



REMark

On Heathkit Computing

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Welcome. This is the first issue of an experimental publication to capture and share knowledge and experiences with Heathkit computers. Each issue will address one or more topics of interest to collectors, hobbyists and computer historians. - Glenn Roberts, Editor.

“I just got an H8 ... now what do I do?”

We hear frequently from hobbyists who come into possession of old Heathkit computer gear (e.g. through inheritance, estate sales, auctions, or just digging out their old system from storage) and want to get it running again. Here are some thoughts and suggestions on how to start. This article covers the model H8 which is a desktop chassis with a front panel keypad and LED display:



More useful general information on the H8 can be found here:

<http://oldcomputers.net/heathkit-h8.html>

https://en.wikipedia.org/wiki/Heathkit_H8

Start by taking inventory

The H8 could be configured in many ways with multiple boards in the chassis and multiple peripherals. The first step you should undertake is to inventory what you've got, both quantity and quality. That will let you make an assessment of what you can realistically accomplish in bringing your system back to life. Remove all the boards from the chassis being careful to note any cabling arrangements. Take notes and pictures! Visually inspect the boards for any damage (e.g. physical damage, burnt or missing components, leaky components, water damage, etc.). Use canned air or a compressor to blow off any dust, or dust lightly with a soft brush. Be careful around the front panel which has many exposed wires that can be broken if jostled too much (I don't recommend you remove the front panel circuit board but you can remove the front gray metal cover to inspect or clean the board.)

To do anything at all the bare minimum you will need is a CPU board and one or more memory boards. The original H8 had a CPU board based on the Intel 8080 processor (Heathkit part number 85-1938) but Heathkit and other vendors subsequently came out with boards that use the Zilog Z80. The CPU board is always the front-most board in the chassis, connected to the front panel by a 5-conductor ribbon cable. Memory boards came in many configurations. Early ones used "static" RAM chips that store bits using "flip flop" integrated circuits. Heathkit originally offered 4K (1K=1,024 bytes) boards that could be upgraded to 8K by adding chips. Later they offered a 16K version.

An alternate technology, "dynamic" RAM (D-RAM) uses chips with arrays of capacitive elements to store the bits. These capacitors must be constantly refreshed and so the D-RAM boards contained special circuitry for that, but in their day they were somewhat more affordable and offered higher capacity and lower power use.

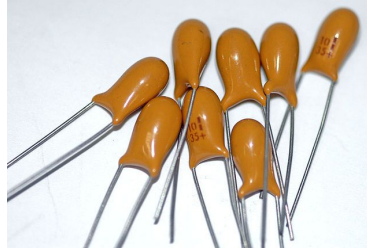
Memory boards are generally recognizable by the rows of RAM chips they contain. You will probably have other boards but my suggestion is to start testing your system with just a CPU board and one memory board. The H8 uses the first 8K of memory space for read only memory (ROM) so the first RAM location is at address 8,192 decimal (0x2000 hex or 040.000 using the "split octal" notation used by the H8.) so your memory board must be set (e.g. via jumpers or switches) to start at this location. We'll talk about other boards later.

Powering up your system

While it is very tempting to just plug your system in and turn it on, this is generally ill advised, especially for systems that have been in storage for some time. These computers used "linear" power supplies that have large filter capacitors. Over time the oxide layers in a capacitor can break down, reducing the voltage it will withstand without conducting current. The recommended approach is to slowly apply voltage to the device using a variable transformer device known as a Variac[®]. A more detailed discussion of this topic is beyond the scope of this article but Google "power up variac" and "reforming capacitors" for more information.

Another common failure on these old systems involves tantalum capacitors which were used on many of the boards, particularly across the input and output lines of the voltage regulators.

https://en.wikipedia.org/wiki/Tantalum_capacitor



These usually fail in a shorted mode which results in a rather dramatic “pop” accompanied by smoke. They are easily replaced with modern equivalents. The part specifications are in the associated Heathkit manual but the most commonly used ones are 2.2 μ F. Use one rated at 35V or higher and be sure to observe polarity when installing (the positive lead is longer and has a small “+” mark next to it).

