Assembling an Altair 8800

by
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My adventure with microprocessors began rather late in the hobby game, at the end of 1974. It was about this time, or so it seemed to me, that micros became the topic of conversation in anything related to computers and automation. With the IMP-16, the 8080, 8008, 4004, etc., it became clear that this was what the computer market was waiting for. However, it was the article on the MITS Altair in the January 1975 issue of Popular Electronics which finally did it. Although inaccurate and vague, it certainly decided me — I was definitely going to own a micro. The next few months saw hurried mailings of information requests to any company which produced a product even remotely connected with a microprocessor. I immediately got out my checkbook, and mailed all my hard earned dollars to every newsletter that was published, in my frantic search for the “right” processor.

The results were both rewarding and disappointing. I found that there were some fantastic processors, but since my hardware background is not all that hot, I decided that I would have to opt for a kit with one of the most powerful micros I could find. I figured that this would enable me to get on line quickly, learn enough hardware to keep up with the state-of-the-art, and permit me to evaluate new micros as they came out, so I could build my “dream machine” when the right parts became available.

I decided to build the Altair 8800. Although the instruction set looked rather impressive, what convinced me was seeing a process control system which used the 8080; I was truly impressed with its capability.

Fig. 1. The schematic diagram of power supply circuitry, showing additional protection diodes.

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The Order

After calling in my order to MITS, I waited nearly seven weeks for delivery. MITS did make it within the advertised 60-day delivery time. All was not roses for those seven weeks, however; it seems that either MITS or BankAmericard got their signals crossed and couldn't get a credit authorization (they both eventually declined to accept responsibility). You can imagine what it was like getting a call during dinner, explaining that my unit was
Of all the assembly, the worst (and easiest to mess up) part was correctly connecting the 60 bus wires between the display/control board and the chassis motherboard.

Did you ever try to ask your insurance agent whether you need extra renter's insurance for a computer?

![Fig. 2. Detail of the additional protective diodes mounted on the Altair CPU board.](image)

Additional zener diodes for overvoltage protection.
Fig. 3. Adding a parallel capacitance of .0047 µF to C8 of the Altair CPU board schematic lengthens the data out enable line time so that memory write does not extend longer than the data out time.

on-card voltage regulators. Finally the big test: Run a program. This is where the only problem finally showed up. I stopped and reset the CPU, set the switches for my spectacular program (JMP 0) and would you believe it, "deposit" wouldn't work. An hour later I had determined that all other panel switches worked correctly (including deposit next), and that the deposit switch itself was in good order. In order to initially get around the problem I had to examine location 177777 (all address bits 1), then use deposit next to get to location 0.

A study of the schematics showed that deposit and deposit next use the same circuitry, except that deposit next first does an examine next. You can verify this visually by loading all ones into the first 10 locations of memory. Then, if you use deposit next to change all the locations to zero, by carefully watching the data LEDs, you will notice that they all flash on as the switch is activated (examine next) and immediately go off again as the deposit is performed.

I concluded that the problem had to be in the timing, since the circuits were otherwise identical. Sure enough, when I looked at the signals on a scope, lo and behold, when a deposit was performed, the memory write line was enabled for approximately 20 ns more than the data out line. There are two oneshots in the deposit circuit; the first enables the memory write line, and the second enables the data out line. The memory write problem was cured by increasing the capacitance on the second deposit oneshot. An increase of .0047 µF (which increases the data out enable time by at least 30 ns) proved sufficient. This was obtained by adding the .0047 µF capacitor as shown in Fig. 3. When building the Altair, this means that C8 (front panel control board) should be approximately .0147 µF; if the board is already assembled into the case, a .0047 µF capacitor can easily be soldered onto the back of the board without removing any components from the case. (Be sure to unplug the computer before making the change, however.) Fig. 4 shows placement of the new capacitor and the change to the Altair schematic diagram.

I feel that the kit is reasonably well made and a good buy — at least at the current $8080 single lot prices, though the add-on options may cost somewhat more than elsewhere.

My plans for my unit currently involve addition of vectored interrupts (a 9318 or 74148 8-bit to 3-bit priority decoder is about all that's needed to translate the eight vectored interrupt lines on the bus into an RST instruction), a real-time clock, monitor clock and some type of I/O (teletype, CRT, etc.).

Fig. 4. The additional .0047 µF capacitor is mounted on the rear of the control panel board.