NorthStar Computers Inc.
2547 Ninth Street
Berkeley, Ca. 94710

Horizon Computer System
Double Density

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HRZ-D-DOC
Revision 1

INTRODUCTION

The North Star Computers HORIZON™ is a high-performance, Z80A based microcomputer system which is especially suited for business, educational, and software development applications. It features fast-access disk storage as an integral part of the package, 4 MHz microprocessor operation, and built-in I/O capability. The HORIZON uses the S-100 bus structure, allowing a large selection of compatible products. The system will support up to 4 disk drives, allowing up to 716K bytes of on-line disk storage. Powerful system software, including North Star Disk BASIC, Disk Operating System, and Monitor program, are provided on diskette with disk versions of the HORIZON. The HORIZON is compatible with nearly all programs previously written for 8080 or Z80 based machines. North Star BASIC programs which run on the North Star MICRO-DISK SYSTEM will also run on the HORIZON. A list of the growing number of HORIZON-compatible applications programs is included in the North Star Newsletter, which you will receive after filling out and returning your Warranty Card.

If you have purchased your HORIZON as a kit, then skim this manual completely once, and then carefully follow the instructions in sequence. Be sure to read the Assembly Information section, even if you are an experienced kit builder.

If you have purchased an assembled HORIZON, be sure to read the Using the Serial Interfaces section for instructions on connecting a terminal. You need only read the assembly and checkout sections for a more complete understanding of how your computer is built. Of course, if you plan to maintain the HORIZON yourself, the checkout steps will be very important.

It is important for every HORIZON user to be familiar with the Operation and Maintenance section, and all sections of this manual and the accompanying manuals describing the North Star software. There is a lot of material presented here, but you will obtain far more performance from your computer if you take the time to read about all of its capabilities. The HORIZON documentation includes:

HORIZON Computer System Manual
North Star Z80A Processor Board Manual
North Star 16K RAM Board Manual
North Star System Software Manual
SA-400 minifloppy OEM Manual
Z80 Technical Manual

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LIMITED HARDWARE WARRANTY

North Star Computers, Inc. warrants the electrical and mechanical parts and workmanship of this product to be free of defects for a period of 90 days from date of purchase. If such defects occur, North Star Computers, Inc. will repair the defect at no cost to the purchaser. This warranty does not extend to defects resulting from improper use or assembly by purchaser, nor does it cover transportation to the factory. Also, the warranty is invalid if all instructions included in the accompanying documentation are not carefully followed. Any adjustment, modification, or disassembly of any disk drive unit will void the warranty on that disk drive unit. Should a unit returned for warranty repair be deemed by North Star Computers, Inc. to be defective due to purchaser's action, then a repair charge not to exceed $30 without purchaser's consent will be assessed. ANY UNIT OR PART RETURNED FOR WARRANTY REPAIR MUST BE ACCOMPANIED BY A COPY OF THE ORIGINAL SALES RECEIPT. This warranty applies to units located outside the United States of America only if all costs and arrangements for transportation of the product to and from the factory are borne entirely by the customer. This limited warranty is made in lieu of all other warranties, expressed or implied, and is limited to the repair or replacement of the product. No warranty, expressed or implied, is extended concerning the completeness, correctness, or suitability of the North Star equipment for any particular application. There are no warranties which extend beyond those expressly stated herein.

LIMITED SOFTWARE WARRANTY

The following limited warranty applies to the North Star BASIC, DOS, and Monitor software delivered on diskette with the HORIZON computer. North Star Computers, Inc. warrants that a copy identical to the North Star master copy of the software has been stored on the customer diskette and can be read into computer RAM memory from the diskette by a properly functioning HORIZON computer using the North Star disk controller board and disk drive. If a diskette malfunctions and has not been damaged by the customer and has not been operated with the write-protect tab removed, then North Star will re-write or replace the diskette if it is returned to North Star, prepaid, within three months from date of purchase.

No warranty, expressed or implied, is extended concerning the completeness, correctness, or suitability of the North Star software for any particular application. No consequential damage resulting from use of the software is covered - this warranty is limited to the repair or replacement of the original software diskette.

CAUTIONS

1. Correct this document from the errata sheets, if any, before doing anything else.

2. Assembly of this product as a kit is a complex, demanding project. It should not be attempted without previous kit building experience.

3. Do NOT insert or remove any boards from the computer when the power is on. Note that the power is not off until the front panel power LED has completely dimmed.

4. Do NOT insert or remove IC's from any board while the power is turned on. Note that the power is not off until the front panel power LED has completely dimmed.

5. Be sure that all IC's are inserted in their correct positions and with correct orientation before turning on the power. Be sure that all IC pins are inserted into the socket holes and are not bent under the IC and are not outside the socket.

6. Do NOT connect or disconnect, mount or dismount, or any way physically tamper with the disk drive(s) or any PC board while the power is turned on.

7. Carefully observe the prescribed rules for handling the MOS type integrated circuits and any PC board containing these devices. The handling procedures are described in the Assembly Information section.

8. To avoid the possibility of a severe shock, do NOT touch the power supply section of the computer whenever the power cord is plugged into an AC outlet.

SOFTWARE LICENSE

The North Star BASIC, DOS and Monitor are copyrighted products of North Star Computers, Inc., and are included with the HORIZON computer under the following license agreement:

The software may be used in conjunction with the North Star HORIZON computer and North Star MICRO-DISK SYSTEM only. The customer may make copies of the software for convenience of use, as long as the North Star copyright notice is preserved with each copy. This license specifically prohibits use of the software in a computer which does NOT include a North Star disk controller board, and also specifically prohibits modification of the software for use in any system which does not contain a North Star disk controller board.

CHASSIS PARTS LIST

SHEET METAL

1	chassis frame
1	disk drive mounting bracket
1	chassis partition piece
1	front panel
1	back panel
2	cover mounting brackets

MISCELLANEOUS PARTS

1	HORIZON nameplate
1	serial number plate
6	plastic card guides
4	plastic cable ties
2	cable tie mounting brackets
1	power-on LED with leads
9	8-32 nuts
9	#8 lock washers
12	6-32x3/8" machine screws
12	#6 lock washers

ADDITIONAL PART FOR HORIZON-1 ONLY

1	black plastic face plate

ADDITIONAL PARTS FOR HORIZON-Ø ONLY

2	black plastic face plates

POWER SUPPLY PARTS LIST

1	transformer, Part No. HRZ-T1
1	180,000uf 15 volt electrolytic capacitor
1	11,000uf 25 volt electrolytic capacitor
1	8,900uf 25 volt electrolytic capacitor
1	cooling fan
1	cooling fan grill
1	line cord
1	line filter, Corcom 6EF1
1	fuseholder
1	5 amp normal blow fuse
1	power switch
1	bridge rectifier, IR 250JB1L
2	stud diodes, MR1120 (wires attached)
1	3" capacitor clamp
2	1 3/8" capacitor clamps
1	stud diode mounting bracket
4	1/4"x5/8" machine screws
4	1/4" lock washers
4	1/4" nuts
17	6-32x3/8" machine screws
4	6-32x7/8" machine screws
5	6-32x1/2" machine screws
1	6-32x5/8" machine screw
27	#6 lock washers
9	6-32 nuts
29	wires (see Table 1 for details)
1	wire label card
4	adhesive backed rubber feet
1	reset switch
4	mica washers
2	#10 teflon spacers
2	#10 flat washers
10	10-32x3/8" machine screws
12	#10 lock washers
2	10-32 nuts

UNIVERSAL POWER SUPPLY OPTION PARTS LIST

1	transformer, Part No. HRZ-T1S (instead of HRZ-T1)
1	2" jumper wire
1	3-terminal white jumper wire
1	3-terminal black jumper wire
1	2.5 amp fuse

MOTHERBOARD PARTS LIST

INTEGRATED CIRCUITS

2	74LS03	2	74LS161
1	74LS04	3	74LS241
1	74LS05	1	74LS259
1	74LS14	1	74LS393
1	74LS74	1	1488
1	74LS132	1	1489
2	74LS136	1	4020(MOS)
1	74LS138	1	8251(MOS)
1	74LS139		

RESISTORS

3	1.2K	1/4 watt 5%
2	2.2K	1/4 watt 5%
1	4.7K	1/4 watt 5%
2	5.6K	1/4 watt 5%
1	1K	1/2 watt
1	1K	1/4 watt
1	560	1/4 watt 5%
2	220	1/4 watt 5%
2	330	2 Watt
1	100	2 Watt

CAPACITORS

3	2.2uf dipped tantalum
3	6.8uf dipped tantalum
14	.047uf ceramic disc
4	470pf ceramic disc

REGULATORS

1	5 volt , 7805 or 340t-5
1	12 volt, 78L12
1	-12 volt, 79L12

IC SOCKETS

14	14-pin sockets
9	16-pin sockets
3	20-pin sockets
1	28-pin sockets

MISCELLANEOUS PARTS

1	printed circuit board, HRZ-MB
1	transistor, 2N3904
3	16-pin DIP headers

3	14-pin DIP headers
1	heat sink, Thermalloy 6030B
1	25-pin connector
3	100-pin edge connectors
9	1/4" quick-connect lugs
2	3/16" quick-connect lugs
11	6-32x3/8" machine screws
11	#6 lock washers
1	6-32 nut
2	4-40x3/8" machine screws
2	#4 lock washers
2	4-40 nuts

WOOD COVER PARTS LIST

1	wood cover
4	6-32x1" brass machine screws
4	#6 brass flat washers

METAL COVER PARTS LIST

1	metal cover
4	6-32x3/8" machine screws

SECOND SERIAL INTERFACE OPTION (HRZ-SIO) PARTS LIST

2	1488 IC's
2	1489 IC's
1	8251 IC
1	transistor, 2N3904
6	14-pin IC sockets
1	16-pin IC sockets
1	28-pin IC socket
3	14-pin DIP headers
1	16-pin DIP header
2	5.6K resistors 1/4 Watt 5%
1	4.7K resistors 1/4 Watt 5%
1	1K resistor 1/4 Watt 5%
1	1K resistor 1/2 Watt
1	560 ohm resistor 1/4 Watt 5%
1	220 ohm resistor 1/4 Watt 5%
8	470pf ceramic disc capacitors
1	25-pin connector
2	4-40x3/8" machine screws
2	#4 lock washers
2	4-40 nuts

PARALLEL I/O INTERFACE OPTION (HRZ-PIO) PARTS LIST

1	74LS74 IC
2	74LS373 IC's
1	7437 IC
3	14-pin IC sockets
2	20-pin IC sockets
1	14-pin DIP header
1	2.2K resistor 1/4 Watt 5%
2	330 ohm resistors 1/4 Watt 5%
2	220 ohm resistors 1/4 Watt 5%
2	15-pin connectors
2	15-pin plugs
2	15-pin plug hood assemblies
4	4-40x3/8" machine screws
4	#4 lock washers
4	4-40 nuts

DISK SUB-SYSTEM (MDS-H) PARTS LIST

(included in HORIZON-1 and HORIZON-2)

1	disk drive, Shugart SA-400 (double density)
1	18" ribbon cable
1	12 1/2" power cable
1	power plug
4	power plug pins
1	5 volt regulator, 7805 or 340T-5
1	12 volt regulator, 7812K or 340K-12
1	heat sink, Thermalloy 6030B
1	heat sink, Thermalloy 6016B
2	.047 ceramic disc capacitors
5	6-32x3/8" machine screws
5	#6 lock washers
3	6-32 nuts
1	blank diskette
1	HORIZON software diskette

DISK CONTROLLER PARTS

1	printed circuit board (5" x 10"), MDS-AD
5	20-pin IC sockets
19	16-pin IC sockets
22	14-pin IC sockets
1	34-pin cable connector header
1	crystal, 4MHz
6	1N4148 diodes
2	+5 volt regulators, 7805 or 340T-5
1	+12 volt regulator, 78L12
2	heat sinks, 6107B-14
2	6-32x3/8" machine screws
2	#6 lock washers
2	6-32 nuts

Integrated Circuits

2	74LS00	3	74LS241
1	74LS02	2	74LS253
1	74LS08	1	74LS257
1	74LS11	1	74LS273
2	74LS14	3	74LS393
1	74LS32	1	7404
6	74LS74	3	7438
3	74LS109	1	74166 or 74LS166
3	74LS123	1	DWE PROM (6301 or 82S129)
1	74LS138	1	DSEL PROM (6301 or 82S129)
4	74LS161	1	DPGM PROM (6309)
1	74LS164	1	LF356
1	74LS174	1	3080

Capacitors

4	2.2uf	tantalum
2	6.8uf	tantalum
1	.01uf	dipped mylar 10%
3	.022uf	dipped mylar 10%
1	.047uf	dipped mylar 10%
1	33pf	dipped mica 5%
1	100pf	dipped mica 5%
2	200pf	dipped mica 5%
2	330pf	dipped mica 1%
1	470pf	dipped mica 5%
1	47pf	ceramic disk 20%
1	100pf	ceramic disk 20%
1	330pf	ceramic disk 20%
18	.047uf	ceramic disk

Resistors

1	3.3	ohm 1/4W 5%	3	5.6K	ohm 1/4W 5%
5	150	ohm 1/4W 5%	1	6.19K	ohm 1/4W 1%
1	330	ohm 1/4W 5%	2	6.8K	ohm 1/4W 5%
4	470	ohm 1/4W 5%	1	9.1K	ohm 1/4W 5%
2	680	ohm 1/4W 5%	1	10K	ohm 1/4W 5%
3	2.2K	ohm 1/4W 5%	1	13K	ohm 1/4W 5%
1	3.3K	ohm 1/4W 5%	1	15K	ohm 1/4W 5%
1	3.6K	ohm 1/4W 5%	3	27K	ohm 1/4W 5%

SECOND DISK DRIVE (HRZ-DRV) PARTS LIST

(included in HORIZON-2)

1	disk drive, Shugart SA-400
1	34-pin edge connector
1	12 1/2" power cable
1	power plug
4	power plug pins
1	5 volt regulator, 7805 or 340t-5
1	12 volt regulator, 7812K or 340K-12
1	heat sink, Thermalloy 6030B
1	heat sink, Thermalloy 6016B
2	.047 ceramic disc capacitors
5	6-32x3/8" machine screws
5	#6 lock washers
3	6-32 nuts

ASSEMBLY INFORMATION

Read completely through each section before beginning the first instruction step of that section. Perform all operations in the sequence indicated. Read each step entirely, including any notes that accompany the step, before beginning to follow the step.

WORK AREA AND TOOLS

Start with a clean, well-lit and well-ventilated area to work. The area should be large enough to accommodate the kit, tools, parts and assembly instructions. Suggested tools are: screwdrivers, needle-nose pliers, diagonal cutters, soldering iron, solder, and masking tape. A number of tests will require using a VOM (ohmmeter-voltmeter), or VTVM. Also highly desirable, but not necessary, are an IC inserter, a screw-holding screwdriver, an oscilloscope or logic probe, and an extender card. [Note that if you do not have an oscilloscope or logic probe, waveforms can be detected by one of the procedures described in Appendix 1.]

SOLDERING TIPS

For best results use a 15 to 25 watt soldering iron or an iron with a temperature controlled tip (approximately 700 degrees). The tip should be no wider than the solder pads on the printed circuit board. Use only a fine gauge rosin core solder (60/40 or 63/37). Do NOT use acid core solder as this can severely damage a printed circuit board. When soldering, keep the soldering iron tip on the pad just long enough for the solder to completely flow. If the solder does not draw up the wire then more solder is required. Do not use so much solder that it overflows the pad. If a solidified joint is not shiny, it may be a cold solder joint and should be remelted. The soldering iron tip should be cleaned frequently by wiping on a damp sponge

When you have completed assembly of a board, inspect it for unintended solder connections or "bridges", as well as unsoldered leads. After soldering, it is recommended that the rosin flux be removed from the board using flux remover, FREON or paint-thinner type solvent. This will make looking for soldering problems easier and give the board a clean, professional appearance.

IC SOCKET INSTALLATION

Integrated circuit (IC) sockets can be installed by first inserting them into the printed circuit board, then placing another flat board over the IC sockets and finally turning over this sandwich. Be sure that each IC socket is inserted into the proper location and is oriented such that pin 1 of the socket corresponds to the pin 1 indication on the PC board layout legend. (Refer to figure 1A to identify pin 1 on an IC socket.) To solder IC sockets, first solder just two opposite corner pins

for all sockets being installed. Then remelt the corner connections while applying pressure down on the board. This will remove any gaps that may be present between the IC sockets and the PC board. Finally, solder the remaining pins of the IC sockets.

DIP HEADER SOLDERING

When making jumper connections on a DIP header, solder resistor or capacitor lead snippings between the leads to be connected. When more than two pins are to be connected together, bend a single wire so that it routes to each pin, and solder each pin once. Insert the header in an IC socket on a PC board to hold it during soldering. Overheating the pins with the soldering iron will melt the plastic of the header. If there are multiple jumpers on a header, make sure that no unintended connections are made by carefully routing the jumpers, or by insulating each jumper with some wire insulation.

RESISTOR AND CAPACITOR INSTALLATION

To install resistors or capacitors, first make right angle bends in the leads to fit the PC board hole spacing. (Some capacitor leads are already appropriately spaced and do not need bending.) Then insert the leads as far as possible through the correct holes in the PC board and spread the leads slightly on the solder side of the board to keep the part in place. After a group of resistors or capacitors has been inserted, then solder the leads on the solder side of the board and snip off the excess leads as close to the board as possible. Use caution to avoid eye injury from flying bits of wire. Save the lead clippings for later use in making jumper connections.

PRINTED CIRCUIT BOARD LAYOUT

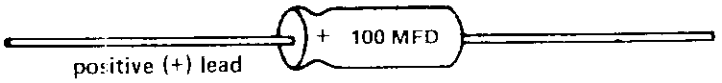
The white component layout legend is printed on the component side of a printed circuit (PC) board. All components are inserted from this side (component side) and soldered on the other side (solder side). Locations on the PC board are identified by two-character codes as marked on the board: a digit followed by a letter indicating the horizontal and vertical coordinates of the location. Note that in North Star kits, IC's can be found on styrene pads in positions corresponding to their intended locations on the PC board.

Pin numbering conventions for the S-100 edge pins are as follows: When viewing the component side of the board (with the pin edge facing down), pins 1,2, ..., 50 range from left to right. When viewing the solder side of the board, pins 100, 99, ..., 51 range from left to right.

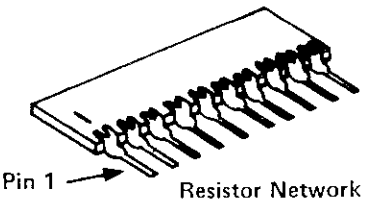
MOS INTEGRATED CIRCUIT HANDLING

Some North Star PC boards use some MOS-type IC's. These parts are identified as such in the instructions. MOS devices can be damaged by static electricity discharge, so special handling is necessary to protect them. Handle MOS devices as little as possible and avoid touching the pins. Place the conductive foam or tube which contains the MOS device onto the PC board before removing the device from the foam or tube. Also, be sure both hands are touching the foam or tube when the device is removed from the foam or tube.

Once a MOS device has been installed in a PC board, handle the board as little as possible. Of course, never insert or remove any IC while power is applied to the board, and never remove or insert a PC board while power is applied to the motherboard.

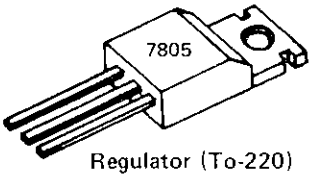


Axial Lead
Electrolytic Capacitor

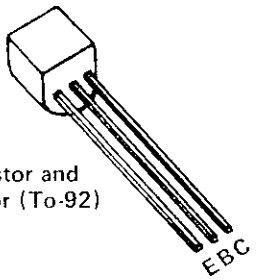


Resistor Network

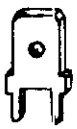
Resistor



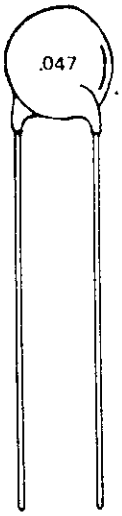
Regulator (To-220)



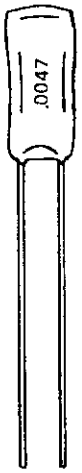
Transistor and
Regulator (To-92)



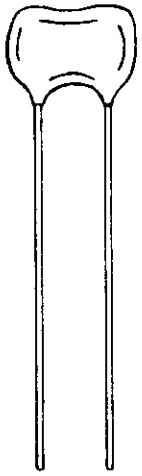
Quick-Connect
Lug



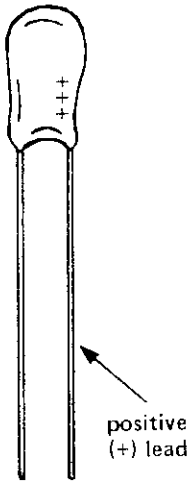
Ceramic
Disc
Capacitor



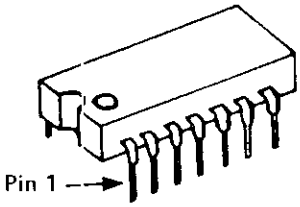
Dipped
Mylar
Capacitor



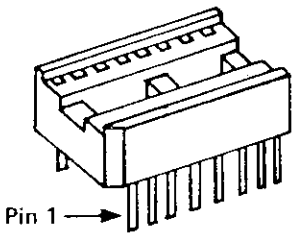
Dipped
Mica
Capacitor



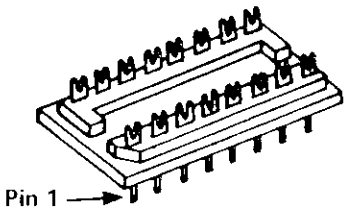
Dipped
Tantalum
Capacitor



Integrated Circuit (IC)

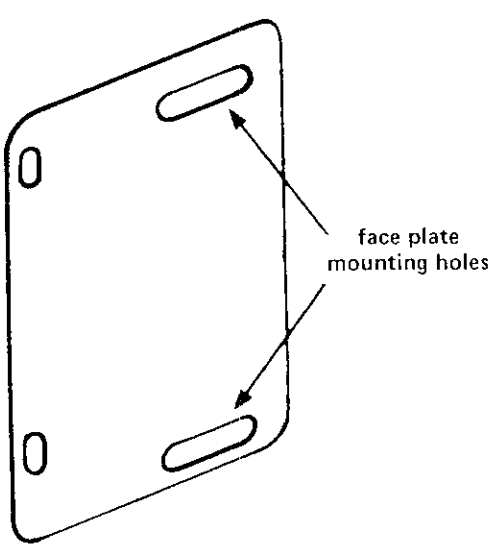


IC Socket

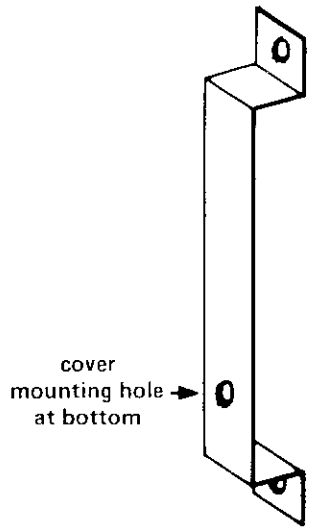


DIP Header

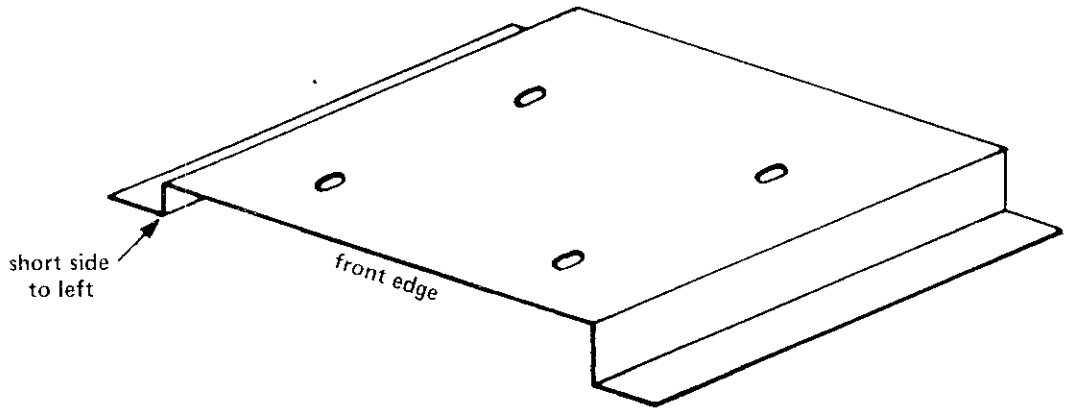
Figure 1A. Identification and orientation of components.



