I. INTRODUCTION

1. MANUAL CONTENTS

This manual consists of 5 major sections and two appendices. These 5 sections cover a) a description of the external connections required, b) detailed descriptions of the operational features and how to use them, c) logic diagrams/schematics and descriptions of how the logic works, d) the expansion buses and how to use them, and e) hints on troubleshooting in case of difficulty. Appendix A contains parts lists and assembly instructions for the basic SUPER ELF and available options. Appendix B contains complete data sheets on both the 1802 CPU and the 1861 video graphics generator.

2. EXTERNAL CONNECTIONS

All external connections are located in the upper left hand corner of the printed circuit board. These connections are summarized here and discussed in more detail in both Section III Logic Design and Appendix A Parts List and Assembly Instructions. Starting at the upper lefthand corner and going to the right, the BAT pair of connections are used for the 2.4V standby Ni-Cad battery included in the memory saver option. Next are the SW1 connections used to connect the battery to the Rams (also used in the memory saver option. Next are the SW2 connections used to disable the Rams (also used in the memory saver option). Next are the AC connections which are used to supply power to the board from the supplied plug-in transformer. Going back to the upper lefthand corner and going down the left edge is the SPKR connections. This is the amplified output of the Q line. Normally a speaker is connected here for audio effects. However, these connections can also be used as a serial output port or a relay driver. Next are the VID connections which are an amplified composite (sync and video) video signal of approximately 2 volts peak to peak. This output may drive a video monitor directly or it may be used to drive an RF modulator to allow connections to any TV set's antenna terminals. Some RF modulators available for this use work much better than others. One that has been tested and approved is the VAMP INC. Model RFVM-1 which is available through QUEST.

II. OPERATION

1. HARDWARE ASSIGNMENTS

The SUPER ELF has been designed using the following hardware assignments.

A. Video Display ON Op Code 61.
B. Video Display OFF Op Code 62.
C. HEX Keyboard Input Op Code 6C.
D. HEX Display Output Op Code 64.
E. Video Display Status Line EF1.
F. Input Switch Status Line EF4.

2. CONTROLS DESCRIPTION

The following is a description of the 24 key keyboard controls.

R RESET - Puts the CPU in the RESET mode. These additional functions are reset if they were set.

1. Single Step
2. Memory Protect
3. ROM Select

L LOAD - Puts the CPU in the LOAD mode from the RESET mode.

I INPUT - Inputs data from the HEX keypad to the data bus in the LOAD mode. In the RUN mode the EF4 Status Line is LOW while the key is depressed.

P MEMORY PROTECT - Prevents writing into memory. Useful in the LOAD mode to verify the load. Cannot be used in the RUN mode with the basic unexpanded board.

M MONITOR - Selects the on-board monitor. Replaces the first 20 HEX locations in memory with the monitor ROM. Location 20 HEX is used by the monitor, so user programs must not start before location 21 HEX when using the monitor.

S SINGLE STEP - Allows single stepping through the program one machine cycle at a time. The stopping point is the negative edge of the TPA pulse of each machine cycle. This function is used with the RUN switch. When in the SINGLE STEP mode, the DATA/OUTPUT displays display the DATA bus.

G RUN or GO puts the CPU in the RUN mode from either the WAIT or RESET modes. If single step has been selected, only one machine cycle will be executed at a time with each momentary key depression. Holding the RUN button down will result in slowly stepping through the program one machine cycle at a time.

W WAIT puts the CPU in the WAIT state if previously in the RUN state. Puts the CPU in the LOAD state from the RESET state. Resets memory protect.

0 through F - HEX keypad stores the last TWO key depressions for input to the 8 bit data bus. The last key depressed is the least significant 4 bits of the 8 bit data word.

3. INDICATORS AND DISPLAYS DESCRIPTION

The SUPER ELF has nine LEDS and two HEX displays (4 additional HEX displays are optional.

A. The LEDS show:

ID	FUNCTION
Q	Status of Q line
L	CPU in LOAD mode
R	CPU in RESET mode
G	CPU in RUN mode
W	CPU in WAIT mode
0	CPU in state 0
1	CPU in state 1
2	CPU in state 2
3	CPU in state 3

NOTE: LED logic is active high.

B. The two HEX displays are normally an output port. However, in the SINGLE STEP mode, the displays show the contents of the data bus.

C. The 4 optional HEX displays show the contents of the address bus.

4. OPERATION WITHOUT THE ROM MONITOR

A. Loading programs is done in the LOAD mode. If you have purchased the address display option, the address just loaded will be displayed along with the address contents. All loading must start at location 00HEX.

(1.) To load a program.

a. Push RESET R key.

b. Push LOAD L key.

c. Push the 2 HEX keypad keys corresponding to the contents of address 00HEX.

d. Push the INPUT I switch.

e. The contents of address 00HEX will be displayed by the data displays.

f. Push the 2 HEX keypad keys corresponding to the contents of the next address.

g. Push the INPUT I switch.

h. The contents of that address will be displayed.

i. Repeat steps f and g until the entire program is loaded.

