

Gemini PC-Emulation Board

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Gemini PC-Emulation Board

Notes:

- The following discussion is from the Gemini Emulator Board's User Guide, with several changes.
- The User Guide kept referring to the H/Z-100 series computer. For brevity and clarity, I replaced the H/Z-100 with Z-100, which includes the Z-110 'Low-profile' computer and the Z-120 'All-in-one' computer.
- I also placed all Z-100 key names within brackets and highlighted them, again for clarity. For example, CTRL-ALT-DEL becomes {CTRL}-{ALT}-{DEL}. This is standard phrasing used for all my articles on the "Z-100 LifeLine" Website.
- Finally, the User Manual made a rather confusing mess of Zenith's Z-100 PC MS-DOS, which was actually Zenith's Z-150 (which was for the several models of Zenith's PC-clones of the time) MS-DOS and Zenith's H/Z-100 MS-DOS. I will refer to these as PC-DOS and Z-DOS.

Section 1 - Introduction

1-1 Preface

The Gemini Emulator Board, (C)1986, gave your H/Z-100 series computer access to the vast library of IBM PC programs. When used with the optional Gemini Sound Board, the Gemini equipped Z-100 can also deliver sound support when operating in IBM Mode.

In order to use the IBM PC Mode, you must use a PC compatible Disk Operating System (PC-DOS). Gemini Technology Inc. recommended the use of the Heath/Zenith MS-DOS for PC compatible computers (Catalog number OS-63-31 or equivalent) since this had been tested extensively with the Gemini Emulator Board.

Although IBM's PC-DOS will generally run satisfactorily on the Gemini Emulator, some problems had been experienced when using that DOS.

If you plan to use the Gemini Emulator with a hard disk, you **MUST** use the Heath/Zenith MS-DOS for PC compatibles. Refer to **Section 5 - Using a Winchester Hard Disk**, for additional information on the installation and use of a hard disk with your Gemini Emulator Board.

The Gemini Emulator Board consists of a printed circuit board (see the title photograph) that is easily installed inside the computer, on top of the Z-100 motherboard, but under the Video Logic Board. You will have to partially disassemble your computer to obtain full access to the Z-100 motherboard. Disassembly procedures are included as another article on the "Z-100 LifeLine" Website.

Briefly, the basic installation procedure is to remove the video logic board from the motherboard, remove U211, an 8088 Central Processing Unit (CPU) Integrated Circuit, from the motherboard, install the 8088 on the Gemini Board, install the Gemini Emulator Board on the motherboard, and when reinstalling the video logic board, route the P104 cable to the connector on the Gemini Board. Installation requires no soldering or additional DRAM (Dynamic Random Access Memory) for main memory. The Z-100 Video Logic Board **MUST** contain 64K DRAM chips for proper IBM PC emulation.

You will need some basic tools to install your Gemini Emulator Board. You should familiarize yourself with the procedures of **Section 2 - Installation and Hardware Information** before you actually perform the installation.

You should also verify that your Z-100 computer operates properly in the Zenith Mode before you begin the installation.

If you have any doubts about your ability to successfully complete the installation of any Gemini product, please contact me by email at: z100lifeline@swvagts.com

1-2 General Theory of Operation

An Emulator as a hardware device or a combination of hardware and software that permits programs written for one computer to be run on another. In this context, the Gemini Emulator Board (a hardware device) adds IBM PC hardware and software features through the use of software emulation subject to the hardware limitations of the Z-100 computer.

The Gemini Emulator Board provides the IBM PC emulation through the use of both the Gemini ROM (Read Only Memory) and Zenith Data System's (ZDS) ROM's that provide a remarkable degree of compatibility with the IBM PC.

The Gemini ROM implements the overhead code necessary to support most of the hardware and software features of the IBM PC while the ZDS ROM's provide the necessary support for PC compatibility.

The Gemini Emulator Board allows you to operate your Z-100 in normal Z-100 Mode or the IBM PC Mode. Either mode can be selected at the time your computer is powered up or is reset.

In the Z-100 Mode, you can still use all of the software that you have already purchased or written for your Z-100.

The Z-100 Mode

When the Z-100 Mode is selected at the Gemini Emulator Board sign-on screen, the Gemini ROM disables the emulation capability and the 8088 CPU at U1 is enabled, which provides complete support for the Z-100 hardware and software.

The second 8088 CPU at U21 is disabled and is only active in the IBM PC Mode. System control is then returned to the Z-100 Monitor ROM (also called the MTR-100, MTR-ROM or ZROM) at U190 on the Z-100 motherboard.

Depending on the hardware switch setting of S101 on the Z-100 motherboard, the 'pointing hand' system prompt will be displayed in the manual boot mode or the system will begin the autoboot process in the normal way.

The IBM PC Mode

When the IBM PC Mode is selected at the Gemini Emulator Board sign on screen, the Gemini ROM activates the emulation features, the 8088 CPU at U21 is enabled, and the 8088 CPU at U1 is disabled.

The Gemini ROM also determines the system clock speed - 5 MHz or 8 MHz - and selects required code for processing at that clock speed.

System control is then turned over to the ZDS Z-150 Multi-Function Monitor ROM (MFM-150), and the standard Z-150 system prompt is displayed. Standard Zenith Z-150 boot strings can then be input for booting the system.

Most of the MFM-150 ROM commands can also be input at the system prompt although the TEST command - selection 3 (Memory Test) - will indicate a memory failure. This is not a true failure, but rather a byproduct of the emulation process.

Additional information on the use of the MFM-150 ROM commands is available through the Help screen (enter {?} followed by {RETURN}) or in the Heath/Zenith Programmer's Utility Pack.

All standard IBM PC software and hardware interrupts are fully supported by the Gemini Emulator Board. All programs that use these standard interrupts can be successfully run on the Gemini Board. This includes all common forms of copy-protected software.

Software that does **not** follow the Microsoft or IBM standards may not function (or even execute) correctly in the IBM PC emulation mode. Two general categories of this software have been identified and include some games and some special software (e.g. COPYIIPC) used to break the copy-protection schemes. They use undocumented hardware and software features of the IBM PC.

IBM PC video emulation is also implemented through the use of the Gemini Emulator Board and the Z-100 video board. Refer to **Section 7 - Video Compatibility**, for additional information.

IBM PC audio emulation is available through the use of the optional Gemini Sound Board. Refer to **Section 9 - Gemini Sound Board**, for additional information.

Emulation of the IBM PC serial and parallel ports has been implemented subject to the limitations of the Z-100 hardware. Refer to **Section 6 - I/O Port Changes**, for additional information.

Significant design and programming considerations were part of Gemini's decision to use software emulation to implement the software and hardware features of the IBM PC.

Software emulation provides the advantage of reducing the overall hardware complexity required to provide IBM PC compatibility.

From the user perspective, this results in a lower initial cost as well as lower maintenance cost due to the fact that fewer hardware problems can occur.

The Gemini Emulator Board does **NOT** use any of the Z-100's expansion slots thereby leaving room for future expansion.

Another advantage is that it is easy to provide upward compatibility for software as new versions of the ROM-BIOS are implemented. Both the Gemini and ZDS ROM chips are user replaceable in the event that changes are required.

A limitation of the software emulation process is that it is extremely difficult to achieve the same performance with an emulator that the original PC system provided. You may find slower system response, particularly with video intensive programs on a Z-100 in the IBM Mode at 5 MHz. System response can be improved by speeding up the Z-100 to 8 MHz operation.

1-3 Initial Gemini Operation

Following correct installation of the Gemini Emulator Board, the Gemini sign-on screen is displayed when the Z-100 is powered ON or is reset with a standard Z-100 {CTRL}-{RESET} key sequence. You will hear a 'keyclick' sound to indicate proper operation.

Note: Do NOT attempt to reset (reboot) your system with the IBM **Ctrl-Alt-Del** sequence or the Zenith **Ctrl-Alt-Ins** sequence; unpredictable results may occur. Always use the Z-100's {CTRL}-{RESET} key sequence, whether in native Z-100 Mode or IBM Mode.

When the Gemini sign-on screen is displayed, you have three options:

Press {I} for the IBM Mode

Press {Z} for the native or regular Z-100 Mode

Press {HELP} for information about the Gemini Emulator Board.

Z-100 Mode

Select the standard Z-100 Mode by pressing {Z}. The screen will be cleared. If your system is set up for manual booting, the standard Z-100 system prompt will appear. If your system is set up for autoboot, your system will begin the autoboot sequence.

Manual and autoboot modes are determined by the setting of switch **S101** on the Z-100 motherboard. You can interrupt the autoboot sequence by pressing the {DELETE} key, which will also return you to the Z-100 system prompt for the input of all standard Z-100 manual boot strings.

IBM PC Mode

Select the IBM PC Mode by pressing {I}. The screen will be cleared and the standard Zenith PC system prompt will be displayed in the following form:

MF-150 Monitor: Version 2.0 (or greater)

Memory Size: 640K bytes (or memory of your computer)

Enter "?" for help.

->

At the standard Zenith PC system prompt, you may boot the system using one of the following commands:

-> {b} {RETURN} (Boot system from floppy drive A:)

-> {bw} {RETURN} (Boot system from the Winchester drive)

Additional information on boot strings is documented in Chapter 6 of the Heath/Zenith PC-DOS. If you are using a Winchester hard disk system for the first time in the IBM PC emulation mode, you must perform the installation as discussed in **Section 5 - Using a Winchester Hard Disk**, before using the {bw} boot string.

The Help Screens

When the Gemini sign-on screen is displayed, you can press the {HELP} key to display on-line help information.

Note: The {HELP} key is NOT active in the IBM PC Mode.

The first help screen shows how the Z-100 keyboard has been changed to reflect keys needed to run IBM PC software. You may also refer to **Section 3 - Keyboard Changes**, for additional information.

The second help screen provides some information on the use of the Gemini Emulator Board with a Winchester hard disk; refer to **Section 5 - Using a Winchester Hard Disk**, for additional information.

The third help screen provides information about the serial ports. Please note that the Z-100's J2 serial port is equivalent to the PC's COM1 and the J1 serial port is equivalent to the PC's COM2. Refer to **Section 6 - I/O Port Changes**, for additional information on configuring these ports.

1-4 H/Z-100 Compatibility and Support

When your computer is operating in the Z-100 Mode, the Gemini Emulator Board is disabled, allowing you to use all of the standard Z-100 functions and programs. All authorized Heath/Zenith Operating Systems and programs function normally in a Gemini equipped Z-100.

All officially supported Heath/Zenith 5-1/4" (**48 TPI only**) and 8" floppy disk drives, and combinations of disk drives, are supported by the Gemini Emulator Board in the Z-100 Mode.

However, if you have 96 TPI 5-1/4" floppy disk drives you **MUST** change your system configuration to 48 TPI drives in order to use the Gemini Emulator Board in the IBM PC Mode.

Due to a space conflict, the Gemini Emulator Board cannot co-exist with the original PC-240 ZCLK accessory board on the Z-100 motherboard as it was configured. However, later ZCLK and ZCLK2 circuit boards have been modified with a flat ribbon cable to position the clock out from under the Gemini Emulator Board, so this is no longer a problem.

Note: The ZCLK2 Real Time Clock accessory is still available from the "Z-100 LifeLine".

1-5 IBM PC Compatibility and Support

The Gemini Emulator Board will allow you to run most of the programs available for the IBM PC using standard IBM PC ROM-BIOS functions, DOS system calls, and direct hardware access through emulation. This includes programs incorporating the more common forms of copy protection.