It’s best to first apply power with no boards installed in the system and check for appropriate voltages as specified in the H8 Assembly manual. Once you’re sure the power is OK you can reinstall the boards. Properly assembled boards have a “key” installed in between the two 25-pin edge connectors. This serves the important purpose of making sure the board is properly aligned when inserted into the backplane. If you’re off by one position (which is easy to do if the key is missing) you will short out the power supply and have to replace the rectifier diodes (I say this, unfortunately, from experience so be careful!). The H8 came with an aluminum bar that connects across the top of all the installed boards. This is actually part of the heat dissipation system and it is best to fasten the screws down on each of the boards. For best heat dissipation it is also advisable to screw the boards into the chassis on the bottom.

When you apply power with the CPU and memory boards installed you will likely get one of two results. If the system is working you’ll hear a “beep” from the speaker and see digits displayed on the LEDs. The front panel keypad should also be operable. If you do not see this then there is an issue with one or more components of your system. Typically you will see only the “PWR” and possibly the “RUN” indicators lit on the left side of the front display. To troubleshoot a non-working 8080-based system start with the Troubleshooting Charts in the H8 Operation manual, which you can download from here:

https://sebhc.github.io/sebhc/documentation/hardware/H8/H8_As_Op_Sc.zip

Troubleshooting chart 2 refers to the original Heathkit 4K/8K static RAM board. If you have a different board you should skip this step, however problems with old memory boards are a common source of trouble. If you have more than one memory you can try swapping that out - just remember to set it to start at 8K (040.000).

Since there are many things that can go wrong a more detailed treatment of troubleshooting is beyond the scope of this article. If you're stuck, email sebhc@googlegroups.com and you'll likely find someone who can help you solve your problem.

OK, it runs... now what?

An H8 with a CPU and memory board is a complete, functional computer, albeit one with only rudimentary input/output capabilities. The front keypad allows you to enter and edit machine code programs, step through execution, set breakpoints and provide input data to your program (details are in the H8 Operation manual.) The only output mechanisms are the front panel LEDs and the audio speaker. Nevertheless, in 1977 the ability to key in and run rudimentary assembly programs was a pretty cool thing!

Heathkit provided two useful such programs in the Operation manual for the H8 (see link above). The first one you may want to enter is the "Initial Test Routine" described starting on page 4. It should produce a message on the front LEDs displaying "your H8 IS up And running" and then beep the speaker.

Testing memory

The other useful program is the "Memory Test Routine." You should use this to test your RAM. The program itself lives in low RAM starting at address 040.100 and so it actually skips testing the area where the program itself resides and it also skips testing the upper 80₁₀ bytes of RAM, which is where the stack lives.

You can use this simple program to test *any* block of RAM on any board. If you have additional memory boards you can set those to be higher in the address space. To do this, leave your good board set for the 8K boundary and then leave a gap in memory space above this board. The reason for that is that the monitor program scans memory on initial startup until it finds a gap, and then sets the stack pointer (SP) just below that. You want your SP to be at the top of the first board so that the entire range of your board-under-test can be scanned without worrying about clobbering the stack. Below is a table with the split octal addresses for the starting point of each memory block

Starting Boundary (Kbytes)	Starting Address (split octal)
0	000.000
8	040.000
16	100.000

24	140.000
32	200.000
40	240.000
48	300.000
56	340.000

The starting and ending memory scan locations are stored in the memory test program at 040.101 and 040.104 respectively. Recall from the 8080 architecture that these are stored in “little endian” format - the low order byte first, then the high order byte. So in the sample program in the operation manual location 040.101/102 has 160 040 stored there, i.e. the memory scan starts at address 040.160. (This is because locations 040.000 to 040.100 are reserved for use by the ROM monitor and the other 60₈ bytes hold the memory test program itself.)

So, say you have an 8K board that has passed the test in the book and you want to test another 8K board. Leave the known good 8K board at address 040.000 and install the board-under-test at, say, 200.000. Then when you run the memory test program place the bytes 000 200 (little-endian notation for the starting address of 200.000) in locations 040.101/102 and the bytes 377 237 in locations 040.104/105 (since the last address you want to test is 237.377, i.e. one shy of the 240.000 boundary for the next 8K space).

The instructions on the Heathkit memory test program provide you with suggestions on how to determine which chip(s) may be causing a test failure. If you have a third party board you may want to consult the manual for similar suggestions.

Hopefully these instructions will get you to the point of having a functioning H8 computer with one or more memory cards. In a future issue of *REMARKS* we can discuss the use of I/O and peripheral cards to talk to storage devices such as tape and disk, as well as a Console such as the H9 or H19 terminal.

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