(2.) To make corrections.

a. Push RESET R key.

b. Push LOAD L key.

c. Push Memory Protect P key.

d. Push the INPUT I key until the preceding location is reached.

e. Load the HEX keypad with the corrected data word.

f. Push the WAIT W key to enable memory writing.

g. Push the INPUT I key to load the correction data word.

(3) To run programs.

a. Push the RESET R key.

b. Push the RUN G key. The program will start executing at address 00HEX.

5. OPERATION WITH THE ROM MONITOR

The SUPER ELF monitor allows us to do three things.

A. Loading a program starting at any location.

B. Examine any location in memory (including the monitor itself).

C. Starting a program at any location.

NOTE: This monitor only works with PAGE ZERO (the first 256 words of memory).

A. To use the monitor to load a program.

(1) Push RESET R key.

(2) Push HEX keys 0 and 2 in that order.

(3) Push the MONITOR M select key.

(4) Push the RUN G key and the data display will indicate 02.

(5) Push the two HEX keypad keys corresponding to the starting address.

(6) Push the INPUT I key and the Q light will come on indicating that memory writing is enabled.

(7) Push the two HEX keypad keys corresponding to the data going into the memory.

(8) Push the INPUT I key and the data displays will display the memory data just entered.

(9) Repeat steps 7 and 8 for the remainder of the program.

(10) Push the RESET R key when completed.

B. To use the monitor to read out memory contents.

(1) Push the RESET R key.

(2) Push HEX keypad keys 0 and 1 in that order.

(3) Push the Monitor M select key.

(4) Push the RUN G key and the data display will indicate 01.

(5) Push the two HEX keypad keys corresponding to the starting address.

(6) Push the INPUT I key.

(7) Push the INPUT I key again and the data display will indicate the contents of the specified memory location.

(8) Continue to push the INPUT I key to step through the memory contents one at a time.

(9) Push the RESET R key when completed.

NOTE: The contents of the monitor may be read out by using memory location 00 in step 5.

C. To use the monitor to start execution of a program at any location.

(1) Push the RESET R key.

(2) Push the HEX keypad key 0 twice.

(3) Push the Monitor M select key.

(4) Push the RUN G key and the data display will indicate 00.

(5) Push the two HEX keypad keys corresponding to the starting address.

(6) Push the INPUT I key and the program will start executing.

6. USING SINGLE STEP/SLOW STEP

The SUPER ELF has the ability to step through programs one machine cycle at a time. Execution is halted at the negative edge of the TPA signal in each machine cycle. At this point, the CPU is in the process of executing the current instruction cycle. The instruction set timing diagrams in APPENDIX B should be consulted to determine the hardware state corresponding to the instruction being executed.

The single step/slow step mode may be entered from the RESET state or the WAIT state by pushing the Single Step S key. Program execution may then be started or resumed by pushing the RUN G key. A single push of the RUN G key will advance the program one machine cycle. Holding the RUN G key down will advance the program at a rate of approximately 1 to 2 machine cycles per second. Releasing the RUN G key will stop execution. Pushing the WAIT W key disables the single step mode and then pushing the RUN G key resumes normal speed operation.

IV EXPANSION BUS

1. CAPABILITIES

The SUPER ELF has two types of expansion buses.

The first is a standard 44-pin connector. This connector and matching plug-in printed circuit cards are readily available locally or may be purchased from QUEST. This 44-pin bus provides all the signals normally required for expanded memory (including all 16 bits of address if address options are incorporated), input/output ports, and other common applications.

The second expansion bus is a 50-pin bus designed to interface with 50-pin flat cable connectors. This bus is specifically designed to interface with the SUPER ELF expansion card containing a 1K super monitor, up to 4K of ram, a cassette interface, and other features. Four additional functions are available on this bus which are used to facilitate the use of the expansion board. For example: the M button becomes a RUN-WITH-MONITOR button. These additional functions require minor (already provided for) modifications to the basic SUPER ELF printed circuit board. Detailed instructions are provided with the expansion board.

2. CONSTRAINTS

When using the 44-pin expansion bus, care must be taken to insure that the power and signal interface requirements are met.

Two unregulated power buses are supplied. One (No. 1) is part of the basic SUPER ELF; the other (No. 2) is part of the low address display option. Expansion bus current drain on No. 1 should be limited to less than 300 ma. Current drain on No.2 should be limited to less than 200 ma. when both high and low address options are installed. In addition, additional filtering may be required on the expansion card. This depends upon

the amount of current being drawn. 500 MFD to 1000 MFD on the input to the regulator is sufficient for the maximum allowable current. If more power is required, or other voltages, an auxiliary power supply is highly recommended.

The signal out lines can drive at least one Low Power TTL or a number of CMOS loads. The address lines are buffered and can drive one Standard TTL load. The input lines may be driven by TTL logic if pull up resistors are used (22K OHMS to 5V). CMOS drivers do not require pull up resistors.

Expansion bus signals which are also used by the main board must be diode isolated ON THE expanded card. For example: $\overline{\text{DMAIN}}$.

Proper bypassing of power leads and avoidance of long expansion bus leads is necessary to avoid problems.