Because the Gemini Board provides software emulation of a number of IBM PC hardware features, the Gemini Emulator Board alone does NOT provide the capability to plug in IBM PC add-on hardware products, such as memory boards.

The IBM PC, most PC compatibles (including the Heath/Zenith PC series), and the Gemini Emulator Board specifically do **NOT support 96 TPI 5-1/4" floppy disk drives and 8" floppy disk drives.** If you have 96 TPI 5-1/4" floppy disk drives in your system, you will need to convert to 48 TPI 5-1/4" floppy disk drives in order to use the IBM PC Mode.

The Gemini Emulator Board supports the IBM standard 640 kilobytes of RAM (Random Access Memory) in the IBM PC Mode.

Color support in the IBM Mode is limited to eight colors because the Z-100 Video Board does not support the high/low intensity feature. See **Section 7 - Video Emulation**, for additional information.

The Gemini Emulator Board, by itself, does NOT support the IBM sound feature. Audio emulation can be achieved by adding the optional Gemini Sound Board. See **Section 9 - Gemini Sound Board**, for additional information.

IBM compatible serial and parallel port (output only) operation is supported by the Gemini Emulator Board. However, data **input** through the parallel port is NOT supported. See **Section 6 - I/O Port Changes**, for additional information on I/O port configuration.

1-6 Programming Information

Since the Gemini Emulator Board functions are disabled in the Z-100 Mode, there is no change to the normal programming and operation for all standard Z-100 operating modes.

User programming for PC functions provided by the Gemini Emulator Board is identical to that required for the IBM PC.

Section 2 - Installation and Hardware Information

2-1 Installation and Testing

2-1-1 Recommended Tools

The following tools are suggested to assist in the installation of your Gemini Emulator Board:

- #2 Phillips screwdriver (for basic disassembly)
- #1 Phillips screwdriver (for Z-100 video board)
- 1/4" nutdriver (deep socket, low profile)
- IC remover or small flat blade screwdriver

See **Subsection 2-2 - Installation**, for detailed installation procedures.

2-1-2 Pre-Installation

Verify that your Z-100 works normally with the ZDS Operating Systems that you use. If you have a Winchester Hard disk, we recommend that you backup the entire hard disk before installing the Gemini Emulator Board. Refer to **Section 5 - Using a Winchester Hard Disk**, for additional information.

The Gemini Emulator Board requires that 64K RAM chips be installed in the Z-100 Video Board. Verify that your Z-100 contains 64K chips by entering {S} at the MTR-100 'pointing hand' prompt. You will see a display similar to the following:

192K of contiguous RAM	(Depends on your exact system memory)
64Kb Video memory	(May display 32Kb)
Monochrome	(May display "Color")

If the above display shows "32Kb Video memory" you **MUST** replace ALL of the 32K RAM chips with 64K RAM chips.

For monochrome displays, eight 64K chips are required in the green video plane. Color displays or variable intensity monochrome displays require an additional 16 64K chips - 8 in the red plane and 8 in the blue plane. You **must** also ensure that jumper J307 (located under the green plane and just above U374) is in the 64K position. The 64K position is the one closest to U374.

The Gemini Emulator Board functions properly at both 5 megahertz and 8 megahertz; however, 8 megahertz operation requires the HA-108 Upgrade Kit (or similar) be installed, as this kit required the installation of several faster IC chips. Refer to **Section 8 - Troubleshooting**, for additional information.

2-1-3 Initial Testing

If you had to replace RAM or other ICs as required above, reconnect the AC power cord to your computer. Reconnect the video monitor and any other cables to external peripherals and run all the diagnostics tests on the Z-100 **BEFORE** installing the Gemini Emulator Board. Ensure the Z-100 is functioning properly. The Gemini Board will **NOT** fix any existing problems.

2-2 Installation

[] Turn off the Z-100 and unplug the computer from AC power. Remove all cables from the back panel and move the computer to a safe work surface with plenty of room.

[] The "Z-100 LifeLine" Website at z100lifeline.swvagts.com has an article on Z-100 Disassembly. Remove the cover.

[] If you have the Z-120 "All-in-one" computer, remove the monitor/drive assembly. If you have the Z-110 "Low-profile" computer, remove the drive assembly. **Note what cables go where!**

[] Remove the base cover and keyboard.

[] Disconnect the cables from the left side of the Z-100 Video Board. It is laying upside down (solder side up) over the motherboard and is attached by three screws and two 40-pin flat ribbon cables toward the rear. Remove the three screws, lift up the Video Board, and disconnect the two flat ribbon cables from the motherboard. Set the Video Board off to the side.

[] Remove the Gemini Board (See the title photo) from packaging and visually inspect it. The solder side is shown in Photo 1. Remove any foam padding from the 40-pin male header on the board and visually inspect that the pins are straight (straighten if necessary). Also note the 40-pin female connector socket. This will eventually plug into the motherboard header, P104. Set the board nearby.

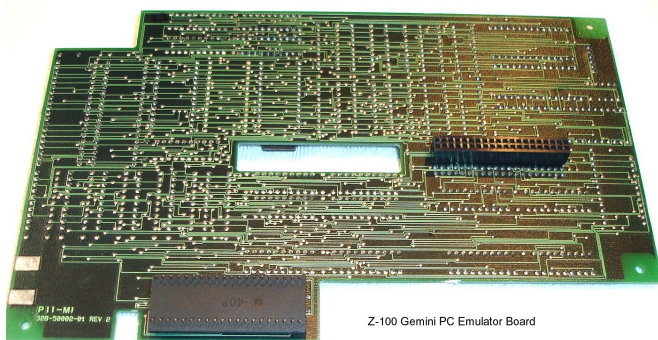


Photo 1 - Solder Side.

[] If you have an 8087 board attached to the motherboard, remove it and:

CAUTION: Do NOT fully pry up an IC at either end on the first try - it will bend the pins remaining in the socket!

[] Using an IC puller or very small jeweler's flat blade screwdriver, gently pry up the 8087 Co-processor, slightly at each end (alternating ends) until it is free.

[] Ensure the 8087 pins are still straight (straighten if necessary).

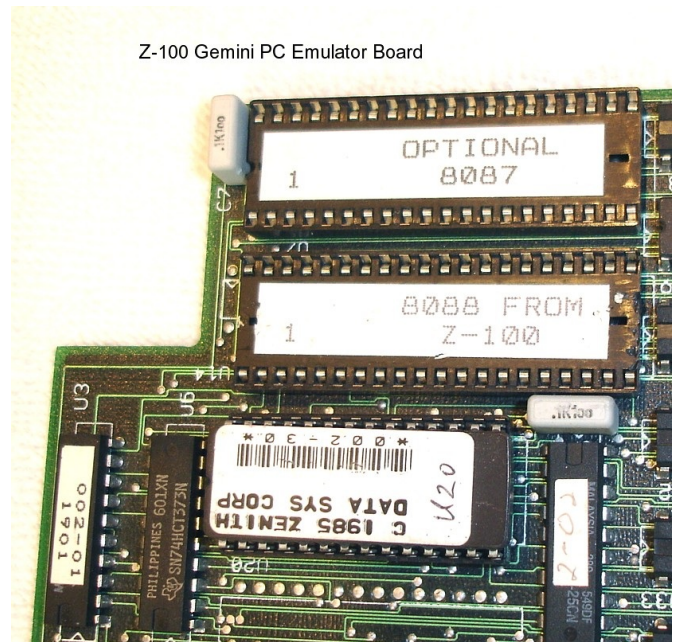


Photo 2 - The 8088 and 8087 Sockets

[] Referring to Photo 2, locate pin 1 (indicated by a notch, dot, or small indentation) on the 8087 and on the notched end of the 8087 socket on the Gemini board, align the pins of the chip with the socket, and gently press the 8087 into its socket. Visually check that all the pins are inserted correctly and are not bent under.

[] Store the 8087 board in a safe location. It will no longer be used.

[] Using an IC puller or very small jeweler's flat blade screwdriver, gently pry up the 8088 CPU at U211 on the motherboard slightly at each end (alternating ends) until it is free.

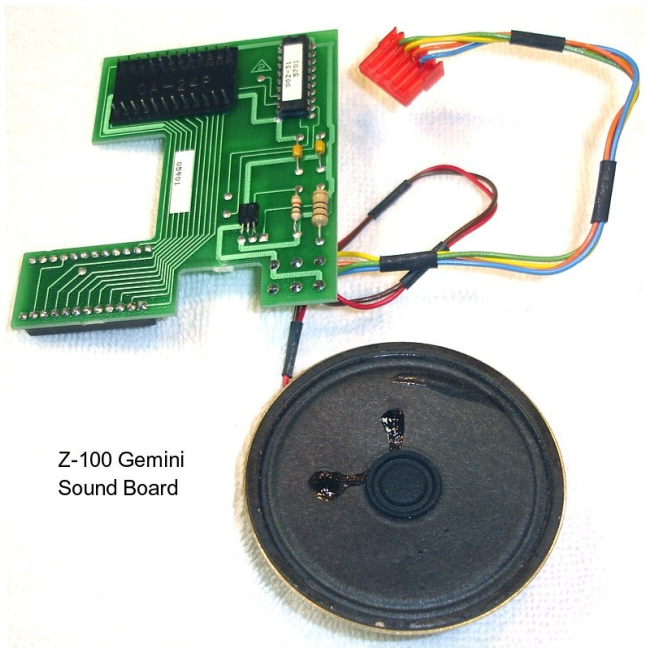
[] Ensure the 8088 pins are still straight (straighten if necessary).

[] Again referring to Photo 2, locate pin 1 (indicated by a notch, dot, or small indentation) on the 8088 and on the notched end of the 8088 socket on the Gemini board, align the pins of the chip with the socket, and gently press the 8088 into its socket. Visually check that all the pins are inserted correctly and are not bent under.

If you are installing the Gemini Sound Board, unpack it and, referring to Photos 3 and 4, inspect the board, wires and speaker. Check that the males pins on the 24-pin header are straight (straighten if necessary).

[] Referring to Photo 5, locate and remove U160 (an 8253 IC) on the Z-100 motherboard.

[] Ensure the 8253 pins are still straight (straighten if necessary).



