THE DIGITAL GROUP
Z-80 DOCUMENTATION

DZ8-0-R2

the digital group inc

po box 6528 denver, colorado 80206 (303) 777-7133

DIGITAL GROUP SYSTEMS

Congratulations on obtaining a Digital Group microprocessor system. We hope you will be more than satisfied with your system. Please send us your negative and positive comments. While no one system will be exactly designed the way every individual would desire, we have tried to provide a system which would satisfy most people's requirements. The designs had to be simple, low cost, easy to build and maintain, updatable and simple to use effectively. These conflicting objectives are difficult to totally meet, but we hope that you will pleased with our resulting system.

System

A minimum Digital Group microprocessor system consists of three P. C. boards (CPU, I/O, and CRT Readout & Cassette) and a mother board to provide the necessary interconnections. Additional PC boards are, or will soon be, available to provide additional storage, storage display, I/O, and I/O related functions.

A power supply provides ±12V at 1 amp, -5V @ 1 amp and +5 volts at the needed current. A cabinet houses the system and connectors provide convenient interfaces to external devices.

TV monitors, ASCII keyboard, and a Cassette recorder provide the required minimum I/O. This general guide to system architecture should enable you or a helper to successfully complete a Digital Group System with a minimum of difficulty.

Construction of PC Boards

So you've got sacks of parts. Now what? First, analyze your own abilities. While we have tried to simplify construction as much as possible, and your responses will help future builders, a certain minimum level of expertise is obviously required. That's one reason why assembled and tested PC boards were advertised. If you find that a kit is just too much for you, arrange for a friend to help you, or contact the Digital Group to arrange an exchange for an assembled unit. We want you to succeed, one way or the other!

The various kits have different levels of expertise required for successful construction. We would recommend that you begin construction with the I/O board. You will find construction fairly open and easy. Wire the jumpers and IC's so that the board is set up for decoding Ports Ø, 1, 2, and 3.

The next board to construct is the CRT Readout/Cassette Interface board. The Cassette Interface section is rather open and easy to solder, but more involved to align. The CRT Readout requires a considerable amount of fine soldering work, so be careful. Be sure to carefully align the Cassette Interface section. Final alignment of the VCO section is accomplished under microprocessor control.

The 8K memory board should be built next if you have ordered one. (You get the idea that you're sneaking up on the CPU card, don't you!) Initially set up the jumpers on the memory board for ØK - 8K range but leave off the lowest order 16 2102's (IC00 - IC17). This will facilitate later memory testing.

Build the CPU card with great care. Initially assign the 2K RAM to the lower 2K of memory.

Cabinet Construction

The cabinet chosen for your Digital Group system is up to your personal desires. Some possible options:

a. A microprocessor only box.
b. A microprocessor and TV set cabinet.
c. A microprocessor and TV set with attached keyboard.
d. Microprocessor as a part of a much larger system.

A discussion of cabinet designs utilized for some Digital Group Standard Motherboard with 26K of memory systems may serve as a guide to those designing their own systems.

A Moduline MCP 7-17-12 @ $30.56 was used for the basic cabinet. This unit looks good, is sturdy, and is fairly reasonable. The measurements are 7" high, 17" wide, and 12" deep. Colors used were blue in one case, tan in another. Moduline cabinets are also available in grey or black. Other slightly larger cases are also available An 8" x 17" x 14" model @ $35.60 gives more room, but seems a bit bulky. For a brochure and local availability, write to:

Insta Fab, Inc.
425 Queens Lane
San Jose, CA 95112
(408) 286-5596

The system pictured in the Digital Group's Flyer #5 showed the 26K Blue system. This system had the +5 @ 12 amp OEM supply mounted on the outside of the rear wall of the cabinet to eliminate a major source of heat from the inside of the cabinet. The ±12V and -5V low-current supplies were mounted inside the cabinet at the left of the system's boards. A flat fan was mounted on the right side near the front, and an exhaust hole was placed on the left. This provides a good flow of air past the memories and CPU card.

The Standard motherboard was mounted upon an 1/8" thick aluminum plate, with a portion cutout to clear the Standard motherboard's connectors and lines. The front memoryboard is spaced about 1" from the front panel. The 1/8" aluminum plate was attached to the sides of the cabinet using some 1/2" angle aluminum available from most hardware stores. The various Power and Reset/Start switches were then wired as well as the power supplies to the appropriate motherboard terminal. Lines may be either soldered to the motherboard terminals, or lugs may be used, but be careful of shorts.

A connector block from an old surplus 2nd generation computer was used with the blue system to provide a ready means of disconnecting and changing external I/O. A 17 or more parallel pin connector block for each port is advisable to provide an 8 bit in, 8 bit out, plus common ground connection per port capability. The tan system used the Molex connectors shown in the Digital Group Flyer #5, and the flat cable lead to external devices was brought directly out through a 1" grommetted hole at the rear.

A BNC connector and two miniature phone jacks are mounted on the rear wall to provide a convenient means of connecting the TV monitor and cassette record/playback.

The power cord is a 3-wire grounded type with the metal chassis grounded.

TV Monitor

The TV monitor used with the Digital Group systems may be either a TV specially designed for use as a monitor, or it may be a converted TV set.

The commercial monitor will generally give the highest quality picture. Some monitors may be overloaded by the Digital Group's CRT Readout. The ≈3V of video output can be easily reduced by placing a 10 ohm resistor across the video output cable near the TV.

Byte magazine, October, 1975 p. 20 gives a good description of converting an old B&W TV set to a monitor. 6MHz or greater bandwidth is highly desirable. Avoid non-transformer operated sets! Small screen transistor sets frequently have very poor quality, especially in corner focus. Older transformer operated tube portables, although bulky, seem to give the best pictures.

Cassette

The cassette recorder can range from a $20 El Cheapo to a $300 Hi Fi wonder. However, we would recommend a well-constructed portable in the $100 range as being the best choice. Our preferred recorder is a Superscope C104 @ $120 list, but generally available for $100. Several desirable features to look for are:

a. Steady tone! (low "wow" and Flutter.)
b. Low noise - freedom from buzzes, crackling & harmonics of tones.)
c. Index counter.
d. Battery or AC operation.

e. Built-in speaker & Amp. (audible monitor of data start & stop).
f. Variable playback speed. (useful for matching data tapes from friends using out of speed tolerance tapes.)

The C104 has all of the above characteristics, and has been a good, troublefree unit. A 3KHz tone was recorded on an expensive "Hi Fi" cassette with very good speed characteristics. The cassette was then played on several recorders at the department store and the best recorder purchased. I got a few strange looks initially, but after explaining my intentions, further questioning by the curious was prudently surpressed.

The recorder's earphone jack should be modified so that insertion of a miniature phone plug cable will not disconnect the speaker (see pictoral).

What cassette tapes to use is another rather general area. Don't waste your money on "cheap" tapes. Rather extensive testing at data rates several times faster than the 1100 baud of the Digital Group Group Systems has resulted in the following recommendations:

Good: Memorex MRX2
Maxell UD

Fair: Sony Low-Noise
Realistic Low-Noise High-Frequency

Poor: Realistic Supertape
Radio Shack Concertape
TDK (low-cost types)

Other experimentation has shown that the better grades of TDK are equivalent in tape quality to the Sony low-noise, but with superior mechanics for an improved speed stability. The tape most frequently has its errors at the beginning of the tape. About 1 in 100 Sony tapes from several batches would exhibit errors caused by a fold on the tape caused by improper factory handling. Letting about 1/2 minute of tape at the beginning of a cassette go unused generally made poor tapes function fine. Some tapes had poor quality control on the pressure pad plate. Since even a 32K program would occupy only about 5 minutes of tape, 30 minute tapes are the best value. I typically have a cassette dedicated to a single program, and can go from program to program with a minimum of searching.

Be sure to rewind the tape before removing the cassette from the recorder. This will prevent damaging the data area of the tape by handling. Always "backup" your programs on a master tape in case of accidental damage to the working cassette. Several months of programming effort can be stored sequentially on one 30 - 60 minute tape.

Keyboard

An ASCII keyboard attached to Input Port Ø is used as the normal input medium to the Digital Group Microprocessor Systems. Surplus ASCII keyboards can provide a low-cost means of data entry, but can be a very risky alternative due to quality problems. The keyboard chosen should have the standard ASCII coded output, preferably with both Upper and Lower case capability, positive logic output, with a delayed keypressed strobe pulse. Some keyboards have extremely bad bounce problems and no strobed pulse. The early SWTP kit keyboard was of this calibre, and you would waste your time on this product. The latest SWTP kit may be better.

Assembling the System

Tools: Soldering iron, diagonal cutters, pliers, screwdrivers, drill, metal sabresaw, hole punches.

Test Equipment: Volt/Ohmeter, Oscilloscope, Frequency Counter

Estimated Construction Time: 2 days

1. Insert the two 22-pin duals, 36 pin dual, and the 50-pin dual connectors into the motherboard from the topside. (The top is indicated by the side where the Digital Group label is printed near the TV 22-pin dual connector). Be sure that the tops of the connectors are at an even height. Some brands of connectors have spacers at the connector bottom, others do not. Use temporary spacers until soldered.

