8 is an example, your port may be different.)
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, nnnnn=file number]
11nnnnnn) [save memory page, nnnnnn=file number]
```

**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):**

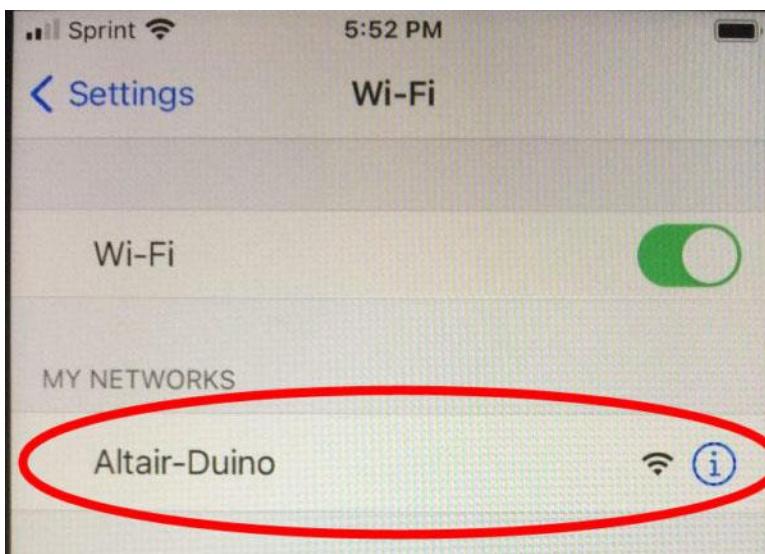
1. Plug a serial cable from the Altair-Duino to your serial device.
2. Connect a power supply to the Altair-Duino.
3. **Make sure the SD card is inserted.**
4. Set front panel data switches to “2” (switch 1 up, all other switches down).
5. Raise (and hold) DEPOSIT up.
6. Turn on Altair-Duino.

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.

## How to use the ESP-01s WiFi Module:

We're going to want to direct the input/output of the Altair-Duino to pins 18/19 of the Arduino. The default is to use the USB connection for communication. Fortunately, configuration #1 on the SD card is set to use pins 18/19 for input/output. Make sure the SD card received with your kit is inserted into the SD card reader. Raise SW0 and leave all other switches down. Hold DEPOSIT up, and turn the power on. You can release DEPOSIT. This instructs the Altair-Duino to load configuration #1 from the SD card.

Now that the Altair-Duino is powered up, grab your smart phone or computer and look at the available WiFi connections. You should see a new WiFi SSID called "Altair-Duino". Select that network.



Once that connection is selected, you will be directed to a captive portal to select your WiFi network. Click "Configure WiFi". If you do not see this page, you can open a browser and navigate to 192.168.4.1.

# Altair-Duino

## WiFiManager



This is how you tell your Altair-Duino which WiFi to connect to. Select your WiFi network and enter your password. Click "Save". In less than 30 seconds, the captive portal should close. Your Altair-Duino is now connected to your WiFi network.

Open a browser and try to connect to "altair.local". Did it work? It may or may not work, this depends on your wifi router.

If it doesn't work for you, download a free utility called Advanced IP Scanner ([www.advanced-ip-scanner.com](http://www.advanced-ip-scanner.com)). This will scan your network for connections.

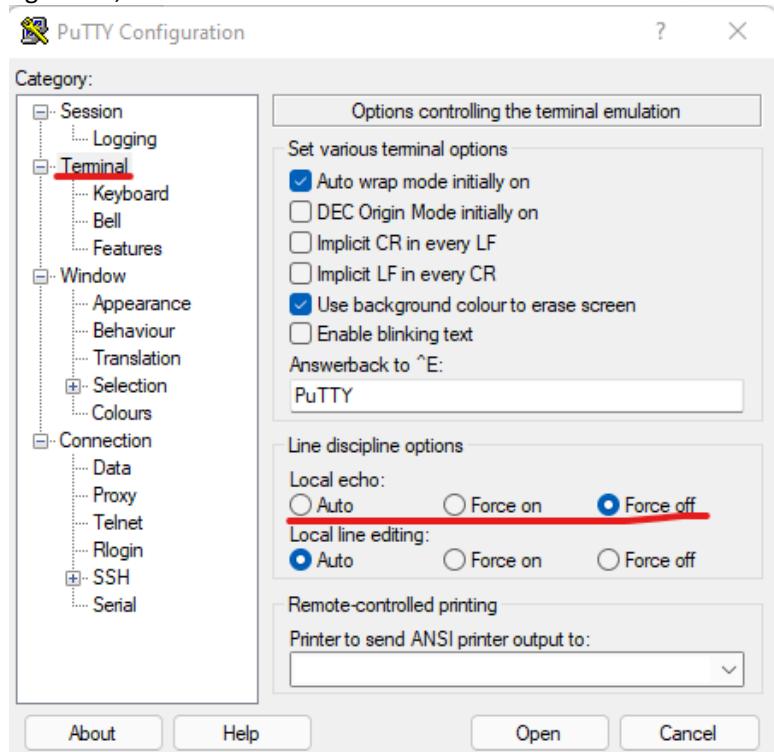
The screenshot shows the results of a network scan. The table has columns for Status, Name, IP, Manufacturer, and MAC address. A red circle highlights the row for "DESKTOP-BD38B56" (IP 192.168.1.152). Other entries include "Vickis-MacBook-Air", "Vickis-iPad", "none", "192.168.1.85", "YOUR-MOM", and "altair".