APPENDIX A PARTS LIST AND ASSEMBLY INSTRUCTIONS

1. PARTS LIST - BASIC

TYPE	NUMBER	QTY	DESCRIPTION
INTEGRATED CIRCUITS			
U1	74L74/74L574	1	Dual D Flip-Flop
U2	74L00/74L500	1	Quad 2-Input NAND Gate
U3	4028	1	BCD-to-Decimal Decoder
U4	4071	1	Quad 2-Input OR Gate
U5	4011	1	Quad 2-Input NAND Gate
U6	1802	1	COSMAC microprocessor
U7	4013	1	Dual D Flip-Flop
U8	4013	1	Dual D Flip-Flop
U9	4001	1	Quad 2-Input NOR Gate
U10	4013	1	Dual D Flip-Flop
U11	4071	1	Quad 2-Input OR Gate
U12	4013	1	Dual D Flip-Flop
U13	4050	1	Hex Non-Inverting Buffer
U14	4016	1	Quad Bilateral Switch
U15	74C175	1	Quad D Flip-Flop
U16	4013	1	Dual D Flip-Flop
U19	1861	1	Video Display Controller
U20	4016	1	Quad Bilateral Switch
U21	4093	1	Quad 2-Input NAND Schmidt Trigger
U23	4050	1	Hex Non-Inverting Buffer
U24	4001	1	Quad 2-Input NOR Gate
U25	74C923	1	20-Key Encoder
U26	4001	1	Quad 2-Input NOR Gate
U27	2101/2101L	1	256 x 4 MOS RAM
U28	4049	1	Hex Inverting Buffer
U29	4049	1	Hex Inverting Buffer
U30	2101/2101L	1	256 x 4 MOS RAM
U32	82S123	1	32x8 PROM Programmed With Monitor
U35	4050	1	Hex Non-Inverting Buffer
U36	4049	1	Hex Inverting Buffer

TYPE	NUMBER	QTY	DESCRIPTION
INTEGRATED CIRCUITS			
U38	4023	1	Triple 3-Input NAND Gate
U41	4049	1	Hex Inverting Buffer
U42	9368	1	Hex Decoder Latch Driver
U43	4011	1	Quad 2-Input NAND Gate
U44	7865/340T-5	1	5V 1A Regulator
U45	9368	1	Hex Decoder Latch Driver
RESISTORS			
R2	200 OHM	1	¼ Watt Carbon Film
R3	30 OHM	1	¼ Watt Carbon Film
R4	100 OHM	1	¼ Watt Carbon Film
R5	10K OHM	1	¼ Watt Carbon Film
R6	47K OHM	1	¼ Watt Carbon Film
R7	47K OHM	1	¼ Watt Carbon Film
R8	47K OHM	1	¼ Watt Carbon Film
R9	10K OHM	1	¼ Watt Carbon Film
R10	1K OHM	1	¼ Watt Carbon Film
R11	2K OHM	1	¼ Watt Carbon Film
R12	47K OHM	1	¼ Watt Carbon Film
R13	47K OHM	1	¼ Watt Carbon Film
R14	10K OHM	1	¼ Watt Carbon Film
R15	330 OHM	1	¼ Watt Carbon Film
R16	330 OHM	1	¼ Watt Carbon Film
R17	1M OHM	1	¼ Watt Carbon Film
R18	22K OHM	1	¼ Watt Carbon Film
R19	47K OHM	1	¼ Watt Carbon Film
R20	47K OHM	1	¼ Watt Carbon Film
R21	47K OHM	1	¼ Watt Carbon Film
R22	47K OHM	1	¼ Watt Carbon Film
R23	47K OHM	1	¼ Watt Carbon Film
R24	47K OHM	1	¼ Watt Carbon Film
R25	47K OHM	1	¼ Watt Carbon Film
R26	47K OHM	1	¼ Watt Carbon Film
R27	47K OHM	1	¼ Watt Carbon Film

LEFT OVER 1 INSTALLED ON U6 38, 40

TYPE	NUMBER	QTY	DESCRIPTION
CAPACITORS			
C1	1000 MFD 16V	1	Electrolytic
C3	0.1 MFD 50V	1	Monolythic
C4	220 PFD 100V	1	Disc Ceramic
C5	0.1 MFD 50V	1	Monolythic
C6	2.2 MFD 25V	1	Tantilum
C7	0.1 MFD 50V	1	Monolythic
C8	2.2 MFD 25V	1	Tantilum
C9	0.1 MFD 50V	1	Monolythic
C10	0.1 MFD 50V	1	Monolythic
C11	0.1 MFD 50V	1	Monolythic
C15	10.0 MFD 35V	1	Tantilum
C16	10.0 MFD 35V	1	Monolythic
C17	0.1 MFD 50V	1	Monolythic
C18	0.1 MFD 50V	1	Monolythic
C19	0.1 MFD 50V	1	Monolythic
C20	0.1 MFD 50V	1	Monolythic
DIODES			
D2	1N4001	1	Silicon Rectifier
D3	1N4001	1	Silicon Rectifier
D6	1N4001	1	Silicon Rectifier
D7	1N4001	1	Silicon Rectifier
D10	1N4001	1	Silicon Rectifier
D12	1N4001	1	Silicon Rectifier
D14	1N4001	1	Silicon Rectifier
D16	1N4001	1	Silicon Rectifier
D17	1N914	1	Switching Diode
MISCELLANEOUS-ELECTRICAL			
Q1	2N2222A	1	Switching Transistor NPN
Q2	2N2222A	1	Switching Transistor NPN
X1	3579.545	1	Crystal
-	LED	9	Jumbo Red
-	FND 500	2	½" Seven Segment Display
-	10V16VA	1	117V Plug-In Transformer
-	Key Switch	6	4 Section NO Push Button Switch