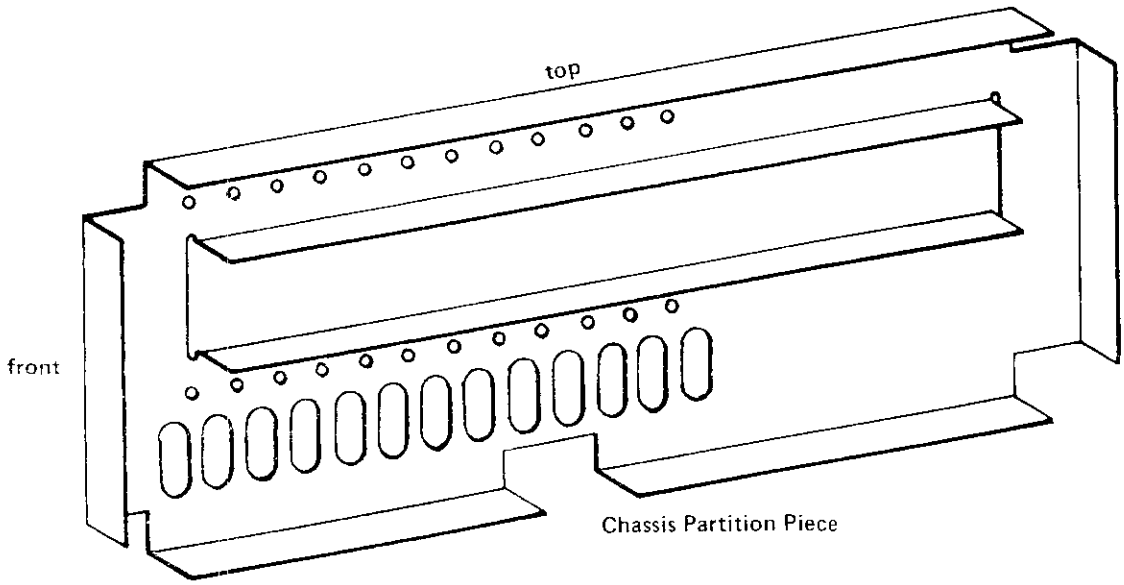
Face Plate Mounting Bracket



Cover Mounting Bracket



Disk Drive Mounting Bracket



Chassis Partition Piece

Figure 1S. Identification and Orientation of Sheet Metal Parts

POWER SUPPLY ASSEMBLY

Assembly of the power supply is the first step in the assembly of the HORIZON. In the following instructions, use of the words "left" and "right" refers to those directions when facing the front of the computer.

P1. Check to be sure you have all the parts for the power supply by referring to the parts list. Identify each of the wires listed in Table 1 (at the end of this section) and neatly tag each wire with the appropriately numbered wire label from the wire label card. The label should be placed near end A to aid in orienting the wires.

P2. Mount the fan and fan guard to the back panel so that the following order results from outside to inside: 6-32x7/8" machine screw heads, fan guard, back panel, fan, #6 lock washers and #6 nuts. The outside of the back panel will be the side away from you when the large fan opening and two rectangular switch holes are on your upper right. See figure 1P. Orient the fan so the power connections are on the lower right and the airflow arrow points outward.

P3. Mount the fuseholder to the outside of the back panel in the position and orientation as shown in figure 1P. Orient the side lug away from the fan, and fasten with the large fuseholder nut. Insert the 5 amp fuse into the fuseholder and twist on the fuseholder cap.

P4. Install the line filter to the outside of the back panel in the position and orientation shown in figure 1P. The following order should result from outside to inside: 6-32x1/2" machine screw heads, line filter, back panel, lock washers, and nuts.

P5. Snap the reset paddle switch into the top rectangular hole to the right of the fan from the outside of the back panel. Orient the switch so that the paddle points toward the fan.

P6. Snap the power rocker switch into the rectangular hole just below the reset switch from the outside of the back panel. Orient the switch so that lugs #3 and #6 are to the left.

P7. Slip end B of wire #2 (see wire descriptions in Table 1 at the end of this section) onto the top center lug (#2) of the power switch.

P8. Slip end B of wire #3 onto the center lug of the fuseholder.

P9. Slip end A of wire #4 onto the side lug of the fuseholder.

P10. Slip end B of wire #4 onto the bottom center lug (#5) of the power switch.

P11. Slip the B ends of wires #7 and #8 onto the two fan lugs. The fan lugs may have to be bent slightly in order to slip on the wires. Twist the wires together and leave the A ends unattached for now. Check your assembly to this point with figure 1P for correctness. Set the back panel aside for now.

P12. Mount the four adhesive-backed rubber feet onto the bottom of the chassis frame, approximately 1" in towards the center from each corner.

P13. Orient the chassis frame on the rubber feet so that the four 1/4" oval holes are on the right, away from you. The front of the chassis is now closest to you.

P14. Mount the 180,000uf electrolytic capacitor as follows: First attach a 6-32x1/2" tightening machine screw to the 3" diameter capacitor clamp with a lock washer and nut. Next, mount the clamp to the chassis frame in the location and orientation as shown in figure 2P, using three 6-32x3/8" machine screws and lock washers. Do not tighten the machine screws yet. Next, insert the capacitor into the clamp, oriented as shown in figure 2P, forcing the bottom of the capacitor to be flush with the frame. Finally, tighten the clamp tightening machine screw and the three clamp mounting machine screws.

P15. Mount the stud diode mounting bracket in the location and orientation shown in figure 2P, using two 6-32x3/8" machine screws and lock washers.

P16. Mount end A of wire #13 and the stud diode with the longer blue wire (#9) to the right hole of the stud diode mounting bracket. The following order should result from back to front: stud diode, mica washer, teflon ring, mounting bracket, mica washer, #10 flat washer, end A of wire #13, lock washer, and nut. Be sure the teflon ring is inside the bracket hole to insulate the diode from the bracket. Leave end B of wire #13 and end A of wire #9 unattached for now.

P17. Similarly mount end A of wire #14 and the other stud diode (with wire #10) to the left hole of the stud diode mounting

bracket. Leave end B of wire #14 and end A of wire #10 unattached for now.

Check with an ohmmeter that there is no short between either diode and the chassis.

P18. Mount the four-prong bridge rectifier to the chassis frame in the location and orientation shown in figure 2P using a 6-32x5/8" machine screw and lock washer. The + lug should be nearest the right rear of the chassis.

P19. Mount the transformer in the location and orientation shown in figure 2P. Be sure that the ring lugs are in the front left position. You may wish to use masking tape to hold the screws in position while mounting the transformer. The following order should result from bottom to top: four 1/4" machine screw heads, chassis frame, transformer brackets, lock washers and nuts. Before tightening the nuts firmly, slide the transformer as far forward as the oval mounting holes will permit, and center the transformer between the 180,00uf capacitor on the left and the wall of the chassis frame on the right.

P20. Connect end A of wire #10 to terminal #4 of the transformer with a #10 machine screw and lock washer. The following order should result from left to right: 10-32x3/8" machine screw head, lock washer, wire end ring terminal, and threaded transformer terminal.

P21. Connect end B of wire #12 to terminal #3 of the transformer.

P22. Connect end B of wire #11 to terminal #2 of the transformer.

P23. Connect end A of wire #9 to terminal #1 of the transformer. If necessary, bend the transformer ring terminals away from the transformer frame and each other so no shorts can occur. Be sure that the lead from the stud diode is straight and does not get bent.

P24. Mount the 11,000uf electrolytic capacitor in the location and orientation shown in figure 2P. Follow the mounting procedure as for the 180,000uf capacitor (see step P14), using a 1 3/8" diameter capacitor clamp.

P25. Mount the 8,900uf capacitor in the location and orientation shown in figure 2P. Follow the mounting procedure as for the 180,000uf capacitor, using a 1 3/8" diameter capacitor clamp. Compare your assembly to this point with figure 2P for correctness.

P26. Connect the following four wires to the + terminal of the 180,000uf capacitor with a 10-32x3/8" machine screw and lock washer: end B of wire #13, end B of wire #14, end A of wire

#17, and end A of wire #18. Run the unattached ends of wires #17 and #18 toward the rear of the chassis.

Note: All subsequent wire connections to capacitor terminals are made using 10-32x3/8" machine screws and lock washers.

P27. Connect the following four wires to the - terminal of the 180,000uf capacitor: end A of wire #11, end A of wire #12, end A of wire #15, and end A of wire #16. Route the unattached ends of wires #15 and #16 toward the rear of the chassis.

P28. Slip end A of wire #20 onto the rear AC lug (may be marked with sine wave) of the bridge rectifier. Slip end B of wire #20 onto lug #7 of the transformer.

P29. Connect the following two wires to the + lug of the 11,000uf capacitor: end B of wire #21 and end A of wire #26. Route the unattached end of wire #26 toward the rear of the chassis. Slip end A of wire #21 onto the + lug of the bridge rectifier.

P30. Connect the following two wires to the - lug of the 11,000uf capacitor: end A of wire #24 and end A of wire #25. Route the unattached end of wire #25 toward the rear of the chassis.

P31. Connect the following two wires to the + lug of the 8,900uf capacitor: end B of wire #24 and end B of wire #23. Slip end A of wire #23 onto the transformer lug #6.

P32. Connect the following two wires to the - lug of the 8,900uf capacitor: end B of wire #22 and end A of wire #27. Route the unattached end of wire #27 toward the rear of the chassis. Slip end A of wire #22 onto the - lug of the bridge rectifier.

P33. Slip end A of wire #19 onto the front AC lug of the bridge rectifier. Slip end B of wire #19 onto lug #5 of the transformer

P34. Lay the back panel with the outside surface down, directly behind the chassis frame.

Note: If you have the universal power supply option for non-U.S. electrical service, refer to the enclosed Universal Power Supply Instruction Sheet at this time.

P35. Slip end A of wire #5 onto the top lug (#8) on the rear left of the transformer. Slip end B of wire #5 onto the lower left lug (#6) of the power switch.

P36. Slip end A of wire #7 onto the second lug (also labeled #8)

from the top on the rear left of the transformer.

P37. Slip end A of wire #6 onto the third lug (#9) from the top on the rear left of the transformer. Slip end B of wire #6 onto the upper left lug (#3) of the power switch.

P38. Slip end A of wire #8 onto the bottom lug (also labeled #9) at the rear of the transformer.

P39. Attach end A of wire #1 to the hole in the chassis frame just behind the 180,000uf capacitor using a 6-32x3/8" machine screw and lock washer.

P40. There should now be exactly seven power supply wires with unattached ends which will be routed to the motherboard later. Carefully check all power supply wiring with the power supply schematic drawing and Table 1 for correctness.

P41. Temporarily route the seven unattached wires to the rear of the back panel and be sure that none of the ends of these wires are touching each other or any other electrically conductive material.

P42. Set the power switch to the off position (side toward fan depressed). Next plug the line cord into the line filter and an AC electrical outlet. Now turn on the power switch. The fan should turn on and blow air toward the outside of the chassis.

P43. The following DC voltages should now be read with a voltmeter at the ends of the unattached wires:

A. +11 volts DC ($\pm$15%) between all four possible pairs of one of the two red wires and one of the two black wires from the 180,000uf capacitor. The red wire should be positive.

B. +22 volts DC ($\pm$15%) between the orange wire and the black wire from the 11,000uf capacitor. The orange wire should be positive.

C. -22 volts DC ($\pm$15%) between the yellow wire from the 8,900 capacitor and the black wire from the 11,000uf capacitor. The yellow wire should be negative.

Turn off the power switch and unplug the line cord from the AC outlet. Discharge each of the three electrolytic capacitors by placing a 100 ohm, 2 watt resistor from the motherboard parts across the two terminals for several seconds. Be careful to hold the resistor by the body and not to touch either of the leads. If any of the voltages were not correct, locate the cause before proceeding.

P44. Slip end A of wire #29 onto the left lug (#1) of the reset switch. Slip end A of wire #28 onto the center (#2) of the reset switch. Twist wires #28 and #29 together and route them under the fan and to the left. They will be attached to the motherboard later.

P45. Attach the back panel to the chassis frame using seven 6-32x3/8" machine screws and lock washers such that the following order results from back to front: machine screw head, lock washer, back panel, and chassis frame. Leave the machine screws loose for now. They will be tightened during chassis assembly. Route the power supply wires so they will not interfere with the free rotation of the fan. The seven unattached power supply wires should be routed over the back panel to the rear for now.

The power supply is now assembled. Proceed to the Motherboard Assembly section.

TABLE 1. POWER SUPPLY WIRES

Note: In the following table, the listed wire lengths are the nominal lengths without terminals. The 12 gauge wires are thicker than the 16 gauge wires.

WIRE TERMINAL TYPES	DESCRIPTION
.110 FISO	.110" wide Fully Insulated Slip-On terminal
3/16 FISO	3/16" wide Fully Insulated Slip-On terminal
1/4 FISO	1/4" wide Fully Insulated Slip-On terminal
1/4 SO	1/4" wide partially insulated Slip-On terminal
#6 ring	ring terminal for #6 machine screw
#10 ring	ring terminal for #10 machine screw

#	COLOR	GAUGE	LENGTH	END A	END B
1	black	16	5	#6 ring chassis	line filter center
2	white	16	7	line filter right	1/4 FISO power switch lug #2
3	black	16	3 1/2	line filter right	3/16 FISO fuseholder center lug
4	black	16	6	3/16 FISO fuseholder side	1/4 FISO power switch lug #5
5	black	16	9	3/16 FISO transformer #8	1/4 FISO power switch lug #6
6	white	16	9	3/16 FISO transformer #9	1/4 FISO power switch lug #3
7	black	16	8 1/2	3/16 FISO transformer #8	.110 FISO fan
8	white	16	8 1/2	3/16 FISO transformer #9	.110 FISO fan
9	blue	12	5	#10 ring transformer #1	right stud diode
10	blue	12	1 3/4	#10 ring transformer #4	left stud diode
11	black	12	6 3/4	#10 ring 180,000uf - lug	#10 ring transformer #2
12	black	12	6 3/4	#10 ring 180,000uf - lug	#10 ring transformer #3

#	COLOR	GAUGE	LENGTH	END A	END B
13	red	12	8	#10 ring stud diode	#10 ring 180,000uf + lug
14	red	12	8	#10 ring stud diode	#10 ring 180,000uf + lug
15	black	12	18 1/4	#10 ring 180,000uf - lug	1/4 SO motherboard GND
16	black	12	18 3/4	#10 ring 180,000uf - lug	1/4 SO motherboard GND
17	red	12	19 1/2	#10 ring 180,000uf + lug	1/4 SO motherboard +8
18	red	12	19 1/2	#10 ring 180,000uf + lug	1/4 SO motherboard +8
19	white	12	4	1/4 SO bridge AC lug	1/4 SO transformer #5
20	white	12	2 3/4	1/4 SO bridge AC lug	1/4 SO transformer #7
21	orange	12	8 1/4	1/4 SO bridge + lug	#10 ring 11,000uf + lug
22	yellow	12	6 1/2	1/4 SO bridge - lug	#10 ring 8,900uf - lug
23	black	12	8 1/4	1/4 SO transformer #6	#10 ring 8,900uf + lug
24	black	12	2 1/4	#10 ring 11,000uf - lug	#10 ring 8,900uf + lug
25	black	12	20 1/4	#10 ring 11,000uf - lug	1/4 SO motherboard GND
26	orange	12	20 1/4	#10 ring 11,000uf + lug	1/4 SO motherboard +16
27	yellow	12	20 1/4	#10 ring 8,900uf - lug	1/4 SO motherboard -16
28	blue	16	23 1/2	1/4 FISO reset switch #2	1/4 FISO motherboard RESET/
29	black	16	24	1/4 FISO reset switch #1	1/4 FISO motherboard GND

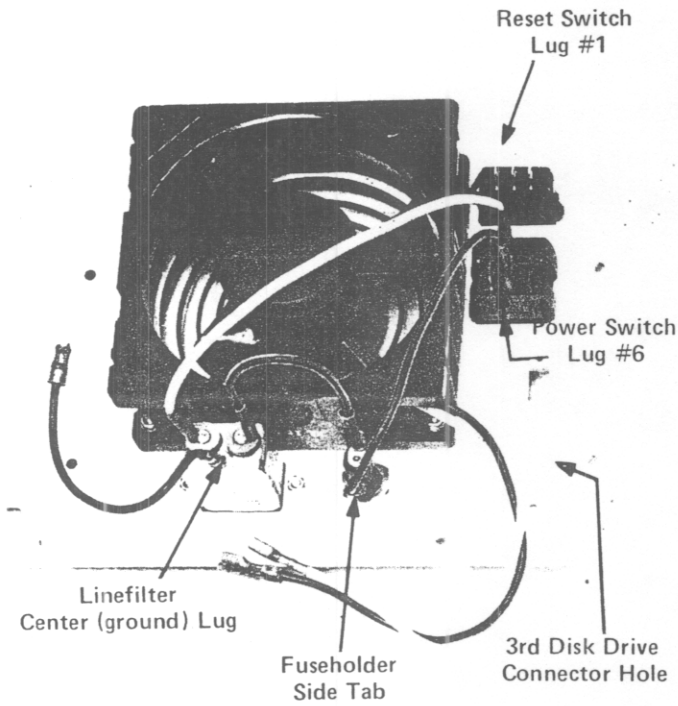


Figure 1P. View of Inside of Back Panel after Assembly Step P11.

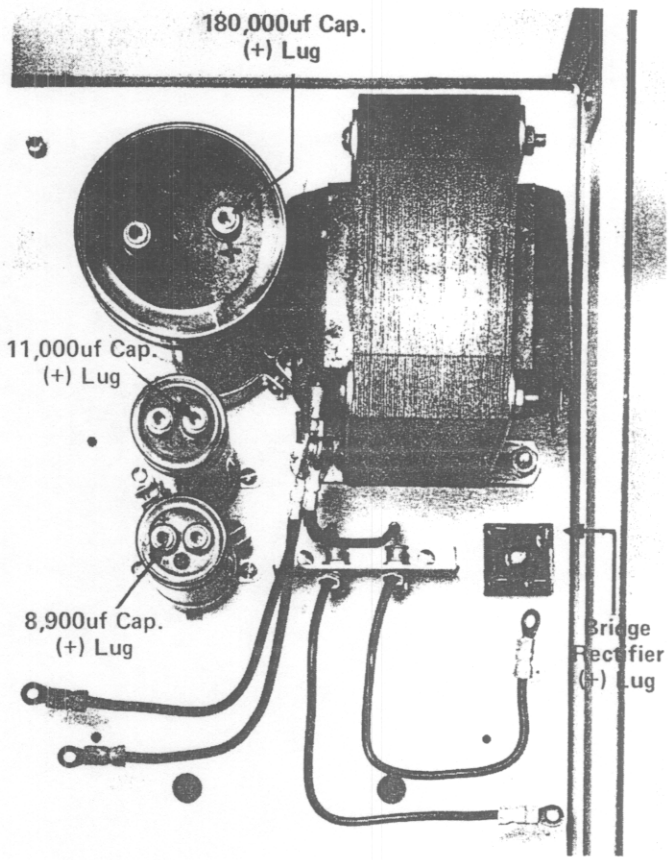


Figure 2P. Top View of Power Supply after Assembly Step P25.

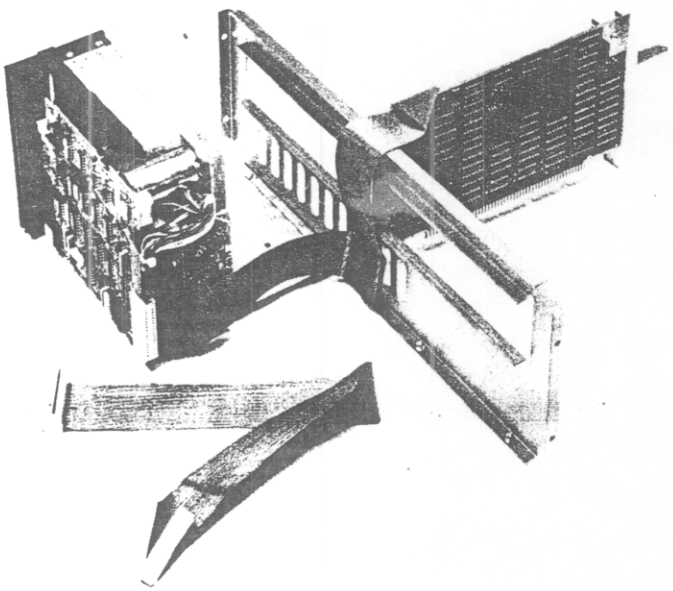


Figure 2C. Ribbon Cable Folding.

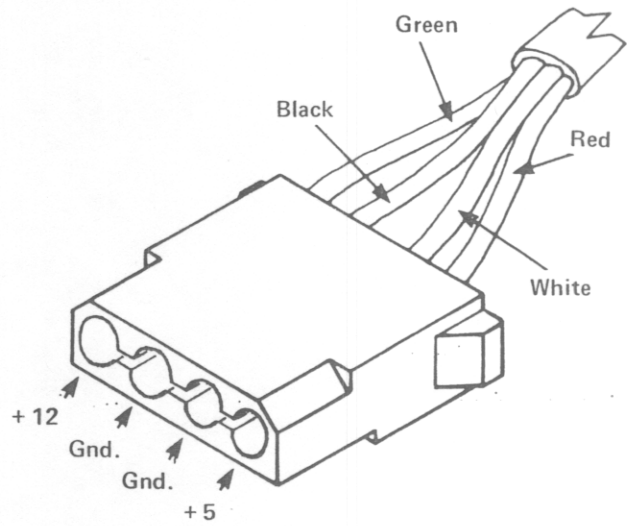


Figure 1D. Disk Power Plug Wiring.