2. After insuring equal height and no warp or twist, invert the board and solder the pins.

3. Mount the motherboard onto the bedplate, avoiding any shorts.

4. Temporarily mount the bedplate to the sides of the cabinet. Allow about 1" of clearence between the bottom of the motherboard and any metal cabinet bottom. This will permit using the Molex connectors if desired. Be sure that the cabinet cover will still clear the tops of the boards. Be sure to space the motherboard on the panel so that there is about 1" of space between the front memory board and the front panel. Mark the level where the top of the bedplate contacts the sides, front, and back of the cabinet. Remove the bedplate.

5. Drill the cabinet holes required for fans, ventilation, switches, jacks, power supply, cable leads, and connector block if used.

6. Mount the low-current supplies of ±12V @1A and -5V @1A on the bedplate. Be sure to leave clearence room for the power and reset switches, PC boards, and I/O cables and connector block.

7. Bolt the bedplate to the cabinet.

8. Mount the 5V power supply, fan, switches, jacks, power cord, and I/O connector block.

9. Connect the switches, etc. to the motherboard using the supplied pictoral.

10. Connect the power cord to the power switch, fan, fuse, and power supply.

11. Measure the power supply outputs and power cord to insure that no shorts exist. Turn on the power supply (no boards in yet, of course) and check for the following voltages at the CPU connector:

Pin 1	= +5	(between +5.5 and 5.0)
Pin 2	= Ground	
Pin 4	= -5	(between -4.75 and -5.25)
Pin 49	= +12	(between +12.5 and +11.5)
Pin 50	= -12	(between -12.5 and -11.5)

Turn off power after verifying proper power supply voltages.

12. Insert the TV Readout board. Temporarily short pin 1 to ground. Connect a TV Monitor to the BNC connector. Turning on the the power should now result in a stable display of 512 characters on the TV screen. Connect the cassette read jack on the cabinet to the earphone output of your recorder via a shielded cable. Playing data from the Operating System cassette supplied should result in an ≈5V peak to peak data signal on the cathode or bar end of G1 on the cassette interface section of the CRT/ Cassette Interface board. Attaching an oscilloscope to the output **of the cassette interface card** should see an ≈1V p-p signal. Putting this output into the cassette mike jack or AUX input should give a capability of recording the tone on a fresh cassette.

13. Plug in the I/O board and the CPU board. Be sure that the I/O board is jumpered to decode Ports 0-3. The CPU must be jumpered to assign its RAM as the bottom 2K of memory.

14. Turn on the system. The screen should now display the Initialize message. In case of trouble, refer to the CPU documentation.

15. Place the **operating system** cassette in the recorder. When the tone begins, press reset, and the system should begin loading data, finally resulting in the Option List. At this point, your system's software descriptions will enable you to use your Digital Group system.

DIGITAL GROUP SYSTEMS PARTS LIST

CPU board
I/O board (assigned to Ports 0-3) others optional
CRT/Cassette Interface board
Optional- 8K memory boards
Motherboard-Minimother, Standard mother
Cabinet
Power supplies: (all should be current limiting and over-voltage prot.)

- +5 volt supply (6 Amp min for 10K or less system.)
  (12 Amp min for 32K or less system.)
  (18 Amp min for 64K.)
- +12 volt supply (.1 amp to 1 amp depending on I/O accessories)
- -12 volt supply (")
- -5 volt supply (" - may not be needed at all with 6501 or 6800 based systems)

TV Monitor - 6Mhz or better bandwidth desireable
Cassette Recorder - Better quality portable with low noise; stable.
ASCII Keyboard - Positive logic, delayed keypressed strobe.
Misc supplies:

- 1/8" thick aluminum sheet for motherboard's bedplate.
- 3 wire grounded power cord.
- Fuse & fuse holder (rating depends on systems size.)
- Power switch & power on indicator.
- Video connector (BNC type UG290U)
- 2 Miniature phone jacks
- I/O port rear mount connectors (optional)
- Fan - flat pancake style (optional)
- 3' strip of 1/2" angle aluminum
- Misc. mounting hardware
- Misc. wire - Heavy guage for +5, lighter for other supplies, shielded cable for video and cassette leads, and ribbon cable for I/O ports.
- 2 6' shielded cables with miniature phone plugs on each end.
- TV cable - BNC type connectors on coaxial cable
- Supply of 1/2" rubber grommets
- Reset switch (normally open push switch)

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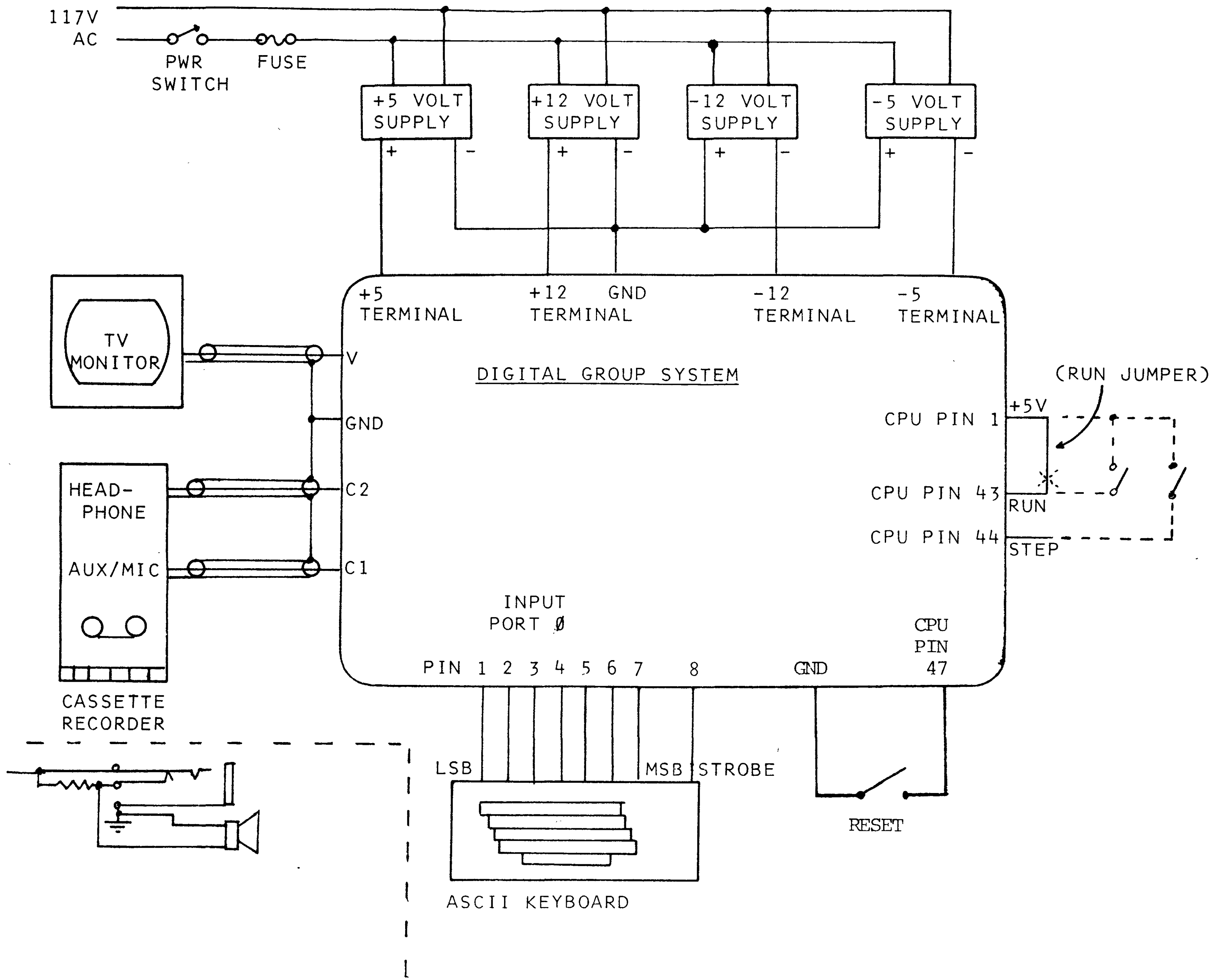
117V
AC
PWR
SWITCH
FUSE
+5 VOLT
SUPPLY
+12 VOLT
SUPPLY
-12 VOLT
SUPPLY
-5 VOLT
SUPPLY
+
-
+5
TERMINAL
+12
TERMINAL
GND
-12
TERMINAL
-5
TERMINAL
TV
MONITOR
V
GND
HEAD-
PHONE
AUX/MIC
C2
C1
CASSETTE
RECORDER
DIGITAL GROUP SYSTEM
(RUN JUMPER)
+5V
CPU PIN 1
CPU PIN 43
RUN
CPU PIN 44
STEP
INPUT
PORT Ø
PIN 1 2 3 4 5 6 7 8
GND
CPU
PIN
47
LSB
MSB
STROBE
ASCII KEYBOARD
RESET

