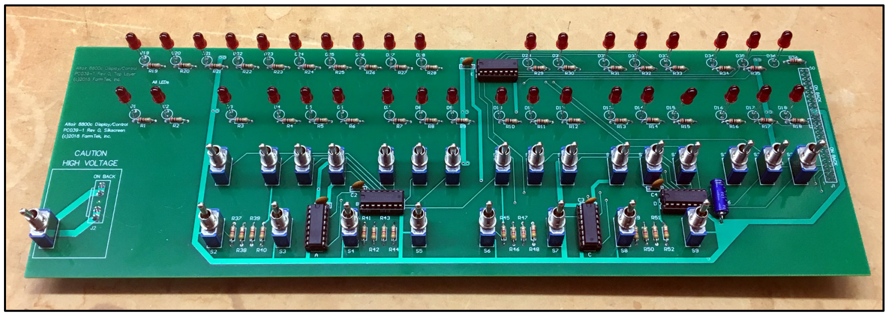
Altair 8800c Front Panel Board Set

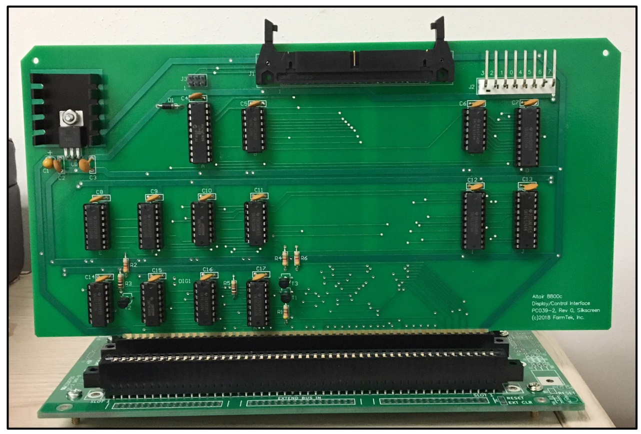
Ver 1.2, Feb 2019

Introduction



The Altair 8800c front panel board set is a drop-in replacement for the original Altair 8800 front panel board. The new board set was created for the following reasons:

1) **Availability**
   Finding an original front panel board to restore or build an Altair is nearly impossible. The new board set provides a drop-in equivalent that is readily available.



2) **Elimination of the Hand-Wired Harness**
   The original front panel board picked up bus signals and connected to the CPU board through a large hand-wired harness. This harness was tedious to build and was often a reliability issue – especially if you had to remove and work on the front panel board. The 8800c board set replaces the hand-wired harness with a 50 pin ribbon cable that connects to a bus interface board (shown here) to pick up and drive the required bus signals.

3) **Mechanical Compatibility with the Altair 8800 Clone Cabinet**
   The original Altair 8800 cabinet made by Optima is no longer manufactured, and like the original front panel board, finding an original cabinet by itself is nearly impossible. As an alternative, the cabinet for the Altair 8800 Clone is still available, however, the original front panel board covers mounting points in the Clone cabinet's front panel bracket. This new front panel board is designed to fit properly in the Clone cabinet's mounting bracket. The new front panel board also fits in an original Altair cabinet.

4) **Compatible with the 8800b CPU Board**
   The original front panel board does not work with an Altair 8800b CPU board and vice-versa. This is due to a change in how the 8800b front panel injects data into the CPU and how it stops the CPU. For increased flexibility, the new front panel set works with both the original and the 8800b CPU boards.

5) **Logic Error Fixes**
   The original front panel board had a few logic problems that are fixed in the new front panel board set. These same problems were also fixed by MITS when they designed the 8800b computer.

CPU "Stop" Timing Error

The Stop switch is designed to put the 8080 into a wait state on an instruction fetch boundary (the M1 cycle). However, due to a timing issue in the run/stop circuit, the front panel doesn't always stop on an M1 cycle.

Indeterminate Power-On State

On power-on, the run/stop flip-flop on the front panel board is not initialized and the 8080 processor is not given a reset signal. These omissions tend to leave the 8080 in an invalid state on power-on. This is why the "STOP/RESET" switch sequence is required to put the computer into a valid state. This fix can be optionally enabled or left like the original.

Reset not Synchronized with phi2

An undocumented 8080 reset timing requirement is that reset be released a minimum of about 200ns prior to the rising edge of phi2. This is implemented in the Intel 8224 clock generator that was used on the 8800b CPU board, but this chip is not used on the original Altair CPU board. The new front panel board enforces this timing for resets generated by the front panel.

Front Panel PRDY Output is not Open Collector

Clients on the bus should drive the PRDY signal with an open collector driver. The signal is terminated on the CPU board with a 1K pull-up resistor. However, the original front panel board actively drives this signal high. Therefore, when any bus client drives PRDY low to insert wait states, its output driver is sinking the active high drive of the front panel's PRDY driver.

6) Enhancements

In addition to duplicating the functionality of the original front panel board, the 8800c front panel board set offers several enhancements that can be optionally enabled:

- An output latch at I/O address 0FFh that can display on the data LEDs (similar to IMSAI 8080)
- Auto repeat single-step at selectable rate from 1hz-8hz, similar to the 8800b
- Code snippet injection: Common Altair bootstrap loaders, port echo routines, Kill-the-Bit, etc. can be injected into RAM by selecting the desired code snippet on the lower eight address switches, then depressing the AUX-Left switch.
- Auto jump on power-on (can be independent of reset operation)
- Auto jump on reset (can be independent of power-on operation)

Front Panel Board Assembly

Assembly of the front panel board is not a beginner's project and these instructions won't teach you how to solder components on a PCB, solder connectors, or show you the difference between a resistor and a diode. If you have any concerns about building this board, please contact me first.

Many assembly details are illustrated in photographs that follow. Rather than print this manual, you may want to view this document on your tablet while you work. A tablet makes it especially easy to zoom into the photos to see the details you may need.

Parts List

Designator	Description	Part Number	Distributor
C1-C5	0.1uf, 50v	2146302	Jameco
C6	100uf, 16v electrolytic	647-TVX1C101MAD	Mouser
D1-D36	Red LED	Everlite HLMPD150A	Digi-Key 1080-1064-ND
J1	50 pin, dual row IDC straight header	517-D3433-6302-AR	Mouser
J2	5-pin, 0.156 locking header	B5P-VH-B-LFSN	Digi-Key 455-1642-ND
	Female Housing	VHR-5N	Digi-Key 455-1186-ND
	Crimp Pins	SVH-21T-P1.1	Digi-Key 455-1133-1-ND
IC-A,B,C,D,E	74LS165 Parallel In Shift Register	595-SN74LS165AN	Mouser
R1-R36	2K, 1/4w, 5%	291-2K-RC	Mouser
R37-R52	4.3K,1/4w, 5%	291-4.3K-RC	Mouser
S1	Toggle Switch On-None-On (Silver)	APEM 5236AB	Search for best deal
S10-S25	Toggle Switch On-None-On (Gold)	APEM 5236CDB	Search for best deal
S2-S9	Toggle Switch (On)-Off-(On) (Gold)	APEM 5237CDB	Search for best deal

Switches

If at all possible, do not use C&K switches for the front panel. The C&K switches have an erratic and stiff feel – especially the momentary switches – compared to the American Switch brand used in the original Altair. In addition, I've had several C&K switches break while gently tightening the bushing nut as well as during normal use. The APEM switch part numbers listed above are much closer to the original American Switch brand. In fact, APEM purchased American Switch a number of years ago.

The power switch must have silver contacts as noted for S1. Ideally, use gold contacts for all remaining switches. Do not mix switch brands as most have slightly different body heights and this causes problems when mounting the front panel to the mounting plate/bracket.

The APEM switches can be expensive. I may be able to help with a bulk buy. Contact me if interested.

Additional Part Notes

Use only LS-TTL parts. Some IC inputs are tied directly to Vcc. Multi-emitter TTL inputs do not tolerate this well (e.g., 74xxx and 74Sxxx).

The specified LEDs provide an appropriate brightness with the 2K resistors specified for R1-R36. You may need to choose a different resistor value if a different LED is used.

Front Panel Assembly Steps

First, insert and solder low-profile parts

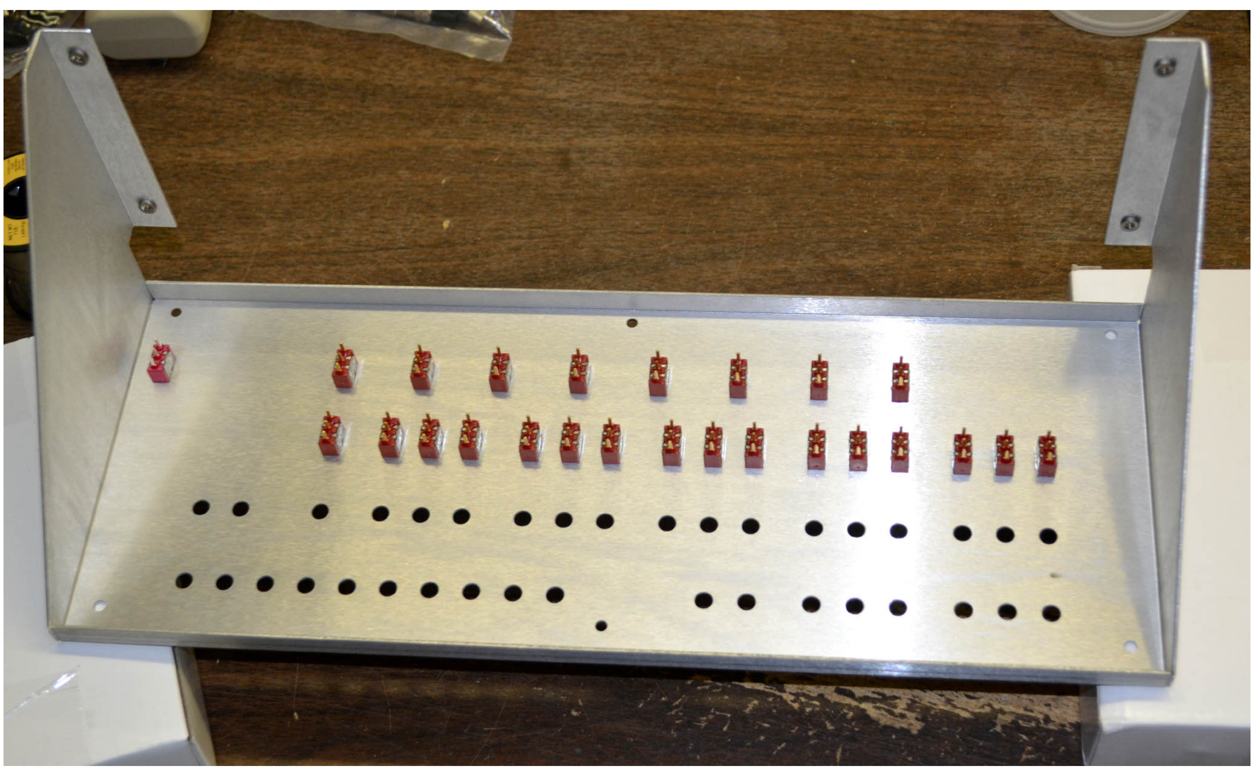
1) Insert and solder R1-R52.
2) Insert and solder IC-A through IC-E (or sockets).
3) Insert and solder C1-C6. Note polarity on C6.