MOTHERBOARD ASSEMBLY

The power supply should be assembled and tested prior to motherboard assembly. Assembly of the motherboard is performed in stages. This section describes the assembly of the basic configuration of the motherboard, including edge connectors, standard serial I/O interface, interrupts, and real-time clock. Assembly of other motherboard features will be described in subsequent sections.

M1. Check to be sure you have all the parts on the Motherboard Parts List.

Note: The component side of the motherboard is the side with the layout legend. The front of the motherboard is the end with the twelve 100-pin edge connector positions.

M2. Using an ohmmeter, check for open circuits between the pair of solder pads for each of the following ten capacitor locations: C1, C2, C3, C4, C5, C6, C7, C8, C9, and C10. If any shorts are found, locate and correct the problem or else return the motherboard for replacement.

M3. Insert and solder the 28-pin IC socket at location 3A, following the instructions given in the Assembly Information section.

M4. Insert and solder the three 20-pin IC sockets at locations 5A, 6A, and 7A.

M5. Insert and solder the nine 16-pin IC sockets at locations 1A, 2D, 3D, 6D, 7D, 8B, 9B, 9D, and 10B.

M6. Insert and solder the fourteen 14-pin IC sockets at locations 2A, 2B, 3B, 3C, 5B, 5C, 5D, 6B, 6C, 7B, 7C, 8D, 10A, and 10D. NOTE: If the parallel I/O interface option or second serial interface option are to be assembled at this time, then install the sockets for these options now, as described in steps U1 and T1.

M7. Install the 100-pin edge connectors as follows: solder the end and center pins of each connector first, then seat the connectors as you did for the IC sockets. All connectors that you plan to eventually use should be installed now to avoid removing the motherboard later. One connector should be installed in location P9 on the motherboard for the disk controller board. Separate the connectors you install as much as possible to facilitate PC board access. The standard HORIZON configuration has connectors at locations P1, P5, and P9.

Note: Bus lines 61 and 70 are connected to the ground plane on the motherboard to reduce bus noise. If you intend to

use S-100 PC boards that require use of these lines, then each line must be cut from the ground plane on the component side at each of the 12 connector pin locations for that line before the edge connectors are installed. Some memory boards which include a "protect" feature use bus line 70, for example.

M8. Insert and solder the nine 1/4" quick-connect lugs into the row of nine positions near location 1D. Solder the pins on both sides of the board for rigidity, and be sure each lug is vertical.

M9. Similarly insert and solder the two 3/16" quick-connect lugs at the front of the motherboard in the positions labeled LED and GND.

M10. Insert and solder the following thirteen resistors. Follow the procedure described in the Assembly Information section.

Resistor	Location	Value	Size	Color-code
( ) R1	5B	2.2K	1/4W	red-red-red
( ) R2	6B	1.2K	1/4W	brn-red-red
( ) R3	6C	1.2K	1/4W	brn-red-red
( ) R4	10A	1.2K	1/4W	brn-red-red
( )*R11	3C	4.7K	1/4W	yel-vio-red
( ) R14	3B	5.6K	1/4W	grn-blu-red
( ) R15	1D	1K	1/2W	brn-blk-red
( ) R16	next to R17	560	1/4W	grn-blu-brn
( ) R17	1D	220	1/4W	red-red-brn
( ) R30	5B	2.2K	1/4W	red-red-red
( ) R31	Front	330	2W	org-org-brn
( ) R32	Front	330	2W	org-org-brn
( ) R33	Front	100	2W	brn-blk-brn
( ) R34	Front	220	1/4W	red-red-brn

* R11 is installed between the hole to the left of the "R11" label on the layout legend and the hole to the right of the "C24" label. The hole in the middle is not used.

M11. Insert and solder the following 6 tantalum capacitors, being careful to match the + lead of the capacitor to the + lead hole on the motherboard:

Capacitor	Location	Value
( ) C1	1B	2.2uf
( ) C2	1B	2.2uf
( ) C3	Heat sink area	6.8uf
( ) C4	1B	2.2uf
( ) C7	Heat sink area	6.8uf
( ) C10	Heat sink area	6.8uf

M12. Insert and solder the following thirteen .047uf ceramic disk capacitors. Either orientation of the capacitor leads is acceptable.

	Capacitor	Location
( )	C11	3A
( )	C12	5A
( )	C13	10A
( )	C14	3B
( )	C15	4B
( )	C16	9B
( )	C17	1D
( )	C18	5C
( )	C19	10D
( )	C20	5D
( )	C21	7D
( )	C22	10D
( )	C48	7A

Similarly insert and solder the following four 470pf ceramic disc capacitors:

	Capacitor	Location
( )	C27	3B
( )	C28	3B
( )	C29	3B
( )	C30	3B

M13. Assemble the +5 volt regulator (7805 or 340T-5) to the inside of the 6030B heat sink so that the following sequence results from outside to inside: 6-32x3/8" machine screw head, heat sink, regulator, lock washer, and nut. The regulator leads should point in the same direction as the heat sink mounting posts. Next, install the regulator heat sink assembly, oriented as shown on the layout legend, into the location for the rear-most 7805 regulator at the left rear of the motherboard. Insert the regulator leads into the motherboard and then insert the heat sink mounting posts. Now solder the regulator leads

M14. Insert and solder the 78L12 and 79L12 regulators in the positions indicated on the layout legend near location 1B. Be sure that the flat sides of the regulators are oriented as indicated on the layout legend.

M15. Install and solder the 25-pin serial I/O interface connector in the position labeled LEFT SERIAL at the rear of the motherboard. The following order should result from top to bottom: Two 4-40x3/8" machine screw heads, connector, motherboard, lock washers, and nuts.

M16. Temporarily place the motherboard on a clean flat non-conductive surface near the back panel and connect the seven unattached wires from the power supply to the motherboard row of quick-connect lugs as follows:

Position	Wire
RESET/	no connection
GND	no connection
-16V	yellow wire
GND	black wire from 11,000uf capacitor
+16V	orange wire
GND	either black wire from 180,000uf capacitor
GND	other black wire from 180,000uf capacitor
+8V	either red wire
+8V	other red wire

M17. Plug the line cord into an AC outlet and turn on the power switch. Test for the following voltages between the lead pairs of the following tantalum capacitors:

Capacitor	Voltage
( ) C10	5V DC ±5%
( ) C4	12V DC ±5%
( ) C2	12V DC ±5%

The + lead of the capacitor should be measured using the + lead of the voltmeter. Now turn off the power and wait several seconds for the capacitors to discharge. Disconnect the line cord, and disconnect the seven power supply wires from the motherboard quick-connect lugs. If the voltages were not as listed then locate the cause before proceeding.

M18. Insert all the IC's except for the 8251 and the 4020 in the locations indicated on the layout legend. Be sure that each IC is oriented so that pin 1 is inserted into the position marked "1" on the layout legend. (Note that all IC's are oriented in the same direction.) Double check that all pins of every IC are properly inserted into the socket (not outside the hole and not bent under the IC).

Location	IC
( ) 2A	74LS05
( ) 2B	74LS03
( ) 3B	1488
( ) 3C	1489
( ) 5A	74LS241
( ) 5C	74LS04
( ) 5D	74LS393
( ) 6A	74LS241

( )	6B	74LS136
( )	6C	74LS136
( )	6D	74LS161
( )	7A	74LS241
( )	7B	74LSØ3
( )	7C	74LS14
( )	7D	74LS161
( )	8B	74LS259
( )	8D	74LS132
( )	9B	74LS138
( )	9D	74LS139
( )	10D	74LS74

M19. For compatibility with the standard HORIZON software conventions, construct the 14-pin port select header as follows (refer to the Assembly Information section for DIP header construction procedure): Connect pin 7 to pins 9, 10, 11, 12, and 13. Insert the header in location 5B with correct orientation. This header configuration selects the HORIZON I/O to ports Ø through 7. If another selection is desired, see the Motherboard I/O Port Addressing section for details.

M20. For 300 baud rate terminal communication, construct a 16-pin DIP header with pins 3, 4, and 11 connected together. Insert the header into position 2D with correct orientation. For other terminal baud rates, see the Using the Serial I/O Interfaces section for details.

M21. For RS-232 terminal communication, construct a 16-pin DIP header as follows:

Connect pin 1 to 12
Connect pin 2 to 16
Connect pin 3 to 15
Connect pin 4 to 14
Connect pin 5 to 11
Connect pin 7 to 8
Connect pin 9 to 10

Be sure that none of the jumper wires touch each other. Insert this header into location 3D with correct orientation. If current loop or modem communication is desired, then see the Using the Serial I/O Interfaces section and Motherboard Interrupts section for details.

M22. Insert a 14-pin DIP header in location 10A and a 16-pin DIP header in location 1A. These headers need be configured only if the real-time clock or interrupt features are desired. See the Using the Real-Time Clock section for details.

M23. Jumper connect (with a piece of resistor snipping) the two solder holes at the location C47 at the extreme left rear corner of the motherboard. This connects chassis ground to signal ground. For a complete discussion of system grounding, see the HORIZON Grounding section.

M24. The following is a partial check of the serial interface: With small gauge wire, temporarily jumper the socket pins 3A pin 3 and 3A pin 19 together. Also jumper pins 3A pin 4, 3A pin 23, and 3A pin 24 together. Plug a terminal into the standard serial interface connector using a 25-conductor cable (see the Using the Serial Interfaces section). With power temporarily applied to the motherboard (as described above), pin 3A3 should normally be HIGH (+5V), and should go LOW momentariliy when a key is depressed. Set the terminal to "full-duplex" mode. Typing a key on the keyboard should result in the serial interface "echoing" the typed character back to the terminal. Now turn off the power and remove the temporary jumpers from socket 3A. If this experiment fails, locate the problem before proceeding.

M25. Insert the 8251 at location 3A and insert the 4020 at location 10B, carefully following the MOS device handling procedures described in the Assembly Information section.

The assembly of the basic configuration of the motherboard is now completed. The following parts will be left over if current loop operation was not configured for the standard serial I/O interface: one 14-pin DIP header, one 2N3904 transistor, one 1K resistor, and one 5.6K resistor. Also, one .047 ceramic disc capacitor will be left over if the standard grounding procedure was followed.

SECOND SERIAL INTERFACE OPTION ASSEMBLY

Skip this section if you have not purchased the second serial interface option for your HORIZON.

Note: the second serial interface option not only includes parts for the second serial interface but also includes parts which allow synchronous mode communication with both serial interfaces.

U1. Insert and solder the following eight IC sockets into the motherboard using the techniques described in the Assembly Information section:

28-pin socket at location 4A
16-pin socket at location 4D
14-pin sockets at locations 1B, 1C, 1D, 2C, 4B and 4C

U2. Insert and solder the following four resistors using the techniques described in the Assembly Information section:

	Resistor	Location	Value	Size	Color-code
( )*	R19	3C	4.7K	1/4W	yel-vio-red
( )	R22	4B	5.6K	1/4W	grn-blu-red
( )	R23	1D	1K	1/2W	brn-blk-red
( )	R24	1D	560	1/4W	grn-blu-brn
( )	R25	1D	220	1/4W	red-red-brn

* R19 is installed between the hole to the left of the "R19" label on the layout legend and the hole to the right of the "C32" label. The hole in the middle is not used.

U3. Insert and solder the eight 470pf ceramic disk capacitors:

Capacitor	Location
( ) C35	3B
( ) C36	3B
( ) C37	3B
( ) C38	3B
( ) C43	1D
( ) C44	1D
( ) C45	1C
( ) C46	1C

U4. Install and solder the 25-pin serial I/O interface connector in the position labeled RIGHT SERIAL at the rear of the motherboard. The following order should result from top to bottom: Two 4-40x3/8" machine screw heads, connector,

motherboard, lock washers, and nuts.

U5. Insert the following five IC's:

Location	IC	
( ) 1B	1488	
( ) 1C	1489	
( ) 4A	8251	(observe MOS device handling procedures)
( ) 4B	1488	
( ) 4C	1489	

U6. For 9600 baud rate communication on the second serial interface, make the following additional connections on the BAUD RATE header at location 2D: connect pins 5, 6, and 16 together. Refer to the Assembly Information section for correct DIP header construction procedures. For other baud rates, see the Using the Serial I/O interfaces section for details.

U7. For RS-232 terminal communication, construct a 16-pin DIP header as follows:

Connect pin 1 to 12
Connect pin 2 to 16
Connect pin 3 to 15
Connect pin 4 to 14
Connect pin 5 to 11
Connect pin 7 to 8
Connect pin 9 to 10

Be sure that none of these jumper wires touch each other. Insert this header into location 4D with correct orientation. If current loop or modem communication is desired, then see the Using the Serial I/O Interfaces section for details.

U8. For standard asynchronous communication, insert two 14-pin headers at locations 1D and 2C without making any jumper connections. These headers need be configured only if synchronous communication is desired on either serial interface. See the Using the Serial I/O Interfaces section for details.

The second serial interface option assembly is now complete. If you did not configure the second serial interface for current-loop operation, then the following parts will be left over: one 2N3904 transistor, one 1K resistor, and one 5.6K resistor.

PARALLEL I/O INTERFACE OPTION ASSEMBLY

Skip this section if you have not purchased the parallel I/O interface option.

T1. Insert and solder the 5 IC sockets of the parallel interface option to the motherboard as follows:

20-pin sockets at locations 8A and 9A
14-pin sockets at locations 8C, 9C, and 10C

T2. Insert and solder a 2.2K 1/4W resistor (red-red-red) at R5 near location 10A.

T3. Normally, R6, R7, R8, and R9 are not recommended. However, if your output device is connected by a long cable and your output device has sufficient drive capability, install R8 (330 ohm, 1/4W, org-org-brn) and R9 (220 ohm, 1/4W, red-red-brn) near location 6D to minimize line reflections on the acknowledge pulse. Similarly, install resistors R6 (220 ohm, 1/4W, red-red-brn) and R7 (330 ohm, 1/4W, org-org-brn) near location 5D for minimizing line reflections on the input strobe signal, if necessary.

T4. Install and solder the two 15-pin parallel I/O interface connectors to the rear of the motherboard. The following order should result from top to bottom: 4-40x3/8" machine screw heads, connector, motherboard, lock washers, and nuts.

T5. Insert the four integrated circuits with correct orientation in their sockets:

	Location	IC
( )	8A	74LS373
( )	8C	7437
( )	9A	74LS373
( )	10C	74LS74

See the "sing the Parallel Interface section for details on configuration of the parallel port header at location 9C, wiring of the cables to the peripheral devices, and programming for parallel I/O.

DISK DRIVE #1 POWER REGULATION ASSEMBLY

Skip this section if you have not purchased a HORIZON system which includes at least one disk drive. The parts required in this section are in the MDS-H SACK.

D1. Insert and solder C5 and C9 (.047 ceramic disk capacitors) on the motherboard in the heat sink area.

D2. Install and solder the 7812 +12 volt regulator with its heat sink (6016B) in the rearmost location marked "7812" in the heat sink area on the motherboard. The following order should result from top to bottom: 6-32x3/8" machine screw heads, regulator, heat sink, motherboard, lock washers, and nuts. Solder the two leads and trim of any excess. Note that there is only one possible orientation for inserting the regulator pins into the motherboard.

D3. Assemble the +5 volt regulator (7805 or 340T-5) to the inside of the 6030B heat sink so that the following sequence results from outside to inside: 6-32x3/8" machine screw head, heat sink, regulator, lock washer, and nut. The regulator leads should point in the same direction as the heat sink mounting posts. Next, install the regulator heat sink assembly, oriented as shown in the layout legend, in the frontmost location marked "7805". Insert the regulator leads into the motherboard and then insert the heat sink mounting posts. Now solder the regulator leads. Note that the two heat sinks may touch each other.

D4. Assemble the disk drive power cable as follows: Remove about one and one quarter inches of outer insulation from each end of the four-conductor power cable. Strip 1/4" of insulation from each conductor at both ends. Crimp and solder each of the four power plug pins to the conductors at one end of the cable. Finally, insert the power plug pins into the power plug using the color code shown in figure 1D.

D5. Connect the power plug cable assembly to the motherboard as follows: Insert the four wires though the frontmost 1/4" hole on the right of the motherboard, from the solder side. Then insert each of the four wires into the frontmost group of four labeled holes from the component side as follows:

+5V	red
GND	white
GND	black
+12V	green

Solder the four wires on the solder side of the board and trim off any excess wire.

D6. Temporarily connect the power supply wires to the

motherboard, turn on the power, and check for the following voltages at the end of the power cable:

+5 volts ±5%	between the red and white wires
+12 volts ±5%	between the green and black wires

Turn off the power. If the voltages were not as listed then correct the problem before going on.

The power regulation circuitry for the disk drive #1 is now assembled and checked out.

DISK DRIVE #2 POWER REGULATION AND CABLE ASSEMBLY

Skip this section if you have not purchased a HORIZON system which includes two disk drives.

E1. Insert and solder C6 and C8 (.047 ceramic disk capacitors) on the motherboard in the heat sink area.

E2. Install and solder the 7812 +12 volt regulator with its heat sink (6016B) in the frontmost location marked "7812" in the heat sink area on the motherboard. The following order should result from top to bottom: 6-32x3/8" machine screw heads, regulator, heat sink, motherboard, lock washers, and nuts. Solder the two leads and trim off any excess. Note that there is only one possible orientation for inserting the regulator pins into the motherboard.

E3. Assemble the +5 volt regulator (7805 or 340T-5) to the inside of the 6030B heat sink so that the following sequence results from outside to inside: 6-32x3/8" machine screw head, heat sink, regulator, lock washer, and nut. The regulator leads should point in the same direction as the heat sink mounting posts. Next, install the regulator heat sink assembly, oriented as shown in the layout legend, in the middle (only remaining) location marked "7805". Insert the regulator leads into the motherboard and then insert the heat sink mounting posts. Now solder the regulator leads.

E4. Assemble the disk drive power cable assembly as follows: Remove about one and one quarter inches of outer insulation from both ends of the four-conductor power cable. Strip 1/4" of insulation from each conductor at both ends. Crimp and solder each of the four power plug pins to the conductors at one end of the cable. Finally, insert the power plug pins into the power plug using the color code

shown in figure 1D.

E5. Connect the power plug cable assembly to the motherboard as follows: Insert the four wires though the rearmost 1/4" hole on the right of the motherboard, from the solder side. Then insert each of the four wires into the rearmost group of four labeled holes from the component side as follows:

+5V	red
GND	white
GND	black
+12V	green

Solder the four wires on the solder side of the board and trim off any excess wire.

E6. Temporarily connect the power supply wires to the motherboard, turn on the power, and check for the following voltages at the end of the power cable:

+5 volts ±5%	between the red and white wires
+12 volts ±5%	between the green and black wires

Turn off the power. If the voltages were not as listed then correct the problem before going on.

E7. Attach the 34-pin ribbon-cable edge connector to the disk drive ribbon cable four inches (center to center) from the EDGE connector at one end of the cable. The second edge connector must face the same way as the already-attached edge connector. To attach the second edge connector, first separate the two parts of the second connector and peel off the adhesive backing from the top piece. Then carefully stick the top piece to the correct side of the ribbon cable so that the connector lies at exactly right angles to the ribbon cable and the bumps on the ribbon cable fit into grooves in the top piece. Now insert the top piece and cable into the bottom piece of the connector and force together either using a vise or by carefully tapping with a woodblock and hammer. When finished, there should be no gap between the ribbon cable and the plastic housing of the connector.

E8. Refer to the Disk Drive Configuration section for instructions about how to configure each disk drive for operation in a multi-drive system.

The power regulation circuitry and ribbon cable for the second disk drive are now assembled.

CHASSIS ASSEMBLY

When assembling the chassis sheet metal pieces. do not tighten any machine screws or nuts until all pieces have been assembled.

C1. Attach the two cover mounting brackets to the outside of the left wall of the chassis frame (one at the front and one at the back), using two 6-32x3/8" machine screws and lock washers for each bracket. Orient each bracket so that the cover mounting hole is at the bottom.

C2. Put the chassis partition piece in place inside the chassis frame oriented so that the twelve oval air holes are at the bottom towards the front. Wires #28 and #29 from the reset switch should be routed under the notch at the bottom rear of the chassis partition piece. Attach the partition loosely to the backpanel with two 6-32x3/8" machine screws and lock washers.

C3. Put the disk drive mounting bracket in place inside the front right corner of the chassis frame. The bracket should be oriented so that the shorter side rests on the bottom lip of the chassis partition piece. The four oval disk drive mounting holes in the bracket should line up with the four large access holes in the chassis frame, and the bracket should be perfectly horizontal.

C4. Fasten the chassis partition piece and the left side of the disk drive mounting bracket to the chassis frame so that the following order results from bottom to top: two 6-32x3/8" machine screw heads, lock washer, chassis frame, chassis partition piece, and disk drive mounting bracket.

C5. Fasten the right side of the disk drive mounting bracket to the chassis frame with two 6-32x3/8" machine screws and lock washers.

C6. Finish fastening the chassis partition piece to the chassis frame with two 6-32x3/8" machine screws and lock washers.

C7. Mount the front panel by carefully inserting the seven threaded studs around the perimeter of the front panel into the matching holes in the chassis frame. The two center studs should insert into the holes in the chassis partition piece. Note: The studs on the front panel are aluminum and the threads can be damaged or stripped if proper care is not taken.

C8. Put lock washers and 8-32 nuts on the three bottom studs and the two studs on the left of the front panel only.

C9. Put 8-32 nuts and lock washers on the two front panel studs on the right.

C10. Put 8-32 nuts and lock washers on the two chassis partition piece front panel studs.

C11. Put the assembled motherboard in place on the left side of the chassis. Wires #28 and #29 should be routed under the motherboard and up though the notch at the left rear of the motherboard. The disk drive power cable(s) should be routed through the hole in the bottom center of the chassis partition piece. Screw down the motherboard using ten 6-32x3/8" machine screws and lock washers.

C12. Install two plastic card guides above each motherboard 100-pin edge connector by snapping them into the appropriate holes in the chassis side and chassis partition piece. Be sure that the beveled ends of the guides are oriented up.

C13. Put an S-100 PC card in each motherboard connector and adjust the chassis partition piece for a good fit. Now tighten all chassis nuts and machine screws and then remove the PC boards. Keep in mind that if your HORIZON has a black face plate then it may have to be adjusted later when the disk drive is installed.

C14. Slip end B of wire #28 (blue) onto the motherboard quick-connect lug labeled RESET/. Slip end B of wire #29 (black) onto the lug labeled GND directly in front of the RESET/ lug.

C15. Attach the two adhesive backed cable-tie mounts to the back panel and chassis partition piece as shown in figure 1C. Orient them so that the cable ties can mount vertically.

C16. Feed the seven unattached power supply wire ends through the large opening in the chassis partition piece.

C17. Now twist the seven wires into a neat bundle and route as shown in figure 1C. Tie the bundle with four plastic cable ties as shown. Two of the cable ties should be threaded through the cable tie mounting brackets. Leave the cable ties loose for now.

