Z-100 LifeLine
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Z-100 Speed Up Options

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Editor, 'Z-100 LifeLine'

Z-100 Speed Up Options

There was only one official Heath/Zenith's Z-100 Speed and RAM Upgrade. This is the preferred, H/Z engineered upgrade and therefore desired before proceeding to faster speeds, and we should begin with that.

Z-100 8 MHz & 256K RAM UPGRADE
Heathkit HA-108 for H-101/H121

IMPORTANT NOTES:

The following contains excerpts from the Heathkit Installation Manual of the same name. The purpose of this document is to provide the H/Z-100 owner the procedures to upgrade their H/Z-100 on their own, as this kit is no longer available.

This upgrade will work in your Z-100 only if the motherboard has part number 85-2806-1. If the center 25-pin D-connector on the rear of the motherboard has a label with the number #181-4919 or #181-4920 attached to it, you have the correct version and may proceed with this upgrade.

If you have a 5 MHz Numeric Co-processor, 8087 (Model Z-216), it will not work with this upgrade. You will need to replace it with an 8 MHz version, 8087-02 or a 10 MHz version, 8087-01, or remove the Co-processor board. **The two PAL chips, 444-269-1 and 444-270-1, are also required.**

This upgrade will not work with any 64K dynamic system RAM ICs left installed in the two remaining "banks" on the main board or on any system memory expansion in the S-100 card slots, such as the Z-205 Memory Expansion Card. All system memory must be 150ns or faster 256k banks of nine ICs per bank and **must be** on the main board.

No other memory configuration was supported by Heath/Zenith and the Z-205 Memory Expansion cards could not be used. Subsequently, thanks to third party software and some minor circuit changes to the Z-205 cards, they can now be used as RAM drives with up to 1 meg RAM each. See the other articles on this '*Z-100 LifeLine*' website.

The 200ns 64k RAM ICs removed during this upgrade **can** still be used in video memory.

Be sure your computer operates properly before you begin these modifications.

This upgrade will improve your H/Z-100 computer in two ways. First, it changes the clock frequency of your computer's 16-bit 8088 microprocessor CPU from 5 to 8 MHz, thereby increasing the program execution speed by as much as 60%. It will **NOT**, however, change the clock speed of the 8-bit 8085 microprocessor.

Secondly, it increases the dynamic random access memory (DRAM) of your Z-100 computer from 128k (or 192k) to 256k, 512k, or 768k, depending upon the amount of memory you wish to install in the three banks. In the past, 256k RAM expansion kits were available from Heath/Zenith as model Z-205-4.

TOOLS REQUIRED:

You will need the following tools to perform this upgrade:

1/4" nut driver
Phillips screwdriver
1/4" flat-blade screwdriver
Long-nose pliers
Diagonal cutters
22-25 watt, pencil-type soldering iron
Rosin core solder & desoldering braid
IC-puller or small flat screwdriver
Conductive Static Pad(s)
Electrical or Foam Tape

PARTS LIST:

The full HA-108 kit included the following parts, many of which are no longer available. As all electrical components have frequency tolerances, your computer may not require all these parts to operate properly. The only critical parts are the programmed ROM, EPROM, or PALs that must recognize the new memory being installed. These are marked with an asterisk following the IC location number.

QTY:	DESCRIPTION:	IC LOCATION:
1	74S74	U234
1	74F244	U126
6	74ALS244	U162,U163,U181, U214,U217,U241
2	74F257	U128,U146
1	74ALS240	U195
5	74ALS373	U196,U197,U198, U213,U227
1	8T98	U200
1	74ALS1032	U221
1	74S280	U153
1	8088-2 (8 MHz)	U211
or	8088-1 (10 MHz)	
1	74AS00	U155
1	74ALS1004	U166
1	74AS373	U133
1	74F367	U180
9	256k DRAM	U101-U109
9	256k DRAM (opt)	U117-U125
9	256k DRAM (opt)	U137-U145
1	MTR-ROM v2.9+	U190 *
1	N82S137AN ROM	U111A *
1	PAL 16L8BCN	U110 *
1	PAL 14L4CN	U173 *
1	150ns delay line	U149
1	24 MHz crystal	Y103

Those items marked with an asterisk are required for the memory upgrade. If your motherboard has already been upgraded for 256k RAM chips through any of a number of third party sources, such as ZMAX or RAMPAL, the speed increase should still work and the asterisked items are not required.

The first source of older parts for me is:
http://unicornelectronics.com/
They have an excellent supply of obsolete parts at reasonable prices. There are several other parts places on line, but their prices are obscene. Ebay is my second choice. I also maintain a fair stock of used parts and monitor ROM chips. Email me at:
z100lifeline@swvagts.com

IC INSTALLATION:

CAUTION: Integrated circuits (ICs) are complex electrical devices that perform many complicated operations in a circuit. These devices can be damaged during installation. Please read all of the following information before you install the ICs.

IMPORTANT: An IC packaged in conductive foam can be damaged by static electricity once you remove the IC. Once removed, do NOT lay the IC down or let go of it until you install it in its socket. When you bend the leads of the IC, hold it in one hand and place the other hand on the work surface before you touch the IC to that surface. This will equalize the static electricity between the work surface and the IC.

The pins of an IC may be bent out at an angle as shown in Figure 1, A. If this is the case, they will not line up with the holes in the IC socket. Before you install an IC, lay it down on its side as shown in A and very carefully roll it toward the pins to bend the lower pins into line. Then turn the IC over and bend the pins on the other side in the same manner.

Figure 1.

We will be removing a lot of ICs during this upgrade. Heath/Zenith recommended using a lever type tool as shown in Figure 2.

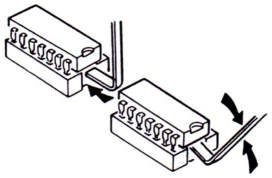

Figure 2 - Removing ICs.

There are also small IC pullers available in the shape of an elongated horseshoe that grab at the IC from both ends; then you gently rock the handle to pry up the IC one end slightly, then the other and repeat until the IC is removed.