The following instructions for installation of the switches and LEDs assume you have an Altair Clone cabinet. If you're installing in an original Altair cabinet, follow the instructions in the original manual for mechanically aligning the switches and LEDs while soldering into the PCB.

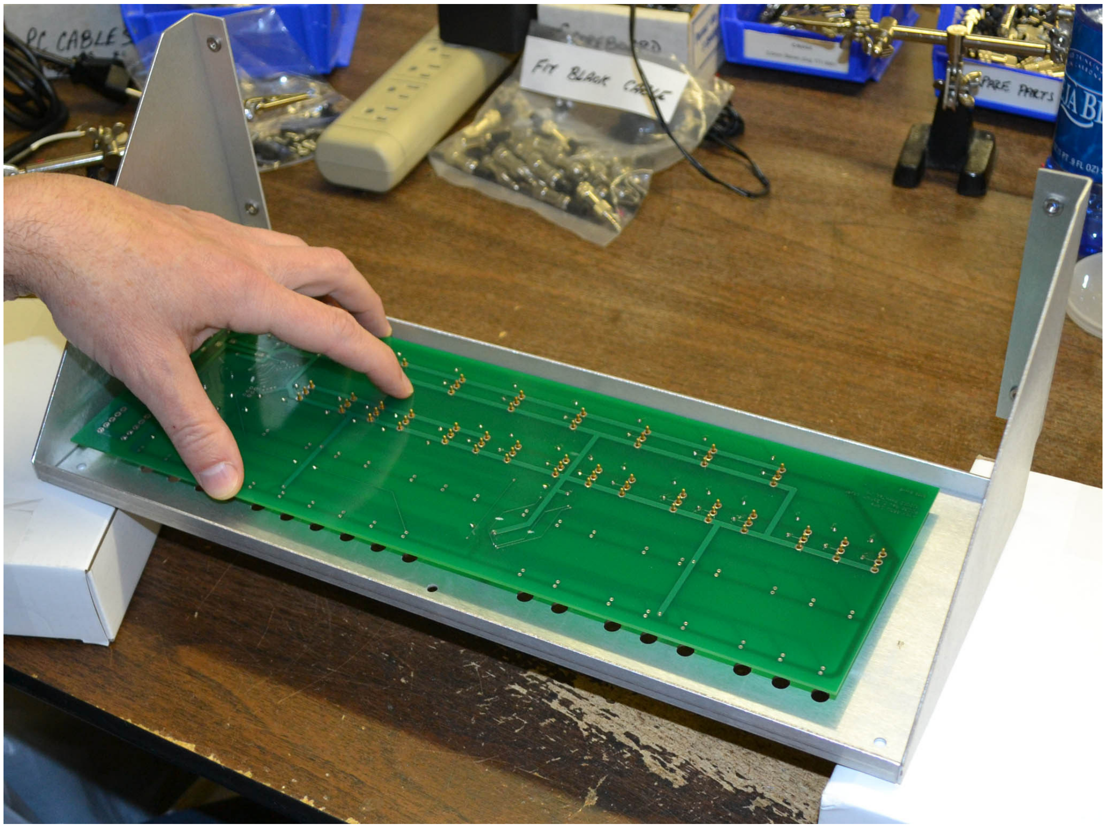
Use the front panel mounting bracket from the Altair Clone cabinet as a jig to help install the front panel switches, S1 through S25. ***Do not attempt to solder the switches without using a jig***.

Note: The following pictures are from the Altair Clone assembly manual, so the PCB looks a bit different than the 8800c front panel board. ***Ignore the LED orientation/polarity shown in the pictures***.

1) Prop the front panel bracket an inch or two above your work surface and orient the bracket as shown in the picture below. Note, ***the APEM switches are blue, not red as show in the picture***.
2) Place the power switch, S1 (toggle switch with silver terminals) in the bracket (far left corner as pictured). Notice that each switch has a slot in the threaded bushing. Orient the slot of all switches away from your view as you place them in the bracket.
3) Place S2-S9 (momentary switches with gold terminals) in the eight holes across the bottom of the bracket (row furthest away from your view). Again, orient the slot of all switches away from your view as you place them in the bracket.
4) Place S10-S25 (toggle switches with gold terminals) in the 16 holes above the eight momentary switches. Again, orient the slot of all switches away from your view.

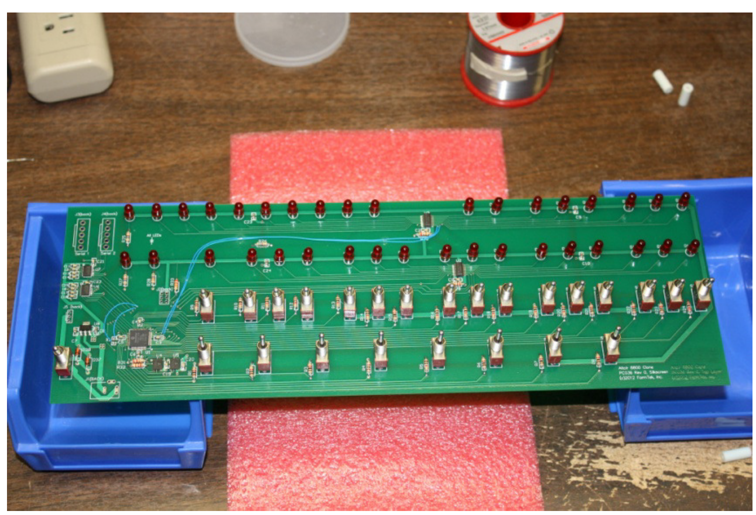


5) Check that all switches are as squarely aligned as possible, then carefully lower the circuit board, component side down, onto the switches. ***Don't let go of the board*** after you have it settled on the switches as the board will tend to rock towards you and fall off the switches.



6) To solder the switches, keep pressure on the board with your "spare" fingers placed in between the two rows of switches and near where you are soldering. This keeps the board level and square on the switches.

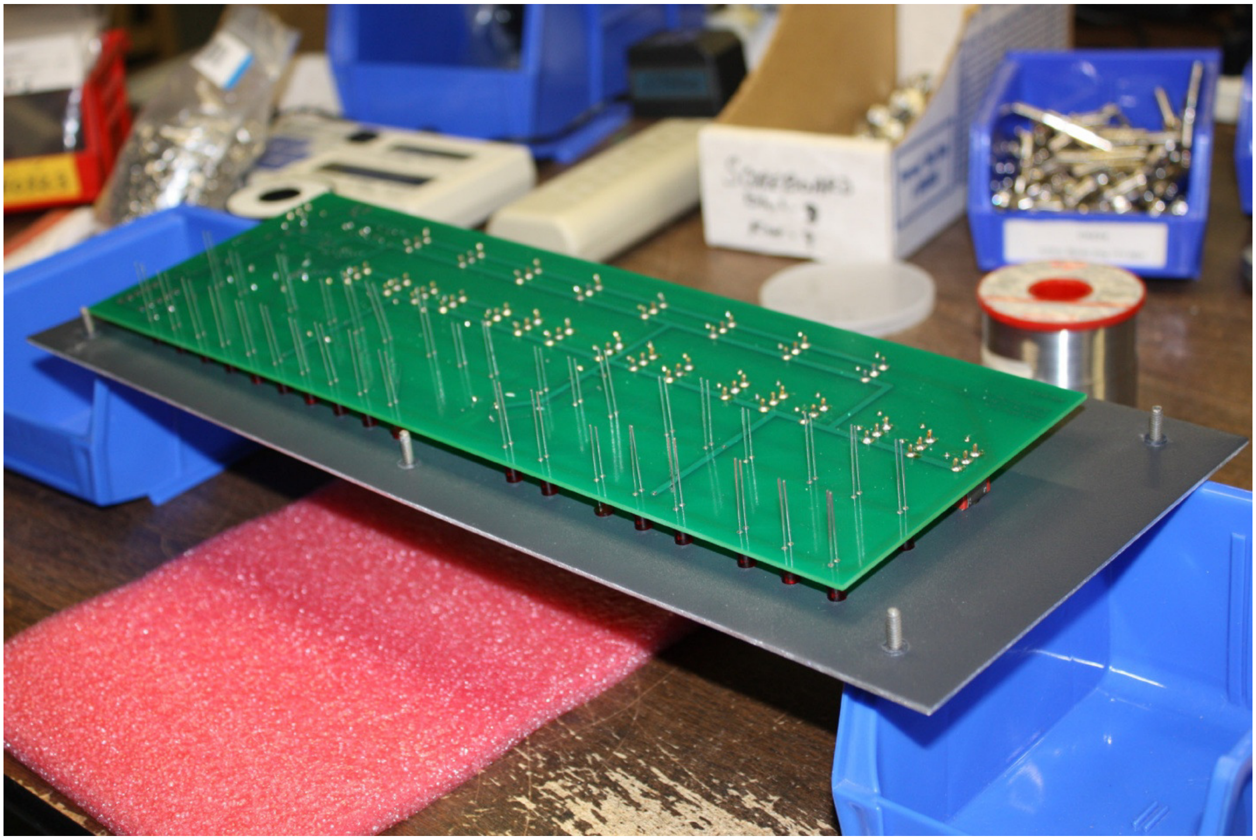
The next step is to install the front panel LEDs. In order to hold the LEDs at the proper and consistent height above the board, use the front dress panel as a jig. ***Do not cut or prep LED leads*** until after soldering is complete!



1) Insert D1-D36 fully into the circuit board. The anode of the LED is indicated by the longer lead and the cathode by the flat spot on flange (for the specific LED in the parts list). The cathode is closer to the top side of the circuit board and the anode is closer to the bottom of the circuit board. You may want to prop the PCB off the work surface as shown to accommodate the long LED leads.

2) Work the front dress panel over the switches and then down the switch bushings slightly. You don't need to push the panel all the way down to the switch body.

3) Turn the PCB/front panel over as shown below and let the LEDs fall into the front panel LED holes. If the front panel sags a bit in the middle, add a third support point near the middle of the panel.



4) Carefully adjust the spacing between the PCB and the front panel in order to accommodate the four 5/8" spacers provided*. The goal is to make the PCB and front panel as parallel as possible. The spacers are used only for this step – they do not remain in the assembly. (Note that once an LED is soldered, it can then serve as a "spacer") ***See the pictures on the next page***.