C18. Slip the seven wire ends onto the motherboard row of quick-connect lugs as follows:

Position	Wire
-16V	yellow wire
GND	black wire from 11,000uf capacitor
+16V	orange wire
GND	either black wire from 180,000uf capacitor
GND	other black wire from 180,000uf capacitor
+8V	either red wire
+8V	other red wire

C19. Adjust the wires to form a neat bundle and then tighten the cable ties by pulling the end of each cable tie firmly with a pair of pliers. Snip off the excess cable tie.

C20. Insert the power indicator LED through the 1/4" front panel hole from the front and push firmly until the bezel is flush with the front panel. Slip the free end of the green wire onto the motherboard quick-connect lug labeled LED and slip the free end of the yellow wire onto the lug labeled GND.

C21. Peel the backing from the blue HORIZON nameplate and carefully attach to the front panel centered under the power LED so that the bottom of the nameplate is 5/8" above the bottom edge of the front panel.

C22. Peel the backing from the serial number tag and carefully attach to the outside of the back panel between the fuse holder and the third disk drive cable mounting hole.

C23. Look inside the disk drive underneath the disk drive PC board. Check that the head carriage guide is seated in the spiral groove on the large black circular stepping motor cam. Sometimes the guide is knocked out of the groove during shipment.

C24. If your HORIZON includes exactly one disk drive, then no disk drive modification is required. Otherwise, if your system includes two or three disk drives, then each drive must be configured for unit selection and cable termination. See the Disk Drive Configuration section for details.

C25. Fold the ribbon cable as shown in figure 2C.

C26. If your HORIZON has one or two disk drives, install them as follows: Orient the disk drive(s) so that the power connector is up and insert through the front panel from the front. Before sliding a drive all the way back, attach the ribbon cable edge connector to the disk drive PC board. Now slide the drive(s) into the chassis and screw to the disk drive mounting bracket from the bottom of the chassis with two 6-32x3/8" machine screws and lock washers. If the disk drive mounting holes do not line up with the corresponding holes in the disk drive mounting bracket, then loosen the four machine scews for the disk drive mounting bracket to adjust its position. Note: Use of a screw-holding screwdriver will make insertion of the mounting screws much easier. Finally, for each disk drive, plug the corresponding disk drive power cable from the motherboard into the power plug at the top rear of the disk drive.

C27. If your HORIZON has no disk drives, then snap the two black plastic face plates into the disk drive mounting hole in the fron panel. If your HORIZON has one disk drive, then snap

the single face plate into position to the left of the disk drive. Note that the face plate should be oriented so that the longer snaps are towards the bottom.

The chassis is now assembled.

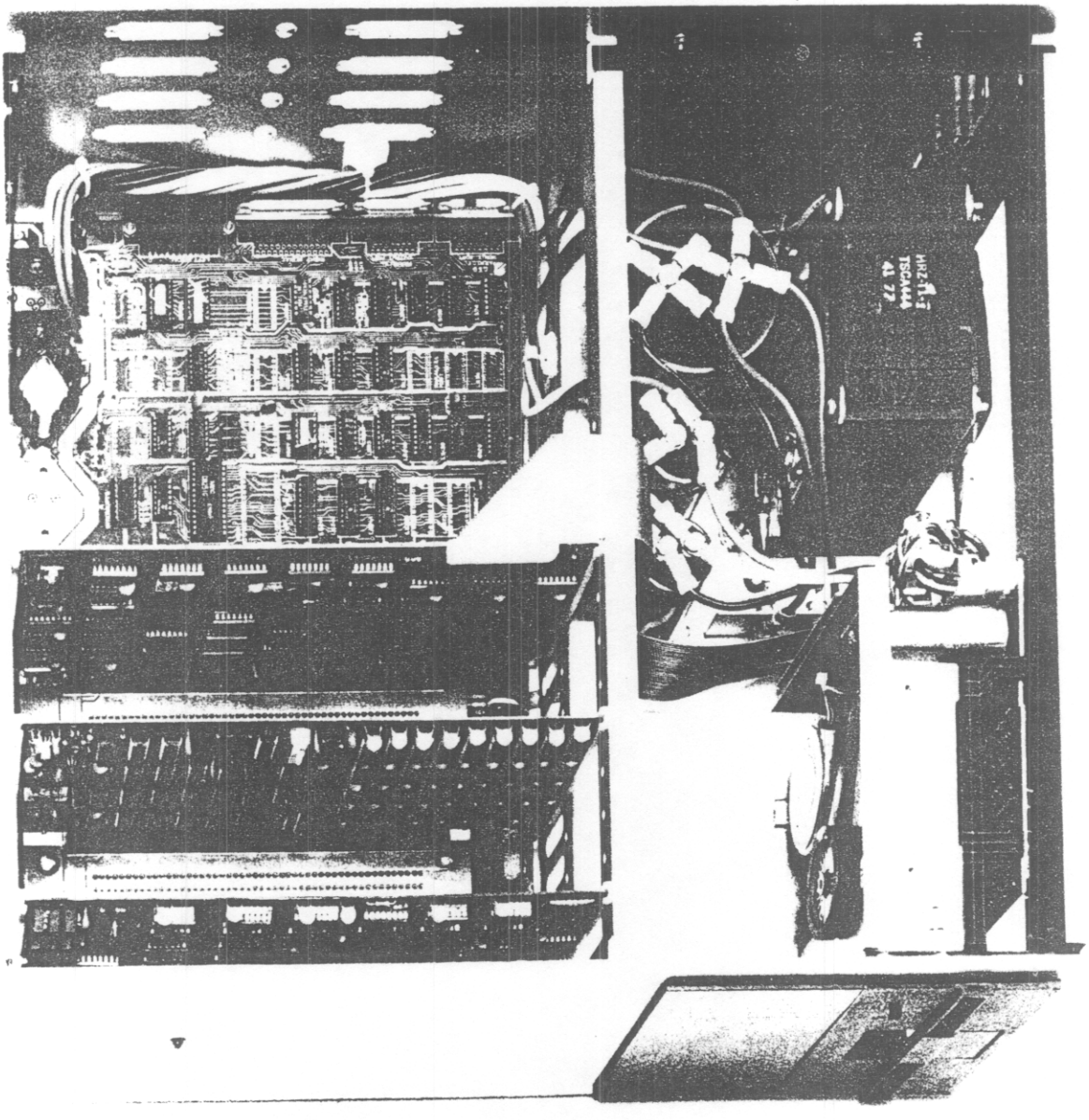


Figure 1C. Top View of Assembled HORIZON-1.

PROCESSOR BOARD ASSEMBLY

You have now completely assembled your computer "mainframe", including the chassis, motherboard and power supply. Now refer to the separate instruction manual to assemble the North Star ZPB-A processor board*. When you have completed those instructions, return to the next section of this manual. Note that a separate Z80 Technical Manual is included in the documentation with the HORIZON giving a full description of the operation and programming instructions for the Z80.

* Note that if you are using a processor board other than the North Star ZPB-A, then some method must be found to force the computer to jump-start to the bootstrap PROM starting address on reset and power-on.

RAM BOARD ASSEMBLY

You now have assembled and checked out your HORIZON mainframe and processor board. Now refer to the separate instruction manual for the North Star 16K RAM board*. When you have completed those instructions, return to the next section of this manual.

* Note that if you will be using memory other than the North Star RAM-16-A, you must keep in mind the following:

  A. Be sure the memory you are using can operate with a Z80. Some S-100 bus memories will not.

  B. If the memory you are using has a protect feature, note the conflict with bus line 70 described in the Motherboard Assembly section.

  C. If your memory does not work at full speed with a 4MHz Z80A, be sure and set the wait state logic correctly on the processor board and/or the memory board.

DISK CONTROLLER BOARD ASSEMBLY

If your HORIZON configuration does not include at least one disk drive, then skip this section.

F1. Insert and solder the 5 twenty-pin IC sockets at locations 7D, 8D, 9D, 10D, and 11D, following the procedure given in the Assembly Information section. Orient them as shown on the layout legend with pin 1 toward the bottom of the board.

F2. Similarly, install the 19 sixteen-pin IC sockets. A sixteen-pin socket is used at location 1A. The two 8-pin IC's will be inserted into this socket.

F3. Similarly, install the 22 fourteen-pin IC sockets.

F4. Install and solder the 31 resistors in the locations indicated by the layout legend. The hole spacing for all the resistors is .5 inches.

Resistor	Location	Value	Size	Color-code
( ) R1	1A	3.3K	1/4W	org-org-red
( ) R2	1B	3.3	1/4W	org-org-gld
( ) R3	1B	5.6K	1/4W	grn-blu-red
( ) R4	2A	27K	1/4W	red-vio-org
( ) R5	2A	27K	1/4W	red-vio-org
( ) R6	2B	5.6K	1/4W	grn-blu-red
( ) R7	2B	6.19K 1%	1/4W	blu-brn-wht-brn
( ) R8	2B	2.2K	1/4W	red-red-red
( ) R9	3A	470	1/4W	yel-vio-brn
( ) R10	3A	470	1/4W	yel-vio-brn
( ) R11	3A	5.6K	1/4W	grn-blu-red
( ) R12	3A	3.6K	1/4W	org-blu-red
( ) R13	3C	6.8K	1/4W	blu-gry-red
( ) R14	3C	13K	1/4W	brn-org-org
( ) R15	3C	27K	1/4W	red-vio-org
( ) R16	3C	6.8K	1/4W	blu-gry-red
( ) R17	4B	2.2K	1/4W	red-red-red
( ) R18	14A	680	1/4W	blu-gry-brn
( ) R19	4A	9.1K	1/4W	wht-brn-red
( ) R20	5A	10K	1/4W	brn-blk-org
( ) R21	5D	470	1/4W	yel-vio-brn
( ) R22	6A	15K	1/4W	brn-grn-org
( ) R23	6D	2.2K	1/4W	red-red-red
( ) R24	6D	330	1/4W	org-org-brn
( ) R25	14A	680	1/4W	blu-gry-brn
( ) R26	11B	470	1/4W	yel-vio-brn
( ) R27	12A	150	1/4W	brn-grn-brn
( ) R28	12A	150	1/4W	brn-grn-brn
( ) R29	12A	150	1/4W	brn-grn-brn
( ) R30	14A	150	1/4W	brn-grn-brn
( ) R31	14A	150	1/4W	brn-grn-brn

F5. Insert and solder the 39 capacitors in the locations indicated by the layout legend. The tantalum capacitors have polarity, so care must be taken to insert the positive lead in the hole marked with a plus sign. The "+" lead of tantalum capacitors is marked with a "+" sign. Some capacitors are marked with a 3-digit code consisting of two significant digits followed by a power of ten expressed in picofarads. Thus, 223 means 22000pf or .022uf and 331 means 330pf. These alternate capacitor markings are given below in parentheses after the capacitor value.

Capacitor	Location	Value	Type
( ) C1	1C	6.8uf	tantalum
( ) C2	1C	2.2uf	tantalum
( ) C3	1D	6.8uf	tantalum
( ) C4	1D	2.2uf	tantalum
( ) C5	2D	2.2uf	tantalum
( ) C6	2D	2.2uf	tantalum
( ) C7	1A	.047uf(473)	dipped mylar
( ) C8	1B	100pf(101)	dipped mica
( ) C9	1C	.022uf(223)	dipped mylar
( ) C10	2A	.01uf(103)	dipped mylar
( ) C11	2B	330pf(331) 1%	dipped mica
( ) C12	3C	200pf(201)	dipped mica
( ) C13	3B	.022uf(223)	dipped mylar
( ) C14	3B	200pf(201)	dipped mica
( ) C15	4A	330pf(331) 1%	dipped mica
( ) C16	5A	.022uf(223)	dipped mylar
( ) C17	5D	330pf(331)	ceramic disc
( ) C18	5D	47pf	ceramic disc
( ) C19	11B	100pf(101)	ceramic disc
( ) C20	15A	33pf	dipped mica
( ) C21	15A	470pf(471)	dipped mica

The remaining eighteen .047uf(473) or .05uf(503) ceramic disc capacitors are bypass capacitors and should be installed in the oval capacitor locations marked with asterisks (*) on the layout legend.

F6. Insert and solder the six 1N4148 diodes at the locations indicated by the layout legend. The end of the diode marked with a band is the cathode end and must be oriented as indicated by the layout legend.

Diode	Location	Orientation
( ) 1	2A	band at left
( ) 2	2A	band at right
( ) 3	2A	band at left
( ) 4	2A	band at right
( ) 5	3A	band at right
( ) 6	3A	band at left

F7. Insert and solder the crystal at location 15A. Bend the leads so that the crystal will lie parallel with the PC board. In addition to the two leads, the crystal should be strapped to the PC board with a piece of clipped resistor lead which is soldered to the pads on either side of the crystal case.

F8. Install each of the two heat sinks and 5 volt regulators at locations 1C and 1D as follows. Bend down the three leads of the 5 volt regulator 90 degrees such that the leads go into the correct holes while the machine screw holes line up. Don't solder yet. Fasten the heat sink and regulator to the PC board so that the following sequence results from bottom to top: 6-32 machine screw head, PC board, heat sink, regulator, lock washer, and nut. Tighten the machine screw. Now solder the regulator leads.

NOTE: Heat sink grease may be used though it is not generally needed. Don't tighten the machine screw too tight or you will crack the PC board.

F9. Install the 12 volt 78L12 regulator (Q3) near location 2B, orienting the regulator so that the flat edge corresponds to the flat edge indicated on the layout legend.

F10. Install and solder the 34-pin cable connector header (J2). The right angle bent pins should be inserted into the PC board and the straight ends of the pins should be pointing toward the top of the board.

F11. Be sure the power is off and then plug the disk controller board into a computer motherboard 100-pin connector. Be sure the board is properly seated in the connector and then turn on the power. Check for +5 volts $\pm$5% (with reference to the ground plane at the left of the board) at 3C pin 16 and at 2C pin 14. Check for +12 volts $\pm$5% at location 1A at pin 7 of both the LF356 and the 3080. Turn off the power and remove the disk controller from the motherboard. If the voltage was not as indicated, locate and correct the problem before going on.

F12. Install all 47 IC's in the locations indicated on the layout legend, being careful to use the correct orientation. All the IC's should be oriented the same way, with pin 1 toward the bottom. Be sure all the IC pins are in the socket holes and not bent under the IC and not outside the socket.

The three PROM's can be identified as follows:

Layout Name	Location	PROM Type	PROM Label
DWE	4C	6301	DWE-y
DSEL	11C	6301	DSEL-xx-y
DPGM	9D	6309	DPGM-xx-y

xx=two high order HEX digits of PROM origin
y =version number

The labels on the PROM's for the standard version #1 are DWE-1, DSEL-E8-1, and DPGM-E8-1.

F13. Install the jumper "G" below location 5D by soldering with a piece of resistor snipping.

The disk controller board is now completely assembled. Proceed to the checkout section.

DISK CONTROLLER BOARD CHECKOUT

The following checkout procedure may be followed for a newly assembled board. However, you may choose to skip this section and return to it later only if the disk controller does not seem to be operating correctly. It can also be used to diagnose problems in previously operational boards.

The following terms are used in specifying expected test results:

GND	ground, Ø volts DC
LOW	logic zero, Ø-.7 volts, normally about .3 volts
HIGH	logic one, 2.4-5.Ø volts, normally about 3 volts
+5V	+5 volts from power supply
AC	Signal with pulses (as opposed to DC signal)

When referring to the name of a signal from the schematic drawings, if the signal is identified with a bar over its name, then the name is followed by a slash (e.g., STORE/) in the checkout instructions. When describing an AC pulse, the notation ($\pm$W,P) refers to a positive or negative pulse with a width of W appearing with a period of P. For example, a positive pulse with width 12Ø nanoseconds appearing every 25 microseconds would be described as (+12Ønsec,25us). See Appendix 1 for details on how to detect pulse signals.

If an oscilloscope will be used to test the board, a "scope ground" may be installed by soldering a "bridge" of jumper wire between the two PC board holes that connect edge connector pins 5Ø and 1ØØ near location 12D. Note that either of the two regulator machine screws can also be used for ground test points.

G1. With the computer power off, install only the disk controller board into the motherboard. The ribbon cable should not be plugged into the board. Turn on the computer power and check for the following counter timing signals:

SIGNAL	LOCATION	DESCRIPTION
LCLK/	15B pin 12	AC, 5ØØns square wave
CC3	6A pin 11	AC, 8us square wave
CC6	7A pin 11	AC, 128us square wave (some jitte
CC11	8A pin 11	AC, 2ms square wave (some jitter)
CC15	9A pin 11	AC, 32ms square wave (some jitter
SCØ3	15C pin 6	AC, 5ØØms square wave
(no name)	3D pin 6	AC, 8.3sec square wave
AUTO-OFF	6C pin 11	AC, (+8.3sec,33sec)

If the signals are not as listed then refer to the schematic drawings and trace backwards to locate and correct the problem.

G2. This step will check the write circuitry while simulating writing a continuous stream of "one" data bits in single-density format during each sector.

A. With the computer power off, remove the disk controller board from the motherboard.

B. Remove the 74LS74 IC from location 14C, bend out pin 9 of the IC, and re-insert the IC so that pin 9 is outside the IC socket and does not make contact with IC socket pin 9.

C. Connect a clip lead between cable connector (J2) pin 22 and pin 30. If you do not have a clip lead, then tack solder a wire on the solder side of the board between 13B pin 11 and 14B pin 13.

D. With the computer power off, install only the disk controller board and the processor board into the motherboard, and turn the computer power on.

E. Check the following signals while the computer reset switch is depressed (hold depressed with a rubber band):

SIGNAL	LOCATION	DESCRIPTION
WR-SHIFT/	6D pin 6	AC, (-1us,8us)
LD-WSR/	6D pin 15	AC, (-8us,64us)
WS7	6D pin 13	AC, (-96us,32ms) i.e. mostly HIGH
WS10	5C pin 15	AC, (-96us,32ms) i.e. mostly HIGH
WRITE PULSE	3C pin 5	AC, (+approx 600-700ns,4us)
(no name)	3C pin 13	AC, (+approx 600-700ns,4us)
READ DATA	14B pin 12	AC, (+approx 600-700ns,4us)

If the signals are not as listed then refer to the schematic drawings and trace backwards to locate and correct the problem.

G3. This step will check the read circuitry while simulating reading a continuous stream of zero" data bits in double-density format during each sector. If using a scope to check signals then sync positive on 13C pin 9. Continue with the same setup as in the previous step. Check the following signals while the computer reset switch is depressed.

SIGNAL	LOCATION	DESCRIPTION
WINDOW	13C pin 9	"Window", HIGH for 96us then LOW
RE	5B pin 6	"Read Enable", goes HIGH at 480us
ACQUIRE	5A pin 5	"Acquire Phase of Incoming Signal", goes HIGH with RE, duration 100-150us

2BR	3B pin 5	"Twice Bit Rate", low at first, 4us square wave for 32us when RE goes high, then 2us square wave
DDI	4B pin 9	"Double-Density Indicator", goes HIGH at 512us (32us after RE)
HE	14C pin 5	"Hunt Enable", goes HIGH at 736us
OP-AMP-OUTPUT	Right side R7	See Note 1.
DATA WINDOW	4D pin 5	May begin either HIGH or LOW, then 4us square waves after RE
WIND DATA	4D pin 9	"Separated Data", always LOW except for 8 extremely narrow pulses at ACQUIRE
RSn	15D pins 3,4,5, 6,10,11,12,13	"Read Shift Register", all outputs always LOW
BODY	5B pin 10	LOW

Note 1: Initializes during WINDOW by slewing to +5 volts. During ACQUIRE there will be numerous small positive or negative pulses (phase corrections). A DC shift of less than 1/4 volt may be seen at this time if a frequency adjustment occurs. The resultant DC level should remain until the next WINDOW pulse.

Note 2: The two op-amp (LF356) inputs are very high impedance and attempts to observe them with a scope probe can affect the circuit.

A. Remove the 74LS74 IC at location 4D, lift pin 9 of the IC, and re-insert the IC so that pin 9 is not inserted in the IC socket. Then, with the computer reset switch depressed, check of the following signals:

SIGNAL	LOCATION	DESCRIPTION
BODY	5B pin 10	Goes HIGH at 780us
SYNC BLANK	1B pin 13	pulse beginning at 780us, duration 38-50us

B. Re-insert the pins of the IC's at locations 14C and 4D into their IC sockets and remove the clip lead or soldered wire.

The disk controller board is now checked-out. If the disk controller is to be used in applications where a special drive motor off time is required, then refer to the Disk Controller Configuration Options section for details. Also, if the disk

controller interrupt logic is to be used, then refer to the Disk Controller Theory of Operation and Configuration Options sections for details.

INTEGRATED SYSTEM CHECKOUT

You have now completely assembled the HORIZON mainframe, processor board, RAM board, and disk controller board and checked out these boards independently of each other as much as possible. This section describes a step-by-step process for integrating the major components of your system in a way designed to localize any remaining problems.

I1. Refer to the assembly instructions for your processor board and configure the auto-jump address to be the disk controller bootstrap PROM starting address (E800H).

I2. Be sure the HORIZON power is off and then plug the processor board into its motherboard connector (normally P1) and plug the disk controller board into its motherboard connector (normally P9). No other board should be plugged into the motherboard at this time, and no diskette should be inserted in the disk drive(s). Connect the disk drive ribbon cable as shown in figure 2C. Be sure the two PC boards are properly seated in their edge connectors, and then turn on the power. The disk drive motor(s) should turn on and the red light on drive #1 should turn on. Then the motor(s) should turn off after twelve seconds. If the motor(s) do start, then proceed to step I3. Otherwise, if the motor(s) do not turn on, continue this step as follows:

A. Depress and release the reset switch. If the motor(s) still do not turn on, then proceed to part B. If the motor(s) now turn on, then check the power sequencing circuitry on the motherboard and the processor board. Proceed to step I3 after locating and correcting the problem.

B. Momentarily ground 12B pin 3 on the disk controller board by briefly shorting it to 12B pin 7 with a piece of jumper wire. If this causes the motor(s) to turn on, then remove the wire and proceed to part C. If this does not cause the motor(s) to turn on, then check the signal cable connections to the disk drive and the power cable connections to the disk drive. After locating and correcting the problem, start over at the beginning of step I2.

C. Momentarily ground 13C pin 1 (MOTOR SET/) by briefly shorting it to 13C pin 8 with a piece of jumper wire. The motor(s) should turn on and then stay on for about 12 seconds after the wire is removed. If this succeeds, then proceed to part D. If this does not succeed, then the problem is with the counting circuitry on the disk controller board. After locating and correcting the problem, start over at step I2.

D. Turn off the power and remove the 74LS00 from location 7C. Remove the 74LS08 from location 6C, bend pin 3 of the IC out

and re-install the IC into the IC socket so that pin 3 of the IC does not make contact with pin 3 of the IC socket. Turn on the computer power and ground motherboard pin 43 by shorting it to motherboard pin 50 with a piece of jumper wire. This experiment will force the processor to sequentially read every address in the computer continuously, including the memory-mapped I/O locations that turn on the drive motor(s) and select the drive(s). If the motor(s) do not turn on, then trace backwards from the signal MOTOR-SET/ to find out why. After correcting the problem, remove the jumper, replace the IC's correctly at locations 7C and 6C, and start over at the beginning of step I2. If the motor(s) do come on, that indicates that the problem detected at the beginning of this step is probably a result of the PROM program not being correctly executed. Remove the jumper, replace the IC's, and proceed to part E.