Z-100 Gemini
Sound Board

Photo 3 - Gemini Sound Board

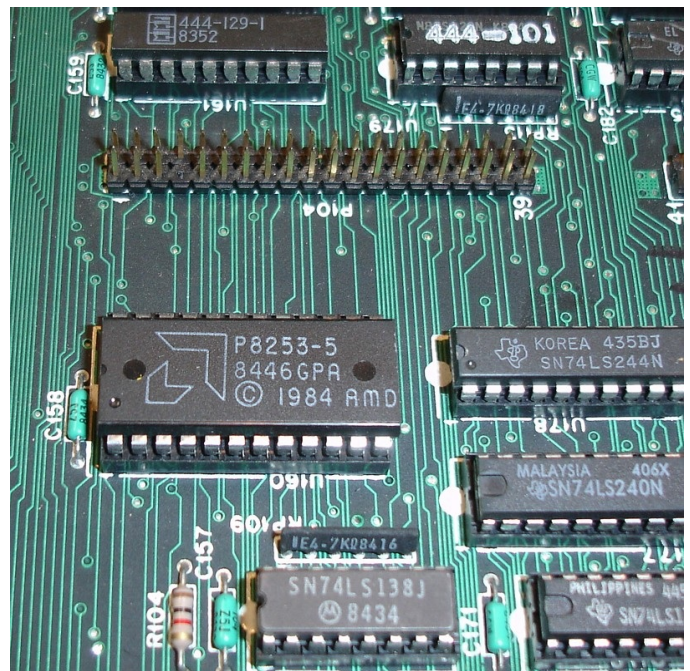
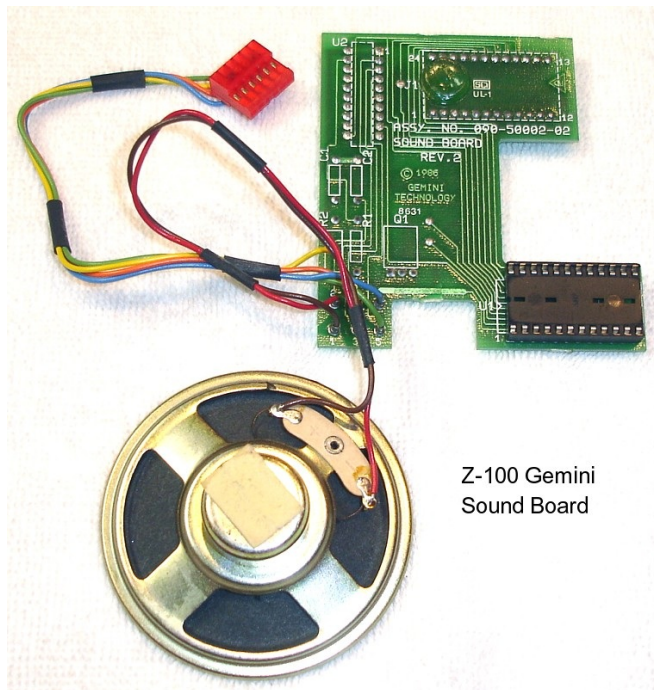


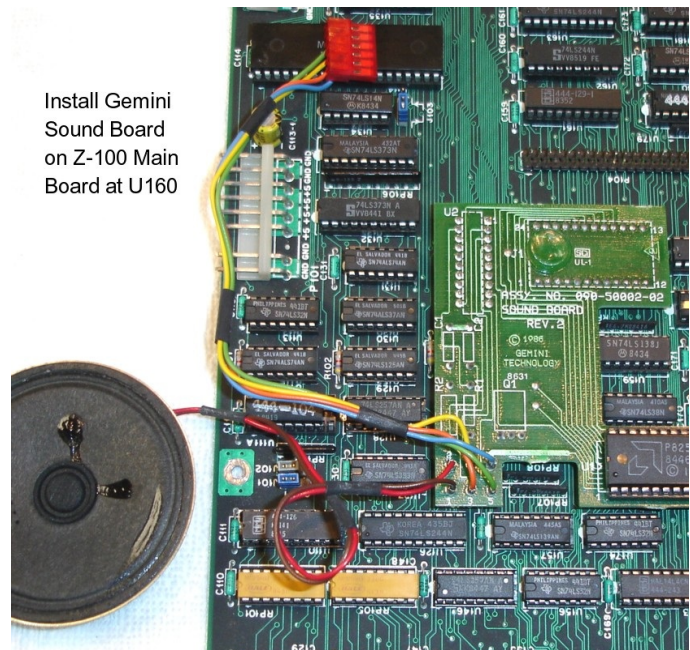
Photo 5 - U160, The 8253 IC



Z-100 Gemini
Sound Board

Photo 4 - Gemini Sound Board

Note: The sound board can only be installed one way, with the pins beneath the back side of the Gemini Sound Board.



Install Gemini
Sound Board
on Z-100 Main
Board at U160

Photo 6 - Installing the Sound Board

[] Insert the 8253 IC you have just removed into the socket on the Gemini Sound Board, with the 'pin 1 end' over the notched end of the socket.

[] Remove any foam padding and check the alignment of the pins on the Gemini Sound Board. If any pins are bent, carefully straighten them. Carefully plug the Gemini Sound Board into the U160 socket on the motherboard.

[] Remove the protective cardboard from the speaker. Remove the paper from the adhesive foam on the back of the speaker, and stick the speaker to the Z-100 metal chassis in the area just in front of the power supply.

Continue with the Gemini Emulator Board installation next...

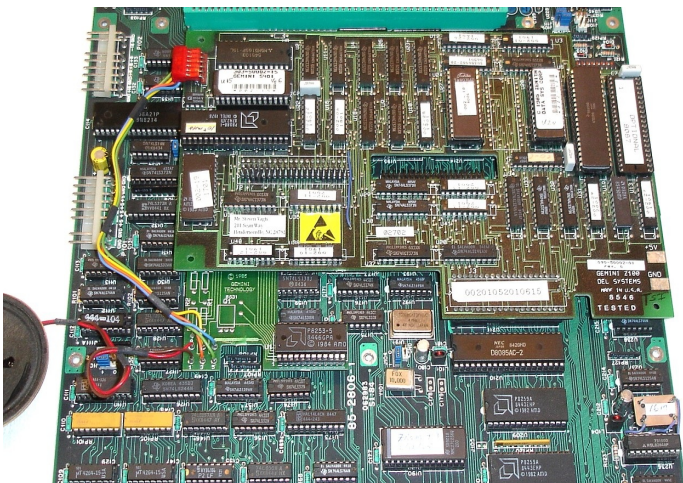


Photo 7 - Gemini Board Installation

[] The Gemini Board is installed over the Z-100 motherboard. It has one 40-pin connector that will connect to the male 40-pin connector at P104 on the motherboard while the 40-pin connector at the front end of the Gemini Board will press into the empty socket at U211 on the motherboard.

WARNING: It is critical that as you set the Gemini Board 8088 connector over the empty socket perfectly, while feeling that the 40-pin connector at P104 is aligned also before pressing down on the Gemini Board. If everything is aligned properly, the Gemini Board will settle perfectly with little pressure. DO NOT FORCE IT!

[] If the Gemini Sound Board is installed, plug the Gemini Sound Board cable connector onto header J4 of the Gemini Emulator Board as shown in Figure 1 below. **CAUTION:** Be sure that the wires from the cable plug come out of the bottom side of the connector as shown (you will also see the pin slots in the connector if the cable is installed correctly).

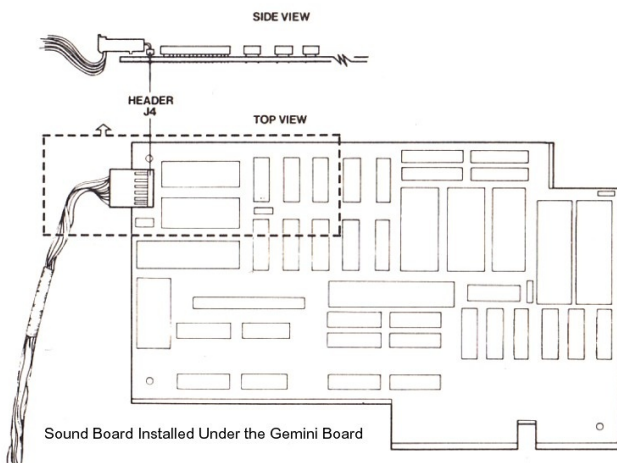


Figure 1 - Sound Board Under Gemini Board

[] Referring to Photo 8, reinstall the Video Board (upside down) over the Gemini Board and the motherboard. The flat ribbon cable that had gone to P104 will now plug into the Gemini Board, while the flat ribbon cable that had gone to P106 will again plug into P106 through a cutout in the Gemini Board. Reinstall the three screws to fasten the Video Board.

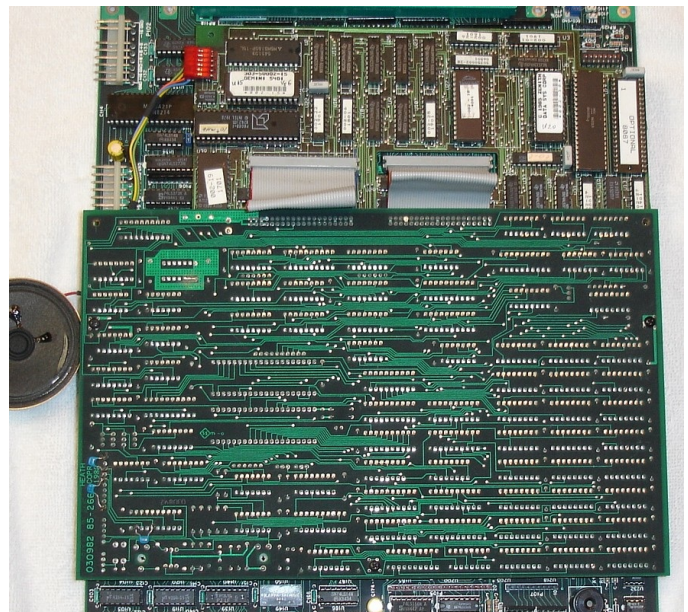


Photo 8 - Video Logic Board Over Gemini

[] Reassemble your computer.

2-2-1 Testing

Reconnect the AC power cord to your computer. Reconnect the video monitor and any other cables to external peripherals.

[] Turn on the power to your Z-100 computer and video monitor. You should hear a keyboard beep, and the Gemini sign-on screen should appear. If this does not happen, disassemble your computer, and refer to **Section 8 - Troubleshooting**.

[] Press the {Z} key to enter the Z-100 Mode. If you have the autoboot feature implemented, the system will begin to boot normally from the designated disk drive, either floppy disk or hard drive. The autoboot process can be defeated by pressing {DELETE} immediately after pressing {Z}. If you are using the manual boot, verify that the standard Z-100 'pointing hand' system prompt appears, then enter the normal boot string for your system.

[] After booting successfully, press the {CTRL}-{RESET} keys simultaneously to reset your computer. The Gemini sign-on screen should reappear.

[] Press the {I} key to enter the IBM PC Mode. The MFM-150 monitor prompt will be displayed. Insert a bootable floppy disk with PC-DOS into drive A. Enter {B} followed by {RETURN}. The system should boot normally.

[] To test the Sound Board, if installed, press the {F2} key. You should hear a short beep that indicates proper installation and operation. If this does NOT happen, disassemble your computer, and refer to **Section 8 - Trouble-shooting**.

[] If you have a Winchester hard disk, refer to **Section 5 - Using a Winchester Hard Disk**, for preparation and testing of the Winchester.

[] Congratulations! You have completed the installation and testing of the Gemini Emulator Board. Now your computer has the capability to run IBM PC software.

2-3 Hardware Information

The following are the Z-100 hardware requirements and Gemini Emulator Board specifications.