5) Push each LED all the way down into its corresponding front panel hole. Re-verify that the front panel and PCB look perfectly parallel to each other and are resting directly on all of the white spacers. ***See the pictures on the next page.***

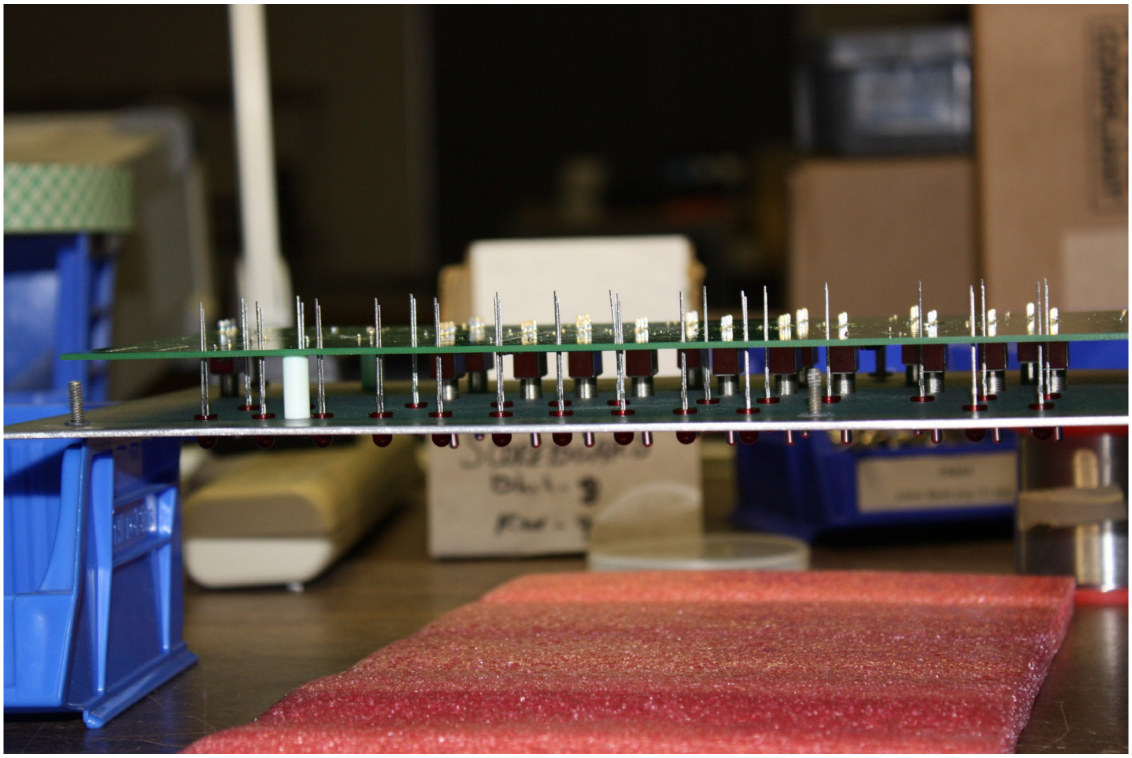
6) Solder the LEDs: Press down gently on the PCB with your "spare" fingers as you solder the LEDs to the PCB. You may want to slide the white spacers near the area you are working as you proceed through the LEDs. Note that once an LED is soldered, it can then serve as a "spacer."

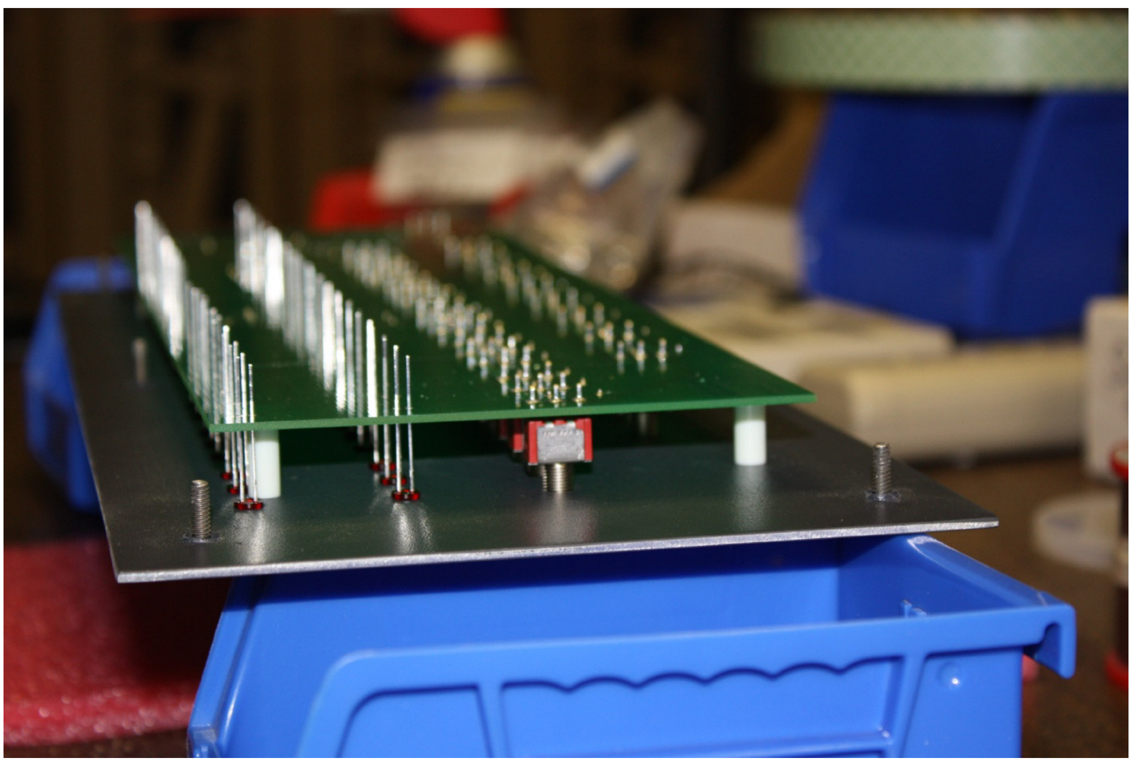
* The spacer height determines how far the LEDs will protrude through the front panel after final assembly. With APEM switches in the Altair Clone case, a spacer height of 5/8" to 11/16" gives a good LED position after final assembly. At 5/8", the LEDs protrude just slightly through the front panel. At 11/16", the LEDs protrude a bit further. You can add something thin under each 5/8" spacer to raise it towards 11/16" depending on your LED position preference. The ***spacing requirement is different*** if you use a different switch brand since switch body height varies slightly between brands.

Lastly, install J1 and J2 ***on the back side*** of the circuit board.

J1 – Note the orientation of the keying slot before soldering the connector onto the board. Again, the connector goes on the ***back*** side of the board.

J2 – Though not a requirement, I'd recommend pulling the center pin out of the J2 connector. If you leave the pin in place, note that its hole on the PCB is not plated and should not be soldered.

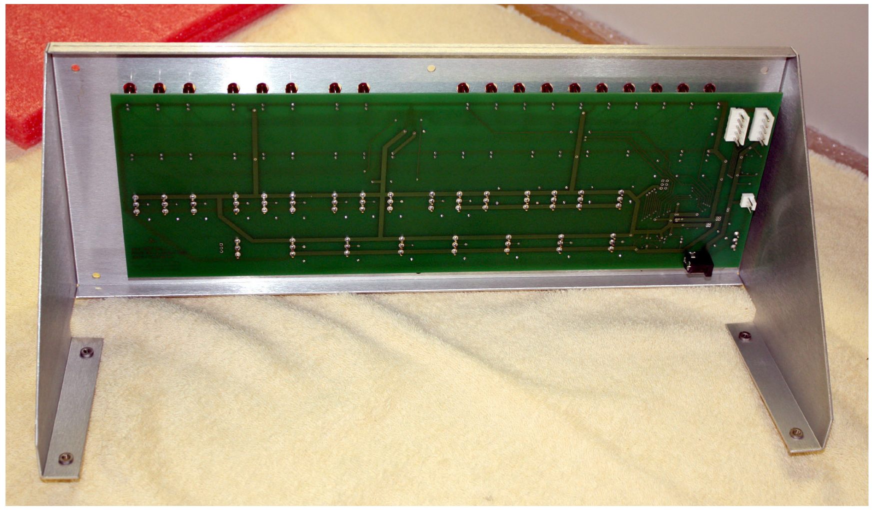




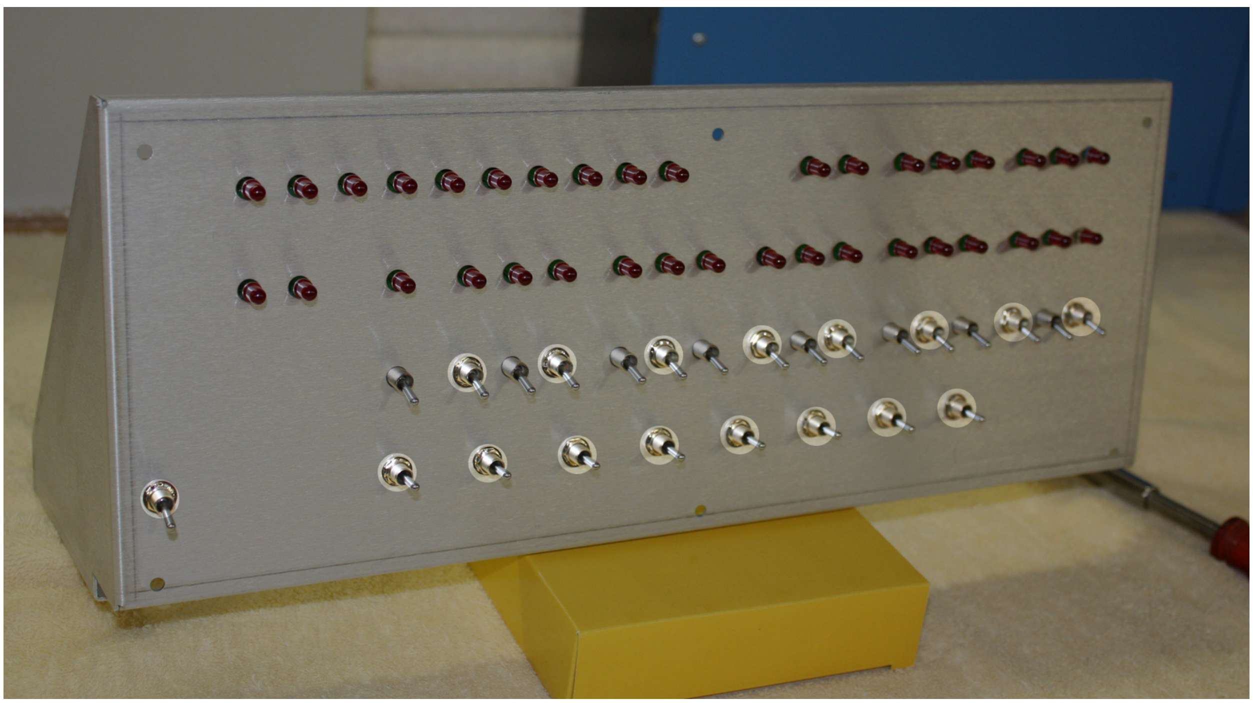
Final Assembly (using an Altair Clone cabinet)

Mount the circuit board to the front panel support bracket.