CPU CARD

CPU Ref Number	Pin No.	Description	CPU Ref Number	Pin No.	Description
1	1	+5V	51	A	+5V
2	2	Ground	52	B	Ground
3	3	Spare Voltage	53	C	Spare Voltage
4	4	-5V	54	D	-5V
5	5	MSB	55	E	MSB
6	6	MSB-1	56	F	MSB-1
7	7	MSB-2	57	H	MSB-2
8	8	MSB-3 Data from	58	J	MSB-3 Data from
9	9	LSB+3 Memory	59	K	LSB+3 I/O
10	10	LSB+2	60	L	LSB+2
11	11	LSB+1	61	M	LSB+1
12	12	LSB	62	N	LSB
13	13	MSB	63	P	MSB
14	14	MSB-1	64	R	MSB-1
15	15	MSB-2	65	S	MSB-2
16	16	MSB-3 Data to	66	T	MSB-3 Data to
17	17	LSB+3 Memory	67	U	LSB+3 I/O
18	18	LSB+2	68	V	LSB+2
19	19	LSB+1	69	W	LSB+1
20	20	LSB	70	X	LSB
21	21	Mem Read Data Strb	71	Y	I/O Input Strobe
22	22	LSB	72	Z	LSB
23	23	LSB+1	73	AA	LSB+1
24	24	LSB+2	74	AB	LSB+2
25	25	LSB+3	75	AC	LSB+3
26	26	LSB+4	76	AD	LSB+4
27	27	LSB+5	77	AE	LSB+5
28	28	LSB+6	78	AF	LSB+6
29	29	LSB+7 Memory	79	AH	LSB+7 Port
30	30	MSB-7 Address	80	AJ	MSB-7 Address
31	31	MSB-6 Lines	81	AK	MSB-6 Lines
32	32	MSB-5	82	AL	MSB-5
33	33	MSB-4	83	AM	MSB-4
34	34	MSB-3	84	AN	MSB-3
35	35	MSB-2	85	AP	MSB-2
36	36	MSB-1	86	AR	MSB-1
37	37	MSB	87	AS	MSB
38	38	Mem Write Data Strb	88	AT	I/O Output Strobe
39	39	Cycle Steal	89	AU	IRQ
40	40	DMA Request	90	AV	Data to Cass. Int.
41	41	DMA Grant	91	AW	I/O Output Port 1 Bit Ø
42	42	Interrupt Request	92	AX	Data from Cass. Int.
43	43	Run	93	AY	I/O Input Port 1 Bit Ø
44	44	Step	94	AZ	NMI
45	45	Wait Request	95	BA	CPU-I/O undefined
46	46	CPU-Mem undefined	96	BB	CPU-I/O undefined
47	47	Reset	97	BC	Spare
48	48	ROM	98	BD	VMA
49	49	+12V	99	BE	+12V
50	50	-12V	100	BF	-12V

MEMORY BUS

CPU Ref Number	Pin No.	Description	CPU Ref Number	Pin No.	Description
1	1	+5V	3	A	Spare Voltage
2	2	Ground	4	B	-5V
5	3	MSB	13	C	MSB
6	4	MSB-1	14	D	MSB-1
7	5	MSB-2	15	E	MSB-2
8	6	MSB-3 Data to	16	F	MSB-3 Data from
9	7	LSB+3 CPU	17	H	LSB+3 CPU
10	8	LSB+2	18	J	LSB+2
11	9	LSB+1	19	K	LSB+1
12	10	LSB	20	L	LSB
21	11	Mem Read Data Strb		M	Spare
30	12	MSB-7	22	N	LSB
31	13	MSB-6	23	P	LSB+1
32	14	MSB-5 Memory Addr	24	R	LSB+2 Memory Addr
33	15	MSB-4 Lines	25	S	LSB+3 Lines
34	16	MSB-3	26	T	LSB+4
35	17	MSB-2	27	U	LSB+5
36	18	MSB-1	28	V	LSB+6
37	19	MSB	29	W	LSB+7
	20	Spare	38	X	Mem. Write Data Strobe
39	21	Cycle Steal		Y	Spare
40	22	DMA Request	41	Z	DMA Grant
42	23	Interrupt Request		$\overline{A}$	Spare
43	24	Run	44	$\overline{B}$	Step
	25	Spare		$\overline{C}$	Spare
	26	Spare		$\overline{D}$	Spare
45	27	Wait Request	46	$\overline{E}$	CPU-Mem Undefined
47	28	Reset	89	$\overline{F}$	IRQ
48	29	ROM	94	$\overline{H}$	NMI
98	30	VMA		$\overline{J}$	Spare
	31	Spare		$\overline{K}$	Spare
	32	Spare		$\overline{L}$	Spare
	33	Spare		$\overline{M}$	Spare
	34	Spare		$\overline{N}$	Spare
	35	Spare	48	$\overline{P}$	Spare
49	36	+12V	50	$\overline{R}$	-12V

INPUT/OUTPUT BUS

Top of Card - Component side			Bottom of Card - Pin side		
CPU Ref Number	Pin No.	Description	CPU Ref Number	Pin No.	Description
51	1	+5V	53	A	+5V
52	2	Ground	54	B	-5V
55	3	MSB	63	C	MSB
56	4	MSB-1	64	D	MSB-1
57	5	MSB-2	65	E	MSB-2
58	6	MSB-3 Data to	66	F	MSB-3 Data from
59	7	LSB+3 CPU	67	H	LSB+3 CPU
60	8	LSB+2	68	J	LSB+2
61	9	LSB+1	69	K	LSB+1
62	10	LSB	70	L	LSB
71	11	Input Strobe		M	Spare
80	12	MSB-7	72	N	LSB
81	13	MSB-6	73	P	LSB+1
82	14	MSB-5 Port	74	R	LSB+2 Port
83	15	MSB-4 Address	75	S	LSB+3 Address
84	16	MSB-3 Lines	76	T	LSB+4 Lines
85	17	MSB-2	77	U	LSB+5
86	18	MSB-1	78	V	LSB+6
87	19	MSB	79	W	LSB+7
94	20	NMI	88	X	Output Strobe
95	21	CPU-I/O undefined	96	Y	CPU-I/O undefined
99	22	+12V	100	Z	-12V

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INPUT/OUTPUT PORT CONNECTIONS

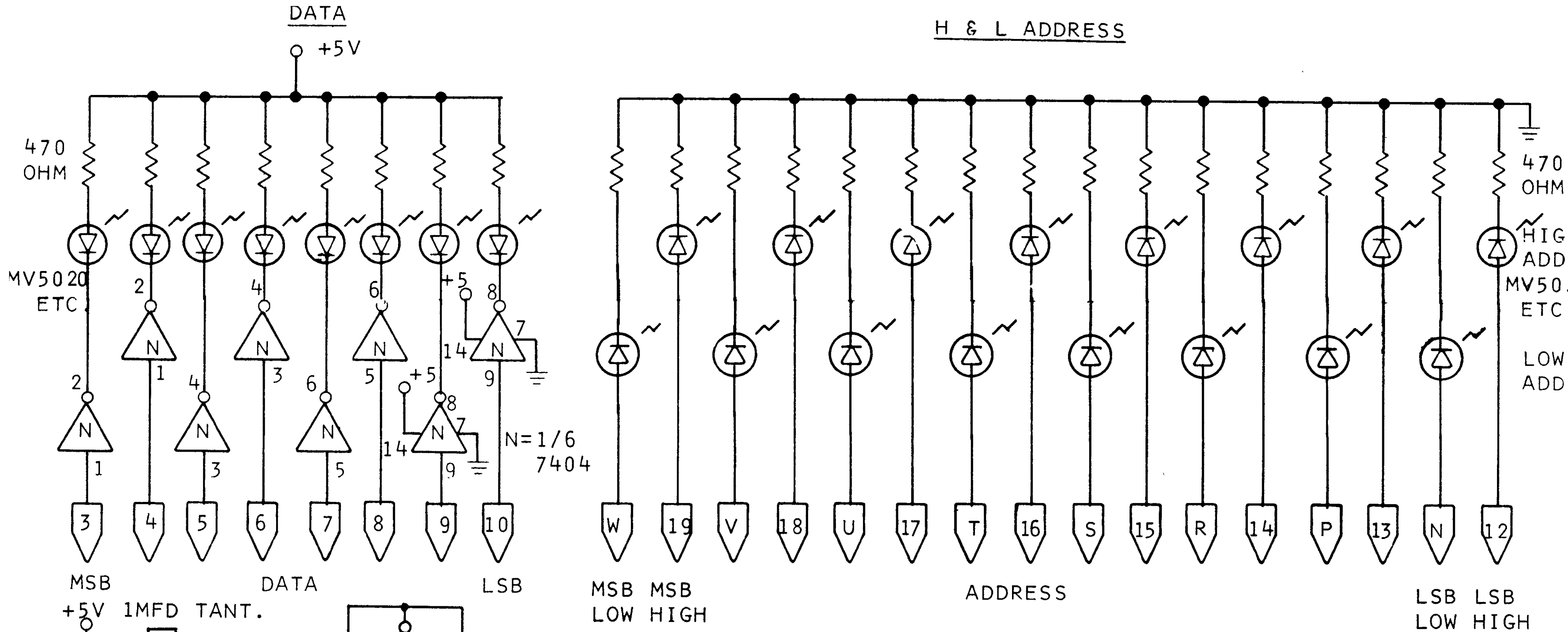
Top of Card - Component side				Bottom of Card - Circuit side			
Pin No.	Description	bit		Pin No.	Description	bit	
1	LSB	Ø		A	LSB	Ø	
2	LSB+1	1		B	LSB+1	1	
3	LSB+2	2		C	LSB+2	2	
4	LSB+3	3	Input	D	LSB+3	3	Output
5	MSB-3	4	Port Ø,4,8,...	E	MSB-3	4	Port Ø,4,8,...
6	MSB-2	5		F	MSB-2	5	
7	MSB-1	6		H	MSB-1	6	
8	MSB	7		J	MSB	7	
9	n/c			K	n/c		
10	LSB	Ø		L	LSB	Ø	
11	LSB+1	1		M	LSB+1	1	
12	LSB+2	2		N	LSB+2	2	
13	LSB+3	3	Input	P	LSB+3	3	Output
14	MSB-3	4	Port 1,5,9,...	R	MSB-3	4	Port 1,5,9,...
15	MSB-2	5		S	MSB-2	5	
16	MSB-1	6		T	MSB-1	6	
17	MSB	7		U	MSB	7	
18	n/c			V	n/c		
19	LSB	Ø		W	LSB	Ø	
20	LSB+1	1		X	LSB+1	1	
21	LSB+2	2		Y	LSB+2	2	
22	LSB+3	3	Input	Z	LSB+3	3	Output
23	MSB-3	4	Port 2,6,10,...	$\overline{A}$	MSB-3	4	Port 2,6,10,...
24	MSB-2	5		$\overline{B}$	MSB-2	5	
25	MSB-1	6		$\overline{C}$	MSB-1	6	
26	MSB	7		$\overline{D}$	MSB	7	
27	n/c			$\overline{E}$	n/c		
28	LSB	Ø		$\overline{F}$	LSB	Ø	
29	LSB+1	1		$\overline{H}$	LSB+1	1	
30	LSB+2	2		$\overline{J}$	LSB+2	2	
31	LSB+3	3	Input	$\overline{K}$	LSB+3	3	Output
32	MSB-3	4	Port 3,7,11,..	$\overline{L}$	MSB-3	4	Port 3,7,11,...
33	MSB-2	5		$\overline{M}$	MSB-2	5	
34	MSB-1	6		$\overline{N}$	MSB-1	6	
35	MSB	7		$\overline{P}$	MSB	7	
36	n/c			$\overline{R}$	n/c		

