Memory Board Allows Faster H8

This memory board enables an H8 to run at 6 MHz—with no wait states.

Norberto Collado, Joseph Gonzàlez, and Juan S. Quintana

More than ten years have passed since the introduction of the H8 computer. Since then, many more powerful and, yes, more reliable, machines have been made. Yet the old dear still commands a large following of die-hard enthusiasts.

That should not be difficult to understand. Many of us cut our computing teeth on the H8. The machine fulfills the needs of those who don't need the whiz-bang of the new-fangled devices. H8 users have WordStar, dBASE, SuperCalc, etc. With all that available, who could ask for anything more?

Through the years, many vendors, including Heath, have managed to keep the H8 up-to-date with add-on boards. This expansion capability has enabled the H8 lover to hook up more devices, and even use color graphics.

One thing, though, has still bugged the majority of users—the darned contraption is slow-w-w!

Several authors have addressed this limitation in the past. So, what is left to be said? Plenty! After reading this article, you'll be able to modify the H8 to run at speeds of up to 6 megahertz, with no wait states. This is accomplished by changing the clock rate of the central processing unit (CPU), and building and installing a new type of random-access memory (RAM) board. This will be a static-memory board.

We are going to assume the following boards are installed in your H8: the Trionyx motherboard with Z80 CPU; the Heath H8-37 soft-sector disk-controller board; and the H8-4 serial input/output (I/O) board. (The H17 hard-sector controller is not designed to operate at speeds over 2 megahertz. It is possible that it will—through hardware and/or software—but we have not tested the system with the H17.)

We dreamed of zipping along in our Y-Wing fighter. . . .

In its first days, the H8 was plagued with reliability problems. The main culprit for many of the problems was the original motherboard, with its tin-plated connector pins. Later Heath motherboards came with gold connectors. If you are still using a tin motherboard, you really should replace it with one that uses gold-plated connector pins. We can also highly recommend the T-H90 motherboard from Trionyx.

(For a full discussion of this board, refer to "Improve Your H8's Reliability: Install the Trionyx Motherboard," by Thomas R. Sears, in *Sextant* #5, Spring 1983.)

Availability?

Some of the products we will talk about are no longer available from the original sources. However, there is light at the end of the tunnel. Some vendors in Heathland still have these products on their shelves. One possible source is Quikdata, Inc.; another is Al Davis, who carries a slew of used and surplus parts for many Heath/Zenith machines.

You might also check the ads in various Heath/Zenith-specific publications, including *Sextant* and *REMark*. Also, *Sextant* has a classified ad section. *Buss* newsletter carries "For Sale" notices and requests for assistance, as does *H-Scoop* newsletter from Quikdata. If you still can't locate what you're looking for, you might try placing an announcement your-

Quantity	Description	Designation
1	H8 wire-wrap board	
4	74LS240	E1, E2, E3, E4
1	74LS138	E5
1	8-position DIP switch	E6
1	74LS30	E7
1	74LS14	E8
1	74LS02	E9
8	HM6264-15 8,192-word x 8-bit RAM (150 ns)	E10, E11, E12, E13, E14, E15, E16, E17
1	2-kilohm resistor	R1
1	7805 5-volt regulator	
2	2.2-microfarad 25-volt capacitors	
8	10-kilohm resistors (IC-type package)	
3	14-pin wire-wrap socket (E7 – E11)	
2	16-pin wire-wrap socket (E5, E12)	
4	20-pin wire-wrap socket (E1 – E4)	
8	28-pin wire-wrap socket (RAM chips)	

Table 1. Parts list for the authors' speed and memory upgrade for the H8.

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self.

The various users' group newsletters are also of great help. One of the most widely distributed is that of the Capital Heath Users' Group (CHUG). Another alternative is the electronic bulletin boards—the HUG board on CompuServe, for example, and local bulletin boards.

For the faint of heart

The parts for building the speed-up board (see Table 1) should cost somewhere around $60: $15 for a wire-wrap board; $12 for chip sockets; and $32 for one bank of memory chips (eight chips), enough for 64 kilobytes.

Because you'll be using a wire-wrap board, many of you may find this a rather challenging project. So, you may want to buy a pre-assembled board.

Approximately 20 of these boards are in use by different people in Heathland. The board is tightly packed with components, with over a thousand plated-through holes; it's solder-masked, and all component locations are silk-screened.

