Experiment No. 1
Introduction to the SANPER Lab Unit
ECE 441

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September 5, 2013

Date Performed:	September 29, 2013
Partners:	Zelin Wu
Instructor:	Professor Saniie

1 Introduction

1.1 Purpose

The purpose of this experiment is to familiarize students with the SANPER lab unit and the TUTOR software to control it. Specifically, it aims to familiarize the student about the M68K instruction set and the functionality of the TRAP #14 instruction.

1.2 Background

The SANPER unit consists of a MC68000 Processor surrounded by peripherals to interface with memory, other computer systems, and users of the device. Some examples of peripherals are: the serial ports, the parallel ports, and the ADCs and DACs.
The TUTOR resident monitor is the environment in which all the programming and debugging work is done for the SANPER unit. TUTOR provides the ability to display and modify registers and memory, and the ability to assemble, run, and debug user programs.
One of the most critical functions of TUTOR was the TRAP 14 handler. Trap 14 is a command that can be called to run useful subroutines to, for example perform input/output commands on the system. In this lab, Trap 14 was used to print a string out through the serial port.

2 Lab Procedure and Equipment List

2.1 Equipment

- SANPER System
- Computer with TUTOR software

2.2 Procedure

2.2.1 Part A

a. Connect to the SANPER unit.

b. Test each of the following commands:

- Help [HE]
- Display Formatted Registers [DF]
- Display/Modify Single Formatted Register [e.g. .A1, .A1 1000]
- Display Formatted Address/Data Registers [.A, .D]

2.2.2 Part B

a. Connect to the SANPER unit.

b. Assemble program in Table 1.2 of the lab manual

c. Set the output string at $900 to 'IT WORKS!!'

d. Run program

e. Capture results (Note: our terminal segfaulted while we were trying to copy our data out of it, so we do not have the full results).

f. Trace program, capturing register changes.

g. Enter and run the program in tables 1.2 to 1.4 in single step mode. Capture results.

h. Reset the SANPER unit and capture results.

3 Results and Analysis

Results are included in the Appendix.
To see a screenshot of the terminal after it crashed while trying to copy information out of it, see the section 'Terminal Output'
Step through for the programs in table 1.2 to 1.4 are in the sections appropriately named. They are recorded in the form of pictures of the front face of the SANPER unit.
Similarly, the pictures of the reset sequence are in the 'Reset' section.

3.1 Discussion

a. See appendix for completed program segments with comments.

b. According to table 7-1 in chapter 7 page 4 of the Educational Board User Manual folder in the class notes: $000900 to $0007FFF address user RAM.

c. The values of the data, address and control lines can be found in the photos of the lab included with this report. Generally, the address lines stepped up by the word size of the 68K, clearly as a result of the processor fetching the next instruction before execution, however, when the instruction used data located in memory, the addresses needed to load and store that memory appeared on the address line. The data line contained either the instruction to be fetched next or the data to be loaded/stored.

d. There are two serial ports (ACIA1 and ACIA2) on the SANPER unit. ACIA1 is located at even addresses $010040 and $010042. ACIA1 is located at odd addresses $010041 and $010043.

e.
- Serial Port
- Parallel Port
- ADC
- DAC
- High Power Output Drivers

f. The LED is off, because those signals assert at low voltage.

4 Conclusions

This experiment was accomplished. SANPER and TUTOR were introduced, as well as the Trap 14 call. From this building block, students can work on more and more complex programs for SANPER and can continue to learn about the functioning of the machine.