Hardware Requirements:

H/Z-100 Series Computer	- 'All-in-one' or 'Low-profile' models
Clock Speed	- 5 MHz or 8 MHz (factory installed or HA-108 Upgrade only)
Gemini Emulator Board:	
Size	- 9" long by 5.25" wide, 4 layer printed circuit board
ROM-BIOS	- ZDS BIOS-ROM version 2.0 or later (Gemini ROM 1.4-2 or later)
Central Process Unit (CPU)	- One on-board 8088-2 CPU for the IBM-PC Mode. - One 8088 (5 MHz) or one 8088-2 (8 MHz) from the Z-100 for Z-100 Mode.
8087 Co-processor Support	- On-board 8087 socket for co-processor support in both Z-100 and IBM PC Modes.
Power Requirements	- 1 amp @ 5Vdc (5.0 watts)

Z-100 Mode:

Hardware Support	- Most authorized Z-100 hardware except for some ZCLK boards. (See Subsection 1-4 - H/Z-100 Compatibility , for more information)
Software Support	- All Z-100 application and operating system software
Memory	- All Z-100 memory configurations (128-768 Kb RAM)
Operating Systems	- All Heath/Zenith H/Z-100 operating systems, including CP/M

IBM PC Mode:

Hardware Support	- Two 5-1/4" 48 TPI floppy disk drives - One or two Winchester hard disks (Limited to 17 Mb partition) (Requires Zenith PC-DOS) - Serial I/O port support of COM1 and COM2 through H/Z-100 J-2 and J-1 ports respectively.
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Software Support

Software Support	- Most PC-compatible software - Two 5-1/4" 48 TPI floppy disk drives - One or two Winchester hard disks (Limited to 17 Mb partition) (Requires Zenith PC-DOS) - Serial I/O port support of COM1 and COM2 through H/Z-100 J-2 and J-1 ports respectively. - Parallel output port support of LPT1 through H/Z-100 J-3.
Memory	- Maximum IBM PC standard of 640 Kilobytes.
Video	- IBM PC-like character font of 256 characters supported by ZDS ROM-BIOS - 40 column by 25 line text and graphics modes in monochrome and color. - 80 column by 25 line text and graphics modes in monochrome and color. - 320x200 pixel graphics in monochrome and color - 640x200 pixel graphics in monochrome and color - Reverse video (by char) - Normal only (8 colors) - Eight colors black, blue, green, cyan, red, magenta, brown, light gray.
Intensity:	
Foreground:	
Background:	

Section 3 - Keyboard Changes

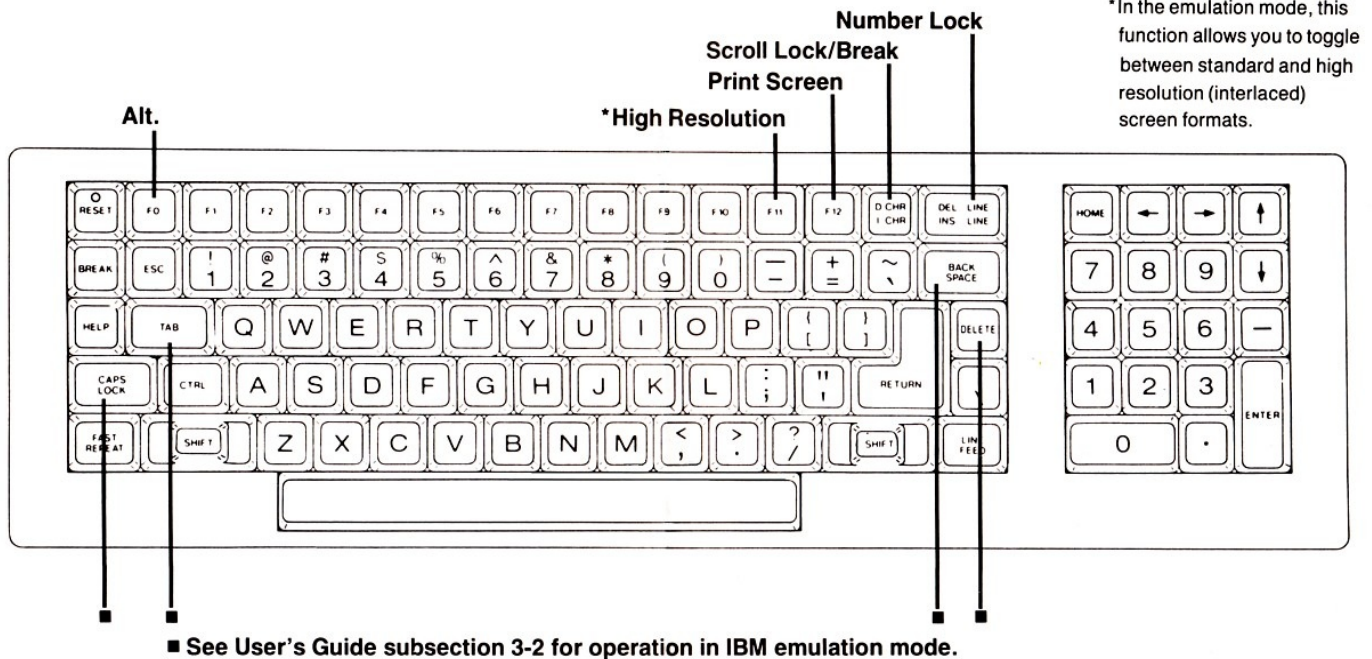
3-1 H/Z-100 Keyboard Changes for IBM PC Compatibility

The purpose of this section is to familiarize Z-100 owners with some of the characteristics of an IBM PC-type keyboard which, in some cases, are significantly different to those of the Z-100 keyboard. Perhaps the most significant changes, aside from key differences that are covered in the next section, are the PC keys and legends that are described in PC software.

For ease of reference, the Z-100 keyboard layout is shown as Figure 2. We recommend that you spend a few minutes reading this entire section because some of the IBM PC keys are new, and there are some significant differences in key usage under the H/Z-100's Z-DOS and PC-DOS.

Refer to Figure 2. Existing Z-100 keytop legends are shown on the main keyboard with the corresponding PC legends indicated by arrows to the keyboard. Some key functions, such as the Tab and Back Space keys, have not been changed. However, the PC keytop legends have also been shown since some software documentation refers to keys by legend instead of by name.

Keyboard function changes in IBM emulation mode



This pullout guide is provided as a handy reference of function changes from the Heath/Zenith keyboard/keypad to IBM keyboard/keypads while in the IBM emulation mode.

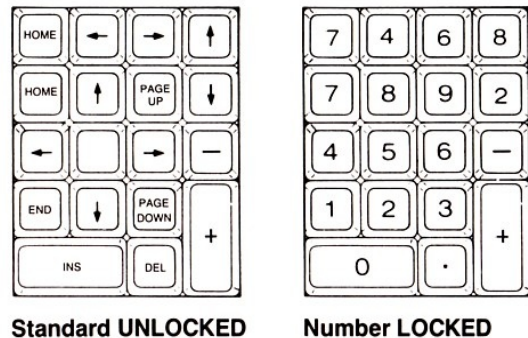


Figure 2 - Keyboard Function Changes in IBM Emulation Mode

3-2 Introduction to the IBM PC Keyboard

Significant differences between the Z-100 keyboard and the IBM PC keyboard are included in this subsection.

Note: For ease of understanding, in section headings the IBM PC equivalent key is noted first, followed by the Z-100 key remapped for the emulation mode in brackets. In the descriptive text, key names are noted in bold letters. As noted earlier, I also enclose the Z-100 key names in brackets.

The Alt Key {F0}

The most significant difference in the two keyboards is the addition of the **Alt** key on the PC keyboard. Since the Z-100 does not have an **Alt** key, the function key {F0} has been remapped to the **Alt** key in the emulation mode.

Much of the commercially available software uses the **Alt** key, usually in combination with the PC function keys (e.g. **F1-F10**), to perform various programmed functions.

For example, most of the popular word processing software (e.g. Word, Word Perfect, MultiMate, etc.) uses the function keys, shifted function keys, **Ctrl** plus the function key, and **Alt** plus the function key to provide as many as 40 key functions activated by the appropriate key-stroke(s).

Although the **Alt** key is also used in the IBM PC **Ctrl-Alt-Del** boot sequence, you must still use the standard Z-100 {**CTRL**}-{**RESET**} sequence to reset your Z-100. One of the particular advantages of this approach is that {**CTRL**}-{**RESET**} performs a hardware reset.

Note: In the IBM PC computers, a system 'freeze' sometimes requires that the computer be powered-off and on to reset the system hardware. This will NOT be required in a Gemini-equipped Z-100 since {CTRL}-{RESET} performs that hardware reset function. It should be noted that a typical system freeze on an IBM PC is usually the result of a user error in command input or syntax as well as some significant problems (i.e. bugs) in some software packages.

However, when a system freeze is encountered, it should be noted that regardless of the problem that caused the freeze in the first place, the possibility of recovering data "lost" as a result of the freeze is directly related to the recovery features of the software. The Gemini Emulator Board will faithfully emulate the PC software features and, if it is possible to recover that "lost" data on an IBM PC, you will be able to recover the data on a Gemini-equipped Z-100.

Gemini High Resolution Key {F11}

The Gemini **High Resolution** key has no counterpart on the IBM PC keyboard. It allows you to toggle the Z-100 between the standard and high resolution (interlaced) video modes. If you have a standard CRT (Cathode Ray Tube), pressing this key will cause the display to "flicker" due to the standard (i.e. short persistence) phosphor compounds typically used in monitors.

If you decide to use the High Resolution feature, we recommend that you consider the purchase of a monitor that has a long persistence CRT phosphor such as the Zenith ZVM-1360 or equivalent.

The */PrtSc Key {F12}

When pressed, this key will display an asterisk (*) just like the main keyboard "8" key in the shifted mode. If a **Shift, */PrtSc** key sequence is input, the current CRT display will be printed on the system printer. Refer to **Subsection 3-3 - CONTROL (Ctrl) Keys for PC software**, for additional information.

The Scroll Lock/Break Key {ICHR/DCHR}

The **Scroll Lock/Break** key is another key unique to the IBM PC keyboard. This key is typically used to control screen scrolling, and when used with the **Ctrl** key (i.e. **Ctrl-Break**), it is used to perform the Z-100 {CTRL}-{C} program interrupt function. It should be noted that specific use of this key depends on the software being run. With the exception of the **Ctrl-Break** function, this key is not always active.

The Num Lock Key {INS LINE/DEL LINE}

The **Num Lock** key is a toggle that, when pressed, shifts the keypad keys (including the Z-100 {HOME} and {Cursor Arrow} key(s) into a numeric mode. That is, the keypad keys will display numbers and can then be used as a 10 key calculator keypad. The default at system boot is that the keypad function, such as **Cursor** control, **PgUP**, **PgDn**, and so on, are active.

You can press the **Num Lock** key at any time, even for a DOS command. However, be aware that some software does not reset the keypad to the default function mode; you must remember to do so yourself if the software does not.

The CAPS Key {CAPS LOCK}

The **Caps** key on the IBM PC is a toggle that automatically defaults to lower case at system boot. Although the Z-100 has a locking {CAPS LOCK} key, the position of this key (either up or down) at system boot in the PC Emulation Mode will automatically default to the lower case characters.

Backspace and Tab Keys {BACK SPACE} and {TAB}

There are two keys that have different labels in the IBM Mode than on the Z-100 keyboard. The first is the **Back Space** key that is labelled with a left-pointing arrow (<--) on the PC keyboard. Some PC software documentation refers to this key by the "PC symbol" which sometimes makes it difficult to tell when reading the documentation which is the back space and which is the left cursor arrow.

Although there is at least one convention that says the **Back Space** left-arrow has a slightly thicker horizontal "shaft", this is by no means standard. Even IBM PC users sometimes have to experiment to understand how a given software package works with the keyboard given the somewhat vague PC keytop legends.

The second key is easier to identify. It is the {TAB} key on the Z-100 which, on the IBM keyboard, is identified as a **right-arrow under a left-arrow**. Both arrows have vertical lines at the tips that usually are included in software documentation when the **Tab** key function is discussed.