Status	Name	IP	Manufacturer	MAC address
>	192.168.1.65	192.168.1.65		7E:BC:46:1E:F7:0B
	Vickis-MacBook-Air	192.168.1.72		14:7D:DA:79:53:5A
>	192.168.1.73	192.168.1.73	Apple, Inc.	FC:FC:48:54:34:70
	Vickis-iPad	192.168.1.74		66:EC:67:96:09:29
>	none	192.168.1.76		08:84:9D:38:7C:FF
>	192.168.1.85	192.168.1.85	Dell Inc.	00:1A:02:2A:63:03
>	YOUR-MOM	192.168.1.118	Microsoft	58:82:A8:70:CE:73
>	DESKTOP-BD38B56	192.168.1.152	GIGA-BYTE TECHNOLOGY CO.,LTD.	E0:D5:E2:24:B0:44
>	altair	192.168.1.152		E8:DB:84:98:A0:19
<	HTTP, ESP8266 Telnet-to-Serial Bridge	192.168.1.154	SAMSUNG ELECTRO-MECHANICS(THAILA...	C0:97:27:30:AF:76
>	192.168.1.154	192.168.1.154		52:54:00:BC:52:4A
>	192.168.1.224	192.168.1.224		52:54:00:BB:32:55
>	192.168.1.225	192.168.1.225		52:54:00:BB:32:55
>	192.168.1.227	192.168.1.227		52:54:00:0D:76:34
<	USER	192.168.1.238	Intel Corporate	84:3A:4B:D3:F3:74

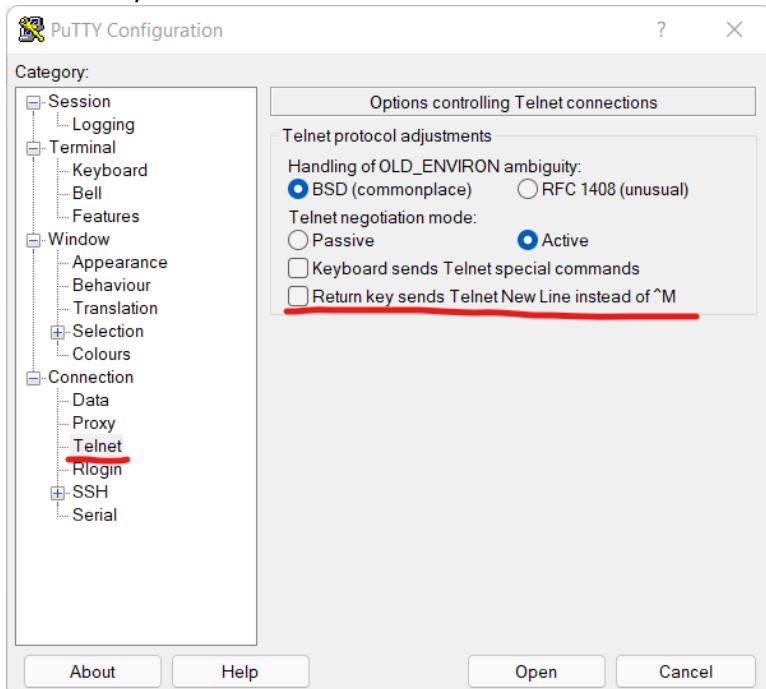
41 alive, 34 dead, 179 unknown

What you're looking for may display a name of "altair" and a manufacturer of "Espressif Inc", but it may not. It should also show a ">" next to it indicating there is a service. When expanded, it should display "HTTP, ESP8266 Telnet-to-Serial Bridge". Remember this IP address.

Open Putty and select a connection type of Telnet. Enter the IP address (or "altair.local" if that works for you). You'll also want to change a couple settings. Under "Category", click "Terminal". On the right side, set Local echo to "Force Off".



Under "Category" on the left, click Connection > Telnet. Make sure "Return key sends Telnet New Line instead of ^M" is unchecked.

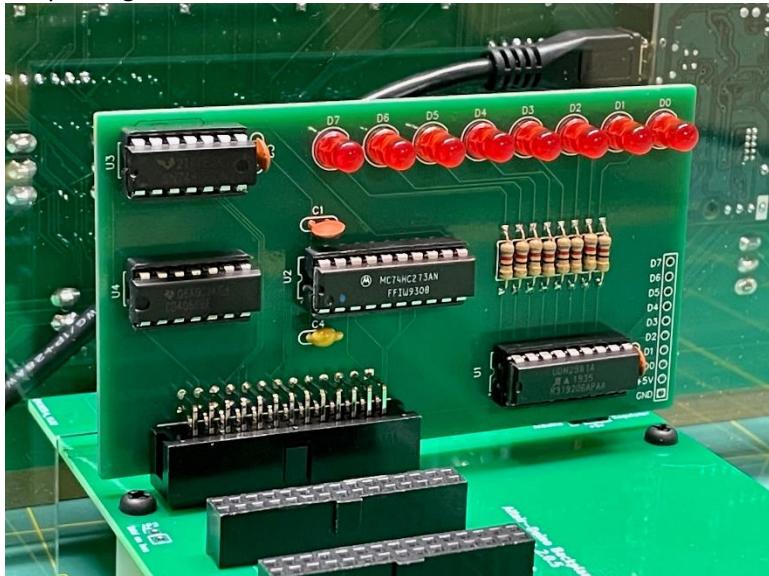


Click "Open".

The next thing you see will be an empty black window. On your Altair-Duino, make sure all switches are down, then press AUX1 down. Do you see a list of built-in applications? No? Make sure your primary host serial is set to "Serial (pin 18/19)". (That should be what configuration #1 is set to.)

```
192.168.1.152 - 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
00010000) Tarbell disk boot ROM
00010001) Cromemco R DOS 1.0 ROM
01xxxxxx) [Read Intel HEX data from primary host interface]
10nnnnnn) [load memory page, nnnnnn=file number]
11nnnnnn) [save memory page, nnnnnn=file number]
```

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](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)).

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

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.