However, both of these tools have difficulty with ICs that are shorter than the socket or where clearance under the IC is insufficient to catch the lip of the IC. I find that a flat-bladed jeweler's screwdriver works well at getting under the IC to pry the IC out gently a little bit at a time at each end.

Before you install an IC, you must first identify the pin 1 end (Figure 3). Make sure this end of the IC is positioned over the index mark on the circuit board, as shown in Figure 4. Also make sure that all of the pins are started into the socket before pressing it into the socket.

Note: An IC pin can become bent under the IC and it will appear as though it is correctly installed in the socket. Visually double check that all the pins are properly aligned in the socket after installation.

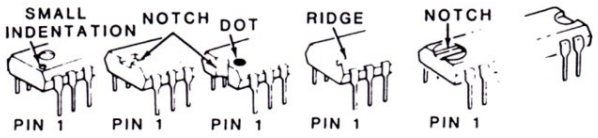

Figure 3 - IC Pin 1 Identification

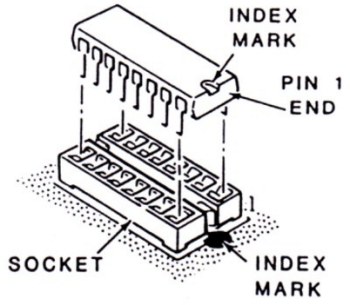

Figure 4 - Installing an IC.

DISASSEMBLY/REASSEMBLY:

Disassembly/Reassembly Procedures are provided in another article on the 'Z-100 LifeLine' Website as 'Z-100 Disassembly'.

For this upgrade, the computer must be disassembled until complete access is gained to the motherboard. This includes removal of any daughter boards, such as a Gemini Board or 8087 Co-processor Board. The motherboard **does not** need to be removed from the computer chassis, but it is encouraged. It would allow better access to the integrated circuits (ICs), better support as you remove and install ICs, and, as long as we are at it, it would permit a visual inspection of the entire motherboard before reinstallation.

MAIN CIRCUIT BOARD UPGRADE:

CRYSTAL REPLACEMENT:

CAUTION: Before proceeding with the crystal replacement, if you can not obtain all the parts listed earlier for this upgrade, we will discuss further options later in this article. There is also a possibility that this upgrade will not work and the following procedure makes reinstalling the working 15 MHz crystal difficult! Please read and understand the entire article before continuing with this upgrade.

[ ] Position the computer motherboard with the S-100 card sockets toward the rear - away from you (See figure XX).

[ ] Locate crystal Y103 in the forward right corner of your motherboard. It should be marked with something similar to 15.000 MHz.

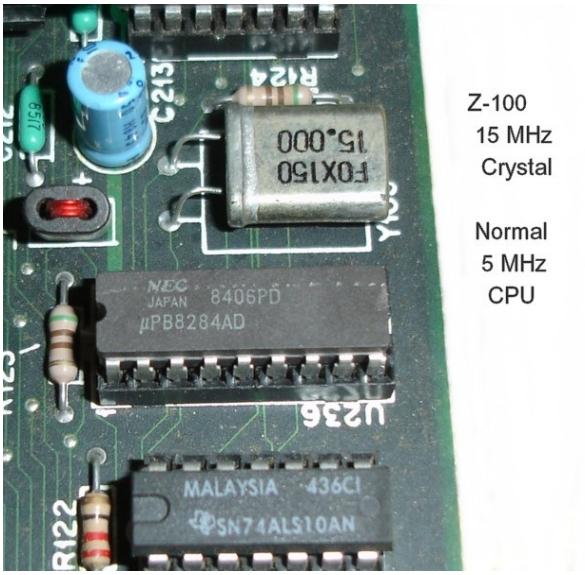

Photo 1 - 15 MHz Crystal

Figure 5 - Clipping the Crystal Leads

[ ] Using a pair of diagonal cutters (Figure 5), carefully cut off both leads of crystal Y103 as close to the crystal body as possible. Then, using long-nosed pliers, form a small hook at the free end of each remaining crystal lead.

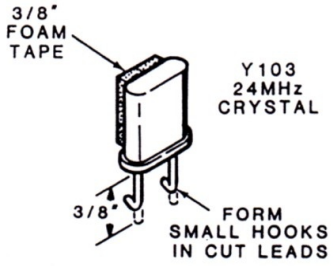

Figure 6 - Preparing the Crystal

[ ] Carefully cut each lead of the 24 MHz crystal to 3/8". Then form a small hook at the free end of each crystal lead.

[ ] Cut a 1" length of electrical tape or 3/8" of foam tape. Loop one end of the tape back over the other to form a continuous loop with the adhesive side out (you're making double stick tape).

[ ] Press the tape to the unlabelled back side of the 24 MHz crystal.

[ ] Connect the prepared 24 MHz crystal to the two leads at Y103 on the circuit board. Crimp each pair of leads together, then lay the crystal on its back, pressing the tape between the crystal and the circuit board. Solder both lead connections.

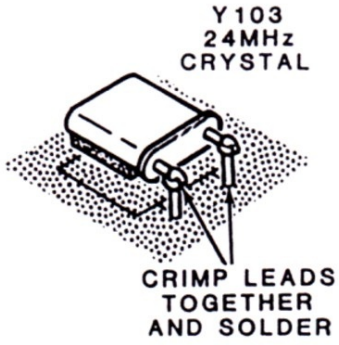

Figure 7 - Installing the Crystal

IC REPLACEMENT:

Static is deadly to ICs. Always ground your hand against the metal computer chassis before handling any IC. If static is prevalent in your home (such as during the dry Winter heating months), be especially careful. Use a grounding strap or you may want to save this for a rainy day.

To remove ICs, either use the angled tool often enclosed in Heathkit projects, any commercial IC puller, or a very small jeweler's screwdriver. Lift or pry the IC from each end gently until it is free and set it aside.

If your computer does not presently have full color capability, you may add this feature by referring to the Video Logic Board Upgrade section of this article, which uses the memory chips being removed from the motherboard.

Always save the ICs being removed for any possible future reuse.

In the following steps, each IC is identified in the step with a special IC callout (U117, for example) and identification.