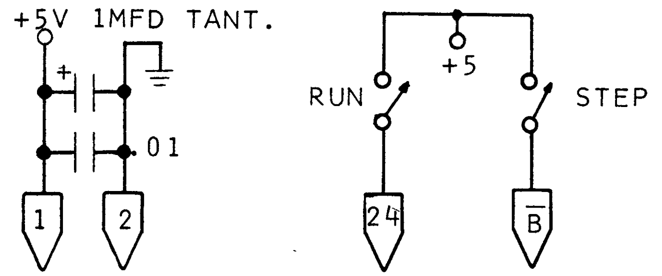
Note: MSB = Most Significant Bit
LSB = Least Significant Bit
n/c = no connection

TV READOUT & CASSETTE

Top of Card - Component side

CPU Ref Number	Pin No.	Description
	1	MSB
	2	MSB-1
	3	MSB-2
	4	MSB-3 Data (connected to
	5	LSB+3 In Output Port Ø)
	6	LSB+2
	7	LSB+1
	8	LSB
	9	Cassette Recorder Output
	10	Cassette Recorder Input
	11	n/c
	12	n/c
	13	n/c
	14	n/c
	15	n/c
	16	Video Out
92	17	Data to CPU
90	18	Data from CPU
	19	+5V
	20	Ground
	21	+12V
	22	-12V





NOTE: ARRANGE ABOVE LED'S IN TWO ROWS OR GROUPS - ONE FOR HIGH ADDRESS (CONNECTED TO NUMBERED PINS), ONE FOR LOW ADDRESS (CONNECTED TO LETTERED PINS).

1. PLUGS INTO ANY MEMORY SLOT OR MAY BE PERMANENT
2. MAY BE BUILT ON A 22-PIN DUAL READOUT CARD IF CAREFULLY INSERTED SO THAT CARD IS AT FAR LEFT AS VIEWED FROM FRONT. (RADIO SHACK BOARD #276-152 @ $2.49 IS ADEQUATE.)
3. TEST 8080, 6501, & 6502 SYSTEMS BY HALTING CPU, THEN SINGLE STEPPING AFTER PRESSING RESET. 6800 WILL NOT SINGLE STEP WITH THIS READOUT. 6800 GOES TRI-STATE WHEN READY LINE IS LOW.
4. THE "STEP" AND "RUN" FUNCTION OF THE CPU MAY BE INCLUDED ON THE CARD IF A 24-36 PIN DUAL CARD IS USED. CONNECT A "RUN" NORMALLY OPEN "PUSH SWITCH" BETWEEN +5 AND PIN 24. CONNECT A "STEP" NORMALLY OPEN "PUSH SWITCH" BETWEEN +5 AND PIN B. DISCONNECT ANY "RUN" TIEUP WIRES IF USED.

DIGITAL GROUP CPU TEST BOARD

READS BINARY OF DATA & ADDRESSES USED FOR TROUBLESHOOTING CPU CARDS

12/7/75 DR. ROBERT SUDING

DGS-14-R0

DIGITAL GROUP Z-80 CPU CARD

The CPU Card is the central component of the Digital Group Microprocessor Systems. Each CPU Card contains the CPU IC, in this case a Z-80 by Zilog or Mostek, 2K bytes of RAM, a 256 byte Erasable Read Only Memory (EROM), and miscellaneous drivers, decoders, and gates.

The Digital Group Z-80 CPU Card also contains special interrupt, processing hardware to aid in the utilization of the extended interrupt capabilities of the Z-80.

Full Direct Memory Access (DMA) is standard on this Digital Group card. DMA capability provides a convenient means for attaching a front panel for direct data loading into memory from switches. High speed data storage devices such as disks can directly load memory by operating its interface under DMA. Parallel processors can use the same memory shared under DMA.

Buffering is included on this board to permit driving a full memory system (65K bytes) and up to 256 I/O ports. Miscellaneous logical CPU functions such as Power On Reset and Single Stepping are provided.

The Digital Group System Architecture is based on CPU independence design constraint. This means that the same set of hardware I/O and memory related components may be driven by a number of different CPU and CPU structures. The user may upgrade or benchmark systems by merely exchanging CPU cards. All CPU dependencies are handled on the CPU Card. A bus structure giving a separate I/O bus and memory bus provides support for several current microprocessor architectures, and future designs.

Since the Digital Group Systems are I/O and application intensive designs, the EROM provides a convenient way to initialize the system at power on, by using a low cost cassette. Use of an EROM allows customized initialization by sophisticated users able to program their own EROMS. EROM deselecting circuitry is included which permits full use of "Ø page" RAM for non-Digital Group software use.

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2K bytes of Random Access Memory (RAM) give sufficient storage for a small operating system allowing the user to Read and Write cassettes, and Key in data and Programming from an ASCII keyboard and Dump Storage contents on an attached TV monitor. A small amount of storage is available to the user for small dedicated programs, or additional memory is available from the Digital Group to support more extensive applications.

Z-80 CPU Description

The Digital Group Z-80 CPU card may be logically divided into six interrelated design groups. They are the CPU and immediate "housekeeping" logic, Run Control, DMA, Interrupt, Buffering, and Memory. The CPU and immediate housekeeping consists of the Z-80, a 7400 single phase crystal controlled clock generator, and Read/Write and Memory or I/O decoders.

A Power On Reset function is provided by IC38, the 4010. An external switch is also attached to the circuitry for a remote "reset and go" operation.

A 7442 (IC48) decodes memory reading and writing at the proper time, Input port reading, and Output port writing.

Run Control logic permits single stepping through a program if a front panel readout is provided for viewing the resulting instruction sequencing. In addition, Wait Stating for slow external memory and the EROM access delay is provided. The Wait line input of the Z-80 is utilized for Run input. A feature of this Z-80 card is the ability to jumper select either "Single Step" or "Step on Instruction". The jumpering for "Single Step" permits stepping in the same manner as the 8080. "Step on Instruction" will display only the first byte of each single or multibyte instruction. Normal CPU running mode is unaffected by which stepping mode is selected.

2/4 of a 7402 (IC28) are used as a Run latch. When the step switch is activated, the Run latch is reset, and the 1/2 74123 (IC37) fires a 50 ms pulse to debounce the switch. The resultant pulse is held in the 1/2 7474 (IC29) for a very short time until synchronized by the Z-80 and acknowledged through 1/2 74123 (IC37). The 1/4 7402 (IC28) OR gate couples either the Continuous Run or the Step pulse. The fourth section of IC28 will then drop the Ready line if either no run command, continuous or step, exists or a "Wait" command goes high.

If no "Single Step" Operation is to be used, tie pin 43 to +5 externally.

DMA consists of sections of IC's 44, 29, and 49. DMA is designed as an external request for control of memory and the granting of this request as soon as the CPU can safely grant the request without current data loss. A DMA request is entered whenever either pin 8 or 9 of IC44 goes high. This will set a latch (IC29), bringing down the Z-80's Bus Request line. When the Z-80 is finished with any needed housekeeping, it issues the Bus Acknowledge signal, granting the request. Further Z-80 operations are suspended and the various buffers (IC's 31,32,33, 41,42, and 47) go to a high impedence state, and the external circuitry making the request is allowed full control over memory.