TYPE	NUMBER	QTY	DESCRIPTION
MISCELLANEOUS-ELECTRICAL			
-	Speaker	1	
-	Wire	6 ft	Two Conductor Pwr Cord
-	Wire	2 ft	No. 26 Stranded
MISCELLANEOUS - MECHANICAL			
-	Heat Sink	1	Regulator Heat Sink
-	6-32 x 3/8 Screw	1	For Regulator
-	6-32 Lock Washer	1	For Regulator
-	6-32 Nut	1	For Regulator
-	2-56 Nut	12	For Key Switch
-	2-56 Lockwasher	12	For Key Switch
-	Key Tops	24	One Each 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F, L, R, G, W, M, S, P, I
-	40 Pin Socket	1	Low Profile
-	24 Pin Socket	1	Low Profile
-	24 Pin Socket	1	Standard or W.W.
-	22 Pin Socket	2	Low Profile
-	20 Pin Socket	1	Low Profile
-	14 Pin Socket	18	Low Profile
-	16 Pin Socket	13	Low Profile
-	Circuit Board	1	SUPER ELF

2. PARTS LIST - OPTIONAL LOW ADDRESS DISPLAY

TYPE	NUMBER	QTY	DESCRIPTION
U33	7805/340T-5	1	5V 1A Regulator
U37	9368	1	Hex Decoder Latch Driver
U40	9368	1	Hex Decoder Latch Driver
C2	1000 MFD 16V	1	Electrolytic
C12	10 MFD 25V	1	Tantilum
C13	10 MFD 25V	1	Tantilum
D4	1N4001	1	Silicon Rectifier
D5	1N4001	1	Silicon Rectifier
D8	1N4001	1	Silicon Rectifier

TYPE	NUMBER	QTY	DESCRIPTION
D9	1N4001	1	Silicon Rectifier
D11	1N4001	1	Silicon Rectifier
D13	1N4001	1	Silicon Rectifier
D15	1N4001	1	Silicon Rectifier
D17	1N4001	1	Silicon Rectifier
-	FND 500	2	½" Seven Segment Display
-	16 Pin Socket	2	Low Profile
-	24 Pin Socket	1	Standard Or W.W.
-	6-32 x 3/8 Screw	1	
-	6-32 Lockwasher	1	
-	6-32 Nut	1	
-	Heat Sink	1	

3. PARTS LIST - OPTIONAL HIGH ADDRESS DISPLAY

TYPE	NUMBER	QTY	DESCRIPTION
U17	4042	1	Quad Clocked D Latch
U18	4042	1	Quad Clocked D Latch
U22	4050	1	Hex Non-Inverting Buffer
U31	9368	1	Hex Decoder Latch Driver
U34	9368	1	Hex Decoder Latch Driver
-	FND 500	2	½" Seven Segment Display
-	16 Pin Socket	4	Low Profile
-	24 Pin Socket	1	Standard Or W.W.

4. PARTS LIST - OPTIONAL MEMORY SAVER

TYPE	NUMBER	QTY	DESCRIPTION
U39	7805/340T-5	1	
C14	10.0 MFD 35V	1	Tantilum
R1	300 OHM	1	½ Watt Carbon Resistor
D1	1N270	1	Germanium Diode
-	2 PST Switch	1	
-	1 AH Battery	2	NI-CAD Battery
-	Wire	4 ft	No. 24 Stranded
-	6-32x3/8 Screw	1	
-	6-32 Lockwasher	1	
-	6-32 Nut	1	

NOTE: INTEL 5101L Rams may be substituted for the 2101L Rams to extend battery life from 20 hrs minimum to 4 weeks minimum.

5. PARTS LIST - OPTIONAL ACCESSORIES

- 44 Pin PC connector for Expansion Bus
- 50 Pin Ribbon cable connector for SUPER ELF Expander Board
- Video modulator kit
- 5101L Rams
- Custom hardwood case and front panel

6. ASSEMBLY INSTRUCTIONS - BASIC

Prior to starting assembly, please carefully read this manual and inspect the printed circuit board to observe the soldering skills and kit building experience required. If you have any doubts about your ability to assemble this kit or do not have the required tools we suggest that you exchange the kit for an assembled SUPER ELF.

You will need the following tools and supplies.

A. A 25 watt soldering iron with a small dia (.063 in. maximum) tip. A higher wattage iron usually has a tip temperature too high for safe printed circuit work. A lower wattage iron may take too long to heat the joint and result in poor solder joints. A larger tip diameter is likely to cause solder bridges.