Because of the high cost of development and production, we are asking $115 for the bare printed-circuit board. If enough interest is generated by this article, we may be able to lower the price. An assembled and tested board, with 64K of memory installed, is $225; with 256K installed, the cost is $350. All the prices are postage paid.

The full 256K on the board may be accessed using the Trionyx bank-select board (the X/2-H8), or the ED-1 board from TD Engineering. The Trionyx board supports operation at 4 MHz and 256K, while the TD board will go up to 8 MHz and 512K. (The 512K will require two of our memory boards.)

Along with the board, we include instructions and hints on further increasing the performance of the H8.

```
; Mini speed program
; This program will toggle the CPU from 3 to 6 MHz only
; File name = 6MHZ.COM

; Program written by: Norberto Collado
;                     Box 765
;                     Rosario, P.R. ØØ746
;                     October 31, 1984

FDOS     EQU     5H
WBOOT    EQU     ØH
PSTRING  EQU     9
;
;
         ORG     1ØØH
CR       EQU     ØDH
LF       EQU     ØAH
ESC      EQU     1BH
PORT1    EQU     77Q

BEGIN    MVI     C,PSTRING        ;clear the screen first...
         LXI     D,MESSAGE        ;and type the messages
         CALL    FDOS
         MVI     A,ØØ1Q           ;load register a with a value of 1q
         OUT     PORT1            ;send data to CPU card
         JMP     WBOOT            ;exit to cpm...warm boot...

; messages

MESSAGE DB       ESC,'x','5'      ;cursor off
        DB       ESC,'E'          ;erase entire screen
        DB       CR,LF,'Mini-speed program',cr,lf
        DB       'Will toggle CPU speed from 3 MHZ to 6 MHZ',cr,lf,lf
        DB       ESC,'p'          ;enter reverse video
        DB       'Your CPU is running at 6 MHZ now....',cr,lf
        DB       ESC,'y','5'      ;cursor on
        DB       ESC,'q'          ;reverse video off
        DB       '$'              ;return to CP/M
        END      BEGIN
```

Listing 1. After the authors' speed upgrade has been installed in the H8, this routine will switch the speed of the H8 from 3 to 6 MHz. (See Listing 2 for switching back to 3 MHz.)

Two choices

To bring the H8 up to speed, we had to make choices in two areas. First, which type of memory would we choose for our design—static or dynamic? Second, upon which CPU board would we base our design? There were two from Heath, one from D-G Electronic Developments Company, and one from Trionyx Electronics.

First, let's look at a little background on memory.

Dynamic versus static memory

Memory chips come in two varieties: dynamic and static. There are differences in cost, in speed of execution, and in how the information is stored.

In static chips, information is stored as a current flow; the power to the chip continuously maintains any information contained there. That information remains the same so long as new information is not written to the address.

With dynamic memory chips, information is stored as an electrical charge. This is not continuously maintained, so the charge stored at each memory bit tends to deteriorate. Information, therefore, is stable for only a very short time. This requires that the board, or the CPU itself, periodically refresh the information stored.

If the RAM board takes care of the refresh, it must signal the CPU to wait for the refresh cycle to end. That way, no instructions are missed. The delay time necessary for the refresh cycle to finish is measured in "wait states."

The disadvantage of static memory is higher power consumption and more expensive hardware; the advantage is speed of execution. On the other hand, memory boards that utilize dynamic chips require less power and therefore can be more densely packed than static ones; they are also a lot cheaper.

Initially, we used Heath's H16 dynamic-RAM board. After all, it was already in the machine. As indicated above, however, we finally decided on a static memory board. The deciding factor was speed, and the drop in price of the static memory chips was the clincher.

Which CPU board?

We faced at least four CPU alternatives for the H8. Two of these are Heath products: the original CPU board based on the 8080 CPU chip, and a later board (the HA-8-6) based on the Z80 CPU. Both operate at 2 MHz.

The D-G board and the Trionyx board are based on the Z80 CPU and operate at either 2 or 4 MHz.

One advantage of the Trionyx board over the D-G board is that the speed can be switched by software. (For a review of the Trionyx Z80 board, see "Make Your '8 Think Like an '89—Only Faster" by Clay Jackson, in *Sextant* #7, Fall 1983.) The D-G board, however, offers the alternative of faster execution by allowing the CPU rather than the memory board to do the necessary refresh. We chose Trionyx because of our expectation of good support.