1) Set all toggle switches in the down position. Feed the switch batons into the holes through the rear of the support bracket. Be sure the bracket is fully seated against the body of every switch. You may have to squeeze/push the panel firmly around a few of the switches to free those spots where the support bracket may be caught on the switch threads.



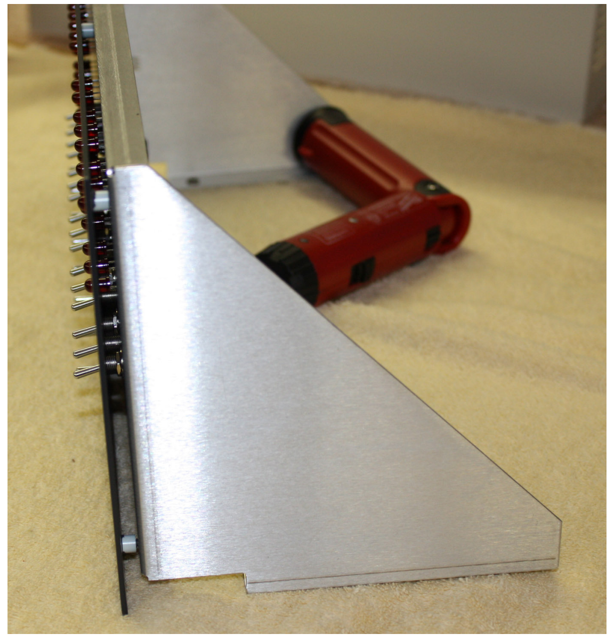
2) Install a lock washer and nut (finger tighten only) on the power switch, all eight momentary switches, and every other address switch (A14, A12, A10,… down to A0) as highlighted below.



3) Incrementally tighten nuts – one on the far left, then one on the far right, working back to the middle, then repeat tightening each nut a bit more. A 5/16” deep socket makes this job much easier. Do not over-tighten the nuts – trust the lock washer.

Mount the front dress panel to the front panel support bracket.

1) Slide a 0.150 white spacer over each of the six studs on the back of the front dress panel.
2) Insert the batons from the switches into the front panel and work the studs into the holes on the front panel support bracket until the front panel and support bracket have fully sandwiched the spacers.
3) Work the front panel down around the switch bushings as needed until the front panel is flat and even over all 25 switches. When properly assembled, the bushings generally protrude just slightly above the surface of the front panel.

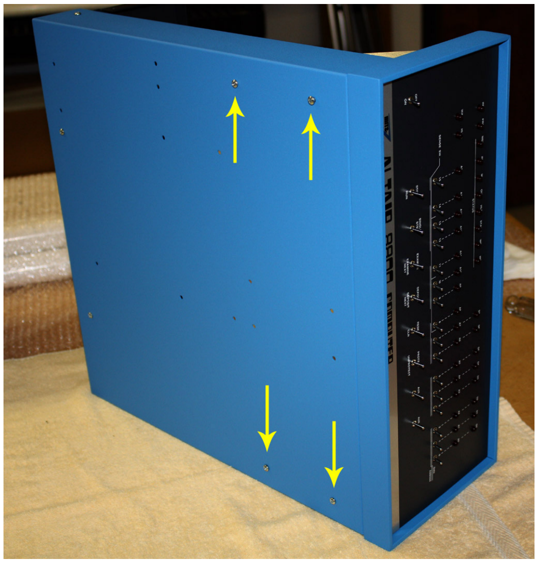


4) Install a #6 nut over each of the studs on the back side of the support bracket(do not tighten). A shallow 5/16" nut driver makes this job easier.
5) Incrementally tighten the nuts – one on the far left, then one on the far right, working back to the middle, then repeat tightening each nut a bit more.

Install the Front Panel Assembly into the Case.

1) Slide the front panel assembly in from the front of the case. The front panel may be snug as it goes into the case bezel. If this is the case, work the panel in bit-by-bit, keeping the amount of insertion on all four sides approximately equal as you work the panel backwards into place (where the mounting bracket's threaded holes line up with the four holes in the bottom of the case).

2) Attach the front panel support bracket using four of the #6 screws you set aside during disassembly of the case. Lockwashers go under the two screws closest to the rear the panel. The lockwashers ensure an electrical connection between the chassis and the front mounting bracket for better static protection.



Interface Board Assembly

Assembly of the interface board is fairly straight forward, however, these instructions won't teach you how to solder components on a PCB, solder connectors, or show you the difference between a resistor and a diode. If you have any concerns about building this board, please contact me first.

Parts List (interface board)

Designator	Description	Part Number	Distributor
C1	10uf, 25v tantalum	80-T350E106K025AT	Mouser
C2-C17	0.1uf, 50v	2146302	Jameco
D1*	1N5817 Schottky Diode	511-1N5817	Mouser
J1	50 pin, dual row IDC right-angle header	517-D3433-5302-AR (3M)	Mouser
	50 pin IDC socket (x2)	MKC50A-ND	DigiKey
	50 pin IDC strain relief (x2)	MKSR50-ND	DigiKey
	50 conductor ribbon cable	MC50G-1-ND	DigiKey
J2	8 pin, right-angle Molex header	538-26-60-3080	Mouser
	Female Housing (x2)	09-50-7081	Mouser
	Crimp Pins (x16)	08-50-0106	Mouser
J3*	Not stuffed		
IC-A	PIC16F1828 Processor	579-PIC16F1828IP	Provided
IC-B	74LS30 Single 8-Input NAND	595-SN74LS30N	Mouser
IC-C	74LS164 Parallel Out Shift Register	595-SN74LS164N	Mouser
IC-D,I	74LS374 Octal Latch	595-SN74LS374N	Mouser
IC-E,F	74LS109 Dual J-K* Flip Flop	595-SN74LS109AN	Mouser
IC-G,L	74LS02 Quad 2-Input NOR	595-SN74LS02N	Mouser
IC-H	74LS00 Quad 2-Input NAND	595-SN74LS00N	Mouser
IC-M	74LS04 Hex Inverter	595-SN74LS04N	Mouser
IC-J	74LS244 Octal Bus Driver	595-SN74LS244N	Mouser
IC-K	74LS10 Triple 3-Input NAND	595-SN74LS10N	Mouser
IC-N	74LS368 Hex Inverting Bus Driver	595-SN74LS368AN	Mouser
R1,R2,R4,R6	4.3K, 1/4w, 5%	291-4.3K-RC	Mouser
R3,R5	1K, 1/4w, 5%	291-1K-RC	Mouser
T1-T3	2N4401 Transistor	610-2N4401	Mouser
VR1	7805 Regulator	511-L7805ACV	Mouser
	Heatsink	129242	Jameco
	4/40 x 3/8" screw		
	#4 internal tooth lockwasher		
	4/40 nut		

* J3 is not stuffed and a jumper wire can be substituted for D1 if this board will never be attached to a Microchip PIC programmer. Since firmware updates can be applied without using a programmer, these parts are most likely not needed.

Part Notes

Use only LS-TTL parts. Some IC inputs are tied directly to Vcc. Multi-emitter TTL inputs do not tolerate this well (e.g., 74xxx and 74Sxxx).

Interface Board Assembly Steps

Insert and solder parts working from shortest to tallest:

1) Insert and solder R1-R6 and D1 (or wire jumper – see * above)
2) Insert and solder VR1. Bend the leads such that the hole in the mounting tab lines up with hole in the circuit board. You may want to temporarily slide the heat sink under the regulator before soldering to make sure the part is the right height off the surface of the board.
3) Insert and solder IC-A through IC-N (or sockets).
4) Insert and solder C1-C17. Note polarity on C1.
5) Insert and solder J1
6) Insert and solder J2
7) Insert and solder T1-T3

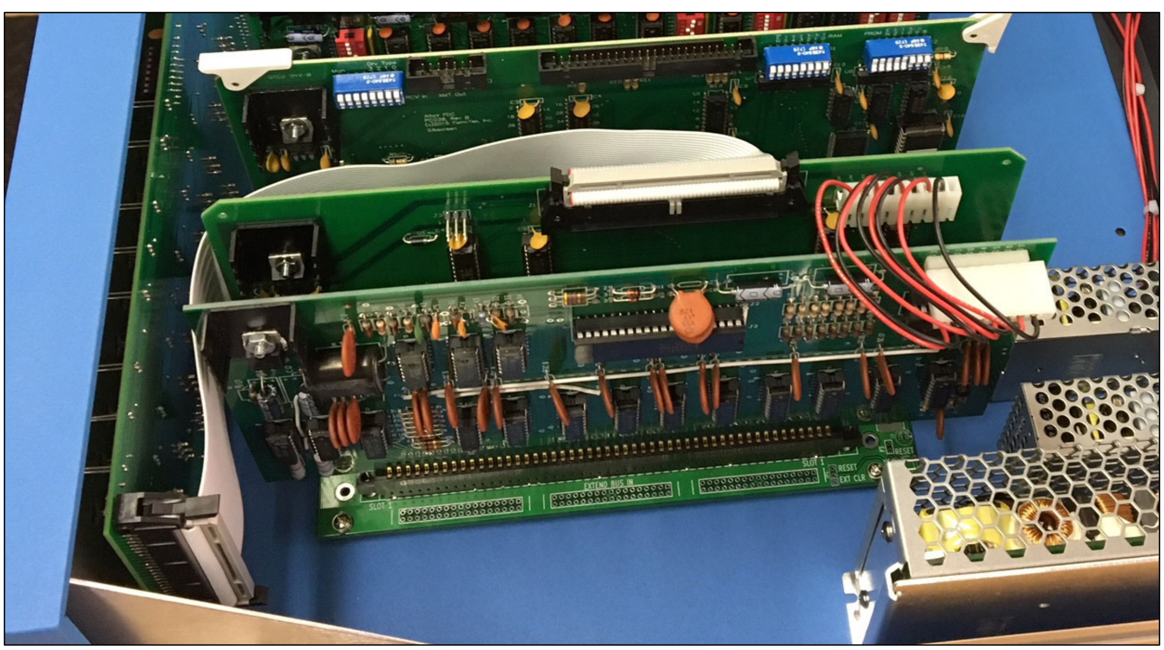
Install the heat sink under VR1 and fully tighten with the #4 hardware listed in the parts list. Do not use a mica insulator. Thermal grease is not required.

J1 Cable Assembly

A 50 pin ribbon cable connects the front panel board to the interface board in the bus. One way to route this cable is shown in the picture below. Here the cable exits towards the back side of the board, takes a $45/90^{o}$ bend, and then runs along the side of the cards to reach the front panel connector. The cable could also come forward over the CPU board, then take a $45/90^{o}$ bend to go left, and then straight into the front panel connector. This latter routing could be employed if a card cage is used that prevents running the ribbon cable out the side. The parts for this cable are listed under J1 in the parts list.