5 Appendix

5.1 Code

5.1.1 Table 1.1

```
LEA.L $2000,A7   ;Load from memory
MOVE.L #$900,A5  ;Prepare registers with addresses
MOVE.L #$90B,A6
MOVE.B #243,D7   ;System call output string to port 1
TRAP #14
MOVE.B #241,D7   ;System call input string from port 1
TRAP #14
MOVE.B #227,D7   ;System call output string plus newline to port 1
TRAP #14
BRA $1004        ;Loop back to beginning
```

5.1.2 Table 1.2

```
MOVE.B D0,D1     ;Copy D0 to D1
MOVE.B #$AA,$1000        ;Move a constant to a memory address
BRA $900         ;Loop back to start
```

5.1.3 Table 1.3

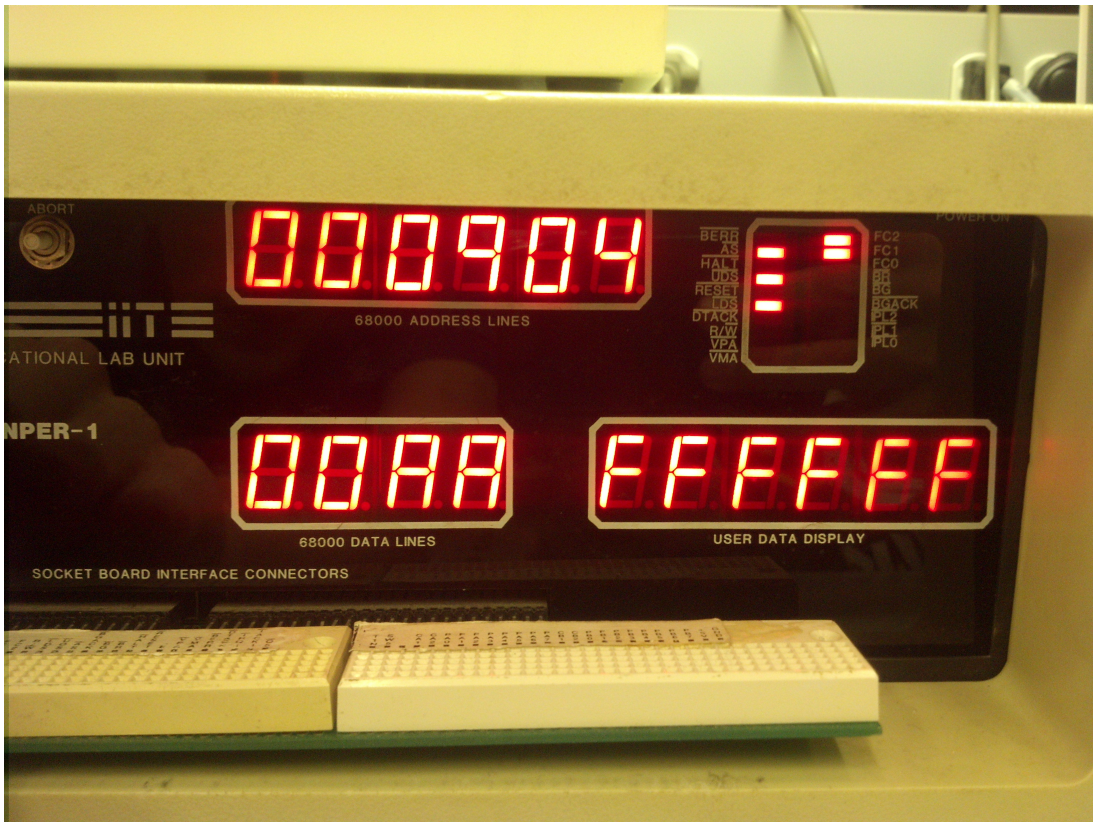
```
MOVE.B D0,D1     ;Copy D0 to D1
MOVE.B #$AA,$1001        ;Move a constant to a memory address
BRA $900         ;Loop back to start
```

5.1.4 Table 1.4

```
MOVE.B D0,D1     ;Copy D0 to D1
MOVE.B $1000,$1001       ;Move a from a memory address to a memory address
BRA $900         ;Loop back to start
```