E. Turn off the power and ground PRDY on the disk controller board by shorting 11A pin 7 to 11A pin 8. Turn on the power. The processor should pause immediately after performing the auto-jump sequence just before executing the first instruction of the disk controller PROM. The S-100 address bus A0-A15 (see the ZPB Manual Appendix 2 for bus pin numbers) should contain E800H. (If this is not so, then the problem is with the auto-jump circuitry on the processor board.) The S-100 data input bus DI0-DI7 (see the ZPB Manual Appendix 2 for pin numbers) should contain 0EH which is the first instruction byte in the PROM. If this is not so, then the problem is with the PROM circuitry on the disk controller board. Trace backwards through this logic to isolate the problem. After correcting the problem, remove the jumper and start over at the beginning of step I2.

I3. Next, power up the HORIZON with no diskette in drive #1 again. Approximately 12 seconds after the drive is selected and the heads load, the motor(s) will turn off. The processor at this point should be executing a tight JMP loop indicating a read error. This can be checked by observing a continuous stream of pulses on the disk controller board at 7C pin 6 (DI-GATE/).

I4. Connect a serial I/O terminal to the standard serial interface connector on the back panel. (See the Using the Serial Interfaces section for a discussion of serial interface cabling.) Be sure the terminal is grounded correctly as described in the HORIZON Grounding section. The terminal should be set for full-duplex operation and the baud rate must match that of the standard serial interface.

I5. With the computer power off plug the RAM board(s) into any free connectors in the motherboard.

I6. Turn on the computer power, and insert the personalized HORIZON diskette into drive #1, referring to the GETTING STARTED Section of the North Star System Software Manual for correct diskette handling procedures. Close the drive door and toggle the reset switch. One of three results will occur:

A. The bootstrap program goes into the error loop as described in step I3. This indicates trouble reading the data from the diskette which can mean a bad diskette, a faulty disk drive, or faulty read circuitry on the disk controller. Return to the disk controller checkout instructions.

B. The bootstrap program loads the DOS but communication with the terminal is not established. If the DOS gets as far as the terminal I/O input routine, then pulses will be seen on pin 46 (SINP) of the bus every three instructions. If you detect these pulses, then the problem is with the terminal or the serial I/O interface circuitry. Otherwise, if these pulses are not observed, then the situation is more complicated and is probably a result of an error in the RAM memory.

C. The bootstrap program successfully loads the DOS and it is possible to enter commands from the terminal. Congratulations! Your HORIZON is now operational. It is completely assembled and can communicate with a terminal. The next step is to use the North Star software to more fully check out your HORIZON. Refer to the GETTING STARTED section of the North Star System Software Manual for complete details.

DISK CONTROLLER THEORY OF OPERATION

The North Star double density disk controller is an integrated combination of hardware and software. It is designed specifically to provide a complete, compact and economical disk drive controller for use with S-100 bus 8080 or Z80 microcomputer systems.

DISK CONTROLLER HARDWARE

The disk controller is implemented from medium and small scale TTL integrated circuits and PROM memory. The entire controller fits on a single 5"x10" printed circuit card. The block diagram below shows the general organization of the disk controller.

1. Address Buffers and Select Logic: The sixteen address lines are received with Schmitt trigger buffers (7D, 10D, 11D) to provide noise immunity. The high order 8 address lines are used by the board select PROM (DSEL, 11C) to determine if the current memory reference is addressing the controller board. The low order eight address lines are used to present data and control information to the controller. The use of these bits is determined by the outputs of the board select PROM.

2. Write Data Logic: If the controller is issued a write data byte command, then the low order eight address bits are interpreted as data to write and are gated into the write shift register (6D). The controller will place the CPU in a wait state until the shift register is empty and only then clock the new data into the shift register. Write encoding (using the FM encoding method for single density and MFM encoding for double density) and write precompensation are controlled by the logic at locations 3C, 4C, and part of 5C.

3. Read Data Logic: Raw data from the disk is standardized by the RD-DAT-OS one-shot (5A). A phase-locked loop (1A, 4A, and parts of 1B, 5A) tracks the trailing edge of RD-DAT-OS to match the frequency of the incoming data. The phase-locked loop output drives the data separator (3B, 4D), whose outputs, DATA-WINDOW (clock) and WIND-DATA (data), go to the 8-bit read data shift register (15D). The read shift register outputs are multiplexed with the status bits (12D, 13D, 14D) and driven onto the Data Input Bus (10D, 11D). When reading, if double density data is encountered, the double density indicator (DDI, 4B) is set.

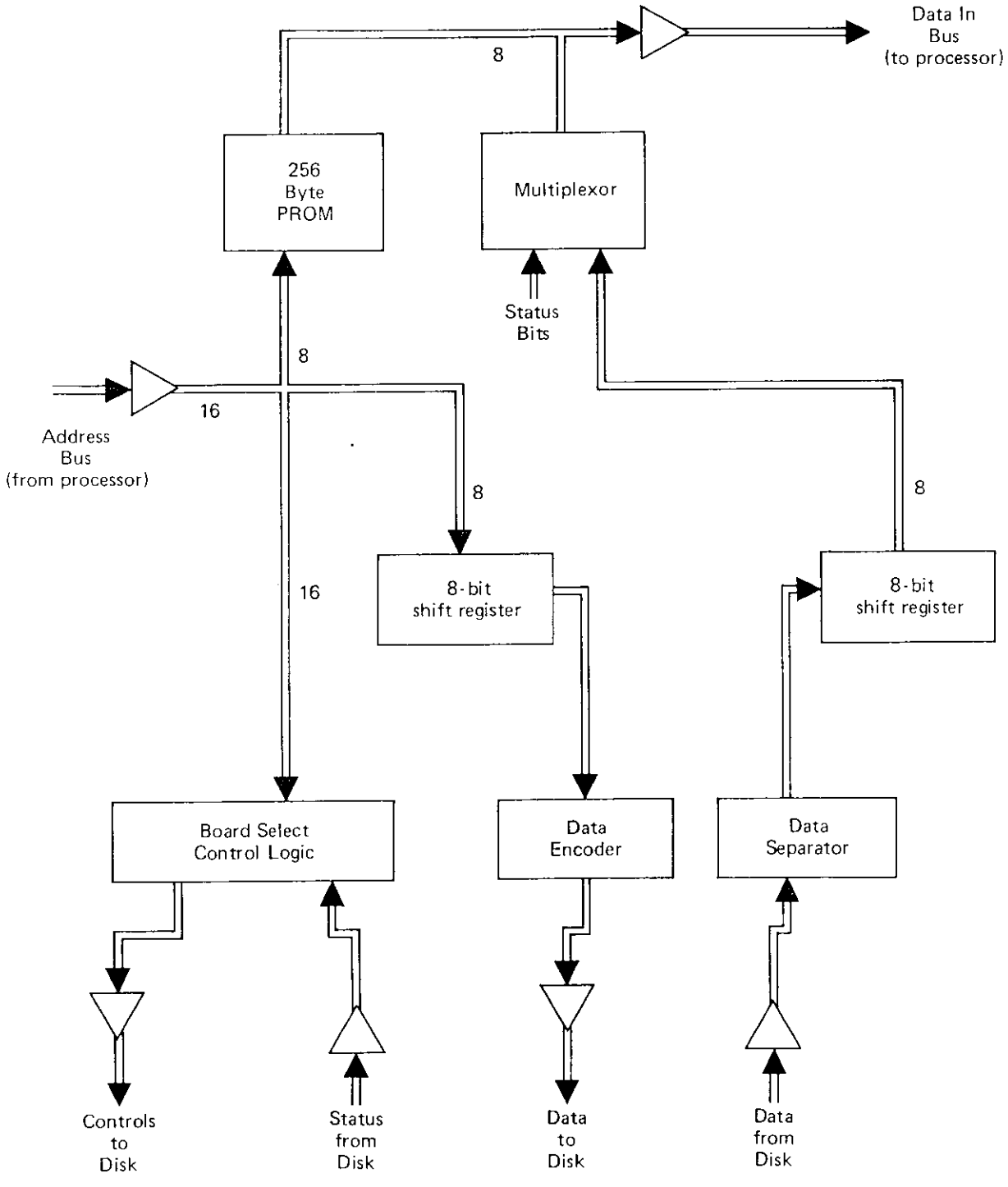


Figure 1T. Disk Controller Block Diagram

4. On Board PROM: Bootstrap software (8080/Z80 machine code) is stored in an on-board 256 byte bipolar PROM (DPGM, 9D). This PROM provides 256 bytes of memory. The 8 low order address bits address the PROMs. The PROM outputs are driven onto the Data Input Bus.

5. Clock Circuit: The crystal clock oscillator circuit (15B) provides 2 MHz clock signals to synchronize the control circuitry.

6. Read, Write Control: A read or write command sequence begins with detection of a sector pulse. A read or write command must be issued to the controller within a 96 microsecond window after the sector pulse. Writing data begins at the end of the window. The controller writes one byte of zeros. Writing of subsequent data is controlled by the software. Writing stops at the next sector pulse. Reading starts some time after the end of the window so as to be in the middle of the written preamble. First the phase-locked loop is turned on by the read enable (RE) signal. After locking to the incoming data is achieved, the hunt enable (HE) signal causes the search for a sync character to begin. When a sync character is detected, the controller enters "body" mode. When the software issues a read command to the controller, the controller will put the CPU into the wait state until the read shift register is full.

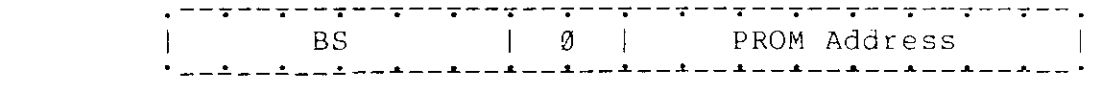
7. Command Decode Logic: When a command address is issued to the controller, the 8 low order address bits are decoded to determine which command actions are to be taken and which disk controls should be performed. See the Disk Controller Commands section for details.

8. Counters: The counters (6A, 7A, 8A, 9A) provide sector timing and read and write command sequencing. The counter (15C) is the sector position counter. The output of 9A provides pseudo sector pulses in case no diskette is inserted in the drive or the drive motor is off and also allows discrimination between sector holes and the index hole. The counter (3D) is used to count disk revolutions to determine when to cause automatic motor off. The counters (9B) are used to count bits while reading or writing data.

DISK CONTROLLER COMMANDS

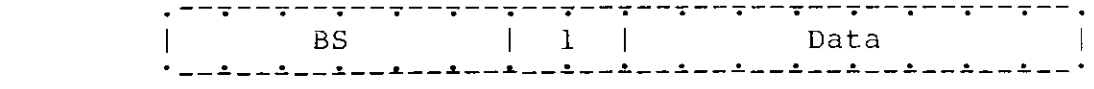
Commands to the disk controller are specified by memory read references to addresses within a particular 1K byte block of the CPU address space. The 1K byte block subdivides into four cases. In all cases the high order 6 address bits (BS) are used to determine if the 1K block is addressed (i.e. the controller board is selected). The next two bits determine the subcase and the use of the low order eight bits depends on the subcase.

CASE Ø PROM addressing



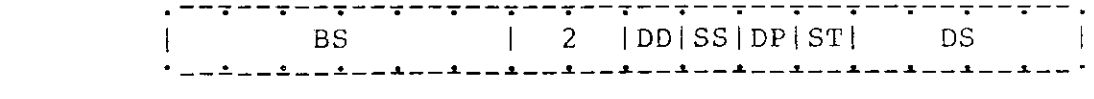
Read byte from the 256 bytes of PROM.

CASE 1 Write byte of data



Write a byte of data to the disk. Wait if the write shift register is not empty. The low order 8 bits specify the byte to be written.

CASE 2 Controller Orders



Load 8-bit order register from low order 8 address bits.

DD Controls density on write DD=1 for double density and DD=Ø for single density.

SS Specifies the side of a double-sided diskette. The bottom side (and only side of a single-sided diskette) is selected when SS=Ø. The second (top) side is selected when SS=1.

DP has shared use. During stepping operations, DP=Ø specifies a step out and DP=1 specifies a step in. During write operations, write precompensation is invoked if and only if DP=1.

ST controls the level of the head step signal to the disk drives.

DS is the drive select field, encoded as follows

Ø=no drive selected
1=drive 1 selected
2=drive 2 selected
4=drive 3 selected
8=drive 4 selected

CASE 3 Controller Commands

Perform a disk controller command. The commands are specified by the 8 low order address bits.

DM The DM field controls what gets multiplexed onto the DI bus during the command.

1=A-status
2=B-status
3=C-status
4=Read data (may enter wait state)

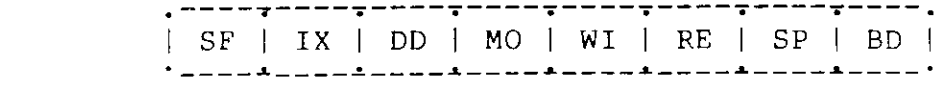
CC Command code.

Ø=no operation
1=reset sector flag
2=disarm interrupt
3=arm interrupt
4=set body (diagnostic)
5=turn on drive motors
6=begin write
7=reset controller, de-select drives, stop motors

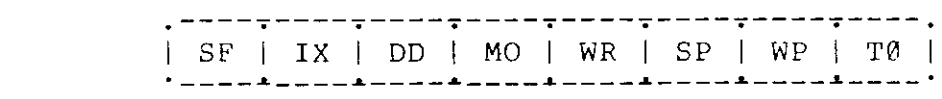
DISK CONTROLLER STATUS BYTES

There are three status bytes that can be read on the Data Input Bus.

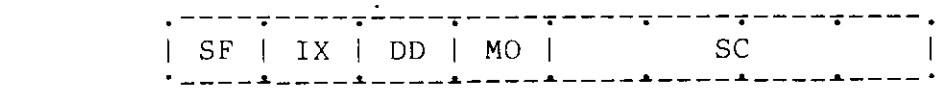
A-Status



B-Status



C-Status



SF Sector Flag: set when sector hole detected, reset by software.

IX Index Detect: true if index hole detected during previous sector.

DD Double Density Indicator: true if data being read is encoded in double density.

MO Motor On: true while motor(s) are on.

WI Window: true during 96-microsecond window at beginning of sector.

RE Read Enable: true while phase-locked loop is enabled.

BD Body: set when sync character is detected.

WR Write: true during valid write operation.

SP Spare: reserved for future use.

WP Write Protect: true while the diskette installed in the selected drive is write protected.

SC Sector Counter: indicates the current sector position.

TØ Track Ø: true if selected drive is at track zero.

DISK CONTROLLER DATA FORMAT

Each diskette has 35 tracks of data. Each track is divided into 10 sectors. The rotational position of the beginning of the sectors is marked by sector holes in the diskette. Each sector is recorded using the following format. This information is recorded starting about 96 microseconds after the sector hole is detected.

	Single Density	Double Density
Zeros	16 bytes	32 bytes
Sync Char(FB)	1 byte	2 bytes
Data	256 bytes	512 bytes
Check Char	1 byte	1 byte
	274 bytes	547 bytes

The check character is computed iteratively by setting it to zero and then exclusive ORing each successive data byte value with the current value of the check character and left cycling the result.

DISK CONTROLLER SOFTWARE

The basic low-level function of the controller is to transfer or verify 256/512 byte blocks of data between a specified area on the disk and a specified area of the RAM. The algorithm now described accomplishes this task. The program to perform this algorithm resides in the DOS.

1. Start the drive motor(s) if they were off and wait for the motor to get up to speed.

2. If the disk drive to be selected is different than the drive currently selected or if the motor(s) were off then select the new drive, and wait for the index detect signal to be true.

3. If the disk read/write heads are not already at the desired track then the heads must be stepped in or out to the correct track. First set the step direction flip-flop and determine the number of tracks to step. Each step is accomplished by the following sequence:

   a. set the step flip-flop
   b. reset the step flip-flop
   c. wait the specified track stepping time.

4. Wait until the next sector pulse and test if the disk is at the desired sector position by reading C-status. If not then repeat this step.

5. If the data write case then

   a. issue begin write command.
   b. wait for WI status bit to be false.
   c. write 15/31 bytes of zeros.
   d. write the sync character(s) (FB hex).
   e. write 256/512 bytes of data from RAM while computing the cyclic check character.
   f. write the check character.
   g. if more blocks to write on the same track then wait until the next sector pulse and repeat from step a, otherwise done.

6. If read case then

   a. wait for RE to be true and test DD status bit.
   b. wait for sync character detection (i.e. body mode). Report an error if the sync character is not detected.
   c. read 256/512 data bytes into RAM while computing the check character.
   d. read the check character and compare with the computed check character. Report an error if they are not equal.
   e. if there are more blocks to read on the same track then wait until the next sector pulse and repeat from step a, otherwise done.

7. If verify case then all is the same as the read case except that in step c data bytes read from the disk should be compared for equality with the data in RAM. Report an error if corresponding bytes do not compare.

DISK CONTROLLER INTERRUPTS

The software provided with the disk system is not interrupt driven. The controller can cause an interrupt on any one of the interrupt lines on the S-100 bus by connecting the appropriate jumper at the lower left corner of the controller board. An interrupt will be generated at every sector pulse while the interrupt is armed in the controller. See the COMMANDS section for details of interrupt arming and disarming. Special user generated, interrupt driven software can be written which uses the controller sector pulse interrupt.

Before the low level controller software is called, interrupts should be disabled. If an interrupt occurs during data transmission then data can be lost as a result of excessive delay in the interrupt routine.

DISK CONTROLLER CONFIGURATION OPTIONS

There are a number of configuration options possible on the disk controller board that are specified by wiring jumpers on the board. The desired configuration should be wired according to the following instructions before the board is used.

J1. Signal grounding. The "G" jumper below location 5D is normally installed when the disk controller is used in a HORIZON. If the disk controller is to be used in another S-100 bus computer, then the "G" jumper should be installed only if motherboard signal 61 is used as ground in that computer.

J2. Automatic motor off time. Normally, the disk drive motor(s) will turn off 9.6 seconds after the last disk activity. If some other automatic motor off delay time is desired, then cut the traces at location 2D on the solder side of the PC board which connect "C" to"2" and "D" to "1". Then connect two jumper wires on the component side of the PC board at location 2D according to the following table:

DELAY TIME	FIRST JUMPER	SECOND JUMPER
3.2 seconds	Connect D to 3	Connect 2 to 1
6.4 seconds	Connect C to 3	Connect 2 to 1
9.6 seconds	Connect C to 2	Connect D to 1
12.8 seconds	Connect B to 3	Connect 2 to 1
16.0 seconds	Connect B to 2	Connect D to 1
19.2 seconds	Connect B to 2	Connect C to 1
25.6 seconds	Connect A to 3	Connect 2 to 1
28.8 seconds	Connect A to 2	Connect D to 1
32.0 seconds	Connect A to 2	Connect C to 1
38.4 seconds	Connect A to 2	Connect B to 1

J3. Sector Interrupts. The disk controller board includes logic which can cause an interrupt to occur each time a sector hole is detected on a diskette. Normally, this logic is disabled. To use this logic, first cut the two traces on the solder side of the PC board near locations 10A and 10B which connect "J" to "K" and "J" to "E". Second, install two jumper wires on the component side of the PC board which connect "S" to "J" and "I" to "K". Third, cut the trace below location 4D on the solder side of the PC board that connects "Y" to "PH/". Finally, connect a jumper wire below location 4D on the component side of the PC board which connects "Y" to the position for the type of interrupt desired (VI0/ to PINT/).

DISK DRIVE CONFIGURATION

If the HORIZON is to be configured with only one disk drive connected to the controller then no modification is required for the disk drive. If two or more drives are to be connected to the controller then the following disk drive modifications must be made. Note that when there are two disk drives mounted in the HORIZON front panel, drive #1 should be on the left and drive #2 should be on the right. If a third or fourth drive is to be connected, then drive #3 and drive #4 will be mounted outside of the HORIZON chassis.

A. The drive number for each drive must be programmed using the program shunt (located at 1F) on the disk drive PC board. The three metal straps labeled DS1, DS2, and DS3 specify whether the drive is to be selected as drive 1, 2, or 3, respectively. For each drive, the strap for the desired drive number should remain connected and the other two straps should be disconnected. Straps can be disconnected by removing the strap assembly from the DIP socket, spreading one of the pins for each undesired strap and plugging the assembly back in such that the spread pins are not inserted into the DIP socket. Each drive should be programmed with a different drive number. One drive must be number one.

   To program a drive as drive number 4 perform the following instructions on the printed circuit board mounted on top of the disk drive.

   a. Solder a jumper wire between pin 34 of edge connector J1 and location 1F pin 6. Take great care to connect the wire to the very tip of pin 34 so that the ribbon cable connector can slip as far onto J1 as possible.
   b. Solder a jumper wire between 1F pin 9 and 1F pin 11.
   c. The unmarked strap location between MX and MH at location 1F is now the location for programming drive 4. It can be labeled DS4. This strap should remain connected and the straps labeled DS1, DS2, and DS3 should be disconnected. Be sure to disconnect this strap if the drive is ever programmed to be drive 1, 2, or 3.

B. The strap labeled MX on the program shunt (located at 1F) should be disconnected. Be sure that the HL strap (alternatively labeled HS on some drives) remains connected and the MH strap remains disconnected.

C. Five pull-up resistors for line termination on the ribbon cable are located in the DIP resistor network at position 1E. Only the drive plugged in at the end of the ribbon cable should have this resistor package plugged in. Additional drives plugged in along the cable should have the resistor package removed. In a dual-drive system, the resistor package should be in the right-hand disk drive (drive #2).

MOTHERBOARD THEORY OF OPERATION

MOTHERBOARD HARDWARE

1. Power Regulators: Three-terminal regulators, types 7805, 7812K, 78L12, and 79L12 supply regulated +5V, +12V, +12V, and -12V, respectively to the motherboard electronics and the floppy disk drive electronics. Tantalum and disk ceramic bypass capacitors are used to suppress oscillations in the regulator outputs and to filter noise on the power lines.

2. S-100 Bus Interface: Octal Bus Drivers/Receivers, at locations 6A and 7A, are used to buffer and drive the S-100 bus Data Output and Data Input buses on the S-100 bus to and from the motherboard internal bidirectional data bus (U0-U7).

   S-100 bus address lines A3-A7 are matched with the code specified on the port select header (5B) to select the motherboard during Z80 IN and OUT instructions. Address lines A0-A2 are decoded (9D) to select one of the eight motherboard ports. See the Motherboard I/O Port Addressing section for details.

   Bus Control signals SINP, SOUT, SWO/, and PDBIN are used to direct data flow to and from the internal bus, peripheral interfaces, and the S-100 backplane lines.

   The power-on-clear (POC) signal is used to reset all logic on the motherboard to a known state when the computer is reset or when power is turned on.

3. Serial Interfaces: The HORIZON motherboard includes two serial I/O interfaces. One comes standard with the HORIZON and the Second Serial Interface is provided as an option. The are both identical in capabilities.