J2 Cable Assembly

A straight-through, eight wire cable assembly connects J2 on the interface board to the data connector on the CPU board. In the picture below, this assembly consists of red and black wires with a white connector at each end. The parts for this assembly are listed under J2 in the parts list.



Grounding

For maximum resistance to static shock, make sure all sections of the metal cabinet are in electrical contact with each and with the power supply enclosures. Then also ensure the power cord ground wire is connected to the chassis ground terminal on each of the power supplies.

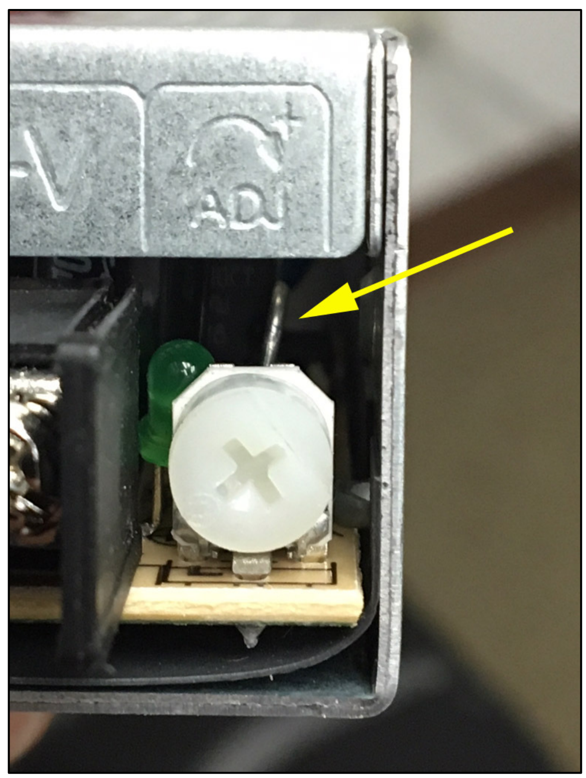
As shipped, the Altair Clone case has lock washers that bite through the paint where the front panel bracket attaches to the bottom pan and where the rear panel attaches to the bottom pan. This provides an electrical connection between these pieces. If you drill holes and use screws to mount the power supplies, the power supply chassis will most likely have good electrical contact with the bottom case pan. If not, use lockwashers under the power supply mounting screws.

Unless connected elsewhere, connect the DC terminal used for signal ground to the chassis ground terminal on at least one power supply. This ensures DC ground is at the same potential as chassis ground. Motherboards with plated mounting holes that are connected to DC ground may make this connection to chassis ground for you as well.

If putting screws through pre-drilled holes in the cabinet, paint may prevent electrical contact with the screw. You can slightly ream the holes or use a lockwasher to bite through the paint to ensure electrical connection to the bottom case pan.

Power Supply Note

An internal lead can accidentally short against a mounting screw in the small Meanwell RS-15 power supplies as shown below. Make sure your mounting screws do not reach in far enough to touch the exposed lead. You can push the lead a bit to the left with a small screwdriver if needed.



High Voltage Wiring

The incoming AC hot wire should be routed to an outside pin on the J2 mating connector. On the opposite outside position on the J2 mating connector (will be switched AC hot), run a wire back to the AC line terminal on each power supply.

Since modern switching power supplies are typically very well self-protected and contain an internal fuse as a backup, an external line fuse is typically not necessary. However, if you're concerned about the AC hot path through the switch prior to the power supplies, an in-line fuse can be added there.

Front Panel Operation

In its default configuration, the 8800c Front Panel board set duplicates the operation of the original Altair front panel. In addition, the following features can be selectively enabled as desired:

- Power-on to a valid reset state
- An output latch at I/O address 0FFh that can display on the data LEDs
- Auto repeat single-step at selectable rate from 1hz-8hz, similar to the 8800b
- Code snippet injection: Common Altair bootstrap loaders, port echo routines, Kill-the-Bit, etc. can be injected into RAM by selecting the desired code snippet on the lower eight address switches, then depressing the AUX-Left switch.
- Auto jump on power-on (can be independent of reset operation)
- Auto jump on reset (can be independent of power-on operation)

These features are configured using three 8-bit "virtual" DIP switches (VDIPs). The following paragraphs define the VDIP settings for each option. The process of setting the value of the virtual DIP switches is covered in the "Updating Virtual DIP Switches" section further down in this manual.

	7	6	5	4	3	2	1	0
VDIP #1	Pwr Reset	FF Latch	Code Inj	----	----	Auto-Steps/sec (zero disables)		
VDIP #2	MSB of Power-On Jump Address (zero disables)							
VDIP #3	MSB of Reset Jump Address (zero disables)							

Power-On Reset

By default, and to behave like the original Altair 8800 front panel, the run state of the 8800c Front Panel is indeterminate at power-on and the 8080 is not given a RESET. This, in turn, tends to leave the 8080 processor in an invalid state as well. This is the reason for the manual STOP/RESET that must be performed on the Altair front panel after power on.

To get around this problem, the 8800c Front Panel can be configured to automatically perform a STOP/RESET during power-up. To enable this feature, set bit 7 of VDIP #1 to 1. To disable automatic reset, set the bit to 0.

Output Latch at 0FFh

An output latch can be enabled at I/O address 0FFh. The latch content can be displayed on the eight data LEDs on the front panel. The AUX-Right switch is used to choose between displaying the output latch or normal output on the data LEDs.

While the computer is running, pressing the AUX-Right switch down displays the output latch on the data LEDs. Conversely, raising the AUX-Right switch restores normal display on the data LEDs.

Behavior while the computer is stopped is slightly different. When stopped, the normal LED display is important for virtually every operation performed. Therefore normal data is automatically shown whenever the computer is stopped. The output latch is displayed only while the AUX-Right switch is held down – normal display is restored as soon as the switch is released.

The output latch feature is controlled by VDIP #1, bit 6. A value of 1 turns on the output latch, a value of 0 turns off the output latch.

Auto-Repeat Single Step

The 8800b provides an auto-repeat single step feature when the SINGLE-STEP switch is held down. This same feature can be enabled on the 8800c Front Panel board. The lower three bits of VDIP #1 specify the approximate auto-repeat rate in steps per second. A value of zero disables the auto-repeat feature.

Code Snippet Injection

A number of code snippets can be injected into RAM by entering the octal identifier for the desired code snippet on switches A7-A0 (see below) and then depressing AUX-Left. After injection, an "examine" of the start address is automatically performed, so simply depressing run starts the loaded code.

The code injection feature is enabled by VDIP #1, bit 5. A value of 1 enables code injection, a value of 0 disables code injection.

Bootstrap Loaders for BASIC

BASIC 1.0
- 000 2SIO
- 002 SIO
- 003 ACR

4K BASIC 3.2
- 004 2SIO
- 006 SIO
- 007 ACR

8K BASIC 3.2
- 010 2SIO
- 012 SIO
- 013 ACR

4K BASIC 4.0
- 014 2SIO
- 016 SIO
- 017 ACR

8K BASIC 4.0
- 020 2SIO
- 022 SIO
- 023 ACR

Extended BASIC 4.0
- 024 2SIO
- 026 SIO
- 027 ACR

Other Routines

ACR Leader Detector
- 030 For BASIC 3.2
- 031 For BASIC 4.0

Port Echo Routines
- 034 2SIO (1st port)
- 035 2SIO (2nd port)
- 036 SIO
- 037 ACR (SIO at 6/7)

Miscellaneous
- 040 Kill the Bit
- 041 Pong
- 044* Intel Hex Loader 2SIO (1st port)
- 045* Intel Hex Loader 2SIO (2nd port)
- 046 Memory Test (2SIO console)

*Relocatable – Set switches A15-A8 to the MSB of the desired load address before depressing AUX-Left

Bootstrap Loaders

The BASIC Version 3.2 and 4.0 bootstrap loaders are straight from the Altair BASIC manuals. Refer to the appropriate BASIC manual for how to load these versions of BASIC.

The Version 1.0 bootstrap loader runs at 1800h (014000 octal). Once BASIC is loaded, STOP/RESET the machine and then depress RUN to get the startup dialog.

ACR Leader Detector

This is the code from the 88-ACR manual that looks for a valid leader byte before jumping to the bootstrap loader. To use the leader detector, first inject the required bootstrap loader, then inject and run the appropriate leader detector. As you'll notice, the leader detector loads and runs at 100h (400 octal).

Kill the Bit

Kill the Bit game by Dean McDaniel, May 15, 1975. Object: Kill the rotating bit. If you miss the lit bit, another bit turns on leaving two bits to destroy. Quickly toggle the switch, don't leave the switch in the up position. Before starting, make sure all the switches are in the down position.

See http://deramp.com/downloads/altair/software/miscellaneous/

Pong

PONG for Altair front panel. Left player quickly toggles A15 to hit the "ball." Right player toggles A8. Score is kept in memory locations 80h and 81h (left and right). Score is missed balls, so the lower number wins.

See http://deramp.com/downloads/altair/software/miscellaneous/

Intel Hex Loader

Loads an Intel hex file through the chosen 2SIO serial port. The program is relocatable: Set switches A15-A8 to the MSB of the desired load address before depressing AUX-Left. The program prompts the operator to send the hex file. Once the complete hex file is received, the program pauses in an endless loop. At this point, STOP/RESET to regain front panel control.

Memory Test

At the "*" prompt, key in four hex characters for the starting address followed by four hex characters for the ending address. Press ESC to restart entry if a mistake is made. The test begins immediately when the last digit of the ending address is typed (RETURN not required).

The starting address is typically 0100h (the program is on page zero). If RAM ends at DFFF (for example), specify an end address of E000. This will cause the program to print an "error" for E000 at the completion of each test cycle as an indicator of activity.

The test runs continuously until reset. The program generates a pseudo-random number sequence, writes a portion of it into RAM, and then regenerates the sequence from the same point to compare with what is read from memory. If the pass is correct, a new portion of the sequence is written to a new section of memory and the process repeats. Errors are printed out with the address, what was written followed by what was read.

Power-On and Reset Auto-Jump

The front panel can force an auto-jump upon power-on and/or reset. The auto-jump address can be different for power-on than for reset. This is unlike many auto-jump circuits which perform the same action for power-on and for reset. For Altair BASIC and Altair DOS, duplicate auto-jump addresses can be problematic. For example, the RESET switch is normally used to regain control from an executing or hung program and return to the BASIC or DOS prompt. However, if the RESET switch instead forces an auto-jump to the cold boot code in PROM, then the entire initialization process for BASIC or DOS – including the slow process of mounting each disk – must be performed. For these programs, it is best to have a power-on auto-jump without a reset auto-jump.

Power-On Auto-Jump

The MSB of the power-on auto-jump address is specified on VDIP #2. If a non-zero value is specified, then upon power-on, the front panel forces a clean reset, an "examine" of the auto-jump address, and then lets the 8080 processor run. If a value of zero is specified, power-on auto-jump is disabled.