5.2 Step Through

5.2.1 Table 1.2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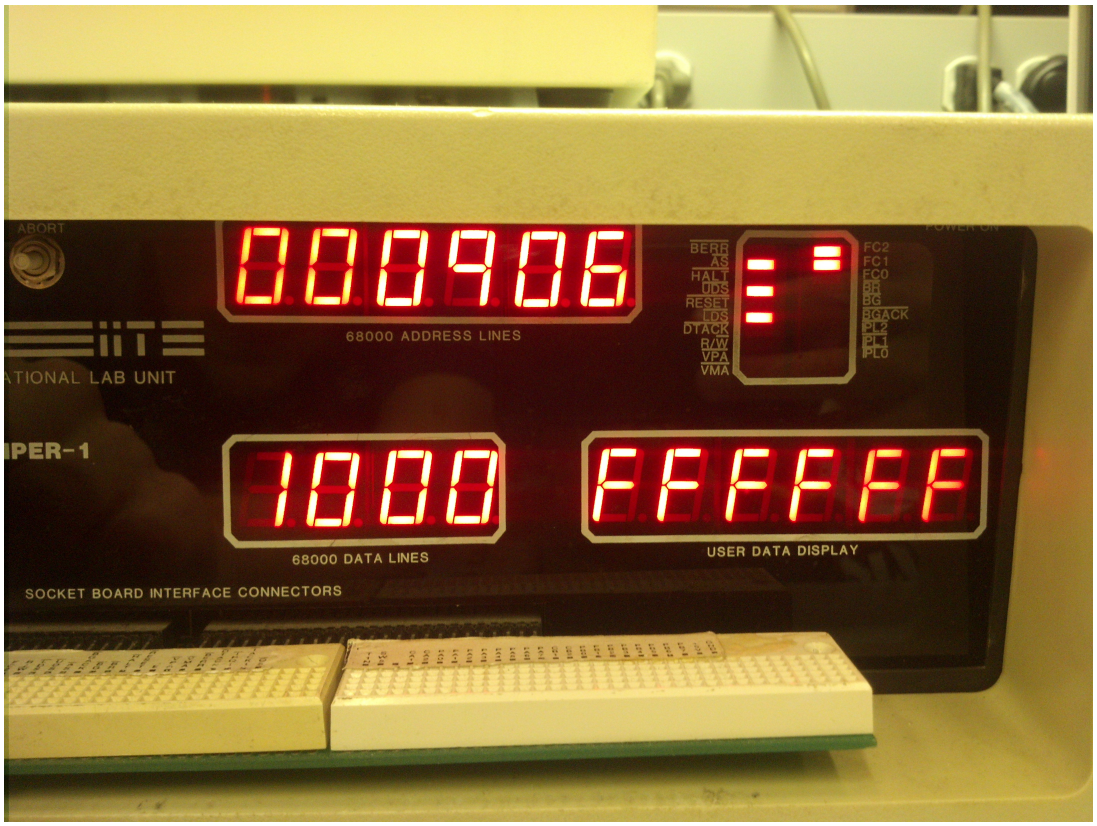
BERR
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
NPER-1
00AA
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS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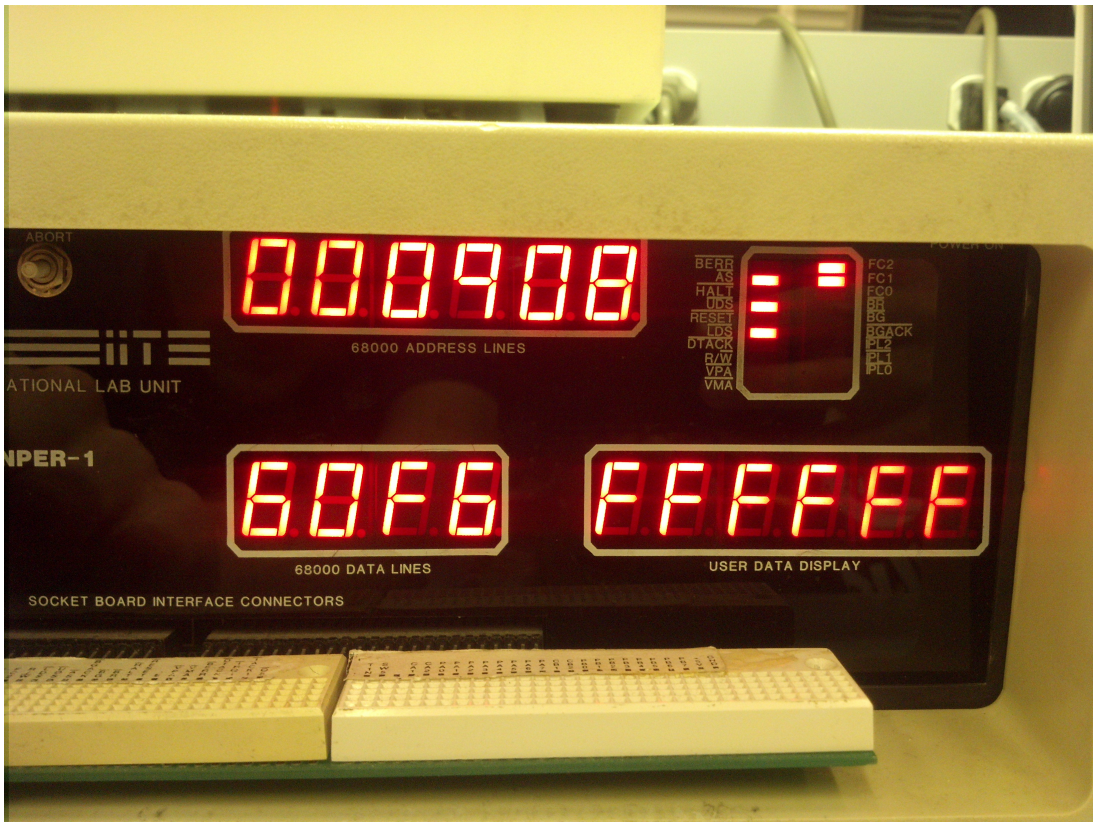
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
PL2
PL1
PL0