The following ICs are located in the lower, left-hand corner of the motherboard:

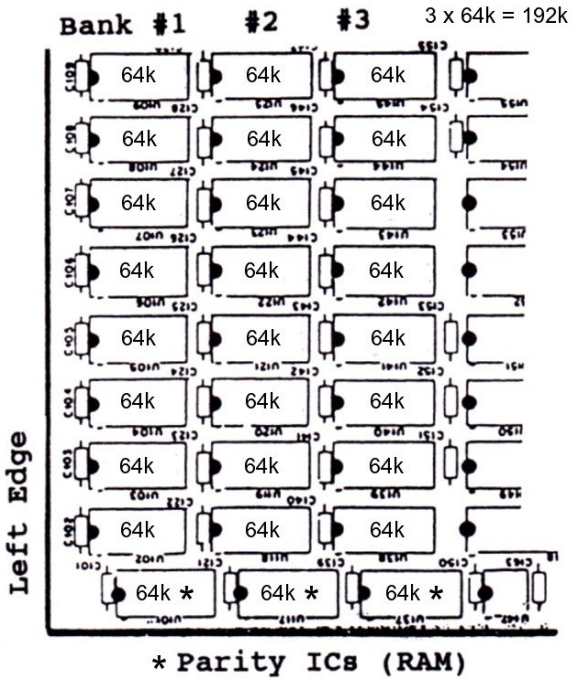

Figure 8 - Left, Front Corner Z-100 Motherboard

[ ] Remove ICs U101 through U109 (#443-970, 4164, 4864, 6665, or similar). These are RAM chips that can be installed on the Video Board.

[ ] Install 256k DRAM chips (4256, 41256, 71256, or similar) in the vacant sockets. This is the first bank of RAM chips.

[ ] If installed, remove ICs U117 through U125 (#443-970, 4164, 4864, 6665, or similar). These are RAM chips that can be installed on the Video Board.

[ ] For 540k RAM, install 256k DRAM chips (4256, 41256, 71256, or similar) in the vacant sockets. This is the second bank of RAM chips.

[ ] If installed, remove ICs U137 through U145 (#443-970, 4164, 4864, 6665, or similar). These are RAM chips that can be installed on the Video Board.

[ ] For 768k RAM, install 256k DRAM chips (4256, 41256, 71256, or similar) in the vacant sockets. This is the third bank of RAM chips.

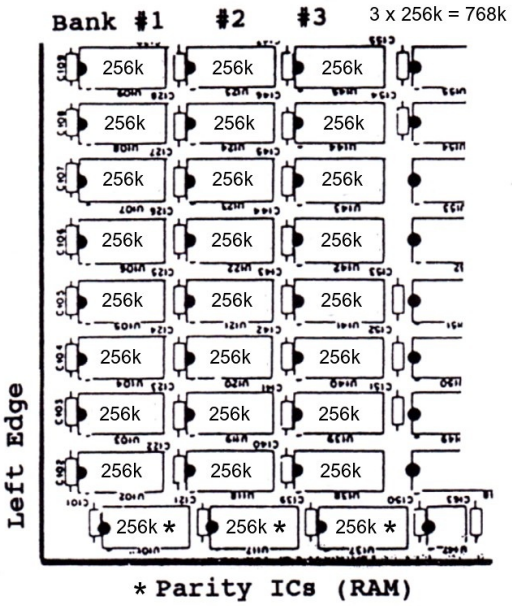

Figure 9 - 768k Motherboard Memory

[ ] Replace U149, 200ns delay line (#41-10,14CB201) with 150ns delay line (14CB151).

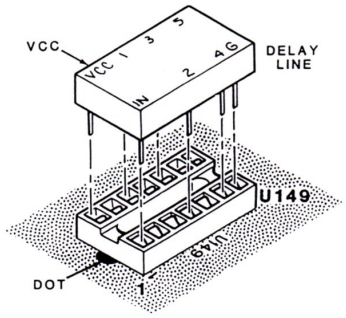

Figure 10 - Installing the Delay Line

Similarly, replace the following 28 ICs on the motherboard:

	IC:	OLD ID:	NEW ID:
[ ]	U166	#443-872,74LS14	74ALS1004
[ ]	U200	#443-1024,74LS368	8T98
[ ]	U153	#443-1001,74LS280	74S280
[ ]	U221	#443-875,74LS32	74ALS1032
[ ]	U234	#443-1051,74ALS74	74S74
[ ]	U155	#443-728,74LS00	74AS00
[ ]	U146	#443-1037,74LS257	74F257
[ ]	U173	#444-243*	#444-368*
[ ]	U190	#444-87* v2.5 or #444-348* v2.8	#444-276* v2.9
[ ]	U110	#444-126*	#444-367*
[ ]	U111A	#444-104*	#444-366*
[ ]	U126	#443-791,74LS244	74F244
[ ]	U128	#443-1037,74LS257	74F257
[ ]	U211	#443-1009,8088	8088-2

Note: If you have removed an 8087 Numeric Co-processor Card (Model Z-216), this part has already been removed. If you are reinstalling an upgraded 8087 Card later, leave this socket empty.

	IC:	OLD ID:	NEW ID:
[ ]	U213	#443-837,74LS373	74ALS373
[ ]	U241	#443-791,74LS244	74ALS244
[ ]	U133	#443-837,74LS373	74**AS**373
[ ]	U195	#443-754,74LS240	74ALS240
[ ]	U214	#443-791,74LS244	74ALS244
[ ]	U162	#443-791,74LS244	74ALS244
[ ]	U180	#443-857,74LS367	74F367
[ ]	U196	#443-837,74LS373	74ALS373
[ ]	U163	#443-791,74LS244	74ALS244
[ ]	U181	#443-791,74LS244	74ALS244
[ ]	U197	#443-837,74LS373	74ALS373
[ ]	U198	#443-837,74LS373	74ALS373
[ ]	U217	#443-791,74LS244	74ALS244
[ ]	U227	#443-837,74LS373	74ALS373

Carefully recheck each of the above ICs for the proper type, installation, and orientation of the pin 1 end.

[ ] Remove the jumper socket from the GND plug near J104 in the center of the motherboard. Install this socket between the center pin and the W2 pin of plug J106-1 at the front, right edge of the motherboard. NOTE: The I/O wait state will now increase from 1 to 2.