B. A radio type rosin core solder of .032 in. dia maximum with an alloy of 60 to 65 percent tin. Do not use 50-50 solder as its melting point is much higher.

C. Small screw driver.

D. Small wrenches.

E. Small diagonal cutters.

F. Needlenose pliers

G. Magnifying glass (to check for shorts)

H. Multimeter (sensitivity at least 20000 OHMS/volt).

I. Heat sink thermal grease.

NOTE: Failure to use good soldering techniques and the proper solder can void the warranty.

The following tools are not required but will be helpful if available.

A. An IC insertion tool.

B. A component lead bender.

C. A nut driver set.

Check the parts in the kit against the parts list to insure that the kit is complete and to familiarize yourself with the parts. CAUTION: DO NOT remove the integrated circuits from the antistatic (black) foam they were shipped in until told to do so.

The printed circuit board is double-sided epoxy glass with plated through holes. The front of the board has component designations on it. All components are installed from the front and all soldering is on the back.

Carefully inspect both sides of the printed circuit board for shorts and defects. The top of the board is more critical since the sockets, etc., cover up the traces, and defects are harder to detect and correct. NOTE: Every board is carefully inspected, under magnification, prior to shipment and the above suggestion is a double check to minimize any inconvenience to you from undetected defects. Any defects found are of course covered by our warranty.

Referring to the component identification on the board and figure 2 component layout, start assembly using the following steps. NOTE: If you purchased options with your SUPER ELF, they can be added now or later. We recommend adding them now by doing all corresponding steps at one time. For example, install both the basic and optional sockets at the same time. CAUTION: in each of the following steps, be sure that you have installed the parts in the correct locations prior to soldering. This is particularly important if you did not buy all the options since some locations will be empty.

( ) A. Install low profile sockets for ICs U1 through U45 except for ICs listed as optional. Note: Install a socket for U18 as part of the basic kit. Slightly bend two leads on diagonally opposite corners to hold the socket in place while you turn the board over. Solder these two pins while the socket is

snug against the board. Before soldering the remaining pins, check to be sure the socket is seated on the board properly. SOLDER all the remaining pins.

( ) B. Install all the resistors. SOLDER. Trim off excess leads. Note: Pre-bending resistors to a lead spacing of 0.4 inch with a lead bender will simplify this job.

( ) C. Install all the diodes. SOLDER. Trim off excess leads. Note: Pre-bending diodes to a lead spacing of 0.4 inch is helpful. Note: The cathode (band) end of all diodes should be next to the hole with a dot or + sign. All diodes have their bands on the right side.

( ) D. Install the standard 24 pin socket horizontally in the right hand set of holes (below IC No. U42 and U45). SOLDER.

( ) E. Install the capacitors. SOLDER. Note: Observe polarity on the electrolytics and tantilums. Note: Some tantilums may not be marked with A+. These will have a colored dot on one side. With the leads down and the dot facing you, the right lead is +.

( ) F. Install the two transistors Q_1 and Q_2. They should stand approximately 1/8 inch off the board. SOLDER.

( ) G. Install the LEDS. The base of the LED should be 3/16 to 1/4 inch from the board. The flat (or short lead or dot) should be toward the bottom of the board. SOLDER.

( ) H. Install the crystal. Carefully bend the leads 90 degrees so the crystal will lie down on its side on the board. One side of the crystal has a foam double-backed tape attached. Remove the protective paper, insert the leads in the holes, and gently press the crystal down on the board so the foam holds it is place. SOLDER.

( ) I. Install U44--the regulator. Bend the 3 leads down to fit the hole spacing. Put thermal grease on the bottom of the regulator and the bottom of the heat sink. Only a SMALL amount is required. Using a 6-32 x 3/8 screw, assemble in the following order. The screw goes through the regulator, then the heat sink, and then the PC board with a lockwasher and nut on the back. Tighten the screw carefully. Avoid over-tightening. The thermal grease is slippery and with a properly tightened assembly you can still move the heat sink with a little effort. SOLDER.

( ) J. Install the 6 4 key key switches. CAREFULLY straighten any bent leads so that they are nearly straight. (Overbending can cause breakage and they need not be perfect for installation). Position the switch over the holes with one end closer to the board and, using a thin screwdriver or other blade, gently push the leads into the holes one set at a time, moving from one end to the other. Start installing switch banks with the left column. Use an OHM meter to verify correct switch closure before installation since later removal of any multi-pin device (like these switches) is very difficult. When the switch bank is in place on the board use 2-56 nuts and lockwashers to bolt the switch down. Then SOLDER the leads.

( ) K. Connect the plug-in transformer to the board using the 6 foot long twisted pair wire. SOLDER to the connections labeled AC on the board.

( ) L. Cut the 2 foot wire in half and twist the two wires together. Using this wire connect the speaker to the connections labeled SPKR on the board. SOLDER.

( ) M. Omit this step if you purchased the high address option. Otherwise, using cut-off resistor leads, make 4 short jumpers and plug them into the socket for U18.