   Each serial interface is based on the 8251 integrated circuit Universal Synchronous/Asynchronous Receiver/Transmitter (USART). The primary function of the USART is to perform serial/parallel conversion of data between the computer and the I/O interface. In addition the USART can perform a wide variety of control function under program control from the processor. In particular, the USART can perform standard asynchronous and synchronous communication, generating and detecting start bits, stop bits, parity bits, sync bytes, and interface control signals. For details of using the USART, consult an 8251 data sheet.

Each serial interface can be configured for RS-232 or current loop operation. TTL to RS-232 level shifting of interface signals is performed by RS-232 drivers 3B and 4B. RS-232 to TTL levels are shifted by RS-232 receivers 3C and 4C. The RS-232 interface signals can be configured onto each 25-pin interface connector so that each serial interface can communicate with either a modem or a serial terminal with the headers at locations 3D and 4D. For current loop operation, the RS-232 driver chip is replaced by a header containing a current loop driver. Resistors R16, R17, R24, and R25 provide current source and sink capabilities for current loop operation.

Provision for synchronous mode communication has been made in the serial interfaces. Baud rate clocks required for synchronous communication can be transmitted with the RS-232 drivers (1B) and received with the RS-232 receiver (1C) by properly configuring the Left Special Clock header (1D) and the Right Special Clock header (2C). Parts for the synchronous logic are not included with the standard HORIZON. Synchronous logic parts for both serial interfaces are included with the Second Serial Interface option.

4. Parallel I/O Interface: Optional 8-Bit parallel ports are interfaced to the internal data bus by octal latches, IC type 74LS373, at locations 9A (input) and 8A (output). These are gated to and from the internal bus by signals PI-to-U/ and LD-PO, respectively. Configuration of the Parallel Port Control header at location 9C allows specification of the conditions which enable the data output latch, load the data input latch, clock the input and output control flip-flops P-O-FLG and P-I-FLG, and drive the SPARE conditions to the parallel interface.

5. Control/Status Byte: When enabled by the port decoder, the motherboard status byte is gated onto the internal data bus by the octal buffer at 5A. In addition to the flags hardwired on the PC board, there are also three spare status bits which may be defined by the user when J1-J3 are cut and the lines are wired.

   Various on-board control functions are performed by control decoder chip 9B, a 74LS138 one-of-eight decoder, and the 74LS259 addressable latch at 8B. These functions include arming and disarming the on-board interrupt request conditions, and resetting the various flags.

6. Interrupt control: Various interrupts can be generated for the on-board serial and parallel I/O interface conditions, as well as the real-time clock. These interrupt request conditions are turned on and off by open collector gates 2A, 2B, and 7B, which furnish signals to the interrupt configuration header at 1A. The user may then route the

various interrupt requests to the backplane interrupt lines VI0/-VI7/, PINT/ and NMI/. These lines are pulled low to request an interrupt.

7. Baud Rate Generation and Selection: A total of 9 baud rate clocks from 9600 x 16 to 75 x 16 are generated on the motherboard from the S-100 bus 2 MHz clock. These are divided down to the proper frequencies by four 4-Bit counters, types 74LS161 and 74LS393, at locations 5D, 6D, and 7D. The baud rates generated are available at the Baud Rate Selection header at 2D. The clocks are expressed sixteen times the desired baud rates since this is what the USARTs generally require.

8. Real-Time Clock: The real-time clock feature allows generation of a signal to the processor at regular intervals. The clock intervals are divided down from a tap on the baud-rate generator by the MOS 14-bit counter at 10B, a type 4020 IC. A total of 12 intervals from 3.328 ms. to 27.263 seconds are available at the Clock Rate header at 10A. The selected clock is used to set the clock flip-flop (CLK-FLG). The clock flag condition is available to programs as a bit in the motherboard status byte. The clock flag condition can also be jumpered to request an interrupt.

MOTHERBOARD CONTROL BYTE

A number of control functions can be executed on the motherboard under program control. To cause a control function from a program, a control byte code should be loaded into the A-register and then an OUT 6 intruction should be executed. The following table gives the control byte codes and their functions.

Code(hex)	Function
00	Reset USARTs' arming bits, and CF inhibit bits
10	Disarm parallel input interrupt
11	Arm parallel input interrupt
12	Disarm parallel output interrupt
13	Arm parallel output interrupt
14	Disarm standard transmitter ready interrupt
15	Arm standard transmitter ready interrupt
16	Disarm standard transmitter empty interrupt
17	Arm standard transmitter empty interrupt
18	Allow standard CF bit (carrier detect)
19	Inhibit standard CF bit
1A	Allow second CF bit
1B	Inhibit second CF bit
1C	Disarm second transmitter ready interrupt
1D	Arm second transmitter ready interrupt
1E	Disarm second transmitter empty interrupt
1F	Arm second transmitter empty interrupt
20	Reset parallel output flag
30	Reset parallel input flag
40	Disarm clock interrupt
50	Reset clock flag
C0	Arm clock interrupt

MOTHERBOARD STATUS BYTE

The status of various motherboard conditions can be read under program control by inputting the motherboard status byte. If a program executes an IN 6 instruction, then the status byte is loaded into the A-register. The following table shows the meaning of the bits in the status byte. Note that three of the bits can be jumpered by the user to provide special status conditions.

Bit	Status Condition
0	Parallel output flag
1	Parallel input flag
2	Clock flag
3	User defined (J3)
4	Second CF bit/
5	Standard CF bit/
6	User defined (J2)
7	User defined (J1)

MOTHERBOARD I/O PORT ADDRESSING

A block of eight contiguous I/O ports is specified by configuration of the Port Select header at location 5B. The 14-pin header is configured to specify the five bit value which matches address bits A3-A7 during an IN or OUT instruction, as follows:

address bit 7	header pin 9
address bit 6	header pin 10
address bit 5	header pin 11
address bit 4	header pin 12
address bit 3	header pin 13

Each address bit that should match a "one" should be connected to pin 1 of the header and each address bit that should match a "zero" should be connected to pin 7. For example, if ports A8-AF are desired, then A3-A7 should be "10101". Thus, pin 7 should be connected to pins 10 and 12 and pin 1 should be connected to pins 9, 11 and 13.

Within a block of eight I/O ports, address bits A0-A2 are decoded as follows:

A0-A2	Function
0	Parallel I/O Data
1	(same as 0)
2	Standard Serial I/O Data
3	Standard Serial I/O Control
4	Second Serial I/O Data
5	Second Serial I/O Control
6	Motherboard Control and Status
7	(same as 6)

MODE CONFIGURATION

The RS-232 communication standard describes the interface between Data Terminal Equipment (terminal) and Data Communication Equipment (modem). If the HORIZON is communicating with a serial terminal (such as a CRT, a teletype, or a hard copy printer), then its serial interface must be configured to play the role of a modem. If the HORIZON is comunicating with a modem, then it must play the role of a terminal. Computer to computer communication is possible if one computer plays the role of a modem and the other computer plays the role of a terminal.

The HORIZON can also communicate with a 20ma current loop terminal such as a teletype.

RS-232 CASES

A. HORIZON as modem

To interface to an asynchronous RS-232 terminal, jumper the 16-pin header at location 3D for the standard serial interface (4D for the second Serial interface) as follows:

Connect pin 1 to pin 12
Connect pin 2 to pin 16
Connect pin 3 to pin 15
Connect pin 4 to pin 14
Connect pin 5 to pin 11
Connect pin 7 to pin 8
Connect pin 9 to pin 10

A full 25-conductor cable must be used to connect the terminal to the serial interface connector. Alternatively, the following header configuration may be used with most RS-232 terminals. With this alternative configuration, a 3-conductor cable between the terminal and computer connector pins 2, 3, and 7 will suffice. The RS-232 control signals are not connected, so serial communication applications which require the control signals should not use this configuration.

Connect pin 6 to 2, 4, 5, and 12
Connect pin 7 to 8
Connect pin 9 to 10

B. HORIZON as Terminal

To interface to an asynchronous modem, the header at 3D for

the standard serial interface (4D for the second serial interface) should be jumpered as follows:

Connect pin 1 to pin 16
Connect pin 2 to pin 12
Connect pin 3 to pin 14
Connect pin 4 to pin 15
Connect pin 5 to pin 13
Connect pin 7 to pin 10
Connect pin 8 to pin 9

Note: Space is provided on the motherboard for adding additional resistors and capacitors (R10-13, R18-21, R26-29, C23-26, C31-34, and C39-41) for connecting to the "response control" inputs of the RS-232 receivers. Refer to a 1488 data sheet for details.

CURRENT LOOP CASES

To configure a serial interface for current loop operation proceed as follows:

a. Connect a 2N3904 transistor to a 14-pin DIP header with the E lead connected to pin 7, the B lead connected to pin 5 and the C lead connected to pin 6.

b. Connect a 5.6K ohm 1/4 Watt resistor (green-blue-red) between pins 4 and 12 on the header.

c. Connect a 1K ohm 1/4 Watt resistor (brown-black-red) between pins 8 and 14 on the header.

d. Remove the 1488 at location 3B Standard (4B Second), and replace it with the header just built.

e. Take a 16-pin DIP header and make the following connections.
Connect pin 6 to pin 7 and pin 8
Connect pin 9 to pin 10
Connect pin 12 to pin 16

f. Install the 16-pin header just built at location 3D (standard serial interface), or 4D (second serial interface).

g. Wire the current loop for the printer part of the device being interfaced to the 25-pin serial interface connector pins 3(-) and 9(+). Wire the keyboard current loop to connector pins 2(+) and 10(-).

SERIAL CONNECTOR PIN ASSIGNMENTS

pin #	Signal Name	Direction T=terminal M=modem	Abbreviation
1	Chassis ground		AA
2	Transmit Data	T to M	BA
3	Receive Data	M to T	BB
4	Request to Send	T to M	CA
5	Clear to Send	M to T	CB
6	Data Set Ready	M to T	CC
7	Signal Ground		AB
8	Carrier Detect	M to T	CF
9	+12 volts	(used in current loop)	
10	-12 volts	(used in current loop)	
11	No Connection		
12	No Connection		
13	No Connection		
14	No Connection		
15	Transmit Clock	M to T	DB
16	No Connection		
17	Receive Clock	M to T	DD
18	No Connection		
19	No Connection		
20	Data Terminal Ready	T to M	CD
21	No Connection		
22	No Connection		
23	No Connection		
24	Transmit Clock	T to M	DA
25	No Connection		

BAUD RATE SELECTION

Baud rates for both the standard and second serial interfaces are specified by configuration of the Baud Rate header at location 2D. The following baud rate clocks are available on the header.

pin 16	9600 x 16 baud
pin 15	4800 x 16 baud
pin 14	2400 x 16 baud
pin 13	1200 x 16 baud
pin 12	600 x 16 baud
pin 11	300 x 16 baud
pin 10	110 x 16 baud
pin 9	150 x 16 baud or 75 X 16 baud (selected by jumper J4 near 5D)

The selected baud rate clocks should be connected to the following serial interface clocks as required.

pin 1	Special Clock connection (see schematics)
pin 2	Special Clock connection
pin 3	Standard Serial Interface Transmitter Clock
pin 4	Standard Serial Interface Receiver Clock
pin 5	Second Serial Interface Transmitter Clock
pin 6	Second Serial Interface Receiver Clock
pin 7	Special Clock connection
pin 8	Special Clock connection

The transmit and receive clocks for a serial interface are generally connected to the same baud rate. However, serial input and output can be configured to occur at two different rates. Note that for asynchronous communication the USARTs are generally programmed to use a clock at sixteen times the desired baud rate. Synchronous communication generally uses a clock the same as the desired baud rate.

PROGRAMMING SERIAL I/O INTERFACES

The DOS section of the North Star System Software Manual shows commented subroutines for the following serial I/O functions: USART initialization, input one character, output one character, and test for a break character (control-C). Note that the initialization routine initializes both the Standard and Second Serial Interfaces after initializing the parity feature. The character input and output routines are programmed for the Standard Serial Interface. The Second Serial Interface can be similarly programed using I/O ports 4 and 5 instead of 2 and 3.

USING THE PARALLEL I/O INTERFACE

To interface a parallel I/O device to the HORIZON a cable must be constructed which connects the device to the appropriate backpanel connector, the PARALLEL PORT header must be configured, and, lastly, a program must be written for performing byte input or output to the parallel interface.

PARALLEL CONNECTOR PIN ASSIGNMENTS

The pin configuration on the 15-pin Parallel Input connector is:

pin 1	Data Bit 7
pin 2	Data Bit 5
pin 3	Ground
pin 4	Data Bit 2
pin 5	Data Bit Ø
pin 6	Input Strobe
pin 7	P-I-FLAG/
pin 8	SPARE/ (extra programable condition)
pin 9	Data Bit 6
pin 1Ø	Data Bit 4
pin 11	Data Bit 3
pin 12	Data Bit 1
pin 13	Ground
pin 14	Ground
pin 15	Ground

The pin configuration on the 15-pin Parallel Output connector is:

pin 1	Data Bit 7
pin 2	Data Bit 5
pin 3	Ground
pin 4	Data Bit 2
pin 5	Data Bit Ø
pin 6	PO-FLAG/
pin 7	ACK/ (output device ready)
pin 8	SPARE/ (extra programmable condition)
pin 9	Data Bit 6
pin 1Ø	Data Bit 4
pin 11	Data Bit 3
pin 12	Data Bit 1
pin 13	Ground
pin 14	Ground
pin 15	Ground

If required, jumpers to pins 13, 14 or 15 on both connectors can be cut and rewired to motherboard power lines to provide modest amounts of power to the peripheral devices.

PARALLEL INTERFACE CONFIGURATION HEADER

The parallel interface control functions are determined by the configuration of the 14-pin Parallel Port DIP header at location 9C. The pins of this header have the following assignments:

Pin	Description
1	Logic LOW (ground).
2	Output Acknowledge signal from pin 7 of the parallel output interface connector.
3	Inverted Output Acknowledge signal from pin 7 of the parallel output interface connector.
4	Available for driving an extra signal onto pin 8 of the parallel output interface connector.
5	Available for driving an extra signal onto pin 8 if the parallel input interface connector.
6	Input Strobe Signal from pin 6 of the parallel input interface connector.
7	Inverted Input Strobe Signal from pin 6 of the parallel input interface connector.
8	Logic HIGH.
9	Tied to clock of parallel input interface flag flip-flop.
10	Free.
11	Free.
12	This signal indicates execution by the processor of a data output instruction to the parallel output port (HIGH while valid data on bus).
13	Tied to the clock of the parallel output interface flag flip-flop.
14	Tied to the output enable control of the parallel output interface data latch.

PARALLEL OUTPUT EXAMPLE

Different printers have different interfacing requirements. The following example is for a hypothetical printer. To configure for output to a parallel printer:

A. Connect pin 1 to pin 14 of the header to permanently enable the data output latch.

B. Connect pin 2 to pin 13 to cause a positive-going edge of the acknowledge signal to set the output flag flip-flop. (Connect pin 3 to pin 13 if a negative-going edge should set the flag flip-flop.)

C. Connect pin 4 to pin 12 to signal the printer of each new data byte to be output.

D. Construct a cable from the 15-pin Parallel Output Connector to the printer which connects:

a. the data bits to the printer

b. the output done signal from the printer to the ACK/ signal at the connector

c. the SPARE/ signal from the connector to the printer strobe signal.

The following assembly language subroutine will output the value in the B-register to the printer and then return.

```
POUT  IN 6          READ MOTHERBOARD STATUS
      ANI 1         MASK TO GET PO FLAG
      JZ POUT       PRINTER NOT YET READY
      MOV A,B       RESTORE DATA TO A-REGISTER
      OUT Ø         OUTPUT DATA TO PRINTER
      MVI A,2ØH     LOAD COMMAND BYTE TO A-REGISTER
      OUT 6         RESET PO FLAG
      RET
```

PARALLEL INPUT EXAMPLE

To configure for input from a parallel keyboard:

A. Connect pin 6 to pin 9 if the positive-going edge of the input strobe signal from the keyboard should set the P-I-FLG flip-flop. (Connect pin 7 to pin 9 if a negative-going edge should set the flip-flop.)

B. Construct a cable from the keyboard to the 15-pin Parallel Input Connector which connects the data bits from the keyboard to the corresponding data bits at the connector and which connects the strobe signal from the keyboard to the input strobe pin at the connector. It is possible to supply power to the keyboard from the motherboard by cutting traces and wiring power to pin 13, 14, or 15 of the connector.

The following assembly language subroutine will input a character from the keyboard and return with the character value in the A-register.

```
PIN   IN 6          READ MOTHERBOARD STATUS
      ANI 2         MASK TO GET PI FLAG
      JZ PIN        NO INPUT TYPED YET
      IN Ø          READ DATA FROM KEYBOARD
      PUSH PSW      SAVE DATA FROM A-REGISTER
      MVI A,3ØH     LOAD COMMAND BYTE TO A-REGISTER
      OUT 6         RESET PI FLAG
      POP PSW       RESTORE DATA TO A-REGISTER
      ANI 7FH
      RET
```

USING THE REAL-TIME CLOCK

To use the Real-Time Clock, select a time interval from among the following and jumper the corresponding pin to pin 13 on the 14-pin DIP header at location 10A:

3.3280 ms	pin 12	851.97 ms	pin 6
26.624 ms	pin 11	1.7039 s	pin 5
53.248 ms	pin 10	3.4079 s	pin 4
106.50 ms	pin 9	6.8157 s	pin 3
213.99 ms	pin 8	13.631 s	pin 2
425.98 ms	pin 7	27.263 s	pin 1

Note that all time intervals are exactly a power of 2 times 3.328 ms. The clock flag (CLK-FLG) can be jumpered to an interrupt or can be read as bit 2 of the motherboard status byte by executing an IN 6 instruction in the standard configuration. The Clock Flag is reset by executing MVI A,50H; OUT 6.

MOTHERBOARD INTERRUPTS

The motherboard I/O interfaces and real-time clock can be configured to generate interrupt request signals to the S-100 bus. There are eleven possible interrupt conditions which are grouped to generate four different interrupt requests as follows:

Standard Serial Interface
1. Receiver Ready
2. Sync Detect
3. Transmitter Ready - disarmable
4. Transmitter Empty - disarmable

Second Serial Interface
5. Receiver Ready
6. Sync Detect
7. Transmitter Ready - disarmable
8. Transmitter Empty - disarmable

Parallel Interface
9. Parallel Input Flag - disarmable
10. Parallel Output Flag - disarmable

Real-Time Clock
11. Clock Flag - disarmable

Note that this grouping can be rearranged by cutting and/or rewiring motherboard jumpers J5-J14. See the schematic drawings for details. Each of the above four interrupt groups can be tied to any one of the ten interrupt request lines on the S-100 bus by

appropriately configuring the 16-pin Interrupt header at location 1A. See the schematic drawings for details. Also, see the Motherboard Control Byte section for programming details for arming and disarming interrupts.

Note that interrupts during disk activity can cause detected read errors as well as undetected write errors. Therefore, it is recommended that interrupts always be disabled during use of the disk(s).

HORIZON GROUNDING

Improper grounding of a complete HORIZON computer system can adversely affect reliablility as a result of ground noise. A complete system is properly grounded if chassis ground and signal ground are connected together in one place only. Therefore, the following grounding procedure is recommended.

1. Connect the HORIZON chassis to signal ground by soldering a jumper wire between the two holes of the location C47 at the extreme left rear corner of the motherboard. If the HORIZON is being used in an environment where static electricity is a problem (e.g. synthetic fiber rugs or dry weather), then install a .Ø47 ceramic disc capacitor at location C47 instead.

2. Be sure that chassis ground and signal ground are not connected on each piece of external equipment connected to the HORIZON. Examples of external equipment are a CRT terminal, a printer or a third disk drive.

3. For shock protection, be sure that the chassis of each piece of external equipment is grounded by using a 3-wire power cord or by connecting it to the HORIZON chassis with a wire. Note that the HORIZON chassis is grounded with a 3-wire power connection.

OPERATION AND MAINTENANCE OF THE HORIZON

OPERATION

When first beginning a session with the HORIZON computer, first check each of the following:

A. Be sure the computer and terminal are plugged into the AC outlet and are known to have been left in a condition ready for use.

B. Check that the terminal cable is properly connected to the terminal and to the HORIZON standard serial interface connector on the backpanel. See the HORIZON Grounding section to be sure the terminal is grounded correctly.

C. Check that the HORIZON and terminal are configured for the same baud rate and RS-232 or current-loop operation. The terminal must be in full-duplex operation mode. DOS, BASIC, and the Monitor use upper-case ASCII characters.

Select a diskette containing a version of the North Star DOS personalized for your I/O configuration (the standard HORIZON diskette is configured for use with the standard serial I/O interface). The DOS must be the first file on the diskette, starting at disk address 4.

Insert the diskette into drive #1 (the left hand drive mounted to the front panel in a two drive system). Orient the diskette so that the write protect notch is up and the label faces to the right. Make sure the diskette is resting gently against the back stop, and then close the drive latch.

If power is not already on (check the power LED on the front panel), then turn on the power switch. Otherwise, toggle the reset switch. Both switches are located on the back panel near the fan. Disk drive #1 should turn on momentarily and the terminal should print a plus sign (+) to indicate that the DOS is loaded and awaiting a command. Any DOS command may now be typed (e.g., GO BASIC).

Refer to the North Star System Software Manual for complete details of the use of the North Star software.

DISKETTES

During the course of a lengthy session with the HORIZON, if additions or modifications are made to any program or data file, it is recommended that the user periodically make a "back-up" copy of the file either on a loaded diskette or, preferably, on an extra diskette. This precaution will minimize the

inconvenience caused by an inadvertent user error, power failure, or computer failure. Keep a piece of masking tape over the write protect notch on each diskette as much as possible to protect against the information being accidentally destroyed. The write-protect tape should NEVER be removed from your original HORIZON diskette.

All diskettes should contain a label describing the diskette contents and relevant version numbers and dates. When not inserted in the computer, diskettes should be filed in the protective envelopes in a dust-free location away from excessive heat and magnetic fields where accidental physical damage can not occur. Avoid any contact with the diskette media through the holes in the diskette case.

MAINTENANCE

Periodically use the North Star Monitor program to test all the RAM memory in the computer, and use the DOS disk test utility to test each drive. Refer to the Getting Started section of the North Star System Software Manual for complete details of how to perform these test procedures.

To keep your computer looking attractive, care for it as you would a piece of furniture: wipe fingerprints and dirt from the front panel, and occasionally polish the wood cover.

TROUBLESHOOTING

Should your computer system become non-operational, the first step is to isolate the problem. If you have determined that the problem is with the HORIZON computer (and not, for example, with the terminal, a bad diskette, or with a change in software), then, if possible, run your boards in another S-100 computer one at a time to isolate the bad board. If this is not possible, then follow the checkout procedure in the assembly manuals for each component of your system.

OUT OF WARRANTY REPAIR

If your unit is out of warranty and you are unsuccessful at diagnosing or repairing the problem, out-of-warranty service may be arranged with a local dealer or other experienced local computer technician. Alternatively, any North Star products may be shipped PREPAID to the North Star address with a clear written description of the problem. Include as many details as possible about the problem and about your system configuration. Your unit will be returned, C.O.D., within 30 days after receipt by North Star. Out-of-warranty repair service is billed at the rate of $25.00 per hour. If you wish to place an upper limit on the amount of time spent on your unit, mention this in the written description.