NUMERIC CO-PROCESSOR UPGRADE:

Complete the next five steps only if you removed an 8087 Numeric Co-processor Card (Model Z-216) from the motherboard. Otherwise, skip these steps. NOTE: This upgrade will allow the card to operate at the 8 MHz CPU clock frequency.

There are two IC PALs marked with an asterisk below that are required to upgrade this board for 8 MHz operation. These were available only from Heath/Zenith. Unless you have these parts, this upgrade **MAY NOT WORK.** As all ICs have speed tolerances, I would still give it a try, though.

The figure below shows an outline of the Numeric Co-processor board with each IC indicated. Replace the following ICs:

	IC:	OLD ID:	NEW ID:
[ ]	U252	#443-1009,8088	8088-2 or -1
[ ]	U253	#443-1168,8087	8087-2 or -1
[ ]	U254	#444-270* PAL	#444-270-1* PAL
[ ]	U255	#444-269* PAL	#444-269-1* PAL

[ ] Reinstall the upgraded Numeric Co-processor Card in socket U211 on the motherboard.

This completes the "Main Circuit Board Upgrade".

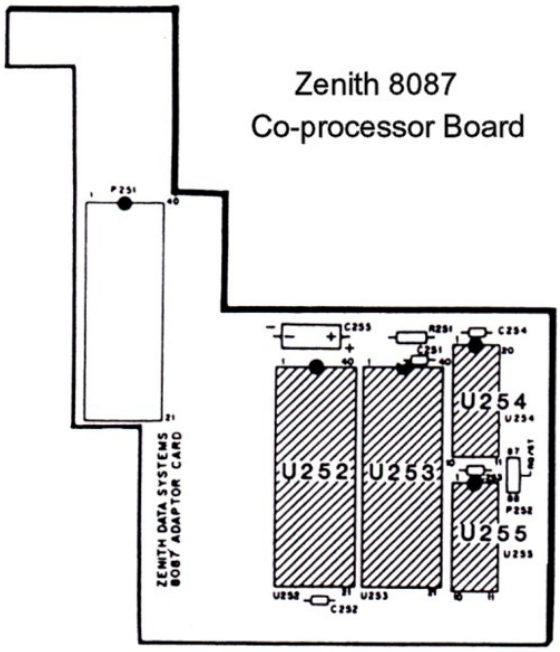

Figure 11 - Zenith 8087 Co-processor Board

TTL SERIES DESIGNATORS:

Due to discontinued and declining stocks of TTL integrated circuits, you may have difficulty in obtaining the specific ICs necessary for this upgrade.

There are numerous different subfamilies of TTL that trade off speed, power, and specific needs for special uses. The regular TTL device has no letters in their part number (such as 7400). Other devices have one or more letters included.

Some of these, and their typical characteristics compared to regular TTL, are:

TTL Subfamily:	Speed:	Power:
Regular TTL (7400)	~35 MHz	~10 mW
Low-power (74L00)	0.1x	0.1x
High-power (74H00)	2.0x	2.0x
Schottky (74S00)	3.5x	2.0x
Low-power Schottky (74LS00)	1.2x	0.2x
Advanced Schottky (74AS00)	6.0x	1.0x
Fairchild AS TTL- FAST (74F00)	6.0x	1.0x
Adv-low-pwr Schottky (74ALS00)	2.0x	0.1x
High-speed CMOS (74HC00)	1.2x	0.02x

Keep in mind that these values are typical and very general; they also vary slightly among manufacturers. So, specific devices have numerous parameter specifications that may vary somewhat from these typical values. If an IC from one manufacturer is having difficulty, try another from a different manufacturer.

All of the devices with the same numbers can be substituted for another device as long as the speed and power specifications are not exceeded. For example, there is usually no problem substituting a 74ALS00 for a 7400 device, but the reverse substitution may not work.

Generally speaking, any 74LSxxx device in the Z-100 can be replaced by: 74HCxxx, 74ALSxxx, 74Fxxx, 74ASxxx, 74Sxxx, or 74Hxxx device, in that order of preference.

That said, however, timing is the next major consideration. Often a faster chip will not work correctly because it is too fast for the surrounding IC chips in the circuit. Depending upon your stock of chips, jump to the next faster chip and do NOT try to skip too many. You will need to find a happy medium.

You may question why the much faster 74ASxxx and 74Fxxx devices are not first, but these require 5 times the amount of power, and therefore heat, used by the 74LSxxx device! For the number of ICs used in the Z-100, this can be a considerable power requirement, especially if your Z-100 is heavily loaded with upgrades, such as EASYPC, GEMINI, RAM Drive Boards, etc.

The extra heat generated may also become a problem. Some individuals have even installed a second cooling fan!

VIDEO LOGIC BOARD UPGRADE

This section provides information on how you may add full color capability to your Z-100 computer by installing the RAM chips that you removed from the motherboard.

Orient the Video Logic Board on the work table so the ribbon cables are toward you (bottom), component side up, and the silkscreen lettering is upright. Before proceeding, we need to discuss the present video memory configuration of the board.

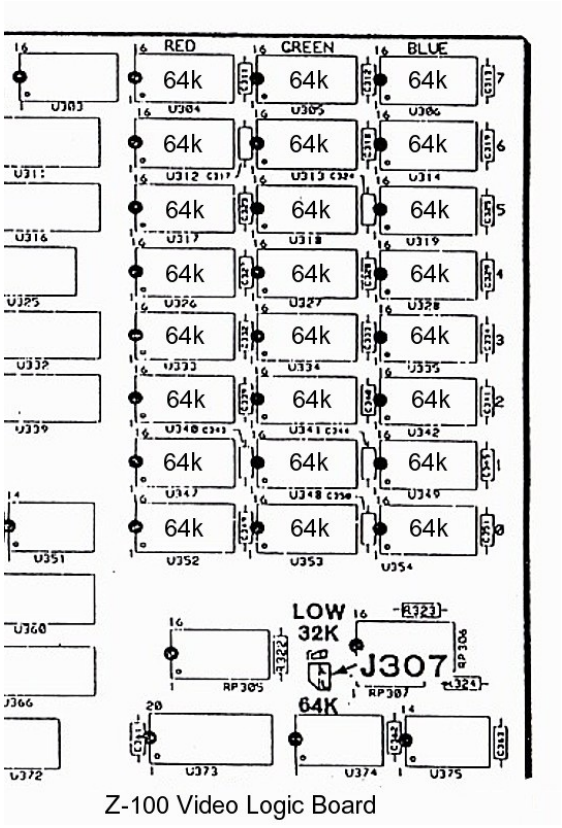

Figure 12 - Right Side of Video Logic Board

Locate jumper J307 toward the lower right corner of the board (Figure 12). This jumper selects the type of RAM chip installed on the Video Board.