The unshifted **Tab** key performs the standard right tab function, and the **Shift, shifted Tab** key performs the back tab function. In a few cases, PC software documentation simply refers to this key as the **Tab** key.

The H/Z-100 {DELETE} Key

The IBM PC does not have a **Delete** key on the main keyboard. Since the Z-100 does have a {Delete} key as part of its main keyboard, it has been remapped to perform the identical functions (including the **Num Lock** toggle), as the **Del** key on the IBM keypad. See the next Subsection - The Keypad, for additional information.

The Keypad

Z-100 users will find some significant differences in Keypad function in the PC emulation mode. Perhaps one of the most significant differences is that the keypad is implemented in the "function" mode when DOS is originally booted. That is, the keypad keys are set to perform the indicated functions, such as cursor movement, at system boot.

The keypad can be shifted into the 'numeric' mode by pressing the **Num Lock** toggle or by pressing the **Shift** key before pressing the keypad key.

As you have seen in Figure 2, the numbers are physically placed above the function legends for the keypad. This was done for two reasons. First, this is the same keytop identification that was used on the IBM 97PC. Second, as previously stated, the function mode is the default mode when DOS is originally booted.

When the **Shift** key is used in combination with a keypad key in the default mode, numbers can be entered on the CRT display. You can, of course, toggle the keypad between the function and the numeric modes at any time by pressing the **Num Lock** key.

Since the Z-100 has the separate {**HOME**} and {**Cursor Arrow**} keys that the IBM PC does not have, these keys also perform their indicated functions in the emulation mode. That is, the Z-100 {**HOME**} key and {**Cursor Arrow**} keys will perform identically the same functions as the IBM 7 (**Home**) key and the 2, 4, 5, and 8 (**Cursor**) keys depending on whether the keypad is in the function or numeric mode.

Additional functions are also indicated on the keypad, such as the **PgUP/0**, **PdOn/3**, and **End/1** keys. These keys are identified in PC software documentation that requires their use.

The **Ins (Insert - 0)** and the **Del (Delete 0.)** keys are commonly used as toggles in PC software as well as command line editing for EDLIN, DEBUG, and DOS command lines. For command line editing, note that the {**INS**} key and {**DEL**} keys are used in place of the {**F6**} and {**F4**} Z-100 keys under the Z-100 PC-DOS. **See Subsection 3-3 - Control (Ctrl) and Editing Keys for PC Software**, for additional details on the Command Line Editing Keys.

Programming for the IBM PC keyboard is usually done by using the Keyboard Scan Codes and interrupts which are listed as **Appendix A** of this manual.

3-3 Control (Ctrl) and Editing Keys for PC Software

There are some significant differences in the use of the (Ctrl) keys that perform a number of functions in DOS, such as echoing the displayed screen to the printer. For ease of reference, you will find a listing of the standard Z-100 key functions with the corresponding PC key functions here.

Control (Ctrl) Key Sequences (Applies only to PC-DOS in IBM Mode)

<u>Function</u>	<u>H/Z-100 Key</u>	<u>IBM (Gemini) Key</u>
Abort Command	{CTRL}-{C}	Ctrl-Break or Ctrl-C
Backspace	{BACKSPACE} or {CTRL}-{H}	Backspace or Ctrl-H
Cancel Current Command	{SHIFT}-{F10} or {CTRL}-{X}	Esc or Ctrl-X
Delete:		
Current Character	{Space Bar}	Space Bar
Previous Character	{BACKSPACE} or {CTRL}-{H}	Backspace or Ctrl-H
Delete Current Input	{SHIFT}-{F0}	Esc
(No change to template)		
Display on CRT:		
Stop	{CTRL}-{S}	Ctrl-Num Lock or Ctrl-S
Start	Press any key	Press any key
End Console Input	{RETURN}	Return or Enter
Line (When command line is longer than CRT display)	{LINEFEED} or {CTRL}-{J}	Ctrl-Return or Ctrl-J
Flush Keyboard Buffer	{BREAK}	Alt-Break
Print Current Screen	n/a	Shift-PrtSc
Printer Echo:		
Start	{CTRL}-{P}	Ctrl-PrtSc
Stop	{CTRL}-{N}	Ctrl-N
- OR -		
Start MS-DOS 2 & 3	{CTRL}-{P}	Ctrl-PrtSc or Ctrl-P
Stop MS-DOS 2 & 3	{CTRL}-{P}	Ctrl-PrtSc or Ctrl-P

Editing Keys For PC Software (Applies only to PC-DOS in IBM Mode)

<u>Function</u>	<u>H/Z-100 Key</u>	<u>IBM (Gemini) Key</u>
Copy:		
One Character	{F1}	F1
Remaining Characters	{F3}	F3
Up to Character 'c'	{F2}{c}	F2c
Define New Template	{F0}	F5
End-of-file Character (in new template)	{CTRL}-{Z}	F6
Insert Mode:		
Enter	{F6}	Ins (Toggle)
Exit	{F7}	Ins (Toggle)
Quit Input (or Void)	{SHIFT}-{F0}	Esc
Skip		
One Character	{F4}	Del
Over to Character c	{F5}{c}	F4c

4 DOS Differences

4-1 H/Z-150 PC MS-DOS

Long-time Z-100 users will find that there are some significant differences in command syntax between the standard Z-100 Z-DOS and the Z-150 PC-DOS. In addition to the differences between the same versions (e.g. version 2 Z-DOS and version 2 PC-DOS), there are some significant differences between DOS version 2 and version 3 for both systems.

If you have MS-DOS version 2 for both systems, you will find that there is some differences in syntax in most of the disk resident commands. Although this is usually a matter of the input of optional values, such as switches (e.g. DISKCOPY /V), some commands also have different valid values for optional switches and other parameters.

In addition to some new commands, Z-100 Z-DOS version 3 has undergone some other changes to existing commands so that they are more like their Z-150 PC-DOS counterparts. Zenith Data Systems (ZDS) has generally improved the Z-100 version 3 Z-DOS so that most of the commands and parameters are the same as the Z-150 PC-DOS in order to reduce confusion when switching between operating systems.

Winchester command syntax and some Winchester hard disk functions are also slightly different for the Z-150 PC-DOS. If you have a Winchester hard disk, be sure to read **Section 5 - Using a Winchester Hard Disk**.

As previously stated, we recommend that you purchase the H/Z-150 PC MS-DOS for use with your Gemini Emulator Board because the Gemini Emulator Board uses the ZDS ROM-BIOS developed for the Z-150 PC series computers and because the emulation functions have been exhaustively tested using the Z-150 PC-DOS.

If you wish to run IBM BASIC programs in the IBM emulation mode, you must also purchase the Zenith GW-BASIC Interpreter (MS-5063-13) or equivalent.

Note: The IBM BASIC Interpreter supplied with IBM PC-DOS will **NOT** run on the Gemini Emulator Board (or the Z-100) due to the absence of the copyrighted IBM ROM-BIOS.

4-2 IBM PC-DOS

All current versions of IBM PC-DOS have been tested on the Z-100 with a Gemini Emulator Board and for the most part, run satisfactorily. In some cases, however, certain unique features of PC-DOS may cause unusual problems that are specifically unique to the PC-DOS implementation. For example, Borland's Sidekick (TM) desktop utility program will display some extraneous characters under PC-DOS. This does not occur under the Z-150 PC-DOS.

If you are quite familiar with the Z-150 PC-DOS, you will also find that many of the Zenith utilities and features are not implemented in IBM PC-DOS. Perhaps the standard Zenith CONFIGUR command is the most noteworthy of these since many users find that it is more difficult to configure a system printer and other peripherals without this command.

In addition, many Z-100 users have also found the Zenith RDCPM command to be extremely helpful in transferring files between the CP/M and MS-DOS operating systems on the Z-100.

Note: If you plan to use a Winchester hard disk with your Gemini Emulator Board, it is important to note that the IBM's PC-DOS FDISK command will NOT function properly because IBM prepares all hard disks with a PREP-like utility that is not available to users. This utility formats the hard disk with specific information that is required for the IBM PC-DOS system before the FORMAT command is used. Since the Z-100 hard disk was obviously not supplied by IBM, it must be configured to emulate the IBM hard disk with the Z-150 PC PREP utility. Refer to **Section 5 - Using a Winchester Hard Disk**, next, for additional information.

5 Using a Winchester Hard Disk

5-1 Backing Up the Winchester Hard Disk

It is always a good idea to backup a hard disk any time you make a hardware change to your computer system.

If you intend to redefine the existing hard disk partitions so that you can use the hard disk in the IBM mode, you **MUST** backup the hard disk first since the use of the Z-100 PART command (described below) to define a Gemini partition will change partition addresses and will probably destroy some or all of the existing hard disk programs and data.

In order to backup the hard disk, we recommend that you use the appropriate BACKUP command supplied with the standard Zenith Z-100 operating systems (e.g. CP/M and MS-DOS).

Once the hard disk backup is complete, you can proceed according to the Hard Disk Preparation Instructions, next.

5-2 Hard Disk Preparation Instructions

After the Gemini Emulator Board is installed and tested in both the Z-100 Mode and the IBM Mode, you will then need to partition the hard disk as described below. We recommend that you verify correct operation in both modes before proceeding with the Z-100 PART command as described below.

Note: Installation of a Winchester hard disk for the IBM Mode requires the use of Z-150 PC-DOS. However, as we mentioned above, the IBM PC-DOS FDISK command cannot be used. We will be using the Z-150 PC-DOS PREP command instead.

Preparation of a Gemini Partition on our hard disk will involve a rather complicated set of procedures that will involve first creating a Gemini Partition on the hard disk using the Z-DOS PART utility, then making that partition useable under PC-DOS by running the Z-150 PC-DOS PREP command. We cover those procedures next...

5-2-1 The H/Z-100 Z-DOS PART Command

Boot your system in the Z-100 Mode. You will need the Z-DOS Winchester Utilities Disk containing the PART command. In later releases of Z-100 Z-DOS, the PART command is also included with the operating system.

If not already, make Drive A: the default drive and insert a disk with the PART command.
Run the command:

```
A: />PART{CR}
```

Assuming our hard disk is the popular 10 Mb size, the Z-DOS PREP utility generally leaves us with two partitions assigned automatically; CPM and DOS split 50% each.

Than a person would need to run the Z-DOS PART utility to create whatever partition configuration is desired, with such partition names as shown in Figure 3 (up to 16 partitions can be created).

```
~~~~~
Partition      Operating
#  Name        System Name  Percentage  Kilobytes
1.  CPM         CPM-85       10%         1000
2.  CPM-DATA    CPM-85       10%         1000
3.  Z-DOS       Z-DOS        50%         5000
4.  Z-DOS-DATA  Z-DOS        30%         3000
5.  (nothing)
|
16. (nothing)
Total Utilization (Allocated/Unallocd) 100/0 10000/0
Default boot partition number: 3 <Z-DOS/Z-DOS  >
~~~~~
```

Figure 3 - Z-100 PART Display Example

The specific procedures are outside the scope of this article, but suffice it to say that you will need to select Partition Maintenance.

The cursor will go to the first Partition Name, where you can change the name or press {RETURN} to leave it unchanged and the cursor goes to the OS Name next. Again, you can change the name or press {RETURN} to accept no change and proceed to the Percentage. As before, you can change the value or press {RETURN}, and so on.

Partition Change Protocol

CAUTION: OK, you can see where we are going with this. As soon as we change the percentage for any of the early partitions, the rest of the partitions following may be affected, with the result being that you could end up having to reFORMAT every partition that is affected by the change.