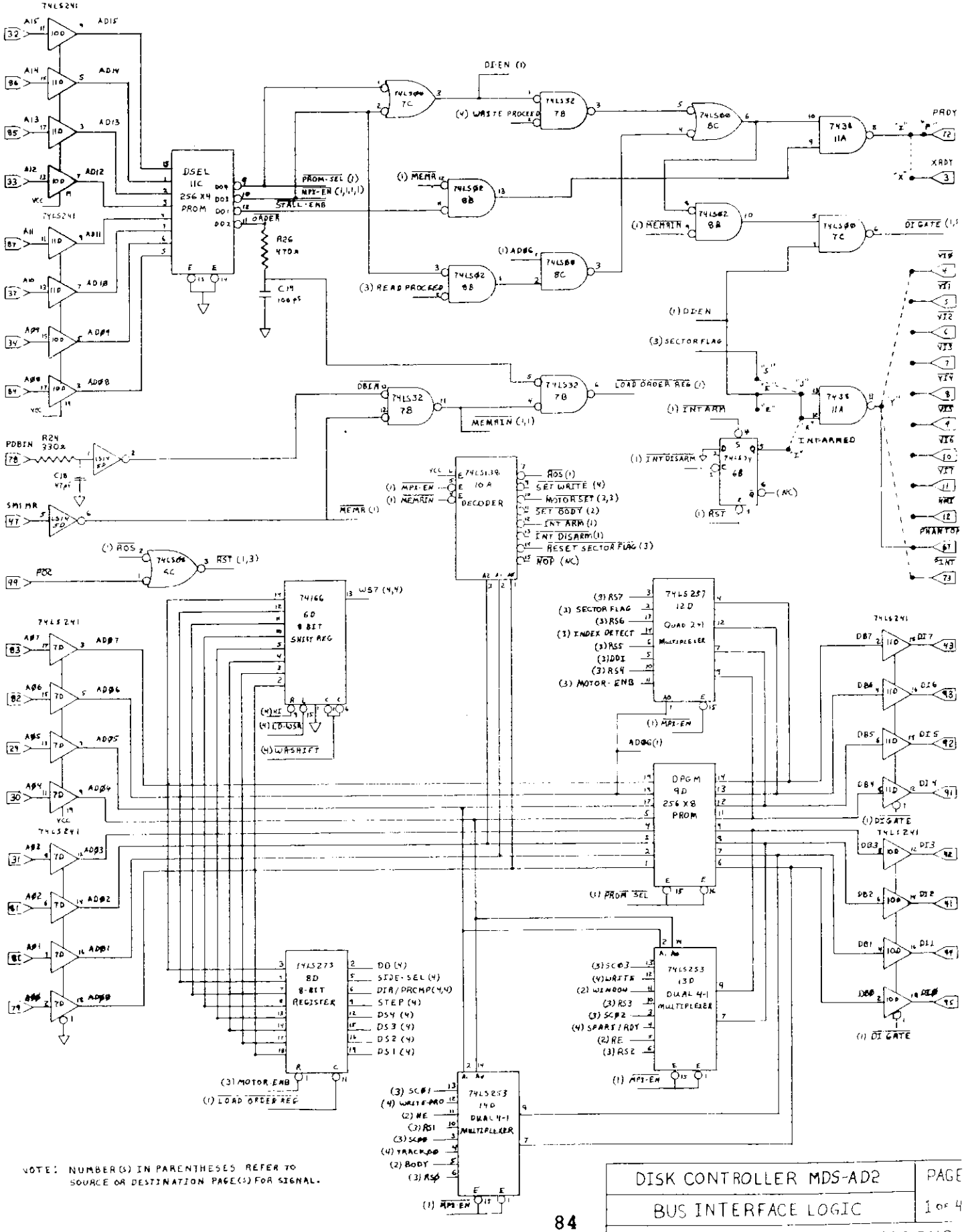
APPENDIX 1. PULSE SIGNAL DETECTION

Some steps in the check-out procedure will require test equipment capable of distinguishing a signal containing pulses from a DC signal. Any one of the following will suffice.

1. Use of an oscilloscope is best since the shape and frequency of the pulses can also be determined.

2. Use a logic probe that detects pulses.

3. Use a counter on the motherboard to divide the frequencies down to the audio range and then play the result through a hi-fi amplifier. To do this, remove the 74LS161 at location 7D on the motherboard. Then attach the test probe wire to jumper 2D pin 16 (this is the input to the divider). Next, take the output of the divider at jumper 10A pin 11 and connect to the AUX input of the audio amplifier. Finally, connect the AUX input ground on the audio amplifier to signal ground on the motherboard. This arrangement will divide high frequency signals by 4096 and thus put the resulting signal in the audible range. Thus a 4 MHz signal will be heard as a tone one octave higher than a 2MHz signal.



NOTE: NUMBER(S) IN PARENTHESES REFER TO SOURCE OR DESTINATION PAGE(S) FOR SIGNAL.

DISK CONTROLLER MDS-AD2	PAGE
BUS INTERFACE LOGIC	1 OF 4
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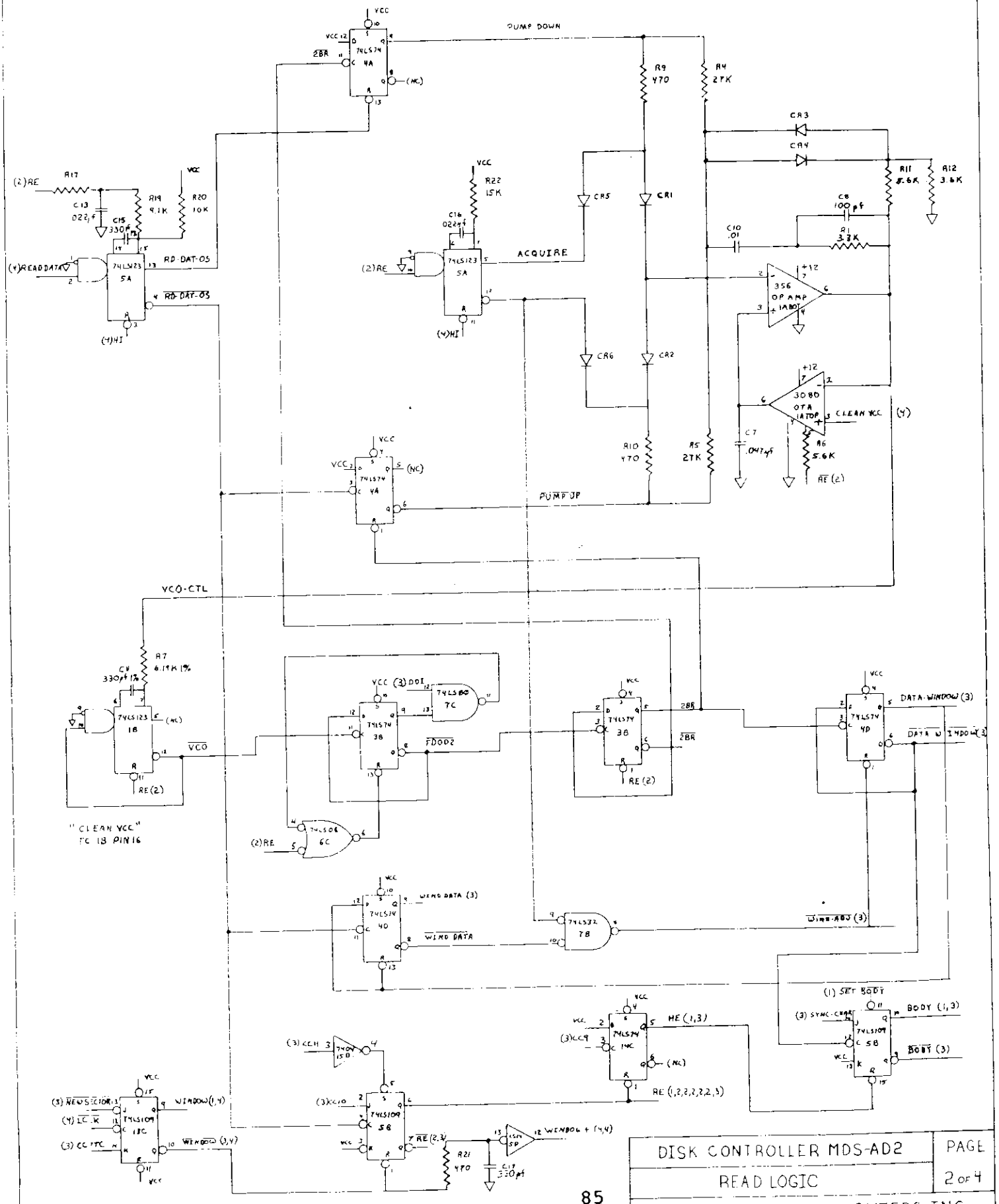

DISK CONTROLLER MDS-AD2	PAGE
READ LOGIC	2 OF 4
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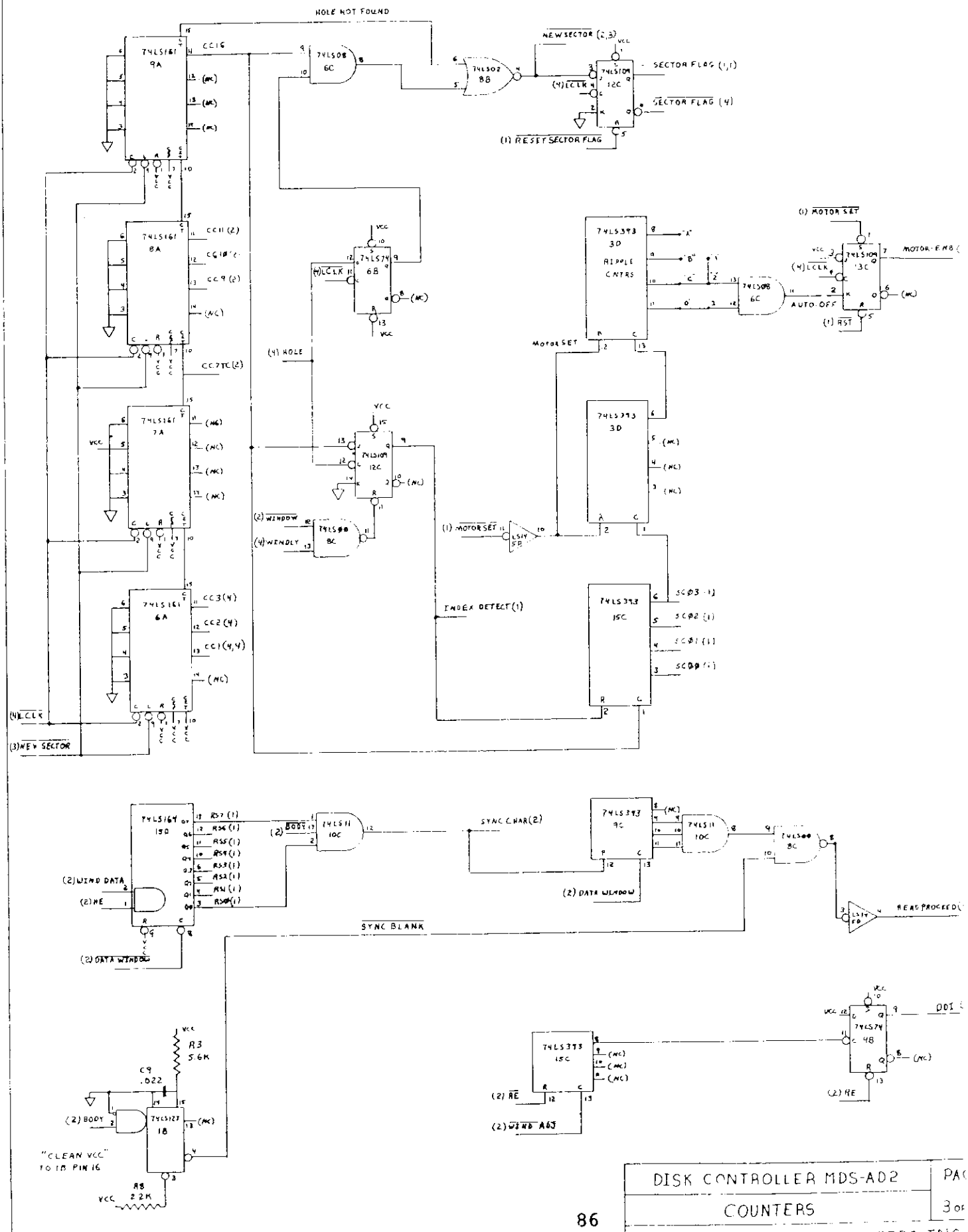

DISK CONTROLLER MDS-AD2	PA(
COUNTERS	3 OF
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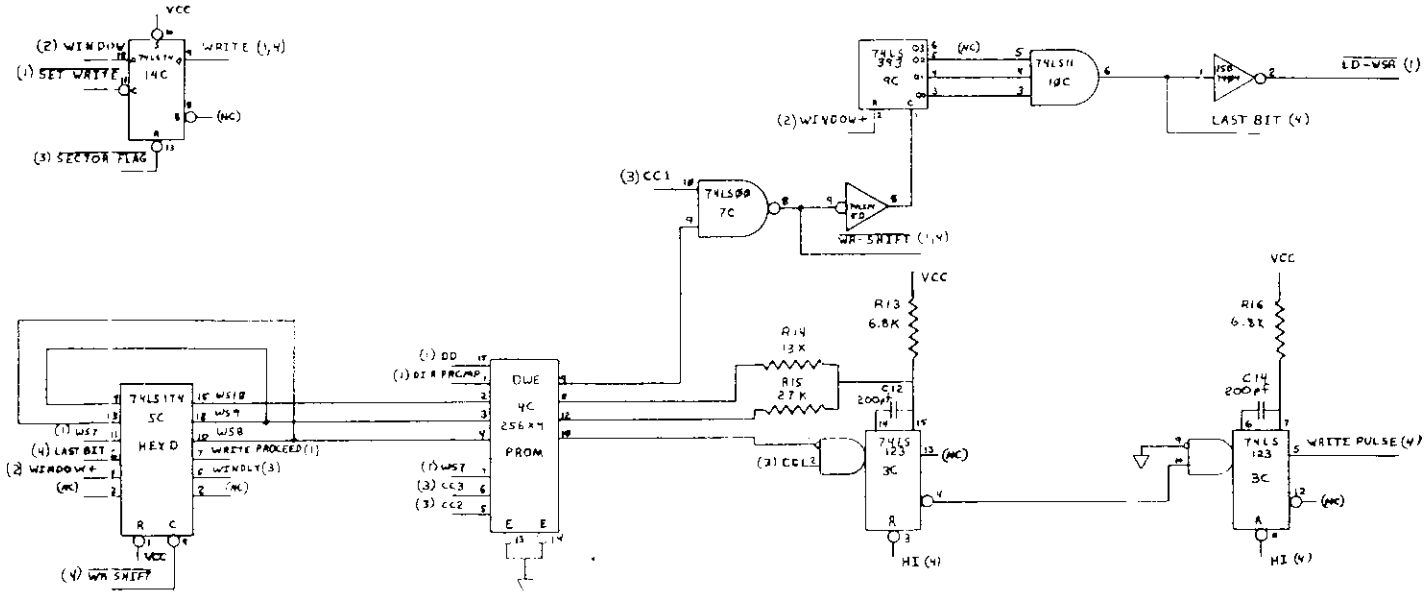

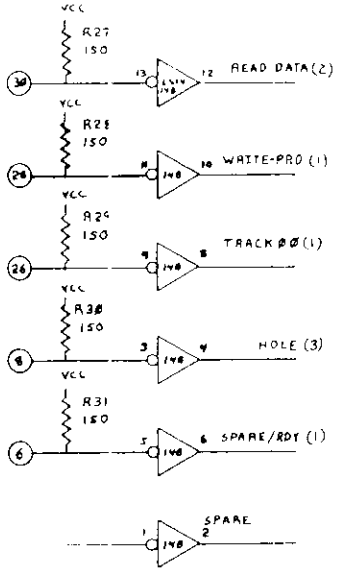

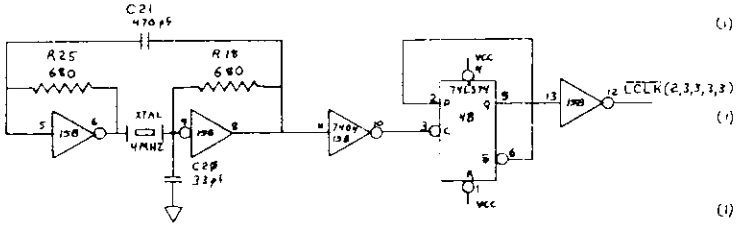

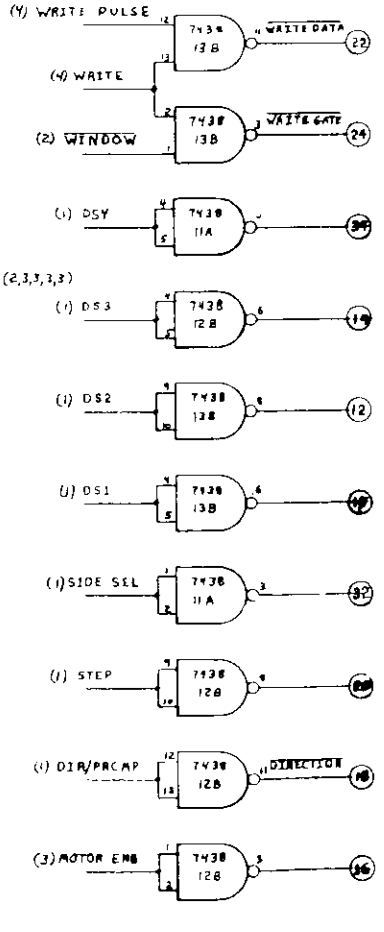

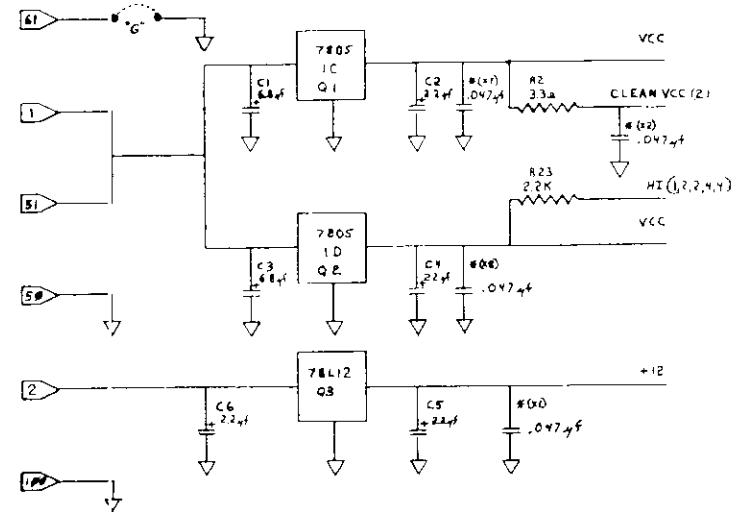

DISK CONTROLLER MDS-AD2	PAGE
DRIVE INTERFACE, WRITE LOGIC, OSC, POWER	4 OF 4

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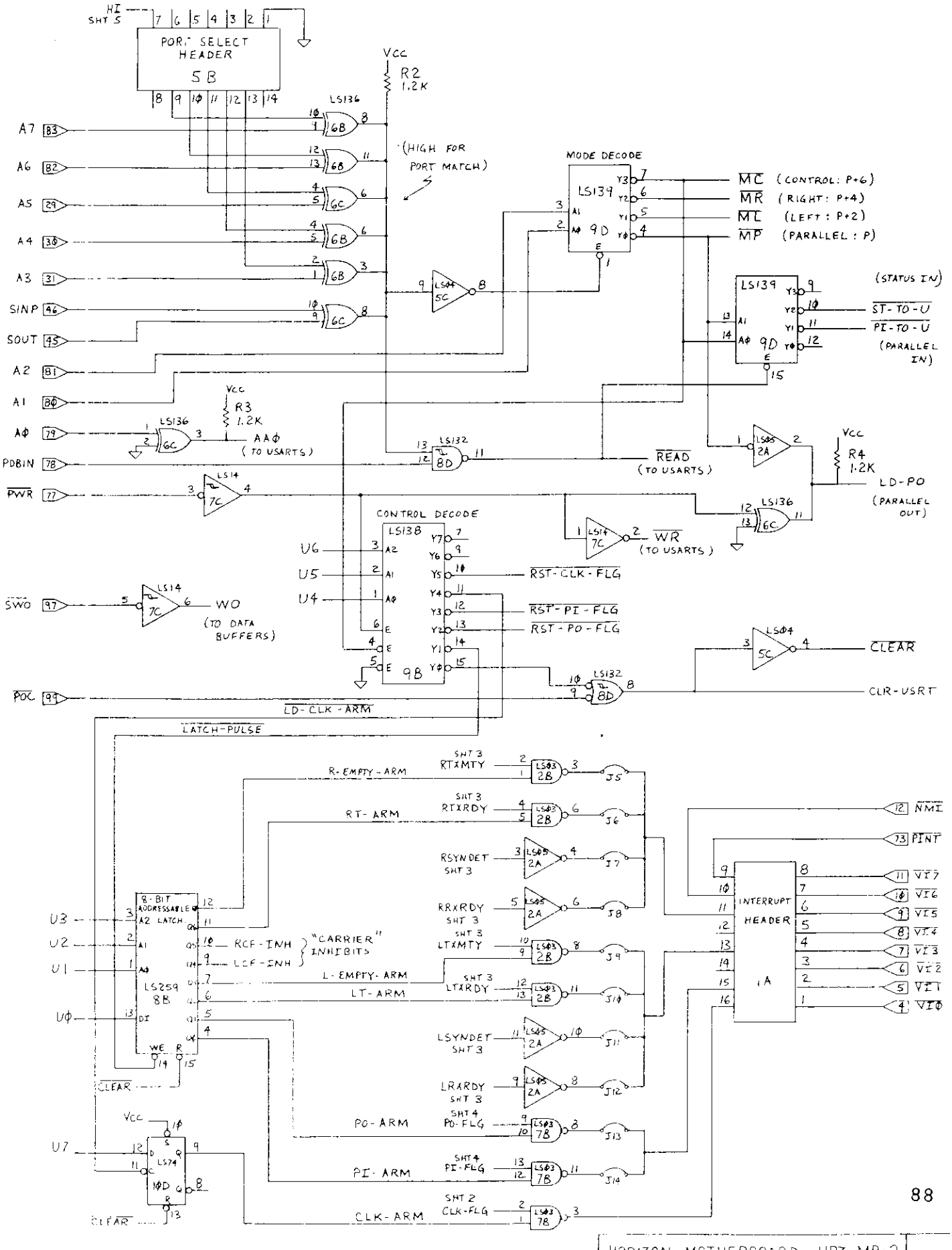