A 32k RAM chip provides one page of video memory for each color to be displayed - red, green and blue.

A 64k RAM chip provides two pages of video memory for each color.

Jumpers J305 and J306, located at the upper center of the video board, determine whether the video board provides a color video signal ("RGB" positions, left) or green-only video signal ("G" positions, right).

Jumpers J301 thru J304, located at the left side of the video board, provide the polarity and configuration of the video signal and will NOT be moved during this upgrade.

Finally, the video memory is located in the upper right corner of the board, in three columns of eight chips each. Each column represents a color plane, printed along the top edge of the board - "RED", "GREEN", and "BLUE".

If all three columns contain chips, jumper J307 was in the "64k" (lower) position, and jumpers J305 and J306 were in the "RGB" (left) position then the board is already configured for two pages of color memory. No changes are needed.

If all three columns contain chips, jumper J307 was in the "32k" (upper) position, and jumpers J305 and J306 were in the "RGB" (left) position then the board is already configured for one page of color memory, all that is needed for nearly all Z-100 applications. No changes are necessary, unless special, rapid, graphics-intensive applications will be used.

If jumper J307 was in the "64k" (lower) position and only the green plane was filled with RAM chips, then the RAM chips from the motherboard (64k chips) can be installed in the video board's red and blue banks for full color capability. Jumpers J305 and J306 can be repositioned to the "RGB" position to use color.

PLEASE NOTE: If there were not enough RAM chips removed from the motherboard, additional chips will need to be obtained before any chips can be installed and color can be used. While the RAM chips may be of different manufacturers, or even of different speeds, ALL RAM chips must be of the same size (32k or 64k) in the same bank; do NOT mix them. ALL RAM sockets must have memory chips to be able to use color.

If jumper J307 was in the "32k" (upper) position and only the green plane was filled with RAM chips, then the RAM chips from the motherboard (64k chips) can be installed in the video board's red and blue banks for full color capability. Jumpers J305 and J306 can be repositioned to the "RGB" position to use color.

But, unless there is a sufficient number of motherboard 64k chips to replace the 32k chips in the green plane, jumper J307 must remain in the "32k" position, providing one page of video memory. **PLEASE NOTE: All video memory chips must be 64k chips to select the "64k" position of J307.**

UPGRADE INSTALLATION:

If the Video Logic Board has two empty columns of memory (red and blue) and there are 16 RAM chips available, proceed as follows:

[ ] Install eight of the memory ICs (4164, 4864, 6665, or similar) removed from the motherboard into the "RED" column of empty sockets (U304,U312,U317,U326,U333,U340,U347, U352) on the Video Logic Board. Ensure you position the pin 1 end of each IC toward the index mark (white indentation) on the board and socket.

[ ] Similarly, install eight of the memory ICs removed from the motherboard into the "BLUE" column of empty sockets (U306,U314,U319,U328, U335,U342,U349,U354) on the Video Logic Board.

[ ] Reposition jumpers J305 and J306 to their respective "RGB" (left) positions to activate the color option.

[ ] If jumper J307 was in the "64k" position already, then you have completed the upgrade to a color system. Reassemble the computer.

[ ] If jumper J307 was in the "32k" position and there **are not** enough 64k motherboard memory chips to replace the "GREEN" plane (all eight chips), then J307 must remain in the "32k" position. You have completed the upgrade to a color system, though only one page of video memory will be available. Reassemble the computer.

[ ] If jumper J307 was in the "32k" position and there **are** enough 64k motherboard memory chips to replace the "GREEN" plane (all eight chips - leaving 3 loose chips left as extra spares), proceed with the following steps:

[ ] Replace the 32k RAM chips from the "GREEN" column (U305,U313,U318,U327,U334,U341, U348,U353) with 64k RAM chips from the mother-board upgrade. Ensure you position the pin 1 end of each IC toward the index mark (white indentation) on the board and socket.

[ ] **ONLY IF ALL THREE COLOR COLUMNS ARE NOW 64K CHIPS**, relocate jumper J307 from the "32k" (upper) position to the "64k" (lower) position.

This completes the "Video Logic Board Upgrade." Reassemble the computer.

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Other Z-100 Speed Up Options

OK, that was the Official Upgrade. There are several articles in previous issues of the *Z-100 LifeLine* that may be of interest. These are:

How to Determine Z-100 Clock Speed	#14
Gernware 10MHz Turbocharger Kit	#25
Z-100 Speed Up Supplement	#35
Speed Mods to Scottie Board	#41

Of particular interest, The "Z-100 Speed Up Supplement" provides the list of all chips for most of the boards in the Z-100 to up the speed to 12-14 MHz!

That said, however, it is getting increasingly difficult to find the required ICs necessary to fully implement that upgrade. Does that mean that we are out of luck?

No, not really. I spent all of November, 2001, experimenting with Speed - using two general methods: a 24 MHz Crystal or 24 - 32 MHz Oscil-lator.

What's the difference?

Well, crystals have been around since crystal radios. They are in a variety of metal cans with two leads out one end, similar to the 15 MHz crystal, case style HC-18, at Y103 at the right edge of the motherboard.