Reset Auto-Jump

Whenever RESET is released, the front panel can force an "examine" of an address you specify. This sets the 8080 program counter to this address and therefore performs an auto-jump to the specified address if the computer is running. Note that if the computer is not running when RESET is actuated (or a STOP/RESET is performed), this has the effect of examining the auto-jump address upon reset with the computer remaining in a stopped state.

The MSB of the reset auto-jump address is specified on VDIP #3. If a value of zero is specified, the reset auto-jump is disabled.

Updating Virtual DIP Switches

The virtual DIP switch (VDIP) values are stored in EEPROM. The VDIP values can be examined and updated from the front panel. The AUX-Right switch is used like the "Ctrl" key on a keyboard to give each front panel switch an additional function. While holding AUX-Right in the UP position, the front panel switches provide the following functions when actuated:

EXAMINE (with AUX-Right held up) places the value of VDIPs 1-3 into Altair RAM locations 1-3. The firmware version is placed into RAM location zero. This allows you to "examine" the virtual DIP switch values.

DEPOSIT (with AUX-Right held up) "deposits" the values from Altair memory locations 1-3 into VDIPs 1-3 in EEPROM.

RESET (with AUX-Right held up) resets the front panel into safe mode. See the "Firmware Updates" section for more information about safe mode.

Once VDIP values are placed into Altair RAM using AUX-Right/EXAMINE, the values can be viewed and changed in Altair memory using normal front panel examine and deposit operations. Once the VDIP values are as you want them, write them back to EEPROM using the AUX-Right/DEPOSIT sequence.

Firmware Updates

The logic on the front panel and interface boards is controlled by a state machine in a PIC16F1828 processor. The firmware in the processor can be updated while the board set is installed in a working Altair computer. The computer must have at least 8K of RAM and a functional 2SIO port at the standard I/O address (10h/11h).

To update firmware, the front panel must be placed into “safe mode” by holding the AUX-Right switch in the UP position while powering on the Altair computer. Safe mode is a fully functional version of the firmware in a protected area of flash memory. Safe mode provides all the functions of the original Altair front panel and also the ability to program the “normal mode” area of flash memory. Safe mode does not rely on parameters from EEPROM and provides none of the enhanced features available in the normal mode firmware. This allows safe mode to serve as a fail-safe backup to ensure front panel functionality even if the normal mode code is missing, corrupted, or has a fatal bug.

To update firmware, connect a PC running a terminal emulator to the 2SIO port in the Altair. The emulator should be set for 8N1 with the baud rate determined by the 2SIO board. With the front panel already in safe mode, raise and hold AUX-Right in the up position, then raise and release AUX-Left to start the firmware update process. A prompt from the Altair should appear on the terminal emulator window. Follow the prompt to send the .hex file that contains the firmware update from the PC. Once the .hex file is received, the update is automatically programmed into flash and the front panel restarts into the updated normal mode code.

When firmware is updated, the EEPROM containing the virtual DIP switch parameters is erased to zero. You will need to re-configure the VDIP switches to match your feature preferences.

Helpful Hints

When the firmware update mode is entered, you should notice the WAIT light turn off (or go very dim) since the Altair is now running a small program that was injected into memory by the front panel. If the WAIT light stays bright, this indicates the 8080 is still stopped and the injected code failed to run. This is typically because the front panel wasn’t actually in safe mode or there is a problem with RAM in the first 8K of address space.

If the Altair is running the injected program, but you don’t have terminal response, try typing a ctrl-c on the terminal and see if an abort message appears. If not, perform a RESET on the front panel which returns the front panel to normal operation, then attempt the AUX-Right/AUX-Left entry sequence again.

Additional Notes about Safe Mode and Normal Mode

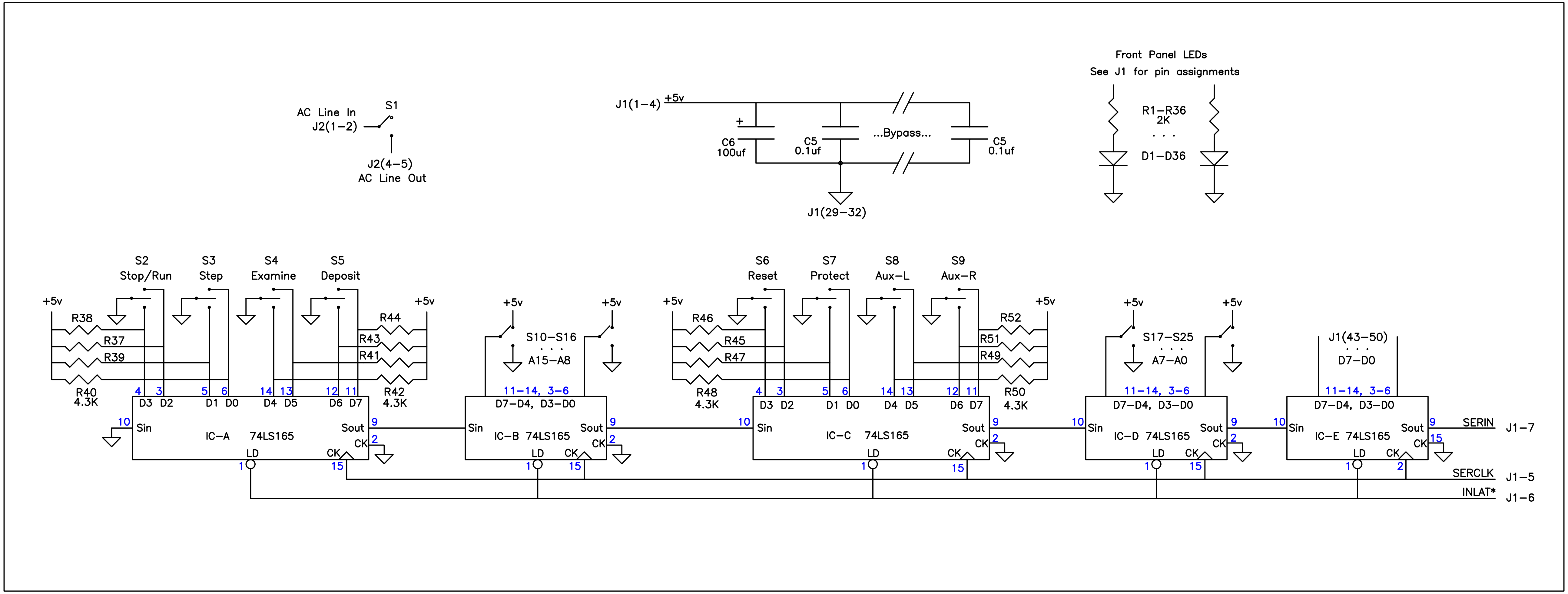
Safe mode is entered in three conditions:

1) AUX-Right is held up when the computer is powered on
2) The normal mode area of flash is erased
3) While in normal mode, RESET is raised and released while AUX-Right is held up

Note that if normal mode is functional, safe mode can be entered from normal mode by performing item #3 above.

Front Panel Board

11/30/2018



Front Panel Interface

State Machine

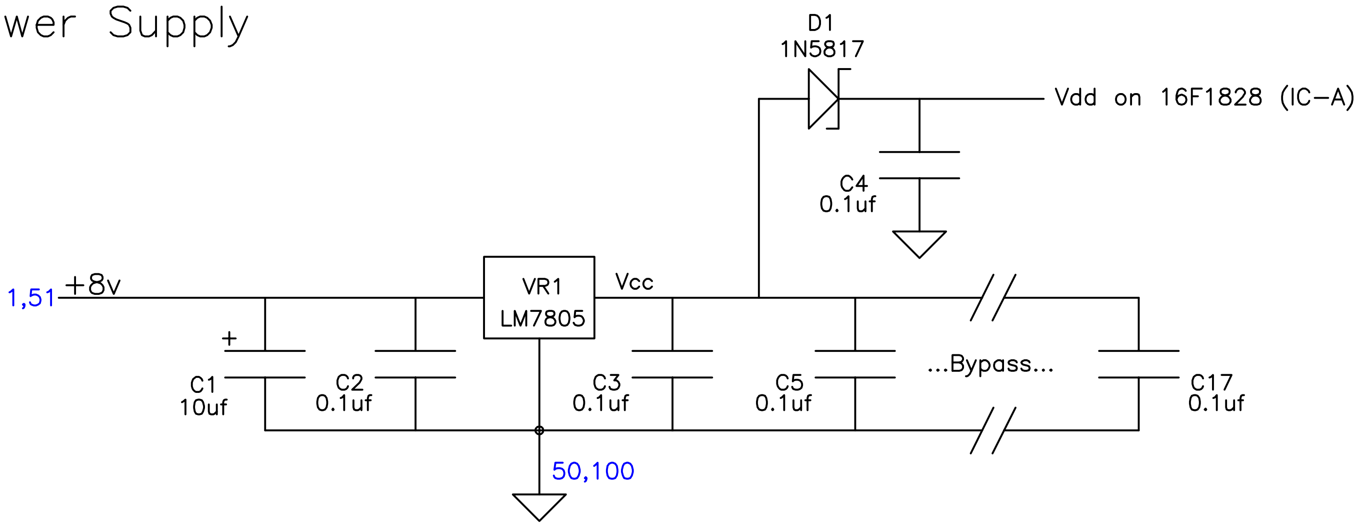
The state machine is a PIC16F1828 processor. All schematic signals of the form "smSIGNAL" are state machine signals from the PIC processor. The pin number shown next to each smSIGNAL name is a pin number on the PIC processor.

5v power to the PIC (pin 1) is through a Schottky diode to isolate the 5v programming supply from the 5v grid of the board. When programming, the board should be removed from the bus and the 50 pin ribbon cable disconnected to ensure the three ICSP signals are not connected to any other electronics. If the board will never be connected to a PIC programmer, then D1 can be replaced with a wire jumper and J3 not stuffed.