After we installed the new motherboard and Z80, the machine was already

```
; Mini speed program
; This program will toggle the CPU from 6 to 3 MHz only
; File name = 3MHZ.COM

; Program written by: Norberto Collado
;                     Box 765
;                     Rosario, P.R. 00746
;                     October 31, 1984

FDOS    EQU     5H
WBOOT   EQU     0H
PSTRING EQU     9
;
;
        ORG     100H
CR      EQU     0DH
LF      EQU     0AH
ESC     EQU     1BH
PORT1   EQU     77Q

BEGIN   MVI     C,PSTRING       ;clear the screen first...
        LXI     D,MESSAGE       ;and type the messages
        CALL    FDOS
        MVI     A,000Q          ;load register a with a value of 0q
        OUT     PORT1           ;send data to CPU card
        JMP     WBOOT           ;exit to cpm...warm boot...

; messages

MESSAGE DB      ESC,'x','5'     ;cursor off
        DB      ESC,'E'         ;erase entire screen
        DB      CR,LF,'Mini-speed program',cr,lf
        DB      'Will toggle CPU speed from 6 MHZ to 3 MHZ',cr,lf,lf
        DB      ESC,'p'         ;enter reverse video
        DB      'Your CPU is running at 3 MHZ now....',cr,lf
        DB      ESC,'y','5'     ;cursor on
        DB      ESC,'q'         ;reverse video off
        DB      '$'             ;return to CP/M
        END     BEGIN
```

Listing 2. This routine will switch a speeded-up H8 from 6 to 3 MHz. (See Listing 1 for switching up to 6 MHz.)

much improved. Then we installed a faster CPU chip (a Z80B) and a faster clock, and dreamed of zipping along in our Y-Wing fighter and zapping the Stormslayer twice as fast as before.

Unfortunately, the Heath H8-16 RAM boards seemed to be holding up the works. To work reliably at the higher speed, the Trionyx CPU had to be set for two wait states. Otherwise, the CPU pushed the H8-16 too hard. But the whole purpose of the board was to make the machine run faster!

Back to the old drawing board.

Which memory board?

D-G advertised a static memory board that could keep pace with the higher CPU speed, but it commanded a stiff price. D-G also advertised a dynamic board, which was less expensive.

One of us already owned the M-H8 board, Trionyx's 64K dynamic-RAM board. This board would also run at 4 MHz with no wait states.

A check of the M-H8 showed that it took care of the refresh cycle. This meant that at times it would still interrupt the CPU to complete the refresh cycle. This was still not satisfactory.

We were caught between the expense of the D-G board and the refresh problem of the Trionyx.

The only alternative was homebrew.

6-MHz mod for the Trionyx Z80 CPU

Increasing the speed of the Trionyx Z80 board is the easiest part of the modification. First, you replace the original Z80A chip (U22) in the CPU board with the new Z80B type. After this, replace the 8-MHz crystal (XL1) with a 12-MHz crystal.

When you power up the system, the first thing you'll notice is a higher-frequency "beep." This is because the new clock rate is used. The CPU's speed will now be 3 MHz, rather than the original 2 MHz. You can switch processing speed from 3 to 6 MHz by one of two methods: either directly through the front-panel keypad, or by software. (The keypad input is given below; Listings 1 and 2 switch from 3 MHz to 6 MHz and 6 MHz to 3 MHz, respectively.)

If you find that the computer is not capable of running at higher speeds, the problem may be in the front-panel board. After studying the operation of the H8, we suspected that the culprit was the chip at location IC112, which is part of the control circuit. Several tests confirmed our suspicion. Replace the 7403 chip at IC112 with a 74S03 or faster chip.

(We have even been successful running the H8 at 8 MHz. This requires a Z80H 120-nanosecond CPU and about 20 changes in the Trionyx CPU board. If you're interested, we'll send you details.)

The rest of the system will operate as it normally does. The only problem you might encounter is if you use the H17 controller board. This board uses the CPU clock rate for some of its own actions. We have tested the H17 with our modifications and have had mixed results.

(You might, however, be able to use it with BIOS 80 from Livingston Logic Labs or SY.DVD from UltiMeth. In addition, D-G produced a speedup module advertised to help the H17 handle higher speeds.)

With the H37 soft-sector controller, faster CPU speed is not a problem, because this controller's timings are independent of the CPU.

New RAM board

We have already implied that running the CPU at higher speeds is of no real value if you use the available dynamic memory boards. The memory is still going to hold up the works while performing a refresh. We addressed this by designing an H8 memory board capable of running at speeds higher than any of the others on the market.