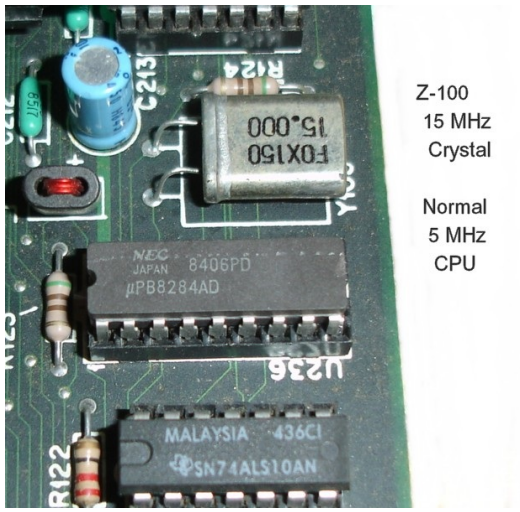

Photo 2 - 15 MHz Crystal at Y103

Popular shapes are:

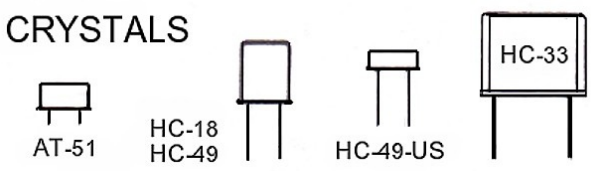

Figure 13 - Crystal Shapes
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Oscillators come in a flat, rectangular metal can, with 4 leads, such as U18 on the Z-207 controller board.

Figure 14 - Crystal Oscillator

This article discusses my findings, and also discusses one of the other alternatives to Heath/Zenith's speed upgrade.

Before leaping into this, you may have a nagging question, "How do we get 5 MHz from a 15 MHz crystal?"

Quite simply, U236, a D8284A device, performs a "divide-by-three" function on the crystal to provide a clock frequency at one third the crystal frequency.

This begs another question; "Instead of using such high frequency (24 to 30 MHz crystals), would it not be better to use 16 to 20 MHz crystals and a "divide-by-two" function?"

This is a natural question, but I do not have an answer. I am told that to change now would require a rather involved modification to the motherboard.

Oh, well, let's press on.

24 MHz Crystal Upgrade

First, try to obtain and install all the parts listed in the Heath/Zenith Upgrade. This will reduce the possibility of multiple problem ICs - having more than one inoperative IC at a time makes IC substitution to find a problem much more difficult.

We are banking on the fact that all ICs have some tolerances to their specifications. Even chips with the same number, 74LS00, for example, have different frequency limits. Some will not work beyond 7 MHz, others will not quit until 10 MHz or more.

Obtain one or two crystals between 15 MHz and 24 MHz, to reduce the speed jumps and again reduce the chance of multiple IC failures.

Perform as much of the Heath/Zenith Upgrade as possible, except for the crystal replacement. Cut off the old crystal as described, but leave enough lead length on the crystal to solder on a wire extension, if necessary.

Instead of permanently installing the new 24 MHz crystal, temporarily hook in each new crystal, increasing the speed gradually from 15 MHz to ensure the computer motherboard works before graduating to the next step. Keep the temporary lead lengths short.

Note the position of all the switch sections of S101 on the motherboard, then set all sections to the rear of the computer. Note: some motherboards have an improperly marked switch. On mine, the rear of the switch places each section "ON".

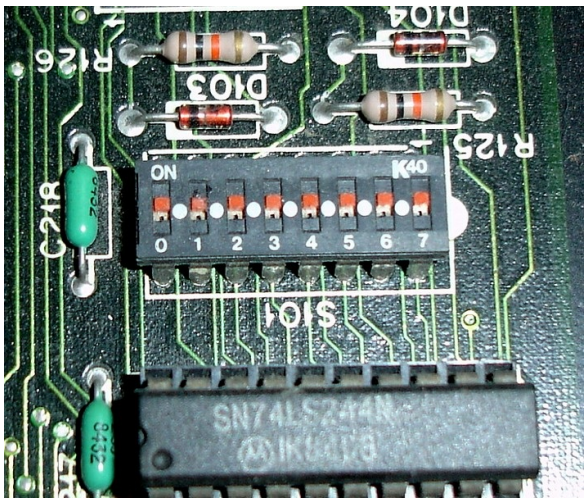


Photo 3 - Motherboard Switch S101

Do not worry about putting the computer together until everything checks out. All we need at this point is the motherboard attached to the power supply (both connectors), the keyboard attached to the motherboard (the keyboard can rest on the table in front of the computer), and the Z-207 Floppy Controller Board installed in one of the S-100 slots at the rear of the motherboard. Remove the card cage to get it out of the way. The floppy drive need not be connected.

If the Z-207 Floppy Controller is not installed at start up, you will get an error "*Primary Z-207 Controller Error*".

Leave any other daughter boards off for now. This includes any Gemini or EasyPC boards, Co-processor boards, clock chips, etc.

When you start the computer after each modification, one of four results will generally happen:

1. Computer starts to the hand prompt normally, with two beeps. If MTR-ROM 4.2 or greater is installed, pressing {**L**} for "Look System" will display the system parameters, including the type of CPU and clock speed. Those using an older MTR-ROM will not be able to tell the clock speed except by counting the beeps during a memory test (See the article "How to Determine Z-100 Clock Speed" in issue #14).

2. At start up, the computer beeps once, displays the "Primary Z-207 Controller Error", then beeps a second time and displays the normal hand prompt. This seems to be a problem with the Z-207 Floppy Controller Card, rather than the motherboard. It is usually because of a "slow" U22, FD1797 Controller Chip, normally rated at 5 MHz. Installing an 8 MHz FD1797-02 chip should take care of this error.

If not, did you remember to install a jumper on the J106-1 "W2" jumper pins? This becomes more important as you approach or exceed 8 MHz, as it provides an extra wait state for speed critical components, such as the Floppy Drive Controller.

Still not working? Try changing the 74LS244 chips in U33, U34, and U36. Above 8 MHz, these chips become even more speed-sensitive.

If still not working, try direct substitution of the other chips on the Z-207 card. This card should be working.

And while we are talking Z-207 errors, running DIAG after attaching a Floppy Drive to the controller will generate other errors, most notably "Access Failure", "Register Failure" and "Head Load Time Error".