Jumper 1 between pin 2 and pin 4.
Jumper 2 between pin 7 and pin 10.
Jumper 3 between pin 11 and pin 13.
Jumper 4 between pin 1 and pin 14.

Be sure the jumpers are short and do not touch each other. You can also use a 4042 instead of the jumpers. The purpose of the jumpers is to terminate the inputs to U23. Failure to terminate CMOS inputs may result in improper operation of other circuits on that IC and even destruction of that IC.

( ) N. Install the integrated circuits. The 14 and 16 pin ICs can be installed using an insertion tool. Most IC leads are spread at the tip and must be bent inward to provide the right row spacing to fit the socket. Most of the ICs are CMOS types and require extra care in handling to prevent static damage. Grounding yourself and the board is recommended. Also avoid wearing nylon or other synthetic clothing during this step.

( ) O. Install the seven segment displays in the 24 pin standard socket. The grooved side goes up (like the notch on the ICs). Install the two displays on the ends of the socket, leaving two socket pins empty between the displays. (Pins 6 and 7, 18 and 19, of the 24 pin socket are not used by the displays.

( ) P. This completes the basic SUPER ELF.

7. ASSEMBLY INSTRUCTIONS LOW ADDRESS DISPLAY OPTION

Refer to corresponding steps in the basic assembly instructions for more details.

( ) A. Install the low profile sockets. SOLDER.

( ) B. Install the diodes. SOLDER.

( ) C. Install the capacitors. SOLDER.

( ) D. Install the regulater and heat sink. SOLDER.

( ) E. Install the standard 24 pin socket in the space provided below U37 and U40. SOLDER.

( ) F. Install the ICs.

( ) G. Install the seven segment displays spaced apart like the data displays.

( ) H. This completes the high address display option.

8. ASSEMBLY INSTRUCTIONS HIGH ADDRESS DISPLAY OPTION

Refer to corresponding steps in the basic assembly instructions for more details.

( ) A. Install the low profile IC sockets. SOLDER.

( ) B. Install the standard 24 pin socket in the space provided below U31 and U34. SOLDER.

( ) C. Install the ICs.

( ) D. Install the seven segment displays spaced apart like the data displays.

( ) E. This completes the high address display option.

9. ASSEMBLY INSTRUCTIONS MEMORY SAVER OPTION

Refer to corresponding steps in the basic assembly instructions for more details.

( ) A. Install the regulator. NOTE: No heat sink is necessary. SOLDER.

CONNECTOR 50 Pin	CONNECTOR 44 Pin	FUNCTION	CONNECTOR 50 Pin	CONNECTOR 44 Pin	FUNCTION
1	1	Ground	26	A	Ground
2	2	+10v Unreg #1	27	B	+10v Unreg #2
3	3	EF3 (22)	28	C	EF2 (23)
4	4	N0 (19)	29	D	N1 (18)
5	5	N2 (17)	30	E	Q (4)
6	6	SC1 (5)	31	F	SC0 (6)
7	7	$\overline{\text{MRD}}$ (7)	32	H	$\overline{\text{CLOCK}}$ (39)
8	8	$\overline{\text{DMAIN}}$ (38)	33	J	$\overline{\text{DMAOUT}}$ (37)
9	9	$\overline{\text{MWR}}$ (35)	34	K	$\overline{\text{INT}}$ (36)
10	10	TPB (33)	35	L	TPA (34)
11	-	M *	36	-	N/C
12	-	G *	37	-	N/C
13	-	$\overline{\text{CS}}$ *	38	-	MP *
14	11	A15	39	M	A14
15	12	A13	40	N	A12
16	13	A11	41	P	A10
17	14	A9	42	R	A8
18	15	A7	43	S	A6
19	16	A5	44	T	A4
20	17	A3	45	U	A2
21	18	A1	46	V	A0
22	19	D7 (8)	47	W	D6 (9)
23	20	D5 (10)	48	X	D4 (11)
24	21	D3 (12)	49	Y	D2 (13)
25	22	D1 (14)	50	Z	D0 (15)

CHANGED

CHANGED

NOTES:

1. 1802 pin numbers shown in parenthesis where directly connected.
2. * Signifies special function for SUPER ELF expansion board.
3. N/C Means no connection.

FIGURE 1 EXPANSION BUS CONNECTIONS

G RUN or GO puts the CPU in the RUN mode from either the WAIT or RESET modes. If single step has been selected, only one machine cycle will be executed at a time with each momentary key depression. Holding the RUN button down will result in slowly stepping through the program one machine cycle at a time.

W WAIT puts the CPU in the WAIT state if previously in the RUN state. Puts the CPU in the LOAD state from the RESET state. Resets memory protect.

0 through F - HEX keypad stores the last TWO key depressions for input to the 8 bit data bus. The last key depressed is the least significant 4 bits of the 8 bit data word.

3. INDICATORS AND DISPLAYS DESCRIPTION

The SUPER ELF has nine LEDS and two HEX displays (4 additional HEX displays are optional.