DMA Request and Grant is ended by any of three methods. A reset operation will always end any current DMA operation. A jumper at pin 9 of IC29 allows selecting one of the other two DMA ending operations. If the jumper is connected from pin 9 to pin 10 of IC29, the the DMA operation will be ended whenever both DMA Request lines return low. If the jumper is connected from pin 9 to the line labeled DMA End, then a latched DMA operation results. One or more positive going pulses at either DMA Request line will initiate DMA. One or more positive going pulses at the DMA End line will end the DMA.

The Z-80 has extended interrupt processing capabilities, and sufficient hardware is included on the Digital Group Z-80 board to support the three Z-80 interrupt modes. Mode Ø is the same as the 8080A, generally considered as the eight Restart instructions which are placed on the data bus upon an interrupt acknowledge signal from the CPU. Mode 1 is an automatic interrupt to address 000070. Mode 2 is an extremely powerful vectored interrupt system new with the Z-80. A new register, called the I Register, is used as a high page address pointer. When an interrupt is encountered and acknowledged, the data placed on the data bus becomes the low address pointer. Another interrupt system provided by the Z-80 is called Non-Maskable Interrupt (NMI). This interrupt will occur anytime the Z-80's pin 17 is brought low.

Sections of IC's 50, 44 and IC's 36,35,34, and 27 provide the needed interrupt processing interfaces. The 74125s' (ICs' 34 and 35) provide tri-state buffering for the interrupt address vectoring required by Z-80 interrupt Modes Ø and 2. The 7442 (IC27) produces an interrupt honored acknowledgement signal (if required) for use in Mode Ø. The INT input at the Z-80 pin 16 will be forced low whenever any interrupt input, except NMI, is brought low.

The Digital Group CPUs are designed to drive full complement of memory and I/O. In addition, the CPUs are designed to operate under Direct Memory Access as mentioned previously, and tri-state buffers permit isolating the CPU from the attached and auxiliary memory.

2 4/6 8T97's provide buffered address outputs from the Z-80 CPU, capable of each driving 30 TTL loads. These drivers handle both memory and I/O port addressing. DMA Grant is connected to these drivers so that when a DMA is in process, the external device

is given full control of the address lines as the drivers go high impedence.

1 2/6 8T97 provides a buffered I/O data output to as many as 7 Digital Group I/O boards (28 ports) without further buffering.

Data In to the CPU is placed on the Internal Bi-directional bus by 2 types of IC's. A pair of 74125's provides a TRI-STATE non-inversion buffering of memory data to the CPU. A pair of 7403's result in a pseudo tri-state inverting operation on I/O data being inputted from the Digital Group I/O board input ports. Notice that the pin connections and operation other than polarities for 74125's and 7403's are identical. If you should not use Digital Group boards for I/O, then use 74126's in place of the 7403's for data non-inversion with a positive I/O READ Strobe.

Memory on the Z-80 CPU card is of two types, EROM and RAM. The EROM is a single IC preprogrammed by the Digital Group to simplify system operation. When power is applied to the system, a "power on reset" function results, which starts up the processor running at address 000 000. IC's 29 and 25 decode the lowest 256 bytes of memory, resulting in a ROM Chip Enable condition. The EROM proceeds through its programming to clear the screen, display a message, initialize some RAM addresses, and control initial cassette reading.

2K of RAM allows an extensive operating system to be entered from cassette. 16 2102's are arranged as 2 banks of 8 IC's. Which of the 2 banks selected (if either) is a function of IC's 23, 24, and 25, as well as the three jumper settings. The 7442 will assign the 2 banks of 2102's as the bottom 2K of 8 - 8K memory allocations.

The 3 jumpers permit assigning the CPU's 2K RAM to addresses other than the bottom 2K (addresses 000 000 - 007 377). When a user wishes to add one or more Digital Group 8K boards to his system, he may move the CPU's 2K to fall above the lastmost address of his highest supplemental 8K board. Example: A user has two Digital Group 8K memory boards on his system. By assigning the CPU's 2K to the address range of 16K - 18K, one memory board to 0 - 8K, and the other to 8k - 16K, an 18K system results.

Alternatively, the bottom 2K of memory on the 0 - 8K board could be omitted and the CPU jumpers arranged for 0 - 2K assignment. However, this example would be a 16K system.

The EROM is a relatively slow device, so the CPU must be forced to wait for its data access. A 74121 provides a 475 nanosecond delaying pulse to the CPU when either the CPU EROM is accessed or an external slow memory access is required. Since the Digital Group RAM's are 500 ns access time or faster static RAM's, the

CPU normally runs at full speed.

Construction

Tools: Very fine tipped, low wattage soldering iron, "wire solder" (around 20 guage resin solder), small diagonal cutters.

Test Equipment: Ohmeter
Voltmeter (Digital Preferred)
20 MHz or better triggered sweep oscilloscope
Front panel in case of trouble

Estimated Construction Time: 5 - 15 Hours

WARNING: The CPU card represents the heart of the computer! Expensive components are used and troubleshooting can be a very challenging operation. A rushed, sloppy job will most likely repay the constructor with long and continuous hours of frustration with very misleading symptoms.

The majority of prototype and field test 8080 CPU boards worked the first time they were plugged in. Almost every initial failure has been traced to carelessness.

1. Insert the 40-pin and 24-pin sockets and solder. If the sockets have a keyway indication, orient this away from the connector. Note: the top side of the board is indicated by the Digital Group label.

2. Insert the 14 and 16 pin sockets. Be careful not to confuse a 16-pin socket position for a 14-pin. A special plating process was specified by the Digital Group to minimize solder joint troubles and discourage solder bridges. Carefully invert the board while holding a flat object against the top of the sockets to prevent falling out. Solder all sockets. We would suggest a "warmup area" by starting with sockets above the crystal which have more open lines.

3. Insert and solder the 47 ohm 1/2 watt resistor and 9V zener diode beneath the 24-pin socket. Note orientation of the zener's bar end towards the right. Space the zener's leads away from top side of board to prevent shorting the leads under the zener, and allow better heat disapation.

4. Insert and solder the 100 pfd capacitor. Be careful of leads running under the capacitor's body.

5. Insert and solder the 22 mfd capacitors. Note that the + polarity indication is towards the right. Avoid shorting any underlying leads.

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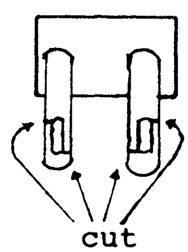
6. Insert the two 4.7K resistors.
   Insert the two 470 ohm resistors.
   Insert the two 2.2M resistors.
   Insert the 22K resistor.
   Insert the 390 ohm resistor.
   Insert the 220 ohm resistor.
   Insert the 100K resistor.
   Insert the 4.3K resistor.

7. Insert the silicon diode. Note the bar is towards the right. Space leads up to avoid shorting leads underneath.

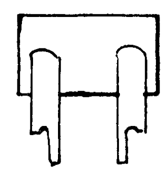
8. A large number of holes for noise supressing bypasses have been provided, not all of which are necessary. Large memory systems (over16K) are more noise sensitive than small systems, and require more bypassing. Insert and solder .01's as shown. Be careful not to mistake a plated through feedthrough hole (smaller) for a bypass hole. One side of every bypass is connected to ground bus (pin 2) if in doubt. Insert and solder the three tantalum bypasses. Note that the positive (+) end of the dipped tantalum capacitors is indicated either by a vertical marking (paint stripe) along one side, or a plus sign.

9. Trim the crystal socket's pins as shown to fit into the crystal holes.

Pin view:



Result:



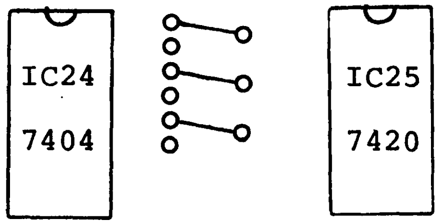
   Press the rear tab into the board hole provided for it. Solder the pins and the rear tab.

   The socket provides a space-saving flat mount as well as avoids soldering to the heat-sensitive crystal.

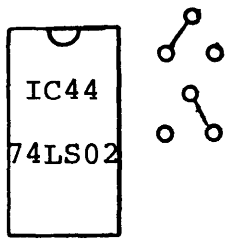
10. Insert and solder the 8-pin flat 470 ohm resistor pack. Note that the end with the dot (common pin end) is oriented away from the connector.

11. Plug in the four 16-pin 2.2K resistor packs. Note that the orientation of the dot or keyway is <u>away</u> from the connector. This places the common lead of the R-pack on the #16 pin lead to +5 respectively.

12. Form the three jumpers from resistor tails or similar wire. Insert to jumper as the lower 2K of the lowest 8K. This permits initial testing without a supplemental memory. The jumpers' orientation should be:



Form two more jumpers which will be used for DMA and Single Stepping. Insert these to the right of IC44 as shown below.