Note: The minimum partition size for the Zenith Z-100 PART command is one percent (1%) of the maximum size of the hard disk.

CAUTION: The "GEMINI" partition is limited to 17 Mb (actually 18 Mb, but I do not like pushing the limits - SWV)! If you go larger than that, you will not get an error, but accessing anything larger than 18 Mb causes the pointer to roll back to the start of the partition, overwriting what may already be there!!

So, we could simply change the name of our second partition from CPM-DATA to "GEMINI", without changing the percentage, and the only change to the hard drive would occur to that second partition. All the other partitions could remain unchanged. They should work as before, and we would not need to reload Z-DOS or our data to the other partitions.

However, change the size of the second partition, and ALL the following partitions would also change and all existing data in those partitions would be lost!

Could we split the second partition or change partition 2 to still be "CPM-DATA" but at 5%, and partition 3 becomes "GEMINI" at 5%?

You would only need to FORMAT partitions 2 and 3. Partition 4 becomes "Z-DOS" at 50%, and partition 5 becomes "Z-DOS-DATA" at 30%. Theoretically, that should work, as long as the partition boundaries do not change. But if the computer is off in its calculations slightly?

If you are starting with a new disk with not much on it, you could give it a try, then see if Z-DOS on partition 4 is still bootable.

Another alternative is to divide the last partition up. Perhaps making partition 4, "Z-DOS-DATA" 20% and create partition 5, "GEMINI" 10%. We know this would work and you would only need to reFORMAT partitions 4 and 5. But, there is a potential issue here also. Gemini may not be found by PC-DOS PREP.

"GEMINI" can theoretically be placed anywhere on the hard disk - but at the time it was developed, hard disks were relatively small, generally less than 40-50 Mb. I believe that as drives became larger, "GEMINI" would no longer be detected by PREP because it took too long to be found. On these larger drives, "GEMINI" needed to be one of the first couple of partitions!

However, it seems that C.D.R. found that it was related to running at faster than 5 MHz (See **Section 10 - Gemini and the CDR-317**, for more information and other issues).

So, what am I saying?

- If you are going to install a "GEMINI" partition on a hard disk, try to make it an early partition, especially on a large hard disk.

- Be serious about backing up your hard disk - all partitions. If you make a mistake with PART, you could lose some or all of your data, in spite of what Gemini Systems claimed at the time.

- If you have a spare hard disk, start from a fresh Z-100 Z-DOS PREP and plan your partition layout in advance of running PART. Stick "GEMINI" first or second and perhaps create a spare partition or two for other operating systems. On some of my computers, I am running two types of CPM, Z-DOS4, Z-DOS3, PC-DOS... You get the idea. Good Luck.

~~~~~

To run the Gemini Emulator Board from our 10 Mb hard drive, we will need to define a "GEMINI" partition.

Reportedly, or perhaps theoretically, the Gemini Board supported a maximum of two physical hard disk drives, and one Gemini partition could exist on each physical disk drive. When the IBM Mode is used, the Gemini partition of each drive was installed as a separate Winchester drive.

For systems having one hard disk drive, the Winchester would be installed as drive "0" (zero). Both the Operating System Name and Percentage could be defined as desired.

If you had more than one physical Winchester hard disk that you intended to use with the Gemini Board in the IBM Mode, each MUST have had a Partition Name of "GEMINI".

However, C.D.R. Systems found they were limited to one Winchester drive. Please see **Section 10 - Gemini and the CDR-317**, for more information.

Nevertheless, I will continue with the text as written in the Gemini User Manual. Just be aware that a second Winchester drive may not work as advertised.

The Gemini partition of the Winchester drive is treated as a single drive when the IBM Mode is used. That is, data and programs in all other Z-100 partitions can NOT be accessed.

Refer to Figures 3 (our initial partition setup) and 4 (our new arrangement). We are still using only a 10 MB hard disk. Let us change partition 4, to 20% and create partition 5, "GEMINI" with 10%.

The screen now looks like:

```

~~~~~
Partition Operating
Name System Name Percentage Kilobytes
1. CPM CPM-85 10% 1000
2. CPM-DATA CPM-85 10% 1000
3. Z-DOS Z-DOS 50% 5000
4. Z-DOS-DATA Z-DOS 20% 2000
5. GEMINI PC-DOS 10% 1000
6. (nothing)
|
16. (nothing)
Total Utilization (Allocated/Unallocd) 100/0 10000/0
Default boot partition number: 3 <Z-DOS/Z-DOS >
~~~~~

```

**Figure 4 - Z-100 PART Display With "GEMINI" Created**

As you can see, line 5 of Figure 4 shows the Partition Name "GEMINI". The GEMINI partition name is required to identify a PC hard disk in the IBM Mode.

Lastly, choose a default partition,  
3 <Z-DOS/Z-DOS >  
and save the settings to our hard disk.

#### 5-2-2 The H/Z-150 PC-DOS PREP Command

After the Gemini partition is assigned in the Z-100 Mode, boot the system with **Z-150 PC-DOS**.

You must now enter the PREP command to create the reserved Winchester area for the IBM PC Mode. Use of the Z-150 PREP command affects **ONLY** the "GEMINI" partition and does **NOT** access, overwrite, or otherwise destroy programs and data in any of the other defined Z-100 partitions. Enter the command:

**A: />PREP{RETURN}**



PREP will ask for the Winchester drive unit number, which is normally zero (0) for single drive systems. If you have a second physical Winchester drive with a "GEMINI" partition, you will also need to run PREP on that drive, which is normally one (1). Refer to your Z-150 PC-DOS documentation for additional information on running PREP.

### 5-2-3 The H/Z-150 PC-DOS PART Command

Use of the Z-150 PART command is optional, but allows you to divide the "GEMINI" partition into a maximum of four PC partitions in the IBM Mode.

Remember that the Z-100 Z-DOS PART command was used to define the "GEMINI" partition, which is simply treated as an entire Winchester hard disk.

The Z-150 PC-DOS PART command allows you to have multiple partitions in the IBM Mode just like its Z-100 counterpart.

Z-100 owners should carefully read the Z-150 PC-DOS documentation on the use of the Z-150 PART command since the implementation is considerably different from the Z-100 PART command. See Figure 5 for a sample of the Z-150 PART display.

```

~~~~~
Partition Start End Size in Percentage
Type Cylndr Cylndr Kilobytes of the Disk
1. DOS 0 (Zero) 300 3000 100.0%
2. Unallocated
3. Unallocated
4. Unallocated
Winchester unit = 0 (Zero)
Default boot partition = 1
Maximum cylinder number = 300
Minimum DOS allocation = 32 kilobytes
~~~~~

```

**Figure 5 - Z-150 PART Display Example**

After you have defined one or more IBM partitions with the PART command, you **MUST** reboot the system from a floppy drive in order to proceed with the next step. Remember that you may also need to assign the Winchester drive(s) using the appropriate Z-150 DOS utility:

```

DOS Version 2 - Use ASSIGN
DOS Version 3, or later
                  - Run ASGNPART 0:1 C:{RETURN}

```

### 5-2-4 The Z-150 PC-DOS FORMAT Command

PC-DOS Version 3 and later automatically assigns one Winchester partition at system boot. This is normally identified as drive C. Older versions (i.e. version 2) of PC-DOS require that the ASSIGN command be used to assign all IBM partitions prior to using the FORMAT command. Refer to your Zenith documentation for the correct command syntax and usage for PC-DOS Version 2.

Assuming that you want to make the IBM partition bootable, enter the command:

```
FORMAT C:/s/v
```

The /S (System) parameter will transfer the MS-DOS operating system to the hard disk so that it will be bootable.

The /V (Verify) option is recommended since it verifies that the hard disk was formatted correctly.

You may format additional IBM partitions in the same way, providing they have been correctly specified with the Z-150 PART command and assigned with the ASGNPART (ASSIGN in DOS Version 2) prior to formatting.

### 5-3 Loading the Winchester Hard Disk

After the IBM Winchester hard disk partition has been formatted, use the DOS COPY command to copy the balance of the Z-150 operating system utilities (e.g. FORMAT, DISKCOPY, etc.) to the hard disk as usual.

If you changed partition sizes with the Z-100 PART command in order to make room for the "GEMINI" partition, you will also need to ASSIGN or ASGNPART, FORMAT, and reload whatever files were on those prior partitions.

### 5-4 Using the Winchester Hard Disk

As explained in Subsection 1-2 - Initial Gemini Operation (IBM PC Mode), you can boot the Winchester by normally entering the "bw" command at the MFM-150 monitor prompt. This command will boot from Winchester drive zero (0), partition 1.

You can boot your system from either physical Winchester drive (drive 0 or drive 1) or from either floppy disk drive as explained in Chapter 6 of the Z-150 PC-DOS Version 3 documentation.

All of the standard Zenith Z-150 PC-DOS Winchester commands can be used with the exception of the **SHIP** command.

The **SHIP** command normally moves the Winchester read/write heads toward the center of the hard disk into the landing zone to prevent damage to the recording surface. But, since the "GEMINI" partition is usually one of several defined Z-100 partitions, and the "GEMINI" partition is treated as a single Winchester drive in the IBM Mode, the SHIP command will not normally be able to move the read/write heads to the correct landing zone location.

Therefore, you **MUST** use the Z-100 Z-DOS SHIP command in order to assure that the Winchester read/write heads are moved to the correct landing zone location.

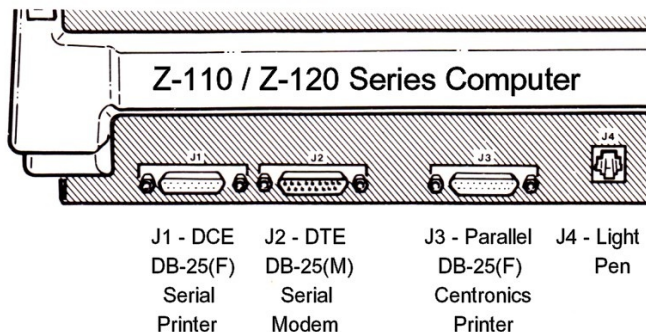
As discussed earlier, the PREP command is used to prepare the hard disk, and the PART command is used to assign one or more IBM partitions.

The ASGNPART (Version 3) or the ASSIGN command (Version 2) is used to access multiple partitions.

BACKUP and RESTORE can be used to backup and recover both programs and data on the Winchester hard disk.

The DETECT program will function normally and identify bad sectors followed by an update to the bad sector table that was originally created by the Z-150 PREP command.

## 6 I/O Port Changes



**Figure 6 - Z-100 Back Panel**

### 6-1 H/Z-100 Serial Ports

The internal hardware configuration of the Z-100 required that the Gemini Emulator Board design considerations provide IBM characteristics for the serial ports. The Z-100 J-1 serial port is hardware defined as a Data Communications Equipment (DCE) port that is usually connected to Data Terminal Equipment (DTE) such as a serial printer.

The Z-100 J-2 serial port is hardware defined as a DTE port that is usually connected to DCE equipment such as a modem. A functional concept in data communications is that DCE units are always connected to DTE ports and DTE units are always connected to DCE ports. Never connect like ports together unless a special null modem cable is used.

The serial port available on the IBM PC with the optional asynchronous adapter card provides a DTE serial port that would normally be used with DCE units such as a modem. When the IBM PC was designed, it was apparently with the plan that the available parallel port (included in the PC) would be used for the system printer. Regardless of the design considerations, the connection of a serial printer (DTE) has always required the use of a special null modem cable to connect DTE units to the IBM DTE port, usually identified as COM1 by the operating system.

One additional difference in the Z-100 hardware is that the Ring Indicator (pin 22 of the standard RS-232 interface) is not implemented. As a result, you may find that some IBM PC telecommunications software does not function properly because of this hardware difference.

### 6-2 J-1 Serial Port (IBM COM2)

The Z-100 J-1 serial port is a DCE port that is normally used for DTE units, such as a printer.

In most cases, existing cables and peripherals that are normally used with the standard Z-100 Z-DOS will also function properly in the IBM Mode. Remember that you must also configure your system to ensure that the port definitions are specified properly. This is normally done with the Z-150 PC-DOS CONFIGUR command.

For configuration purposes, note that the J-1 serial port must be addressed as COM2 so that the operating system and/or application software will function properly with the attached peripheral. As previously mentioned, this is easy to do with the Zenith CONFIGUR command.

If you want to use an IBM compatible peripheral and standard IBM cable for that peripheral on J-1, you may need to obtain (or make) a null modem cable. We recommend, however, that you connect all IBM peripherals (such as a modem or a mouse) direct to J-2 using the standard IBM cable since no other modifications are required.

**Note:** You can make a null modem cable using the pin connections described in Figure 7. The Z-100 end of the cable has a female DB-25 connector and the IBM PC end of the cable has a male DB-25 connector. The cable wiring connections shown in Figure 7 will work with most IBM PC peripherals and standard cables. Standard 9-wire cable is normally used to make this cable.

Remember that you can avoid the difficulties of making or obtaining a null modem cable by connecting an IBM peripheral with a standard IBM cable direct to Z-100 serial port J-2.

| H/Z-100 J-1<br>(DCE Port)<br>(Female DB-25)<br>Pin | IBM PC Serial Port 2<br>(COM2 - DTE port)<br>(Male DB-25 Connector)<br>Pin |
|----------------------------------------------------|----------------------------------------------------------------------------|
| 1                                                  | 1                                                                          |
| 2                                                  | 3                                                                          |
| 3                                                  | 2                                                                          |
| 4                                                  | 5                                                                          |
| 5                                                  | 4                                                                          |
| 6                                                  | 20                                                                         |
| 7                                                  | 7                                                                          |
| 20                                                 | 6                                                                          |

**Note:** Two jumpers (J109 and J111) on the Z-100 motherboard must be in their normal positions as specified in the Z-100 Manual. These jumpers are factory set in their correct positions and should NOT be modified.

**Figure 7 - Null Modem Cable for Z-100 J-1**

### 6-3 J-2 Serial Port (IBM COM1)

The Z-100 J-2 serial port is a DTE port that is essentially the same as the IBM COM1 port that would normally be used for all IBM compatible peripherals and standard IBM cables. Since this port is nearly identical to the IBM configuration, except for the RS-232 Ring Indicator on pin 22, it was defined as COM1 since it is nearly 100% plug compatible with the IBM port.

You will be able to use IBM compatible serial hardware and cables without making any cable modifications. This includes serial printers and serial mouse hardware. Special serial hardware, such as the mouse, also requires application support software that is usually supplied with the unit.

Similar to the J-1 serial port, the J-2 serial port **MUST** be addressed as COM1 in order for the attached peripheral to function properly. The Zenith CONFIGUR command provides an easy way to define peripherals attached to this port.

#### 6-4 J-3 Parallel Port (IBM PRN or LPT1)

The Z-100 J-3 parallel port can be used in the same way as the IBM parallel port for data **output** to a printer or similar peripheral. However, due to the hardware design of the Z-100, it is NOT possible to use this port for data input with devices like a mouse. You must use one of the serial ports for data input devices.

In most PC-DOS and compatible operating systems, this port can be addressed as either PRN or LPT1.

Like the other Z-100 ports, we recommend that you use the Zenith CONFIGUR command to define the attached peripheral to this port.

## 7 Video Compatibility

The Gemini Emulator Board supports most of the IBM standard video formats subject to the hardware limitations of the Z-100 video board. The character display on the CRT is supported by a 256 character set in the ZDS ROM-BIOS.

Video support includes 40 column by 25 line and 80 column by 25 line formats in both text and graphics modes. Both monochrome and color are supported in these formats and modes.

In addition, 320 by 200 pixel graphics and 640 by 200 pixel graphics are supported in both monochrome and color.

The reverse video and blinking character attributes are supported at normal intensity.

The Gemini Emulator Board supports only eight colors in IBM emulation mode because the Z-100 video board can not inherently support the high /low intensity attributes IBM uses to generate eight additional colors.

## 8 Troubleshooting

### 8-1 Hardware Support and Repair

The Gemini Emulator Board was designed to work with Heath and Zenith computer hardware as a complete system. Proper operation of Heath, Zenith, and Gemini products can only be assured when your system is used with Heath/Zenith and Gemini approved accessories. All Gemini products have been specifically tested on various models of Heath and Zenith computers.

As Gemini Technologies is no longer in business, if you have any difficulties you may contact me, Steve Vagts at: [z100lifeline@swvagts.com](mailto:z100lifeline@swvagts.com)

I will do my best to assist.

### 8-2 Some Possible Problems

#### PROBLEM: No Video on CRT

##### POSSIBLE CAUSE:

Monitor not connected or Power OFF.

##### ACTION:

Connect monitor or Turn Power ON.

Video cable(s) not connected to Z-100 Video Board.

Power OFF computer and connect cables.

Z-207 Floppy Controller not installed or improperly installed.

Install or reinstall Z-207 Floppy Controller.

Gemini Emulator Board improperly installed.

Reinstall the Gemini Board.

#### PROBLEM: System will not boot in IBM Mode

##### POSSIBLE CAUSE:

Not using Zenith IBM PC-DOS.

##### ACTION:

Change DOS to Zenith PC-DOS (i.e. for the Z-150 series computer).

Attempting to boot from 96 TPI drives.

Gemini will NOT support 96 TPI, 5-1/4" floppy drives. You must use 48 TPI drives.

Disk drive cable not Connected.

Connect drive cable.

J-106-1 is not installed in the W2 position on "new motherboard".

Install J-106-1 in the W2 position. (Old motherboards are not capable of running properly at 8 MHz).

#### PROBLEM: System will not boot in Z-100 Mode

##### POSSIBLE CAUSE:

Not using Z-100 Z-DOS.

##### ACTION:

Run Z-100 Z-DOS.

Drive cable not connected properly.

Check disk drive cable.

#### PROBLEM: CP/M-85 not running properly or intermittent system problems at 8 MHz.

##### POSSIBLE CAUSE:

Computer operating at 8 MHz on an old motherboard.

##### ACTION:

Reduce speed on old motherboard.

Computer operating at 8 MHz on new motherboard w/o HA-108 upgrade.

Install HA-108 (or equivalent) Upgrade.



Computer operating at  
at 8 MHz on new  
motherboard with  
HA-108 upgrade.

Install J-106-1 in the  
W2 position, & check for  
installation of correct  
Delay Line at U149.  
Use 100 or 150 ns.

**PROBLEM: IBM BASIC will NOT run**

**POSSIBLE CAUSE:**

IBM BASIC requires IBM  
PC BASIC ROM in the IBM  
PC, XT, or AT.

**ACTION:**

Use Zenith GW BASIC (disk  
-based BASIC version).

**PROBLEM: Gemini Board does NOT work in either  
Mode, but Gemini Logo appears on CRT.**

**POSSIBLE CAUSE:**

Slow or bad (out of  
Spec) 8088 CPU from  
motherboard.

**ACTION:**

Replace 8088 from  
motherboard.

Non-factory hardware  
modification.

Restore to factory  
configuration.

Defective Gemini Board.

Email:  
[z100lifeline@swvagts.com](mailto:z100lifeline@swvagts.com)

**PROBLEM: PC Software does NOT work**

**POSSIBLE CAUSE:**

Improper installation.

**ACTION:**

Remove Gemini Board and  
check all pins are straight  
(not bent under).

Exotic Copy Protect  
scheme.

Consult software  
manufacturer or Email:  
[z100lifeline@swvagts.com](mailto:z100lifeline@swvagts.com)

**PROBLEM: Printer serial/parallel not working in  
IBM Mode**

**POSSIBLE CAUSE:**

Improper software  
registration.

**ACTION:**

Configure applications  
software.

Improper OS  
configuration.

Run CONFIGUR to set OS  
to talk to peripherals.

Improper cable  
configuration for  
operation in IBM Mode.

Reconfigure cable for  
device.

**PROBLEM: Serial port NOT working with IBM**

**POSSIBLE CAUSE:**

Motherboard jumpers  
and/or J-111 in wrong  
position.

**ACTION:**

Restore jumpers to factory  
recommended position.

**PROBLEM: No sound from the Gemini Sound Board**

**POSSIBLE CAUSE:**

8253 IC installed  
backwards.

**ACTION:**

Remove 8253 IC and check  
pins. Reinstall and/or  
replace 8253 IC.

J4 cable connector  
Installed improperly.

Reinstall J4 cable.  
Check pin slots are  
facing up.

Speaker cable loose or  
disconnected.

Resolder speaker cables.

**PROBLEM: Steady or continuous noise from the  
Gemini Sound Board**

**POSSIBLE CAUSE:**

J4 cable installed  