Our board uses static memory devices; not only does it run faster, but it is capable of bank-select operations compatible with the Trionyx scheme. (For more information on bank select for the H8, refer to "Put an Electronic Disk into Your H8," by Thomas R. Sears, in *Sextant* #10, May-June 1984.)

To install the new memory board, you'll need the following ingredients: an H8 microcomputer system with a Trionyx Z80 CPU module, an H37 soft-sector drive controller, and a Trionyx TH-90 motherboard. You'll also need either our PC board or an H8 wire-wrap board, plus the components in the parts list in Table 1.

For assembly, follow the logical diagram in Figure 1. Using DIP switches and jumpers, you can configure the board for a capacity of between 64K and 256K. The settings are indicated in the diagrams.

The design for the board was the work of Norberto Collado. When we first put the board together, the price of the static RAM chips was rather stiff. However, we have seen them advertised for as low as $4 each, and the price continues to drop. This makes our design much more attractive.

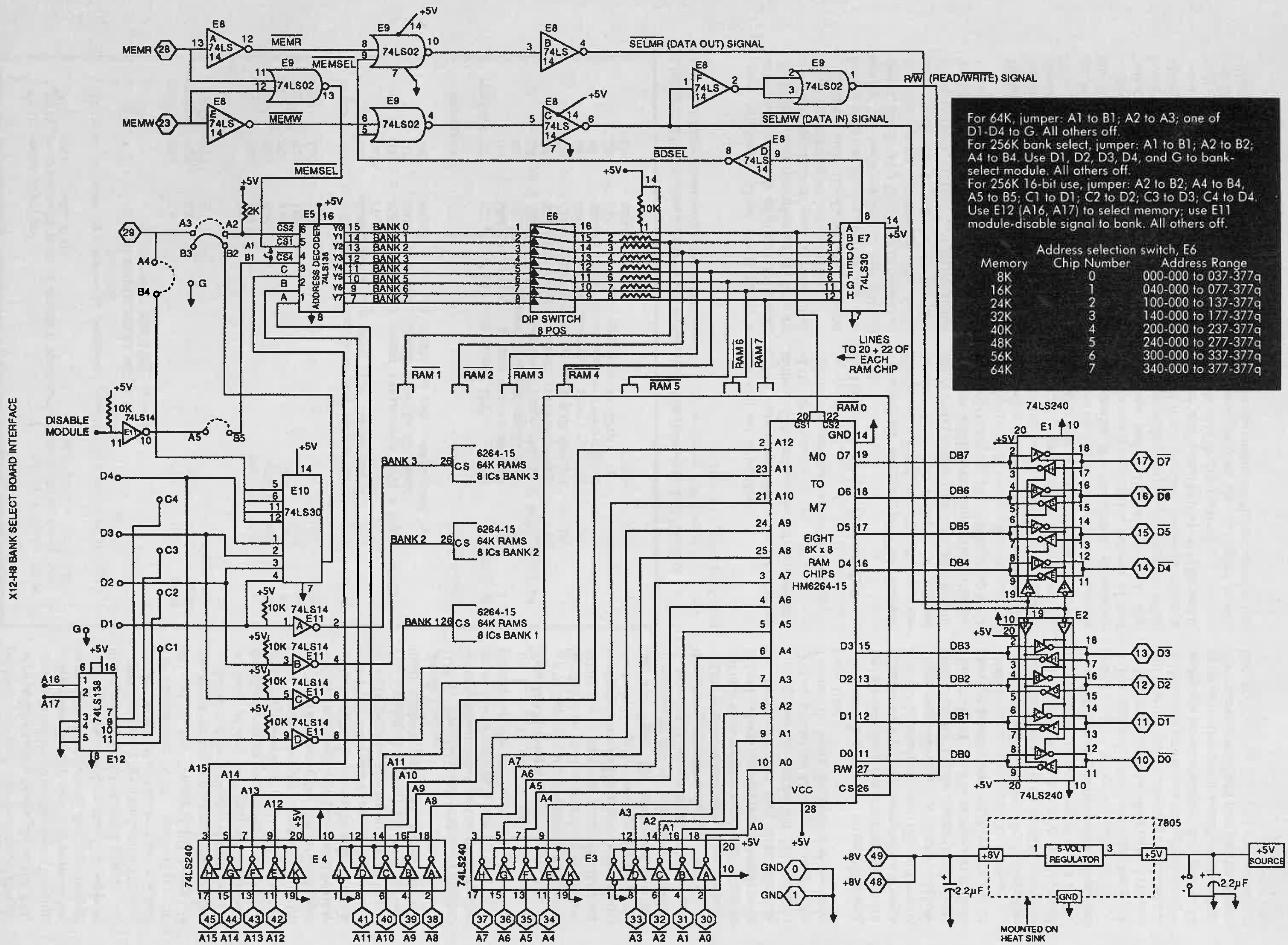

Figure 1. Schematic diagram of the authors' memory board for the H8.