A. The LEDS show:

ID	FUNCTION
Q	Status of Q line
L	CPU in LOAD mode
R	CPU in RESET mode
G	CPU in RUN mode
W	CPU in WAIT mode
0	CPU in state 0
1	CPU in state 1
2	CPU in state 2
3	CPU in state 3

NOTE: LED logic is active high.

B. The two HEX displays are normally an output port. However, in the SINGLE STEP mode, the displays show the contents of the data bus.

C. The 4 optional HEX displays show the contents of the address bus.

II. OPERATION

1. HARDWARE ASSIGNMENTS

The SUPER ELF has been designed using the following hardware assignments.

A. Video Display ON Op Code 61.
B. Video Display OFF Op Code 62.
C. HEX Keyboard Input Op Code 6C.
D. HEX Display Output Op Code 64.
E. Video Display Status Line EF1.
F. Input Switch Status Line EF4.

2. CONTROLS DESCRIPTION

The following is a description of the 24 key keyboard controls.

R RESET - Puts the CPU in the RESET mode. These additional functions are reset if they were set.

1. Single Step
2. Memory Protect
3. ROM Select

L LOAD - Puts the CPU in the LOAD mode from the RESET mode.

I INPUT - Inputs data from the HEX keypad to the data bus in the LOAD mode. In the RUN mode the EF4 Status Line is LOW while the key is depressed.

P MEMORY PROTECT - Prevents writing into memory. Useful in the LOAD mode to verify the load. Cannot be used in the RUN mode with the basic unexpanded board.

M MONITOR - Selects the on-board monitor. Replaces the first 20 HEX locations in memory with the monitor ROM. Location 20 HEX is used by the monitor, so user programs must not start before location 21 HEX when using the monitor.

S SINGLE STEP - Allows single stepping through the program one machine cycle at a time. The stopping point is the negative edge of the TPA pulse of each machine cycle. This function is used with the RUN switch. When in the SINGLE STEP mode, the DATA/OUTPUT displays display the DATA bus.

5. OPERATION WITH THE ROM MONITOR

The SUPER ELF monitor allows us to do three things.

A. Loading a program starting at any location.

B. Examine any location in memory (including the monitor itself).

C. Starting a program at any location.

NOTE: This monitor only works with PAGE ZERO (the first 256 words of memory).

A. To use the monitor to load a program.

(1) Push RESET R key.

(2) Push HEX keys 0 and 2 in that order.

(3) Push the MONITOR M select key.

(4) Push the RUN G key and the data display will indicate 02.

(5) Push the two HEX keypad keys corresponding to the starting address.

(6) Push the INPUT I key and the Q light will come on indicating that memory writing is enabled.

(7) Push the two HEX keypad keys corresponding to the data going into the memory.

(8) Push the INPUT I key and the data displays will display the memory data just entered.

(9) Repeat steps 7 and 8 for the remainder of the program.

(10) Push the RESET R key when completed.

B. To use the monitor to read out memory contents.

(1) Push the RESET R key.

(2) Push HEX keypad keys 0 and 1 in that order.

(3) Push the Monitor M select key.

(4) Push the RUN G key and the data display will indicate 01.

(5) Push the two HEX keypad keys corresponding to the starting address.

(6) Push the INPUT I key.

(7) Push the INPUT I key again and the data display will indicate the contents of the specified memory location.

CONNECTOR		FUNCTION	CONNECTOR		FUNCTION
50 Pin	44 Pin		50 Pin	44 Pin	
1	1	Ground	26	A	Ground
2	2	+10v Unreg #1	27	B	+10v Unreg #2
3	3	EF3 (22)	28	C	EF2 (23)
4	4	N0 (19)	29	D	N1 (18)
5	5	N2 (17)	30	E	Q (4)
6	6	SC1 (5)	31	F	SC0 (6)
7	7	$\overline{\text{MRD}}$ (7)	32	H	$\overline{\text{CLOCK}}$ (39)
8	8	$\overline{\text{DMAIN}}$ (38)	33	J	$\overline{\text{DMAOUT}}$ (37)
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16	13	A11	41	P	A10
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18	15	A7	43	S	A6
19	16	A5	44	T	A4
20	17	A3	45	U	A2
21	18	A1	46	V	A0
22	19	D7 (8)	47	W	D6 (9)
23	20	D5 (10)	48	X	D4 (11)
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NOTES:

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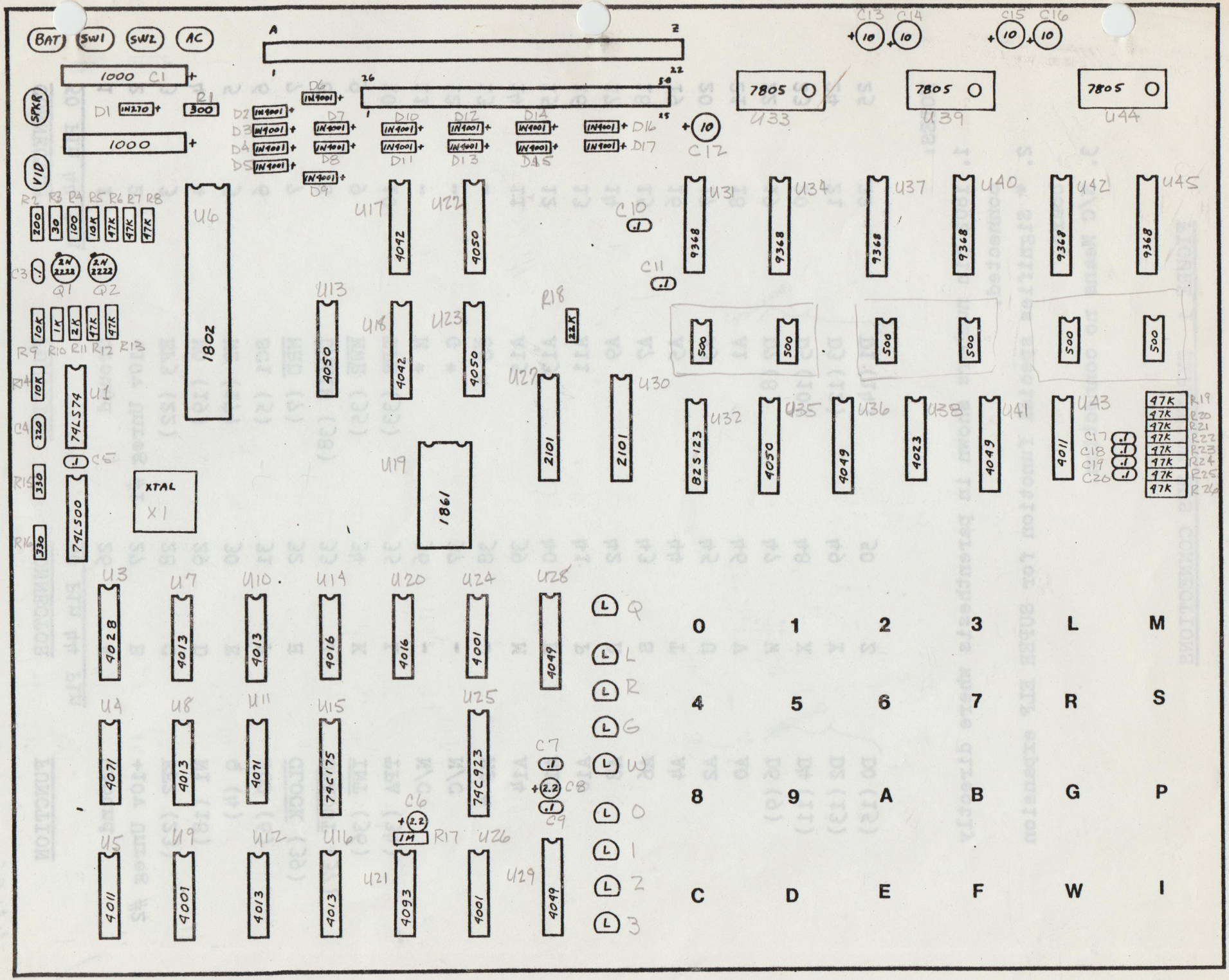
3. N/C Means no connection.

FIGURE 1 EXPANSION BUS CONNECTIONS


BAT
SW1
SW2
AC
SPKR
VID
1000 C1
D1 IN270
R1 300
1000
A
1
2
26
50
22
25
D2 IN4001
D3 IN4001
D4 IN4001
D5 IN4001
D6 IN4001
D7 IN4001
D8 IN4001
D9 IN4001
D10 IN4001
D11 IN4001
D12 IN4001
D13 IN4001
D14 IN4001
D15 IN4001
D16 IN4001
D17 IN4001
C12 10
C13 10
C14 10
C15 10
C16 10
7805 U33
7805 U39
7805 U44
R2 200
R3 30
R4 100
R5 10K
R6 47K
R7 47K
R8 47K
C3 .1
Q1 2N2222
Q2 2N2222
R9 10K
R10 1K
R11 2K
R12 47K
R13 47K
R14 10K
C4 330
R15 330
R16 330
U1 74LS74
C5 .1
74LS00
XTAL X1
U6 1802
U17 4042
U22 4050
U113 4050
U18 4042
U23 4050
U19 1861
U27 2101
U30 2101
C10 .1
C11 .1
U31 9368
U34 9368
U37 9368
U40 9368
U42 9368
U45 9368
R18 22K
500
U32 BZS123
U35 4050
U36 4049
U38 4023
U41 4049
U43 4011
C17 .1
C18 .1
C19 .1
C20 .1
R19 47K
R20 47K
R21 47K
R22 47K
R23 47K
R24 47K
R25 47K
R26 47K
U3 4028
U7 4013
U10 4013
U14 4016
U20 4016
U24 4001
U28 4049
U4 4071
U8 4013
U11 4071
U15 74C175
U25 74C923
C7 .1
C8 2.2
C9 .1
C6 2.2
1M R17
U5 4011
U9 4001
U12 4013
U16 4013
U21 4093
U26 4001
U29 4049
L Q
L L
L R
L G
L W
L O
L I
L Z
L 3
0 1 2 3 L M
4 5 6 7 R S
8 9 A B G P
C D E F W I