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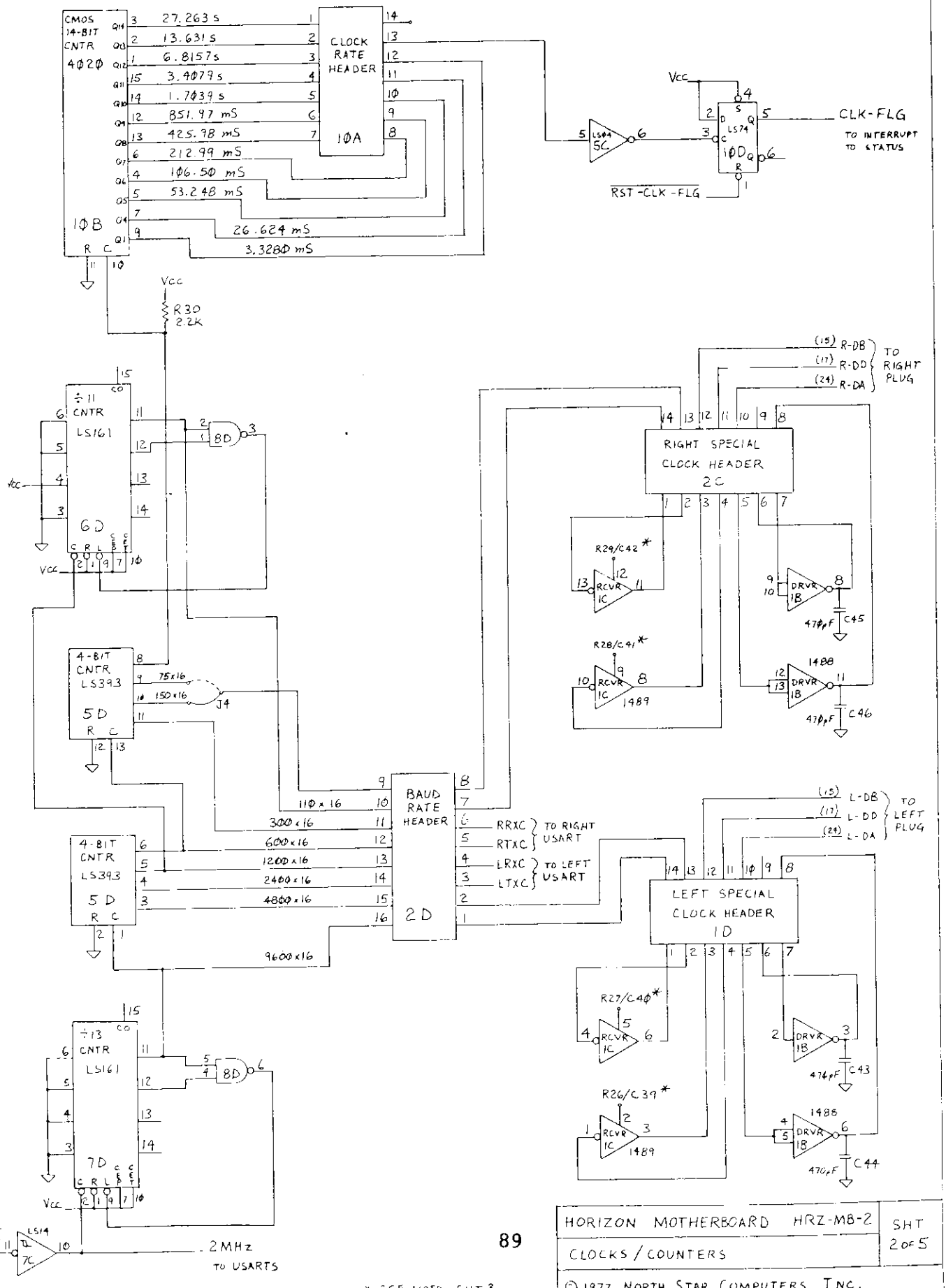
HORIZON MOTHERBOARD HRZ-MB-2 | SHT 1 OF 5

CONTROL & INTERRUPT LOGIC



HORIZON MOTHERBOARD HRZ-MB-2	SHT 2 OF 5
CLOCKS / COUNTERS	

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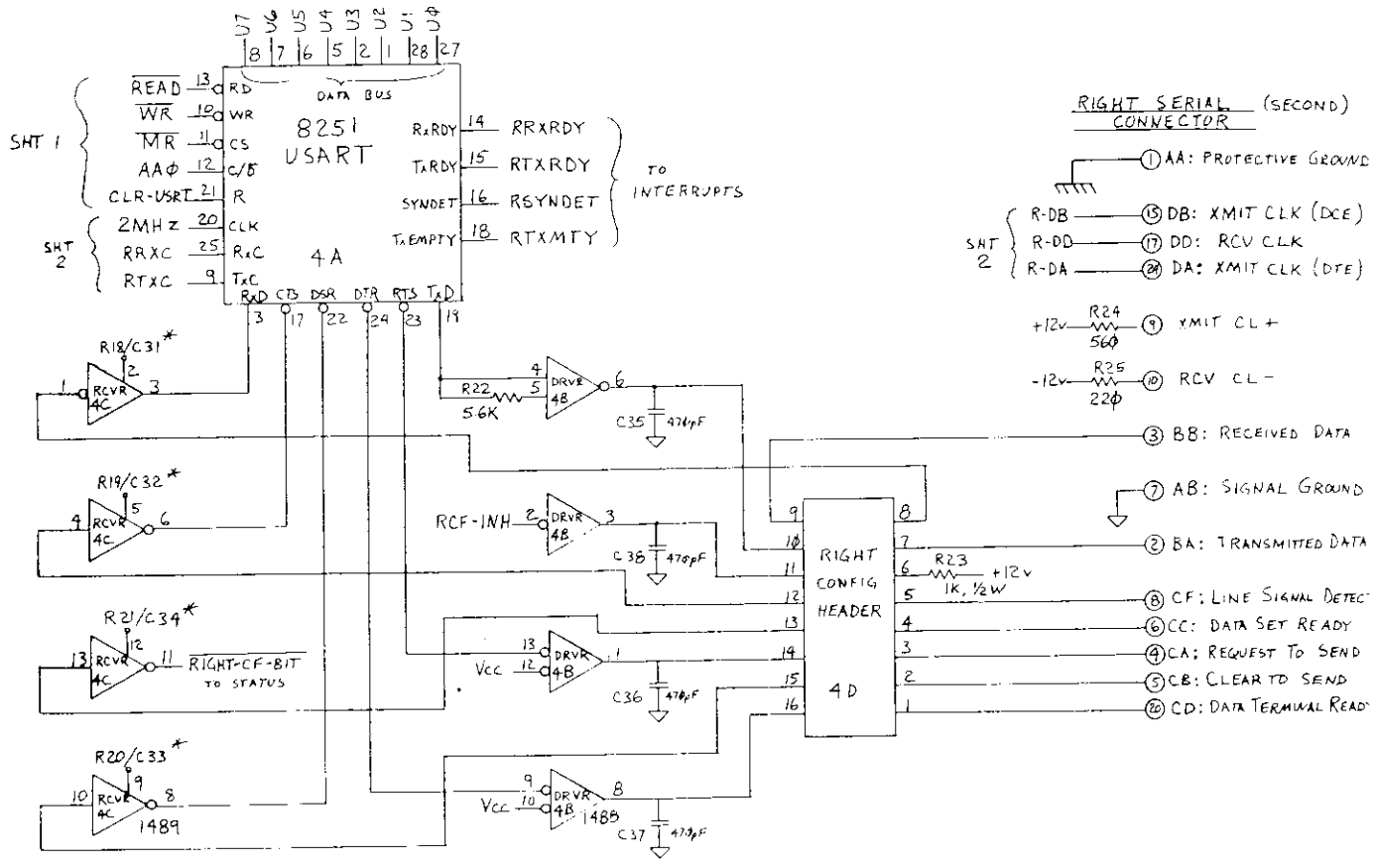

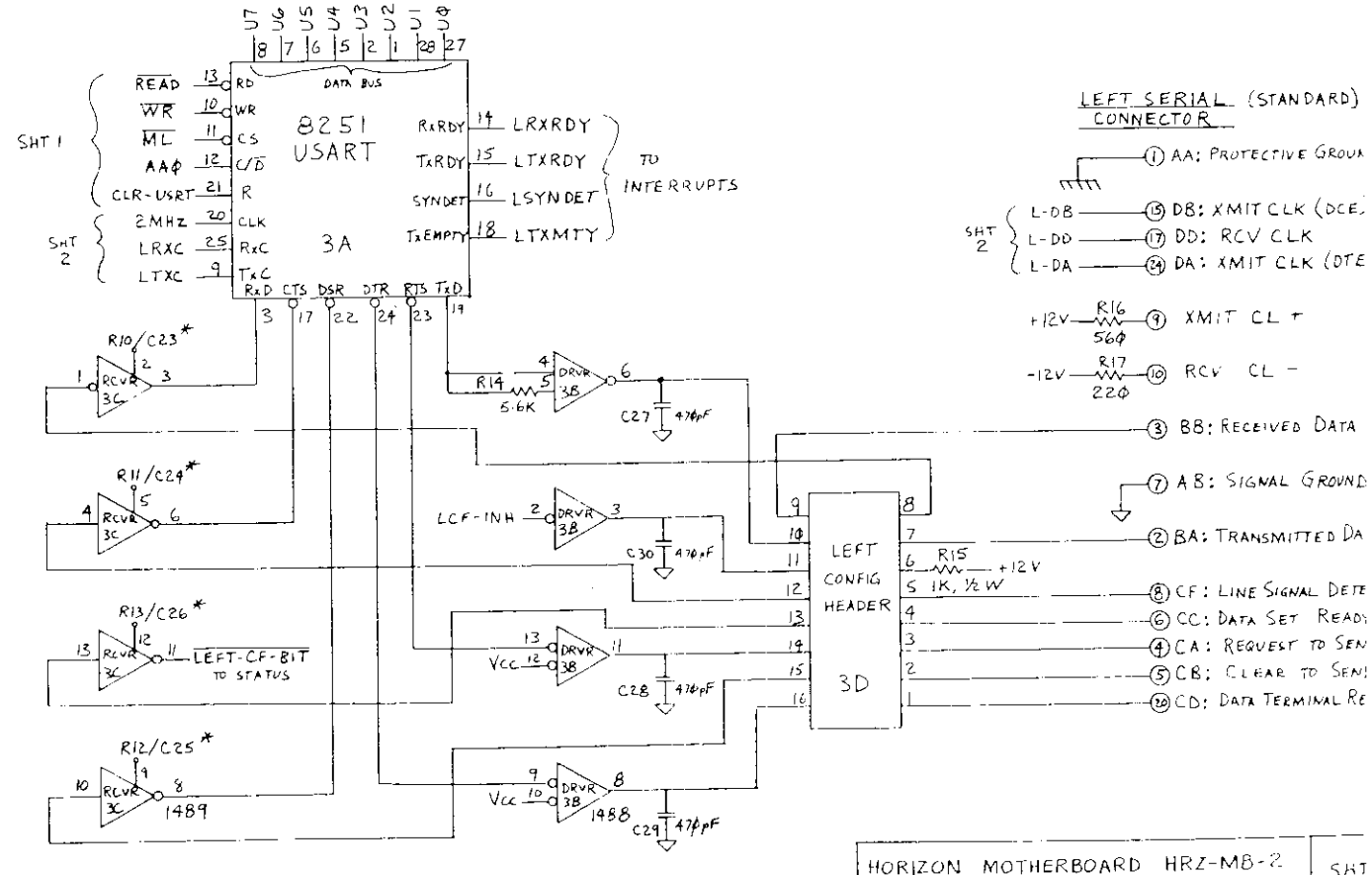

* NOTE: TO EACH RS232 RECEIVER (12 PLACES), USER MAY ADD RESISTOR TO Vcc OR CAPACITOIR TO GND.

HORIZON MOTHERBOARD HRZ-MB-2	SHT 3 OF
SERIAL PORTS	

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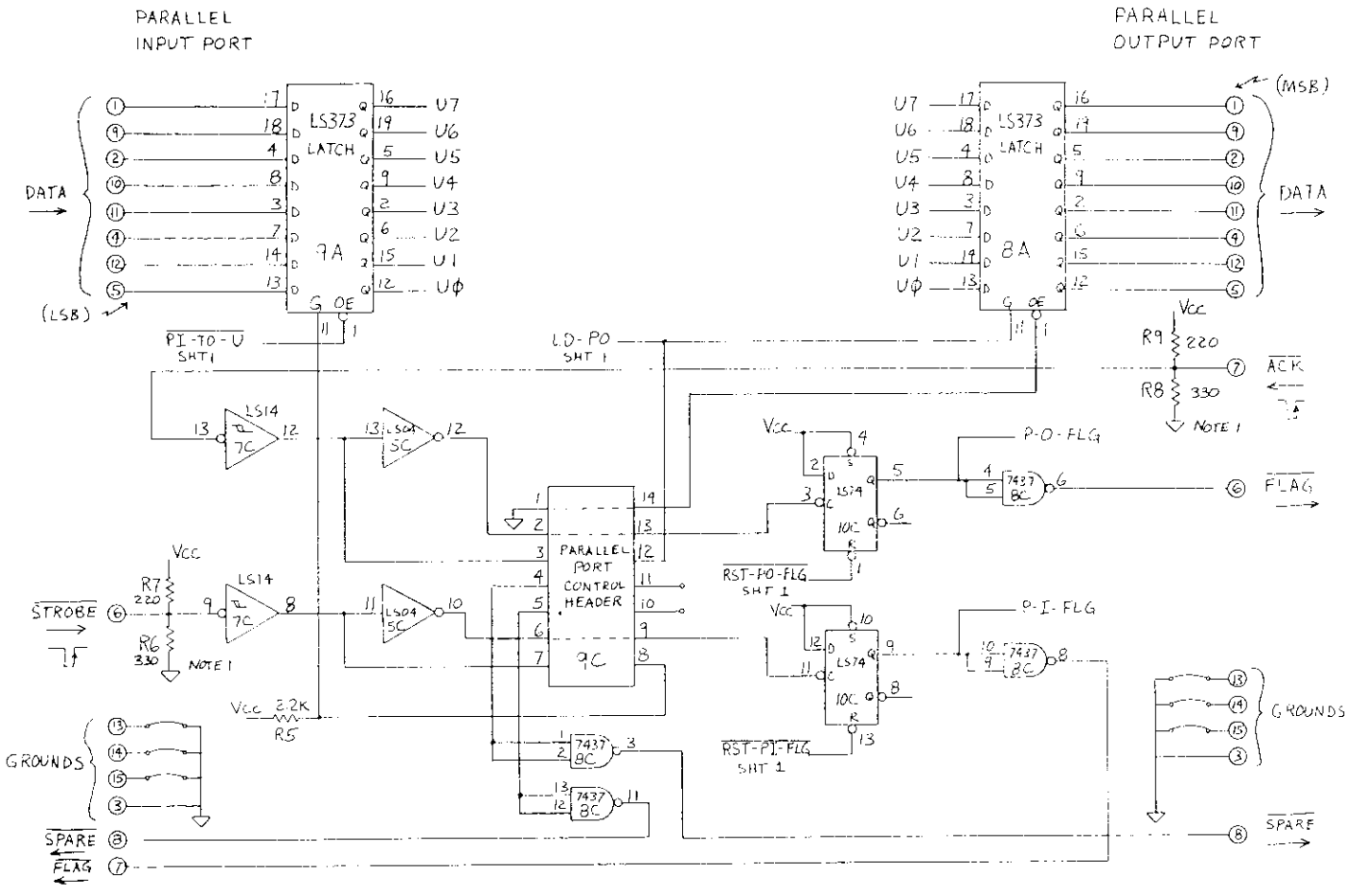

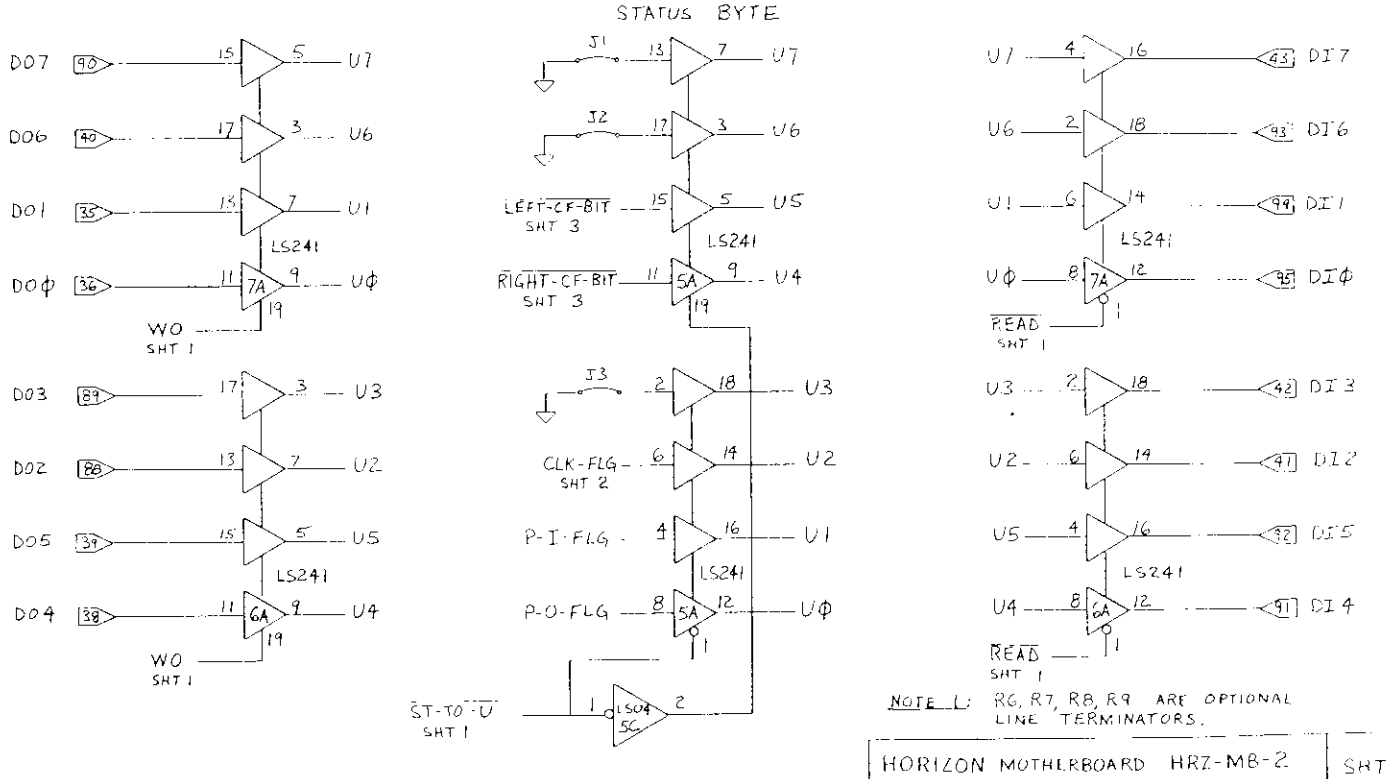

NOTE 1: R6, R7, R8, R9 ARE OPTIONAL LINE TERMINATORS.

HORIZON MOTHERBOARD HRZ-MB-2	SHT 4 OF 5
BUFFERS, STATUS, PARALLEL PORTS	

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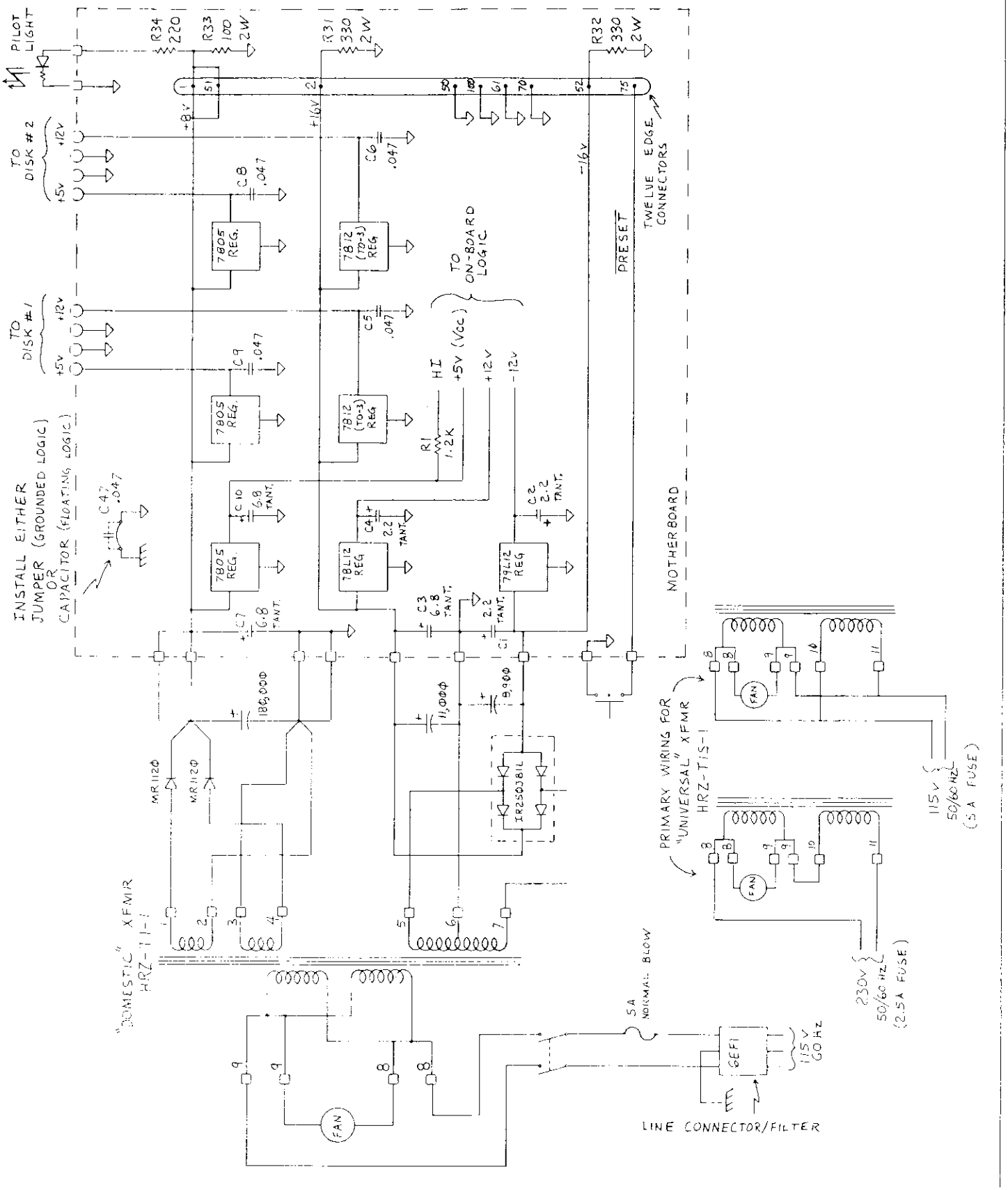

HORIZON CHASSIS/MOTHERBOARD	SHT 5 OF 5
POWER SUPPLIES	
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