The troubleshooting procedures mentioned earlier, especially installing the "W2" wait state jumper, will generally eliminate these, except I found one anomaly to the general order of "faster" chips. The "Head Load Time Error" was caused by a slow 92LS02, U15 on two Z-207 cards. Replacing with a "slower" 9202 chip worked fine!

Other problems: I had one instance of U167, a 74S74, causing a malformed hand prompt. I had to replace with a 74F74. I also had one instance of a bad U132, 74LS373, at 8 MHz. Neither were on H/Z's list of HA-108 chips.

3. At start up, the computer emits a continuous pattern of beeps. I found that a slow 74LS257 chip in U146 or U128 on the motherboard may cause the beeps, as will a wrong size delay line. Also check for the "W2" wait state jumper on J106-1.

4. At start up, the computer beeps once, or not at all, and there is no display. If the power supply fan is running - it generally is not the power supply (unless you also heard a "pop" or "pssst" sound). There is an IC on the motherboard that is not working at the higher speed.

Temporarily clipping the 15 MHz crystal back in place will confirm that the computer IS still working. Reinstall the faster crystal again and perform the following steps, which I have placed in priority order:

1) Did you remember to install a jumper on the J106-1 "W2" jumper pins?

2) Using the Heath/Zenith Speed Up parts list as a guide, begin substituting those parts that you could not replace with faster units. If you do not have spares, try swapping chips from other areas of the board.

3) If you are trying to use an 8088, some will work up to 8 MHz, but you are pushing it. Faster units, 8088-2 8 MHz and 8088-1 10 MHz are still readily available at reasonable prices.

4) You may have a bad 150ns delay line. Try using the old 200ns delay line. I've found that some of these will work to 9 MHz! If you could not find a 150ns delay line, try replacing the 200ns delay line with spares.

5) Try another D8284A chip in U236. While virtually all work up to 8 MHz, they become very speed sensitive above 8 MHz. More info later on these hard to find chips.

6) Try another 24 MHz crystal. Some crystals seem to be better than others - and some work with some D8284 chips, while others work better with other D8284 chips!

7) As a last resort, begin substituting the rest of the chips on the motherboard. It would be best to use the chips from another working motherboard.

As you are successful at each speed, perform the system memory and video memory checks before continuing to the next speed. The fastest I was able to get using a crystal was 8 MHz (a 24 MHz crystal). As soon as I exceeded this speed, I could not find a D8284 chip (U236) that would work with a particular crystal. I bought faster CP82C84A chips, but these would not work at all with the crystals, and only with 10 MHz or faster oscillators!

5/7.5 MHz CDR Speed Module Upgrade

Before proceeding to my 24 MHz oscillator, let me introduce another Speed Up Upgrade from Controlled Data Recording (CDR) Systems Inc. - the Z-100 Speed Module, ZS100.

The ZS100 Speed Module was a small 2x2" circuit board that plugged into U236 after the D8284A chip was removed. The D8284A chip was installed in the socket provided on the speed module's board.

The board had a 22.5 MHz oscillator installed and a two conductor cable to a separate SPST switch that mounted on the computer's back panel. The switch permitted us to select between the computer's 15 MHz crystal or the Speed Module's 22.5 oscillator to allow the computer to operate at 5 MHz or 7.5 MHz.

Installation of the Speed Module did not require any changes except installation of the board itself. The schematic follows:

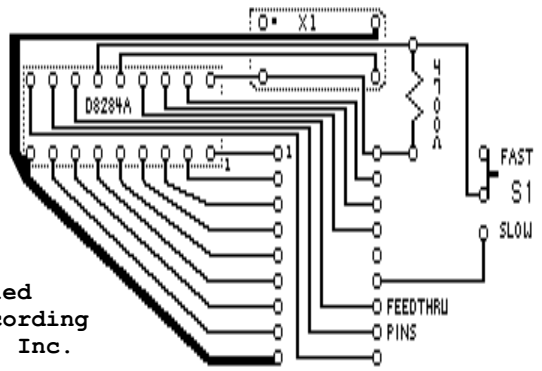


Figure 15 - Z-100 Speed Module, ZS100

This Speed Up method worked well in most Z-100 computers, relying on device tolerances to permit the extra speed. At 8 MHz, problems began to arise, which is why the unit had its 22.5 MHz oscillator.

If you aren't happy with the 7.5 MHz limit, I recommend unsoldering and removing the 22.5 MHz oscillator and installing four feed-thru pins that would allow you to plug the oscillator into the pins. Place heat shrink tubing around each of the four pins.

Also, be aware that the feed-thru pins may make contact with the metal case of the bottom of the oscillator, causing a short. Make an insulator by taking electrical tape and applying it to the bottom of the oscillator by pressing the oscillator pins right through the plastic tape.

Finally, because of the increased height of the oscillator when the board is inverted and installed, the metal oscillator case may short some of the exposed traces on the motherboard. Insulate this area with a small section of electrical tape, applied to the motherboard in that location.

Now you can change the oscillator by simply removing the CDR Speed Module, changing the oscillator, and reinstalling the module. This comes in very handy when exploring speeds greater than 8 MHz, where speed increases need to be made very gradually.

If the installation has problems, fall back on the troubleshooting procedures I discussed in the last section.

24 MHz Oscillator Upgrade

As with the 24 MHz Crystal Upgrade, first try to obtain and install all the parts listed in the Heath/Zenith Upgrade. This will reduce the possibility of multiple problem ICs. All the considerations and troubleshooting procedures provided in the Crystal Upgrade still apply.

The modified CDR Speed Module, mentioned in the last section, works ideal for experimentation - the idea being to find the fastest speed at which the computer still operates. Once this maximum speed is found, since it is pushing the maximum limits of some IC somewhere, reduce the speed to the next highest speed, which should then operate reliably for some extended length of time.

For example, if the computer works well at 10.67 MHz (a 32 MHz oscillator), drop back to 10 MHz (a 30 MHz oscillator) to protect the limiting IC(s).