Programming Header (J3)

J3 Pin	IC-A Pin	Signal
1	1	Vcc
2	18	ICSPCLK
3	4	MCLR/Vpp
4	19	ICSPDAT
5	20	Ground
6	-	N/C

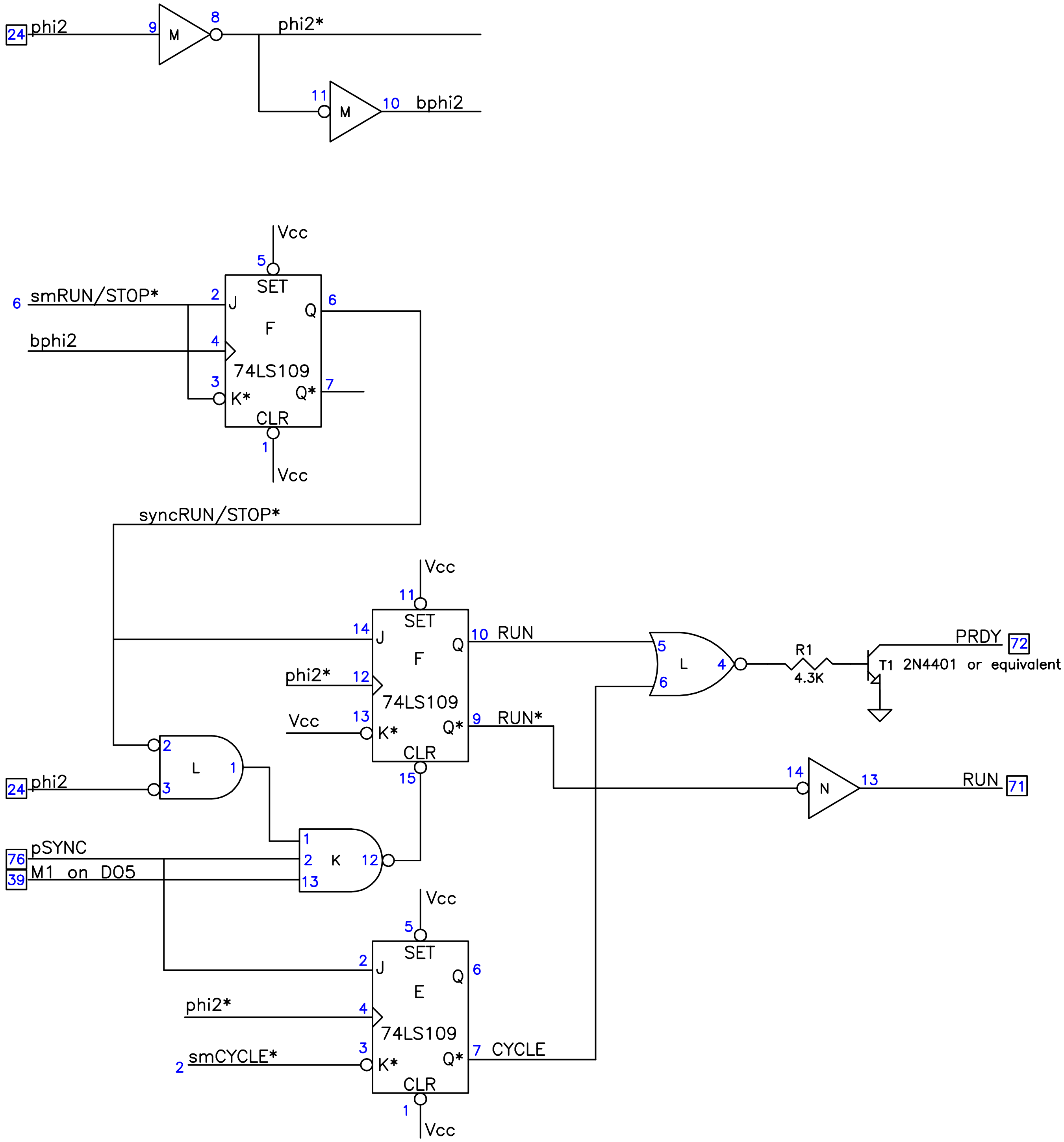
Power Supply



Misc Notes

Use ONLY 74LSxxx parts since some inputs are tied directly to Vcc. Multi-emitter TTL does not tolerate this well (e.g., 74xxx and 74Sxxx).

CPU Run/Stop and Single Cycle



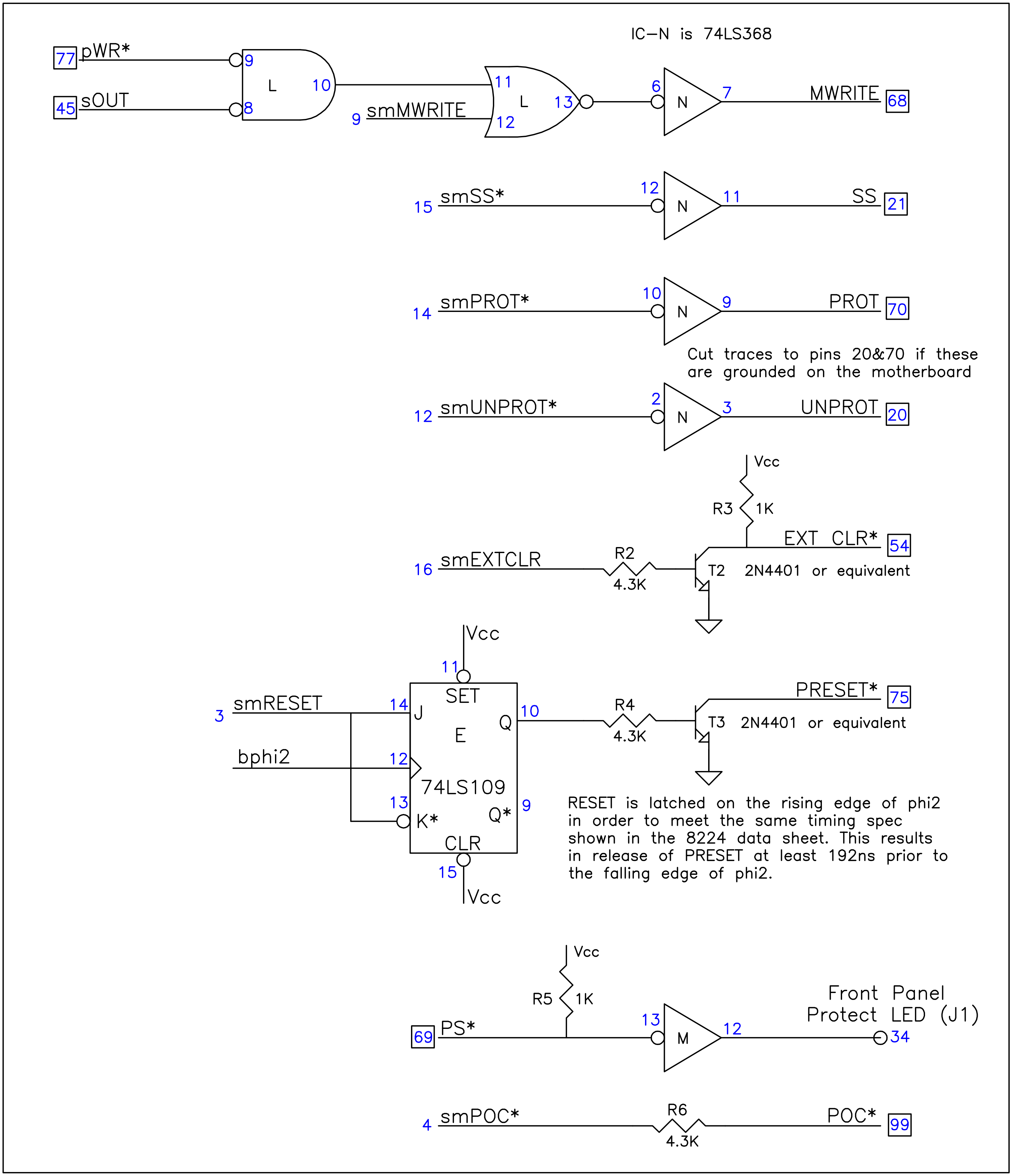
The CPU board latches pRDY on the rising edge of phi2. Two 74L00's on the CPU board prior to the latch delay this by 66ns. Accounting for setup time of the latch, the pRDY output to the S100 bus must be at least 86ns prior to the rising edge of phi2.

To always stop on an instruction fetch, the run/stop logic picks up the M1 status flag (instruction fetch) on D05 during pSYNC. Status on D0–D7 during pSYNC is guaranteed valid at phi1. However, phi1 to phi2 has a minimum time of just 80ns, so due to the CPU board's pRDY timing requirement, there is not enough time to use phi1 to qualify the M1 stop criteria.

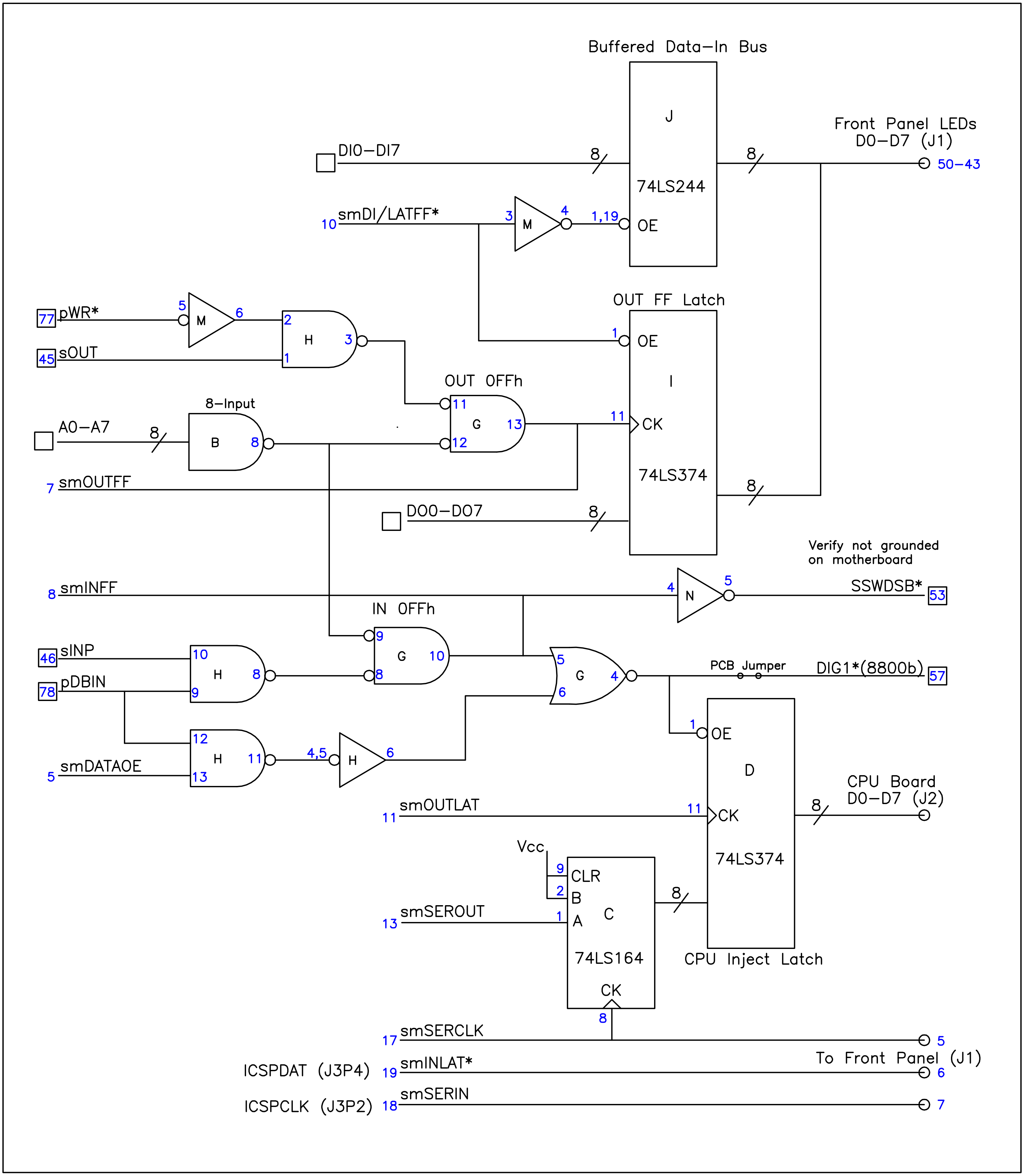
D0–D7 are guaranteed to be valid by the falling edge of phi2 and the minimum time from the falling to rising edge of phi2 is 150ns. If the falling edge of phi2 is used to qualify M1, then at least 64ns (150ns–86ns) are available to generate the pRDY signal on this board.