upside down.

**ACTION:**

Reinstall J4 cable. Check  
pin slots are facing up.

Program bug.

See Subsection 9-3.

## 9 Gemini Sound Board

### 9-1 Preface

When installed with the Gemini Emulator Board,  
the Gemini Sound Board emulates IBM PC audio.

Installation of the Gemini Sound Board requires  
no soldering or additional RAM (Random Access  
Memory). You will need some basic tools and the  
installation instructions presented in **Section 2**  
- **Installation and Hardware Information.**

The Gemini Sound Board consists of a small  
printed circuit board, a speaker, and a plug  
which is attached to jack J4 on the Gemini  
Emulator Board. You must partially disassemble  
your computer (including the removal of the  
Gemini Emulator Board) to obtain full access to  
the Z-100 motherboard.

Briefly, the basic installation procedure is to  
remove U160, an 8253 Integrated Circuit (IC),  
from the Z-100 motherboard, install the chip on  
the Gemini Sound Board, and install the Gemini  
Sound Board on the Z-100 motherboard.

We recommend that you verify that your Z-100  
computer operates properly in both the Z-100 and  
IBM Modes before you begin the installation. If  
your computer includes a Winchester hard disk,  
be sure to invoke the 'SHIP' command from the  
Z-100 Mode before disassembling your computer.

### 9-2 Operating and Programming Information

When the Gemini Emulator Board is operating in  
the IBM Mode, all hardware-related interrupts  
are specifically processed to provide PC emula-  
tion. Since the IBM PC also uses an 8253 IC as  
a timer to control the duration of the sound  
pulses (among other things), this process is  
emulated by the Gemini Board in conjunction with  
the Gemini Sound Board.

The U160 (an 8253 IC) on the Z-100 is the timer  
status port. In the IBM PC Mode, the Gemini  
Emulator Board separates the interrupts that  
initiate sound in PC software. When the Gemini  
Sound Board is connected, sound is transmitted  
to the speaker for the software specified  
duration as determined by the timing circuit  
based on the 8253 timer chip.

In the Z-100 Mode, there is no change to the  
normal operation of U160 since the Gemini Board  
is disabled to allow for standard operation in  
all normal Z-100 operating modes.

User programming for the Gemini Sound Board is  
identical to that required for the IBM PC.

### 9-3 Program Bugs and Corrective Procedures

Some programs cause, under certain conditions, all PC's and compatibles (including the Gemini products) to emit a continuous tone from the speaker. For all Gemini equipped Z-100's, the following procedures can normally be used without any loss of data:

1. Press **Ctrl-Alt-Return** to display the MFM-150 monitor prompt. This will **not** normally cause a loss of data unless the current program has additional bugs. (I do not know if the Z-100 equivalent key combination will work - SWV)

2. Press any function key on the keyboard (e.g. {F1}). The sound will normally stop at this point.

3. Enter a {G} (the monitor ROM command for Go) followed by a {RETURN}. This should return you to the existing screen that you had when the continuous tone began.

**CAUTION:** This procedure ONLY works with Heath /Zenith PC compatibles and Gemini equipped Z-100's. It should not be attempted on other hardware because it may cause unpredictable system freezes or loss of data.

## 10 Gemini and the CDR-317

This Section is from an addendum dated February 5, 1987, by C.D.R. Systems, Inc. from San Diego.

The Gemini Emulator Board runs great with the CDR-317 SCSI Controller, but watch for the following:

The Gemini ROM set is in the process of being upgraded (I am NOT aware of any later ROM set - SWV), but if you have Gemini ROM version 1.42 or earlier, this is what will happen:

1. The 1.42 Gemini ROM set will not function properly with two hard disk drives installed. This problem is present with the CDR-317 and with the Zenith Z-217 controller.

2. The Gemini partition can NOT be larger than 18 megabytes. This problem is present with the CDR-317 and with the Z-217 controller.

3. At 8 MHz, the Gemini partition should start near the front of the drive or the partition will NOT be recognized. With the CDR-317 controller, the partition needs to be closer to the front than with the Z-217 controller.

4. There is only one known problem that is specific to the CDR-317 controller and the version 1.42 ROM set from Gemini. The problem stems from the two drive problem in the Gemini controller. Any time that the Gemini firmware recognizes that there may be a second drive in the system, there is a register that is not updated which leads to a not recognizable Winchester controller error, if there is not a second drive present, or other errors if there is a second drive present.

At Power ON, with the Z-100 going to the IBM Mode, the Gemini board performs a Recal on each drive to determine if there is a drive present. This works fine for both the Zenith and the CDR Controllers.

After a {CTRL}-{RESET} however, the Gemini firmware does not perform a Recal. It simply asks for the status of each drive to determine if it is there. For some reason, the answer given back at this time from the CDR-317 controller for each drive leads the Gemini controller to believe that there are two drives available. This situation is not handled correctly by the Gemini 1.42 ROMs.

The Zenith monitor and boot side does not have this problem because it always sends a set drive command to each drive to determine if a drive is present before doing any hard disk accessing, upon power up and upon resetting.

Gemini sent to C.D.R. Systems a Beta Version of a new ROM set that alleviated the reset accessing problem. We were told that the release version of this new ROM set will fix all of the above problems with Gemini and CDR-317 or Z-217 hard disk interfacing, and that it should be available from Gemini sometime in the second week of February 1987.

Until the new Gemini ROM set is available (I do not know if this new ROM set was EVER made available - SWV), to use the Gemini in IBM Mode with the CDR-317, the computer must be turned OFF, then ON, whenever a Reset is to be performed.

When the {I} is pressed to enter the IBM Mode, the Gemini monitor side will normally flash on the screen, a message recognizing that a Gemini partition was located on the hard disk.

**Note:** To be sure that the Gemini information in RAM is cleared, please wait approximately 10 seconds before power ON.

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

[z100lifeline@swvagts.com](mailto:z100lifeline@swvagts.com)

Cheers,

Steven W. Vagts



## Appendix A

### IBM PC Keyboard Scan Codes

- Keyboard scan codes for printable characters contain two bytes.
- The first byte describes the actual key position on the keyboard.
- The second byte contains the ASCII value of the printable character.
- Values shown in the Table are **hex** values generated as a default when DOS is originally booted.
- Unshifted and shifted values may be reversed depending on the state of the **Num Lock** and **CAPS** key(s) after DOS is originally booted.
- When a keytop has two legends, the unshifted keytop is shown first.

### Main Keyboard

| Keytop             | Unshifted | Shifted | Control (Ctrl) | Alternate (Alt) |
|--------------------|-----------|---------|----------------|-----------------|
| ESC                | 011Bh     | 011Bh   | 011Bh          | n/a             |
| 1 or !             | 0231h     | 0231h   | n/a            | 7800h           |
| 2 or @             | 0332h     | 0340h   | 0300h          | 7900h           |
| 3 or #             | 0433h     | 0423h   | n/a            | 7A00h           |
| 4 or \$            | 0534h     | 0524h   | n/a            | 7B00h           |
| 5 or %             | 0635h     | 0625h   | n/a            | 7C00h           |
| 6 or ^             | 0736h     | 075Eh   | 071Eh          | 7D00h           |
| 7 or &             | 0837h     | 0826h   | n/a            | 7E00h           |
| 8 or *             | 0938h     | 092Ah   | n/a            | 7F00h           |
| 9 or (             | 0A39h     | 0A28h   | n/a            | 8000h           |
| 0 or )             | 0B30h     | 0B29h   | n/a            | 8100h           |
| - or _             | 0C2Dh     | 0C5Fh   | 0C1Fh          | 8200h           |
| = or +             | 0D3Dh     | 0D2Bh   | n/a            | 8300h           |
| Backspace          | 0E08h     | 0E08h   | 0E7Fh          | 0E7Fh           |
| Tab                | 0F09h     | 0F00h   | n/a            | n/a             |
| Q                  | 1071h     | 1051h   | 1011h          | 1000h           |
| W                  | 1177h     | 1157h   | 1117h          | 1100h           |
| E                  | 1265h     | 2045h   | 1205h          | 1200h           |
| R                  | 1372h     | 1352h   | 1312h          | 1300h           |
| T                  | 1474h     | 1454h   | 1414h          | 1400h           |
| Y                  | 1579h     | 1559h   | 1519h          | 1500h           |
| U                  | 1675h     | 1655h   | 1615h          | 1600h           |
| I                  | 1769h     | 1749h   | 1709h          | 1700h           |
| O                  | 186Fh     | 184Fh   | 180Fh          | 1800h           |
| P                  | 1970h     | 1950h   | 1910h          | 1900h           |
| [ or {             | 1A5Bh     | 1A7Bh   | 1A1Bh          | n/a             |
| ] or }             | 1B5Dh     | 1B7Dh   | 1B1Dh          | n/a             |
| Return             | 1C0Dh     | 1C0Dh   | 1C0Ah          | 1C0Ah           |
| A                  | 1E61h     | 1E41h   | 1E01h          | 1E00h           |
| S                  | 1F73h     | 1F53h   | 1F13h          | 1F00h           |
| D                  | 2064h     | 2044h   | 2004h          | 2000h           |
| F                  | 2166h     | 2146h   | 2106h          | 2100h           |
| G                  | 2267h     | 2247h   | 2207h          | 2200h           |
| H                  | 2368h     | 2348h   | 2308h          | 2300h           |
| J                  | 246Ah     | 244Ah   | 240Ah          | 2400h           |
| K                  | 256Bh     | 254Bh   | 250Bh          | 2500h           |
| L                  | 266Ch     | 264Ch   | 260Ch          | 2600h           |
| ; or :             | 273Bh     | 273Ah   | n/a            | n/a             |
| ' or "             | 2827h     | 2822h   | n/a            | n/a             |
| ` or ~             | 2960h     | 297Eh   | n/a            | n/a             |
| \ or               | 2B5Ch     | 2B7Ch   | 2B1Ch          | n/a             |
| Z                  | 2C7Ah     | 2C5Ah   | 2C1Ah          | 2C00h           |
| X                  | 2D78h     | 2D58h   | 2D18h          | 2D00h           |
| C                  | 2E63h     | 2E43h   | 2E03h          | 2E00h           |
| V                  | 2F76h     | 2F56h   | 2F16h          | 2F00h           |
| B                  | 3062h     | 3042h   | 3002h          | 3000h           |
| N                  | 316Eh     | 314Eh   | 310Eh          | 3100h           |
| M                  | 326Dh     | 324Dh   | 320Dh          | 3200h           |
| , or <             | 332Ch     | 333Ch   | n/a            | n/a             |
| . or >             | 342Eh     | 343Eh   | n/a            | n/a             |
| / or ?             | 352Fh     | 353Fh   | n/a            | n/a             |
| SysReq or<br>PrtSc | 372Ah     | n/a     | 7200h          | n/a             |
| Space bar          | 3920h     | 3920h   | 3920h          | 3920h           |



## Function Keys

| Keytop | Unshifted | Shifted | Control<br>(Ctrl) | Alternate<br>(Alt) |
|--------|-----------|---------|-------------------|--------------------|
| F1     | 3B00h     | 5400h   | 5E00h             | 6800h              |
| F2     | 3C00h     | 5500h   | 5F00h             | 6900h              |
| F3     | 3D00h     | 5600h   | 6000h             | 6A00h              |
| F4     | 3E00h     | 5700h   | 6100h             | 6B00h              |
| F5     | 3F00h     | 5800h   | 6200h             | 6C00h              |
| F6     | 4000h     | 5900h   | 6300h             | 6D00h              |
| F7     | 4100h     | 5A00h   | 6400h             | 6E00h              |
| F8     | 4200h     | 5B00h   | 6500h             | 6F00h              |
| F9     | 4300h     | 5C00h   | 6600h             | 7000h              |
| F10    | 4400h     | 5D00h   | 6700h             | 7100h              |

## Keypad Keys

| Keytop      | Unshifted | Shifted | Control<br>(Ctrl) | Alternate<br>(Alt) |
|-------------|-----------|---------|-------------------|--------------------|
| 7 or Home   | 4700h     | 4737h   | 7700h             | 0007h              |
| 8 or ^arrow | 4800h     | 4838h   | n/a               | 0008h              |
| 9 or PgUp   | 4900h     | 4939h   | 8400h             | 0009h              |
| -           | 4A2Dh     | 4A2Dh   | n/a               | n/a                |
| 4 or <arrow | 4B00h     | 4B34h   | 7300h             | 0004h              |
| 5           | n/a       | 4C35h   | n/a               | 0005h              |
| 6 or >arrow | 4D00h     | 4D36h   | 7400h             | 0006h              |
| + (*)       | 4E2Bh     | 4E2Bh   | n/a               | n/a                |
| 1 or End    | 4F00h     | 4F31h   | 7500h             | 0001h              |
| 2 or varrow | 5000h     | 5032h   | n/a               | 0002h              |
| 3 or PgDn   | 5100h     | 5133h   | 7600h             | 0003h              |
| 0/Ins       | 5200h     | 5230h   | n/a               | n/a                |
| ./Del       | 5300h     | 532Eh   | n/a               | n/a                |

(\*) Note: The plus sign (+) has been remapped to the keypad **ENTER** key on the H/Z-100 keyboard.

The following keys are used with the Keyboard I/O Interrupt 16h.

- Right Shift
- Left Shift
- Ctrl
- Alt
- Scroll Lock
- Num Lock
- Caps
- Ins