Description of the memory board

The memory board is a 64K-to-256K static RAM card. (See Figure 1.) The memory chip we use is an 8K x 8-bit (64-kilobit) device. The memory chips are arranged in four groups (banks) of eight chips each; each bank has a 64K capacity. Filling all four banks will pump up the capacity of the board to its maximum of 256K.

Because of low power consumption, only one 5-volt regulator is needed. The advantage is a much cooler H8.

Data going into the memory array from the bus is buffered and inverted by the buffers, half of E2 (D0-D3) and half of E1 (D4-D7). These buffers are enabled when pin 19 (SELMW) is low.

Address lines A0-A7 are buffered and inverted by E3, while address lines A8-A12 are buffered and inverted by E4. These 13 address lines are connected directly to, and decoded within, each memory chip. The address decoding within each memory chip determines which of the 8K memory cells is selected by the lower 13 address lines (A0-A12).

Address lines A13-A15 are buffered and inverted by half of E4. These three lines, in turn, are inputs to E5, a 74LS138 address decoder. The values on these address lines determine which memory bank is enabled: 000 enables bank 0, 111 enables bank 7, etc. (For a more technical discussion, refer to the operation manual for the Heath WH8-16 memory board.)

Each of the eight bank-select signals is connected through an eight-position DIP switch (E6) to a 74LS30 chip (E7), a bank sensor used to enable the H8 data bus. Using this switch allows our memory board (when not fully populated) to be used with any other type of memory board.

When E7 senses a low at any of its inputs, it drives pin 8 high; the high output is then inverted to create BDSEL low (Data Bus Selected). This signal is applied to E9, which selects either the memory-read or memory-write cycle (SELMR or SELMW) through its respective inverter.

When the SELMW signal is low, it turns on the Data Bus Drivers (E1 and E2), to place data into the memory array. The SELMW signal is also fed to E8 pin 1, and from there to E9 pins 2 and 3, to create the signal R/W (low); the R/W signal is then applied to pin 27 of all the RAM chips.

Here, E8 and E9 form a "do-nothing" circuit that simply delays the R/W signal; this is done because, when the CPU is writing to RAM, the data buffers must be turned on first. Then, when the data is inside the RAM bus, the RAM-write signal should be asserted next, to guarantee data integrity. Reading from the RAM is not as complex a problem as writing to it.

When the CPU wants to read from or write to the RAM array, it drives the MEMR or MEMW signal to the memory board. These two signals are constantly monitored by E9 pins 11 and 12. While E9 senses one of the two signals, it creates the MEMSEL (low) signal, which turns on the Address Decoder E5 to drive the corresponding RAM bank. The reset signal, which is applied to E5 pin 6, is used to protect the contents of memory during power-up and system reset, when the status of other bus signals is uncontrolled.

The CPU's speed will now be 6 MHz.

The different arrangements of jumpers and switches determine the amount of RAM installed, bank-select capability and addressing, and 8- or 16-bit configuration.

Changing speeds

After you have modified the Trionyx Z80 CPU, you can change the CPU speed under program control with the programs given in Listings 1 and 2 (6MHZ.ASM and 3MHZ.ASM). You will need ASM and LOAD to assemble them.

To toggle from 3 to 6 MHz using the keypad, do the following:

1. Press the MEM key.
2. Press the 0 0 1 0 7 7 keys; this sequence specifies the data and port address.
3. Press the OUT key; this selects the 6-MHz clock.
4. Now boot the system.

To toggle from 6 to 3 MHz:

1. Press the MEM key.
2. Press the 0 0 0 0 7 7 keys.
3. Press the OUT key; 3 MHz is selected.
4. Boot the system.

So what are you waiting for? Get your soldering gun, wrap away, and enjoy your H8 at *true* speed!

Ordering Information

Bare printed circuit board, $115.
Assembled and tested board, with 64K, $225; with 256K, $350.
Juan S. Quintana
Ramirez de Arellano B-6
Garden Hills
Guaynabo, PR 00657

Heath Company
Benton Harbor, MI 49022
Orders: 800/253-0570; in Michigan, 800/782-2702

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