However, worst case timing leaves zero setup time for D0–D7 at the falling edge of phi2, therefore, the low period of phi2 is used to clear the run/stop flip–flop instead of the phi2 falling edge. But using the entire low period of phi2 presents a problem since the RUN/STOP signal from the PIC processor (smRUN/STOP*) is asynchronous to the phi2 clock and could occur too late in the phi2 period to generate a proper stop at M1. To prevent this problem, a phi2 sync'd version (syncRUN/STOP*) is generated on the rising edge of phi2 using JK flip–flop U8A.

Misc Signals



LED and Direct-to-CPU Data



State Machine Signals

Port	Pin	Name	Description
A5	2	smCYCLE*	Low to start a single 8080 machine cycle. Must hold low at least 500ns to ensure phi2 edge has occurred. Must return high within 1500ns max. Recommend 750ns low to cycle the processor one cycle.
A4	3	smRESET	High to assert bus PRESET* signal (processor reset). Synced with the rising edge of phi2 to meet the undocumented 8080 reset timing requirement provided by the 8224
A3	4	smPOC*	POC (Power On Clear) signal from the bus
C5	5	smDATAOE	High to enable output of the CPU inject latch directly to the 8080's data pins
C4	6	smRUN/STOP*	High to let the 8080 run, low to stop the 8080
C3	7	smFFOUT	Positive pulse (<500ns) when OUT to 0FFh performed by 8080
C6	8	smFFIN	Positive pulse (<500ns) when IN from 0FFh performed by 8080
C7	9	smMWRITE	Pulse high to assert bus MWRITE signal and deposit the value from the CPU inject latch into memory The original front panel asserts this for about 8.5us
B7	10	smDI/LATFF*	High to display data input bus on data LEDs, low to display OUT 0FFh latch on data LEDs
B6	11	smOUTLAT	Pulse high to latch shift register parallel outputs into the CPU inject latch
B5	12	smUNPROT*	Low to assert bus UNPROT signal (memory unprotect)
B4	13	smSEROUT	Serial data output to shift register to update the CPU inject latch. 74LS164 data loads on rising edge
C2	14	smPROT*	Low to assert bus PROT signal (memory protect)
C1	15	smSS*	Low to assert bus SS (single step) to properly enable input buffers on the CPU board during single step
C0	16	smEXTCLR	High to assert bus EXT CLR* signal (external clear)
A2	17	smSERCLK	Serial clock to data shift registers
A1	18	smSERIN	Serial data input from shift registers (front panel switches and value on data LEDs). 74LS165 changes on rise, so read on falling
A0	19	smINLAT*	Pulse low to latch parallel data (front panel switches and value on data LEDs) into serial input shift registers

Port A	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
Signal	-	-	smCYCLE*	smRESET	smPOC*	smSERCLK	smSERIN	smINLAT*	
Init Value	0	0	1	1	Input	0	Input	1	0x31
Tristate	0	0	0	0	1	0	1	0	0x0A

Port B	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
Signal	smDI/LATFF*	smOUTLAT	smUNPROT*	smSEROUT	-	-	-	-	
Init Value	1	0	1	0	0	0	0	0	0xA0
Tristate	0	0	0	0	0	0	0	0	0x00

Port C	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
Signal	smMWRITE	smFFIN	smDATAOE	smRUN/STOP*	smFFOUT	smPROT*	smSS*	smEXTCLR	
Init Value	0	Input	0	0	Input	1	1	0	0x06
Tristate	0	1	0	0	1	0	0	0	0x48

50 Pin Ribbon Cable to Front Panel

Pin	Signal	Pin	Signal
1	+5v	2	+5v
3	+5v	4	+5v
5	SERCLK	6	INLAT
7	SERIN	8	N/C
9	N/C	10	WAIT
11	HLDA	12	A15
13	A14	14	A13
15	A12	16	A11
17	A10	18	A9
19	A8	20	A7
21	A6	22	A5
23	A4	24	A3
25	A2	26	A1
27	A0	28	N/C
29	Gnd	30	Gnd
31	Gnd	32	Gnd
33	INTE	34	PROT
35	MEMR	36	INP
37	M1	38	OUT
39	HLTA	40	STACK
41	WO	42	INT
43	D7	44	D6
45	D5	46	D4
47	D3	48	D2
49	D1	50	D0

IC Utilization

Front Panel Interface

	Gates	IC's	Designator	
74LS02 Quad 2-Input NOR	7	2	L,G	3/4 of G used
74LS00 Quad 2-Input NAND	4	1	H	
74LS10 Triple 3-Input NAND	1	1	K	1/3 of K used
74LS30 Single 8-Input NAND	1	1	B	
74LS04 Hex Inverter	5	1	M	5/6 of M used
74LS368 Hex Bus Driver	6	1	N	
74LS109 Dual J-K* Flip Flop	4	2	E, F	
74LS374 Octal Latch	2	2	D, I	
74LS244 Octal Bus Driver	1	1	J	
74LS164 Parallel Out Shift Register	1	1	C	
PIC16F1828 Processor	1	1	A	
Chip Count		14		

Front Panel

74LS165 Parallel Load Shift Register	5	5	A-E

Altair Bus Signals

Pin	Signal	Description	Pin	Signal	Description
1	+8v		51	+8v	
2	+18v		52	-18v	
3	XRDY	Another RDY signal OR'd to 8080	53	SSWDSB*	Direct sense switch input to the processor
4	VI0*	Vectored interrupts 0-7	54	EXTCLR*	Return all slave boards to known state
5	VI1*		55	RTC	60hz for Real-Time Clock
6	VI2*		56	STSTB*	Status strobe
7	VI3*		57	DIG1	Data input gate 1 (for 8800b front panel)
8	VI4*		58	FRDY	8800b Front panel RDY to 8080
9	VI5*		59		
10	VI6*		60		
11	VI7*		61		
12			62		
13			63		
14			64		
15			65		
16			66		
17			67	PHANT*	Not used in Altair
18	SDSB*	Status disable (sMEMR, sWO, sM1, sINP, sOUT, sHLTA)	68	MWRT	Memory Write (pWR* asserted and not SOUT)
19	CDSB*	Control disable (pSYNC, pSTVAL, pDBIN, pWR, pHLDA)	69	PS*	Memory protect status (out from addressed card)
20	UNPROT	Front panel memory unprotect operation	70	PROT	Front panel memory protect operation
21	SS	Front panel single-step	71	RUN	Machine is in the RUN state
22	ADSB*	Address bus disable (A15-A0)	72	pRDY	RDY signal OR'd with others to 8080
23	DODSB*	Data Out bus disable (DO7-DO0)	73	pINT*	Interrupt request to 8080
24	PHI2	Phase 2 clock	74	pHOLD*	Hold request to 8080
25	PHI1	Phase 1 clock	75	pRESET*	Reset line from from front panel reset switch
26	pHLDA	8080 hold acknowledge output	76	pSYNC	8080 start of machine cycle
27	pWAIT	8080 wait acknowledge output	77	pWR*	8080 write data valid
28	pINTE	Asserted when the 8080 has interrupts enabled	78	pDBIN	8080 reading data bus
29	A5		79	A0	
30	A4		80	A1	
31	A3		81	A2	
32	A15		82	A6	
33	A12		83	A7	
34	A9		84	A8	
35	DO1		85	A13	
36	DO0		86	A14	
37	A10		87	A11	
38	DO4		88	DO2	
39	DO5		89	DO3	
40	DO6		90	DO7	
41	DI2		91	DI4	
42	DI3		92	DI5	
43	DI7		93	DI6	
44	sM1	Machine cycle #1 (instruction fetch)	94	DI1	
45	sOUT	Write cycle for an OUT instruction taking place	95	DI0	
46	sINP	Read cycle for an IN instruction taking place	96	sINTA	Bus cycle is interrupt acknowledge
47	sMEMR	Read cycle is a memory read	97	sWO*	Bus cycle is a write (memory or I/O)
48	sHLTA	8080 halt acknowledge output	98	sSTACK	Bus cycle is a stack operation
49	CLOCK*		99	POC*	Power on clear
50	GND		100	GND	

(red) Ground in IEEE-696 bus spec

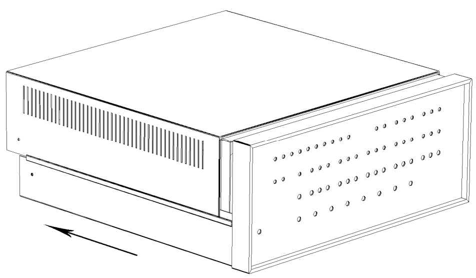
Altair Clone Case

For shipping purposes, the Altair Clone enclosure has been assembled. To install items into the case, the top of the case and the front panel assembly (dress panel and bracket) must be removed and disassembled. Save all screws, nuts and spacers as you disassemble these items.

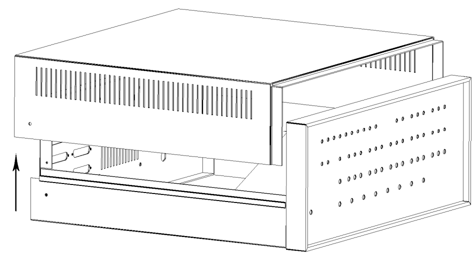
1) Remove the two screws towards the rear of the case cover that hold the cover in place.

2) Tilt the rear of the cover up *slightly* and then slide the cover backwards to pull the front lip out from underneath the blue bezel. Finally, lift and remove the case cover.

1)



2)



3) Four screws and two lockwashers on the bottom of the case hold the unpainted front panel support bracket in place. Remove these four screws and slide the front panel and support bracket out the ***front*** of the case.

4) Remove the front dress panel from the unpainted support bracket by removing the six nuts from the back side of the support bracket. Remove and save all hardware including the six white spacers present on the front dress panel studs.

Be sure to find these additional parts before discarding packing material:

- PIC16F1828 processor (if you've ordered the front panel board set)
- Four white 5/8" spacers (if you've ordered the front panel board set and are using APEM switches)
- One power cord strain relief
- Four black feet (probably attached to the case already)

Important!

The bezel weldment on the front of the Altair cabinet is fragile. Do not pick the case up by the weldment. When re-installing the cabinet top, always support the weldment with your hand as you push the case top into place under the bezel. You may find it easier to have the front bezel pressed against your hips/stomach to provide support as you work the top cover into place under the bezel.