(DMA mode select) shown @ "Latching DMA"

(Step mode select) shown @ "single step"

13. OK, now for a little ohmeter testing. Check for a short between pins 1&2; 2&50; and 1&50. 1&2 should show an initial momentary low resistance and then approach infinity as the bypassing tantalum condenser charges. 2&50 will show some **resistance** due to the zener, and ohmeter polarity, but not a short.

14. Two techniques are possible at this point. One way (referred to in fine literature as the "smoke test") is to plug in all IC's and insert card. Another way is to insert only one or two IC's - function by function - and test as you go. The Digital Group has found a compromise seems to work best, namely, to plug in all but most critical and/or expensive IC's, then test. Then if ok so far, plug them in and go ahead.

15. Insert all IC's <u>except</u> Z-80, 1702A, and 2102's. Note that all IC's except 2102's have their keyway or dot indicating the pin 1 end oriented away from the connector.

16. Measure the resistance at the pins mentioned in step 13 again. In particular, note the lower resistance value between pins 1&2. Reverse the ohmeter and remeasure. A shorted reading

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indicates a bad IC, and near equal readings indicate a reversed IC. Insert the crystal into the holder by snapping in the body of the crystal (gently), then pushing forward to contact the pins.

17. Before inserting the CPU card into its connector, measure the voltages at the connector. A single wrong voltage may cost you a CPU board worth of IC's.
Measure against ground:

Pin 1 - +5V ±5%
Pin 2 - ØV
Pin 50 - -12V±10%

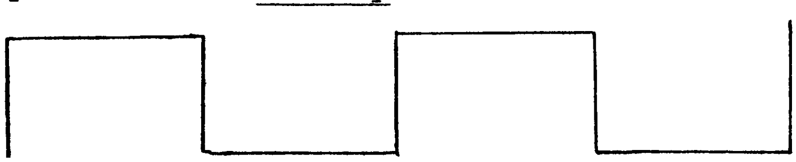
(Pin 1 end is marked on the card. It is the connector pin nearest the memory end of the board).

18. Make a final inspection of the card. Check for shorts between components on the top and lines running underneath, and solder bridges. IC's and R-packs should be inserted with pin 1 indicator, a dot or a notch, facing away from the connector. Some manufacturers have a notch at both ends and a dot at one end - the dot takes precedence. Sight down the rows of pins for missing solder points. Missed solder points typically seem to occur at the end pins of IC sockets, and one side of resistors or capacitors.

19. Insert the CPU board into its connector. Be sure that the pin 1 indication on the board is next to the pin 1 indication on the motherboard.

20. Apply power to the system. Again measure voltages at the CPU Card as noted in step 17.

21. Connect a calibrated triggered sweep oscilloscope to pin 6 of the 7400 (IC50). Set the triggering to occur on the + rise time, and the sweep setting to 100 ns/div. Look for a 2 cycle time of 800 nanoseconds as shown below. If your oscilloscope does not sweep as fast as 100 ns/div, then a slower sweep can be used, but be absolutely sure that the 2 cycle time is <u>exactly</u> 800 nanoseconds.



800 ns

A frequency counter may also be attached to pin 6 of IC50. The desired frequency is 2.5 MHz. Any appreciable error indicates either a defective crystal, a bad 7400, or an overtone oscillation (correct by using 74L00 for IC50).

22. Measure the voltage at the following pins. Correct any discrepancy.

Z-80 (IC43) :	pin 29 - ØV pin 11 - +5V
1702A (IC20):	pins 24 & 16- -9V pins 12,13,15,22&23- +5V
Any 2102 RAM:	pin 9 - ØV pin 10- +5V

23. Remove the CPU card. Plug in the TV Readout board. Connect a monitor, and place a temporary jumper to ground on pin 1 of the TV Readout board. A random assortment of characters should be displayed on the monitor when power is turned on. Remove power from the TV Readout and then remove the temporary jumper.

24. Insert the I/O board. Be sure that the I/O board address jumpers are connected so that the Ports Ø, 1, 2, and 3 are being accessed.

25. Carefully insert the Z-80, 1702A, and the 2102's. Note that pin 1 is indicated by either a dot or a "1" on these IC's, and should be oriented away from the connector. The 2102's are mounted horizontally, so the dots (sometimes notches) are oriented towards the left edge of the board (away from the connector). Recheck the board for orientation, lead shorts, solder shorts, and missing solder joints.

26. Think courageous thoughts. Plug in the CPU board. Bravely turn on power. If things are working, a message will appear on the screen.

27. The message should begin at the top leftmost edge of the screen and say, "Read Z-80 INITIALIZE Cassette". This message checks outs the major portion of the Digital Group Microprocessor Systems. Pressing the "Reset/Start" switch should cause the screen to flash and redraw the message.

28. Insert the Z-80 INITIALIZE cassette into the cassette recorder. Read the first recorded data burst. When the tone begins, press the "Reset/Start" switch momentarily. When the data begins, the screen should progressively display 256 "1's", 256 "2's", ... up through 256 "7's" as data is read. The displayed numbers indicate the page of the current data byte being read. After the Z-80 INITIALIZE cassette has been read, the screen should display the selections of the Operations Monitor.

29. Press "3" on your ASCII keyboard attached to Input Port Ø. The screen should display the content of the fourteen inter-

nal Z-80 registers, two indeces, etc. Press "Space" and you should page through memory.

30. Try the other Operations Monitor routines described in the Z-80 software description.

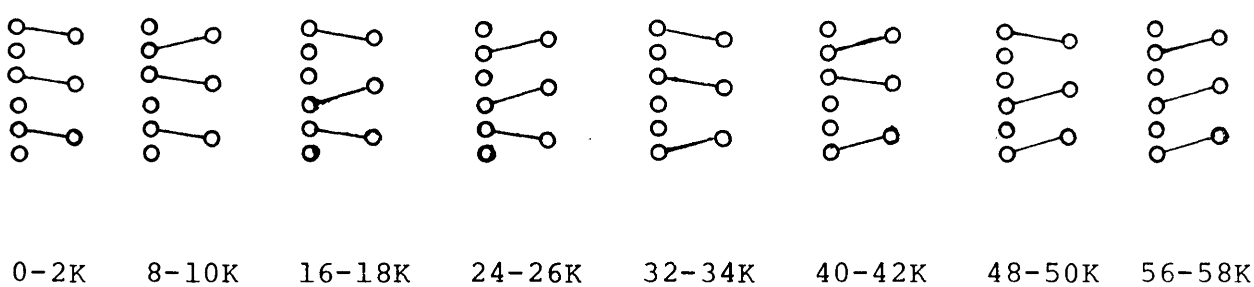
31. Load the special Memory test routine. Run the test as described in the Z-80 Distribution Cassette documentation.

32. This completes the major testing of the Digital Group Z-80 CPU card. Further testing involves connecting supplemental Digital Group 8K memory boards and verifying proper operation, and running extensive test loops to find any heat sensitive components. Use of surplus parts has a tendency towards temperature failure should you have used surplus 2102's in an unpopulated memory board. Noise sensitivities may show up with various card arrangements, and the "Troubles" section may aid you in your troubleshooting.

Using the CPU Board in a System

1. The Digital Group Z-80 CPU board's 2K of RAM memory is initially set to the lowest 2K of the potential 64K in a system for testing. However, the three jumpers between IC24 and IC25 may be rearranged so that the 2K may be assigned to seven higher addresses in memory. This allows Digital Group 8K memory boards to be used with the system and the 2K of RAM on the CPU board to be assigned immediately above the lastmost address of the external RAM.

   The jumpers are:



Example: You have an 8K board to use with your system. Connect the 8K memory to assign its 64 - 2102's to 0 - 8K. Select the above second jumper combination to assign the CPU's 2102's to 8 - 10K. Your system now has 10K for its 80 2102's. However, be aware that the supplemental 8K board must now be plugged in so that the system initialization at the lowest 2K may occur!

2. Noise problems can occur, particularly in large systems. Several fixes have been found successful.

   a. "Pin bars" on the ground and +5 lines on the mother board to lower the noise impedence.

   b. Tantalum bypasses at power supply regulators.

   c. Remove the .01 bypasses from the 8K boards.

   d. Use 74L04's instead of 7404's on the 8K boards. This may cause access time problems.

   e. Even IC's on the I/O board can cause troubles. 74LS01's instead of 7401's were found to cause strange noise problems which disappeared when the original 7401's were used.

   f. Changing the 8T97's to slower speed equivalents has been suggested.

   g. Impedence matching the bus lines (See Computer Design, Dec.'75 p. 97, for design concepts.)

3. A small, quiet blower is advisable in larger, enclosed systems. We would suggest mounting the blower near the CPU card and memories, on the Z-80 side of the cabinet. Have an exhaust vent on the opposite side for a steady cross current of ventilation.

4. The EROM may be deselected by connecting a SPST switch between ground and CPU pin BA. The EROM will be deselected when pin BA is at ground (Ø) level.