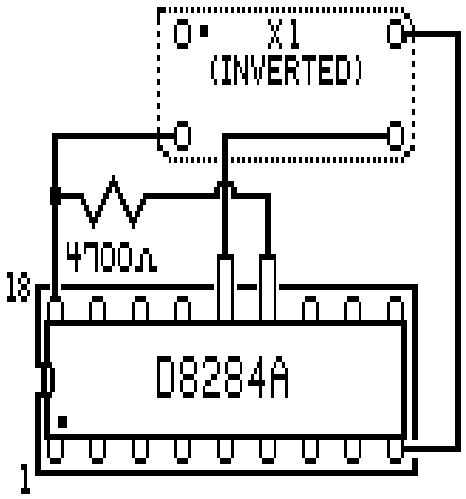
Once this speed is found, you can assemble a simple three-piece speed module to replace the CDR Speed Module, which you may want to keep to play with another Z-100.

The seemingly complex CDR schematic can be reduced to a much simpler version. This version loses the ability to switch to slow speed, however.

As some games may be more difficult if they do not correct automatically for the faster speed, installing a switch to short pin 13 of the D8284A chip to any handy ground point will reduce the clock speed back to 5 MHz, if a 15 MHz crystal remained installed.

To make Steve's Speed Module, you will need the oscillator and D8284A chip for the speed that you found works, an 18 pin low-profile DIP socket, a 4700 ohm resistor and some hookup wire. The schematic follows:

Steve's Speed Module:



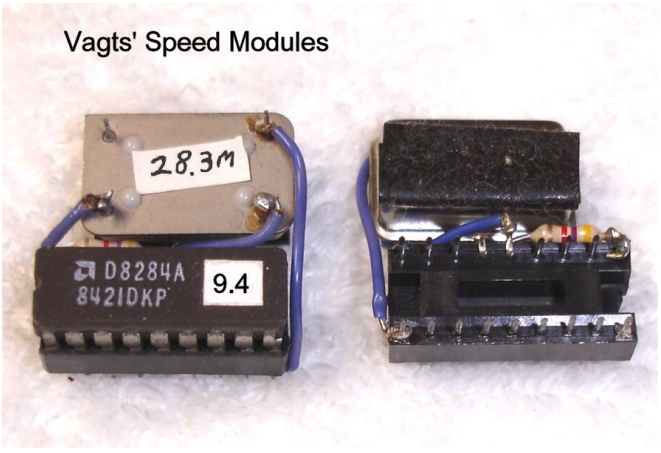


Photo 4 - Speed Modules

[ ] Paying attention to the notch in one end of the socket that designates where pin 1 is located, bend out socket pins 13 and 14.

[ ] Using the location of the components in the schematic as a guide, solder the 4700 ohm resistor between pin 18 and bent out pin 13. The resistor should rest against the side of the socket.

[ ] Position the oscillator, upside down, along side of the resistor, watching the location of pin 1 (generally marked with a dot on the top and the only corner of the oscillator that is not rounded.

[ ] Solder a short piece of hook-up wire between the socket's bent out pin 14 to pin 3 of the oscillator, diagonally opposite of pin 1.

[ ] Solder a short piece of hook-up wire between the socket's pin 18 (keep the wire close to the socket's body) and pin 4 of the oscillator.

[ ] Solder a short piece of hook-up wire between the socket's pin 9 (keep the wire close to the socket's body) and pin 2 of the oscillator.

[ ] Check that pin 1 of the oscillator has no wires attached to it and the other pins are attached per the schematic.

[ ] Test fit the constructed speed module in socket U236. The oscillator should fit on its back (top) over the crystal Y103. and beside capacitor C213. Adjust as necessary.

[ ] Remove the assembly. Using a one inch length of electrical tape, double it over on itself and attach it end-to-end to create a loop of double-stick tape. Stick it to the top of the oscillator.

[ ] Reinstall the assembly, pressing the top of the oscillator to the crystal, where the tape should hold it in place.

[ ] Install the D8284A IC into the new socket, watching that pin 1 of the IC is inserted into pin 1 of the socket.

[ ] Ensure the power supply and the keyboard are connected to the motherboard.

[ ] Install the Z-207 Floppy Disk Controller Card in any S-100 card slot.

[ ] Turn on the computer, and enjoy your success. If the computer does not start properly, recheck your work on the speed module, then follow the troubleshooting procedures provided earlier.

Additional Findings:

So now that we've covered all the options, where does it get us.

Well, I am surprised that you generally do not need to replace as many parts as the HA-108 kit leads you to believe. For upgrading the RAM to 768k using 256k RAM chips, you certainly need the asterisked chips. But for the most part, the other chips are to increase the speed, and are not all needed.

Even the 8088 chips worked well at higher than rated speeds. My 5 MHz rated 8088 even worked at 8.9 MHz, but was getting hot to the touch. All my 8 MHz 8088-2s worked well at 10 MHz. Limits on the 10 MHz 8088-1 are unknown, though Mike Zinkow was running one at 14 MHz reliably.

The list of parts in the HA-108 kit does provide a good place to start looking if there is difficulty, however.

I am also surprised that I could run faster using an oscillator (10+ MHz) than I could with a crystal (8 MHz max). Whether this is because the waveform signal is cleaner or less noisy, I do not know.

While I could get the motherboard to run at 10.7 MHz (32 MHz oscillator) without difficulty, I could not get the Z-207 Floppy Disk Controller Card (7 cards and 10 controller chips tried) to run faster than 10 MHz, and even at 10 MHz, my diagnostics program, DIAG, would still report a "Floppy Drive Failure" on 50% of the controller tests, though all Read/Write tests worked fine.

I had tried three different motherboards, and maybe there is a chip on each motherboard that is causing the error - or the speed is just too fast for DIAG to process reliably - I do not know yet.

The most critical part on the Floppy Controller Card is U22, the FD1797 controller chip. While my 5 MHz rated FD1797 worked at 8 MHz, none of my 8 MHz rated FD1797-02 chips worked beyond 10 MHz.

While you may be able to squeeze by at 8 MHz without setting the "W2" wait state jumper on J106-1, it is certainly required for the Floppy Controller at faster speeds. The "W3" jumper, however, provided little additional help.

I have had no problems running any of the Z-217 Hard Drive Controllers at 10 MHz.

If you have any questions or comments, please email me at:

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Cheers,

Steven W. Vagts