Troubles

1. Troubleshooting a Microprocessor system can be an extremely challenging situation even for experienced electronics servicemen. Several general principles should be followed where possible. We want you to enjoy your system quickly, not religate it to a closet pending a potential stroke of genius.

   a. Bring up a card at a time, preferrably by inserting in place of a card in another complete working system.

   b. Use the best tools and test equipment.

   c. If unfamiliar with logic circuit analysis, get a knowledgeable friend to help you.

   d. Attack the obvious problems first. Often very misleading

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"major" troubles are caused by a "trivial, easy to get later" trouble.

e. Keep exact records of the troubles, symptoms, and cures. Send us a copy so that we can help others.

f. If you and others are hopelessly baffled by your CPU card, try "Easter Egging" - replace the IC's which might even remotely affect the problem.

g. If all else fails, take advantage of our repair policy.

2. Perhaps 90% of the troubles are fixed by one or more of the following problems (listed in order of probability of occurance):

   a. IC or R-pack inverted in socket.

   b. Missing solder joint - generally on the end pins of an IC socket or one side of a resistor or capacitor.

   c. IC pin folded under an IC rather than inserted into socket.

   d. Solder bridge, "splash", or PC board drilling burr.

   e. Wrong IC or Resistor in a given location - Confusing a plated-through hole (smaller) for a component pad.

   f. You reassigned the bottom 2K of RAM to a supplemental 8K board, but don't have it plugged in.

   g. You have multiple memories at the same address. Generally this occurs when your CPU is 0-2K and a supplemental memory board is 0-8K.

3. 9% of the problems are caused by the following:

   a. Defective crystal or 7400 oscillator. The Digital Group spent two weeks on one board to discover the value of step 21 of the construction guide.

   b. Misc. defective or mismarked components. In case of totally illogical troubles, don't assume component marked values truthfully represent what lies inside.

   c. Defective sockets making intermittant connection. Tap and flex the board while running. Measure IC's <u>only</u> from the top side of the board. Memory IC's are very misleading since an unconnected address pin will result in multiple addressing of the same location.

   d. A very slow access 1702A - none seen so far, but possible.

   e. Noise. Extremely difficult to trace, but generally only shows up on large memory systems.

4. The remaining 1% are truly difficult ones, and require imagination, inspiration, and luck. Maybe a prayer too.

We want to compile a list of troubles found as a guide to future builders, and would like to hear about your strange troubles - causes and cures.

5. The troubled CPU card may be carefully analysed for apparent problems, but eventually must be carefully diagnosed to get the difficult ones. The single step operation generally finds the problems quickly.

6. Use the following procedure when attempting the single step analysis.

    a. Disconnect the "Run" jumper between +5 and CPU pin 43 (if connected).

    b. Install a "Run" and "Stop/Step" normally open push switch. Use a good quality, low bounce switch for "Stop/Step". Connect to CPU pins 43 & 44 as shown in the schematic.

    c. Measure the pulse at IC37 (74123) pin 5. It should be ≈50 ms long single pulse for each "Stop/Step" depression.

    d. Next, look at IC28 (7402) pin 13. Again a single pulse high for each depression should be seen. The pulse will be very short, even invisible on lower cost oscilloscopes.

    e. Build the emergency front panel (or borrow from a friend).

    f. Insert the card and turn on the system while holding the "Stop/Step" switch.

    g. Step through the chart provided. Carefully note the slightest discrepancy.

7. Once the single step operation operates successfully, try the "Run" to see if the message will appear now.

8. Once the Start-up routine works, retry loading the cassette.

Specific Troubles

1. Shorted address lines on CPU board.
    Shows up on single step as non-addressable memory positions.

2. Strange memory jumps.

    a. Resulted from a defective 74125 which was not passing back the right memory data.

    b. Another resulted from a defective 74121 (IC21) single shot not delaying the CPU when addressing ROM.

    c. Defective 7400/crystal oscillated on its overtone frequency instead of 2.5 MHz.

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d. Defective 2102 in memory, returning a bad address (particularly the leftmost column when singlestepping).

No single step.

Reversed diode leading from Step switch.

Single steps ok, but no TV operation.

a. I/O board not properly decoding to port Ø.

b. Defective 74100 on I/O board.

Cassette won't read.

a. Defective 7403.

b. Maladjusted Cassette interface on TV board. Defective 7401 (IC3) on I/O board.

Cassette loads data but won't end in Operations Monitor display.

a. Bad 2102 in Memory (generally in the IC10 - IC17 column).

b. Defective cassette - noisy, dropouts, poor recorder used.

c. Worn or misaligned heads on cassette recorder.

d. Recorder volume too low.

e. Recorder used to read the cassette is running at the wrong speed.

f. 74121 (IC21) on CPU board not 475 ns. This IC provides a fixed length delay so that the slower 1702A can function properly. Connect a calibrated triggered sweep oscilloscope to pin 6 of the 74121 (IC21). Set the triggering to occur on the + rise time, and the sweep setting to 100 ns/div. Turn on the system. Look for a high pulse between 400 ns. and 600 ns. long. Should the pulse be at an edge or outside the range, correct by changing the value of R2. (A larger value will lenghten; a smaller value will shorten the pulse).

Single Step Testing of Z-80 CPU Card

1. Press and hold Halt/Single Step switch
2. Power on
3. Press Reset
4. Stepping should display:

((XXX) = Data varies)
(*** data varies depending on release date of 1702 PROM)

Step Depression	Address Displayed	Data	Comments
Initial	0 000	303	(512 Char TV Screen may be dark or have random characters; 1024 Char TV screen will have 1024 light blocks)
1	0 001	063	
2	0 002	000	
3	0 063	041	
4	0 064	000	
5	0 065	001	
6	0 066	030	
7	0 067	003	
8	0 073	176	
9	1 000	(XXX)	
10	0 074	376	
11	0 075	123	
12	0 076	040	
13	0 077	007	
14	0 107	061	
15	0 110	000	
16	0 111	002	
17	0 112	315	
18	0 113	346	
19	0 114	000	
20	1 377	000	
21	1 376	115	
22	0 346	076	
23	0 347	177 ***	
24	0 350	315	
25	0 351	372	
26	0 352	000	
27	1 375	000	
28	1 374	353	
29	0 372	323	
30	0 373	000	
31	0 374	257	(Screen may Blank or Change)
32	0 375	323	
33	0 376	000	
34	0 377	311	(Screen Reappears - "Block" at lower rightmost corner (position 512)
35	1 374	353	} Failure here indicates RAM problem.
36	1 375	000	(Most likely in IC00-IC07. Swap with IC10-IC17 to see if trouble disappears at this point.)
37	0 353	006	
38	0 354	000	
39	0 355	016	
40	0 356	004 ***	
41	0 357	315	
42	0 360	370	
43	0 361	000	

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Step Depression	Address Displayed	Data	Comments
44	1 375	000	
45	1 374	362	
46	0 370	076	
47	0 371	240	
48	0 372	323	
49	0 373	000	
50	0 374	257	(Screen Blanks)
51	0 375	323	
52	0 376	000	
53	0 377	311	(Screen Reappears - "Blank" appears
54	1 374	362	upperleftmost corner (position 1).
55	1 375	000	
56	0 362	015	
	↓		Loops, clearing screen, character by character.

6. Press Run. Message should appear on screen. Numbers running indicates a "Ø" cassette output (or a bad Port 1 or I/O line into CPU 7403's). Press Halt/Single step. Each subsequent depression should step around the loop. The initial address may be anywhere in the loop.

	0 236	006	
	0 237	003	
Looping	0 240	333	
	0 241	001	Read
	0 242	313	Cass
	0 243	107	Loop
	0 244	040	
	0 245	370	

Z-80 CPU Parts List

Qty	IC's
1	Z-80
1	1702A-programmed
16	2102-1
6	8T97 or 74367
2	7400
1	7402
1	74LS02
2	7403
2	7404
1	7420
2	7430
1	7440
3	7442
1	7474
1	74121
1	74123
4	74125
1	4010

Diodes

1	9V 1W Zener
1	1N4148

Resistor Packs

4	16-pin 2.2K dip
1	8-pin 470 ohm

Capacitors

16	.01 disc
1	100 pfd mylar or silver mica
3	1 mfd tantalum 25V
2	22 mfd tantalum - 1" centers

Qty	Resistors
1	47 ohm ½ Watt 5%
1	220 ohm ¼ Watt 5%
1	330 ohm " "
2	470 ohm " "
1	4.3K " "
2	4.7K " "
1	22K " "
1	100K " "
2	2.2Meg. " "

Sockets

18	14-pin
32	16-pin
1	24-pin
1	40-pin

Miscellaneous

1	2.5 MHz crystal
1	Crystal socket
1	PC Board
1	50-pin dual connector
1	Z-80 Initialize Cassette

Documentation

1	"Digital Group Systems"
1	"Digital Group Z-80 CPU Card"
1	"Z-80 Operating System"
1	"Z-80 Distribution Cassette"
1	"Digital Group Bus Structure"

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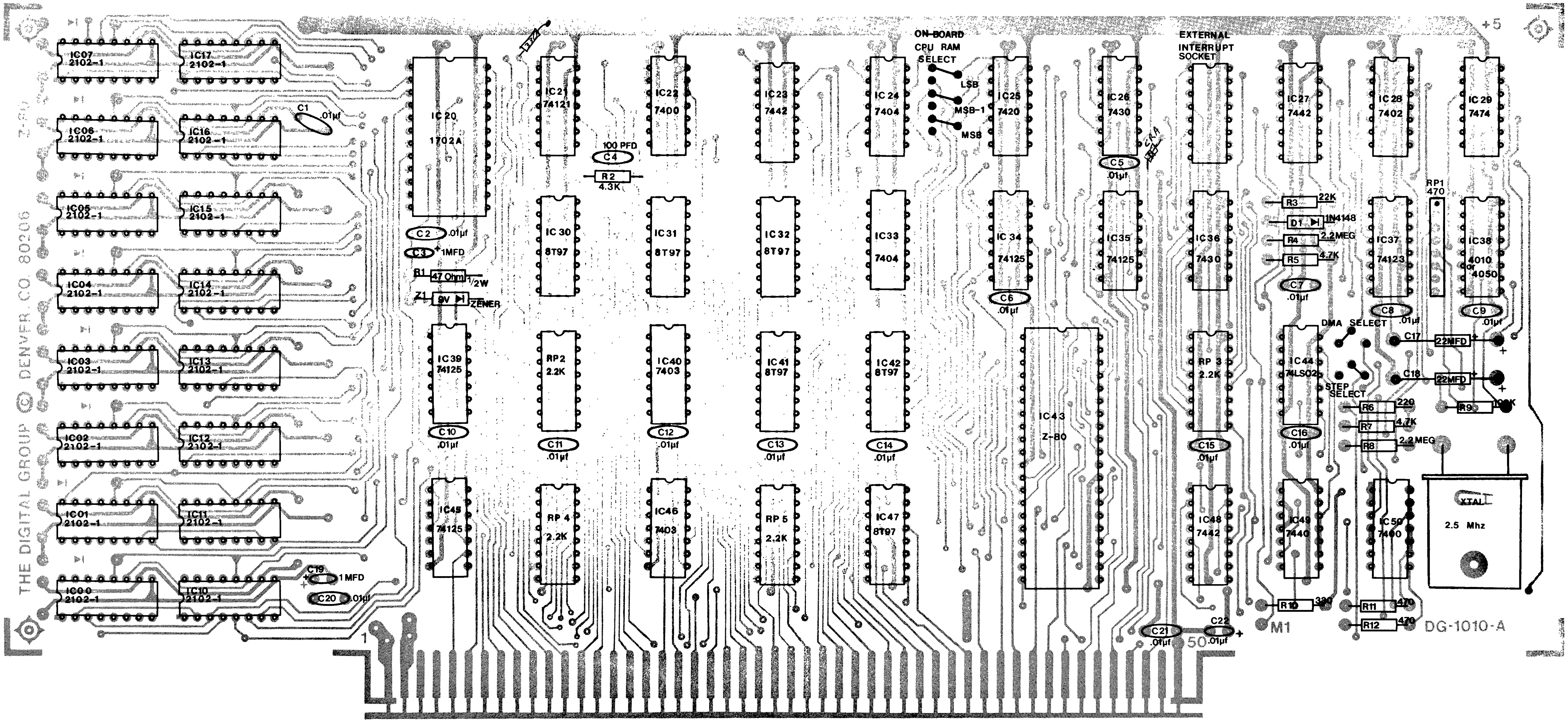
po box 6528 denver, colorado 80206 (303) 777-7133


THE DIGITAL GROUP © DENVER, CO. 80206
Z-80
ON-BOARD CPU RAM SELECT
LSB
MSB-1
MSB
EXTERNAL INTERRUPT SOCKET
+5
IC07 2102-1
IC17 2102-1
IC06 2102-1
IC16 2102-1
IC05 2102-1
IC15 2102-1
IC04 2102-1
IC14 2102-1
IC03 2102-1
IC13 2102-1
IC02 2102-1
IC12 2102-1
IC01 2102-1
IC11 2102-1
IC00 2102-1
IC10 2102-1
IC 20 1702A
IC21 74121
IC22 7400
IC23 7442
IC 24 7404
IC25 7420
IC 26 7430
IC27 7442
IC 28 7402
IC 29 7474
IC 30 8T97
IC31 8T97
IC32 8T97
IC33 7404
IC 34 74125
IC35 74125
IC36 7430
IC37 74123
IC38 4010 or 4050
IC39 74125
RP2 2.2K
IC40 7403
IC41 8T97
IC42 8T97
IC43 Z-80
RP 3 2.2K
IC44 74LS02
IC45 74125
RP 4 2.2K
IC46 7403
RP 5 2.2K
IC47 8T97
IC48 7442
IC49 7440
IC50 7400
RP1 470
C1 .01µf
C2 .01µf
C3 1MFD
C4 100 PFD
R2 4.3K
R1 47 Ohm 1/2W
Z1 9V ZENER
C5 .01µf
C6 .01µf
C7 .01µf
C8 .01µf
C9 .01µf
C10 .01µf
C11 .01µf
C12 .01µf
C13 .01µf
C14 .01µf
C15 .01µf
C16 .01µf
C17 22MFD
C18 22MFD
C19 1MFD
C20 .01µf
C21 .01µf
C22 .01µf
R3 22K
D1 1N4148
R4 2.2MEG
R5 4.7K
R6 220
R7 4.7K
R8 2.2MEG
R9 100K
R10 330
R11 470
R12 470
DMA SELECT
STEP SELECT
XTAL 2.5 Mhz
M1
1
50
DG-1010-A

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Z-80 CPU SCHEMATIC

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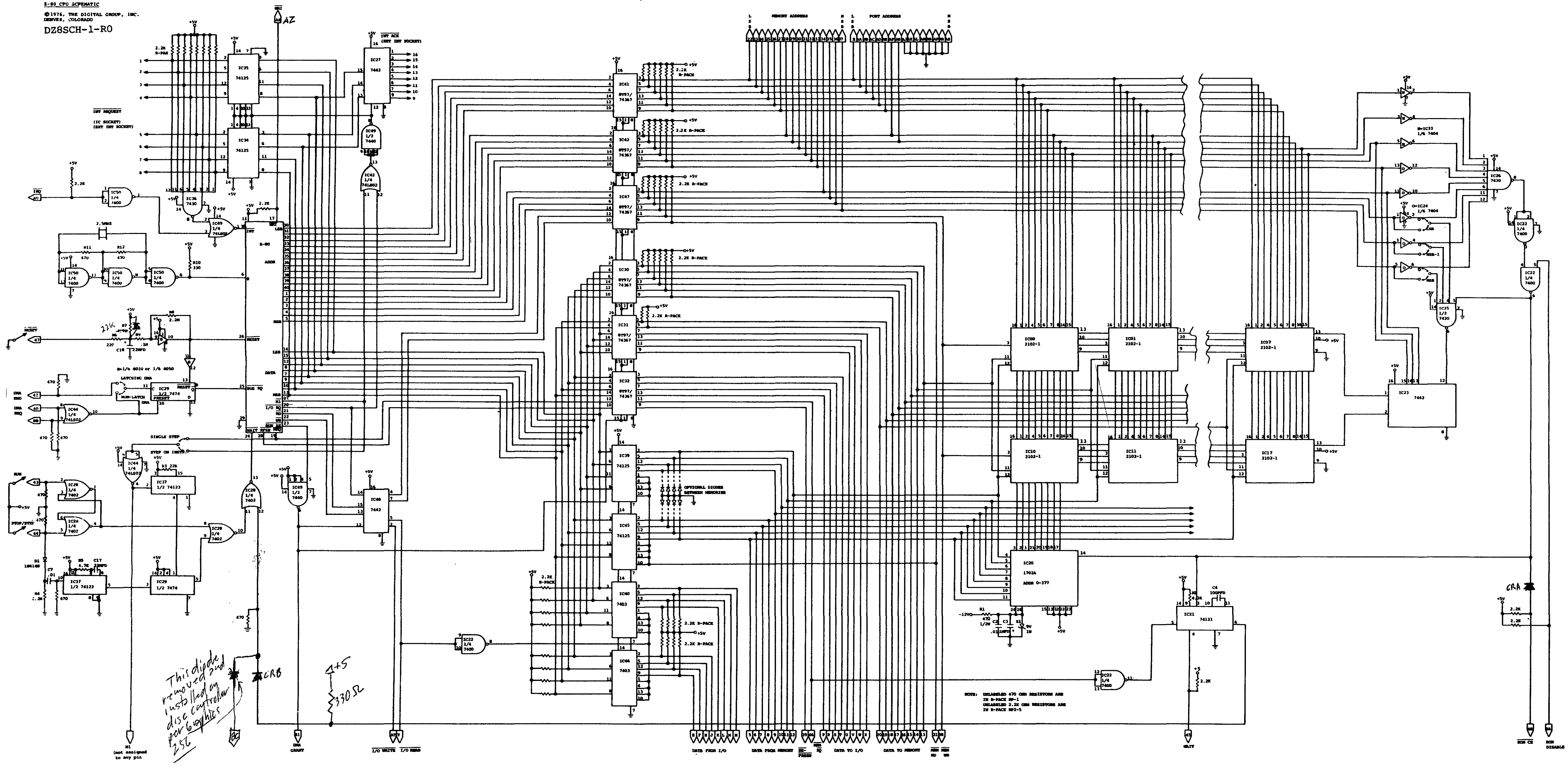

Modifications per Graphics 256, p1&2
and per D.O. Disk Cntrlr System Installation manual, p 2-5