ATIONAL LAB UNIT
PER-1
1000
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS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BERR
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
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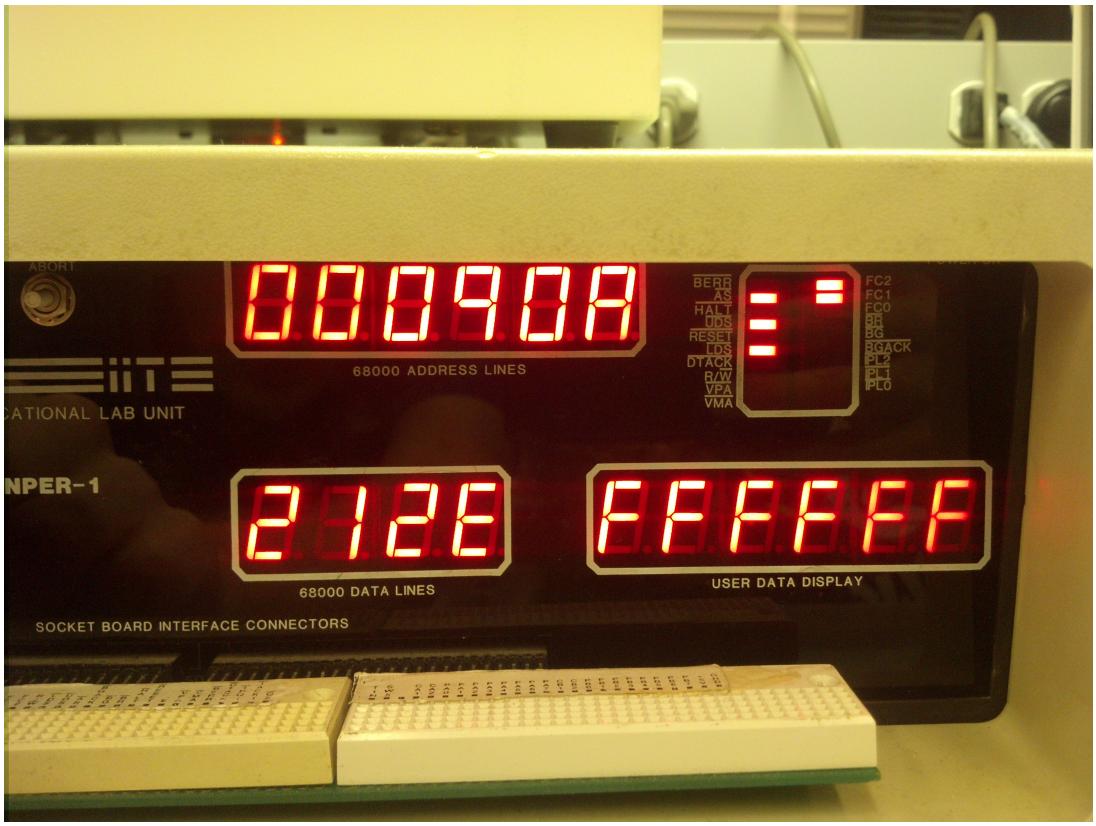
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
ATIONAL LAB UNIT
NPER-1
60F6
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS


ABORT
ATIONAL LAB UNIT
NPER-1
00 1000
68000 ADDRESS LINES
BERR
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
AAF6
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS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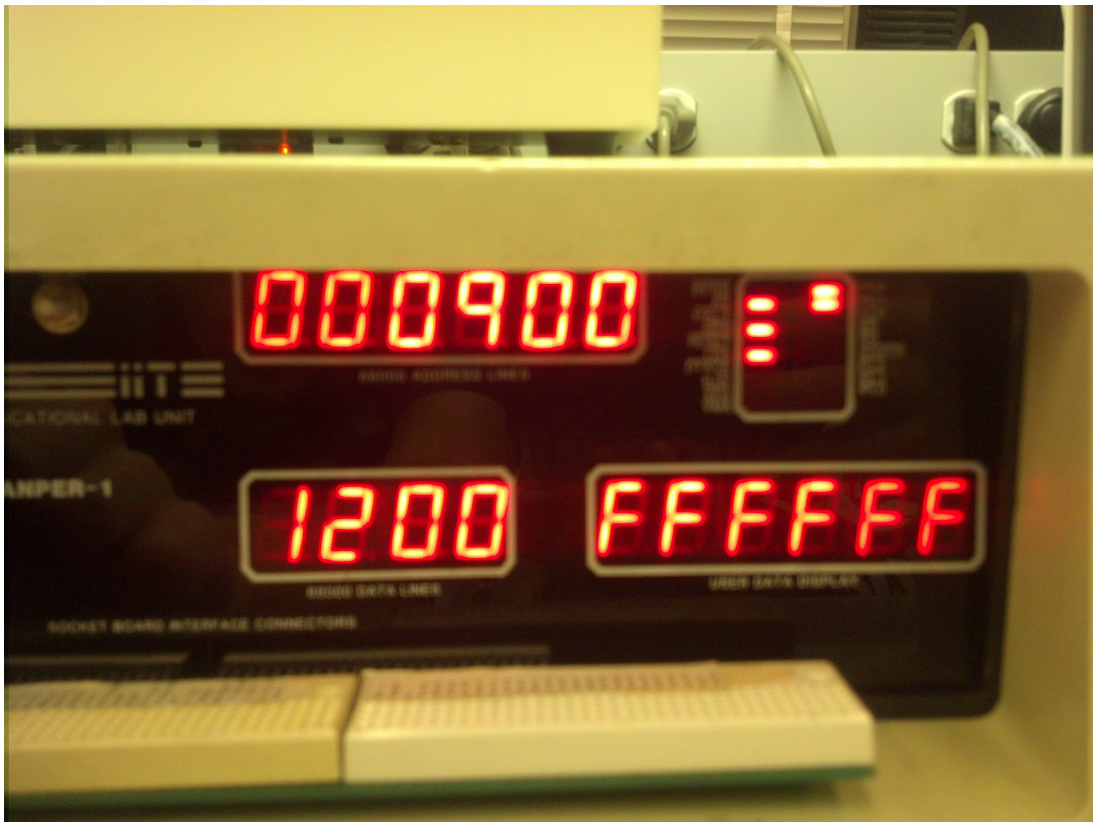
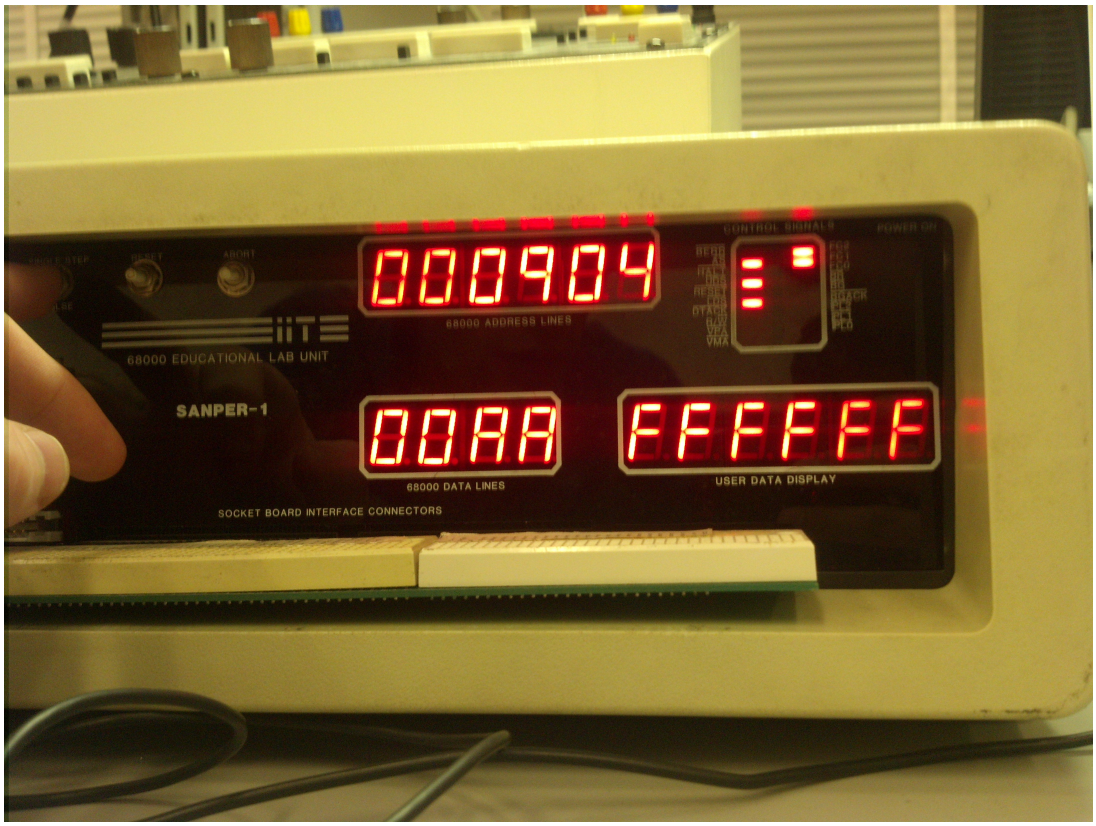
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
CATIONAL LAB UNIT
NPER-1
212E
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS


000900
1200
FFFFFF

5.2.2 Table 1.3


000900
1200
FFFFFF


000902
68000 ADDRESS LINES
CONTROL SIGNALS
POWER ON
RESET
ABORT
68000 EDUCATIONAL LAB UNIT
SANPER-1
11FC
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS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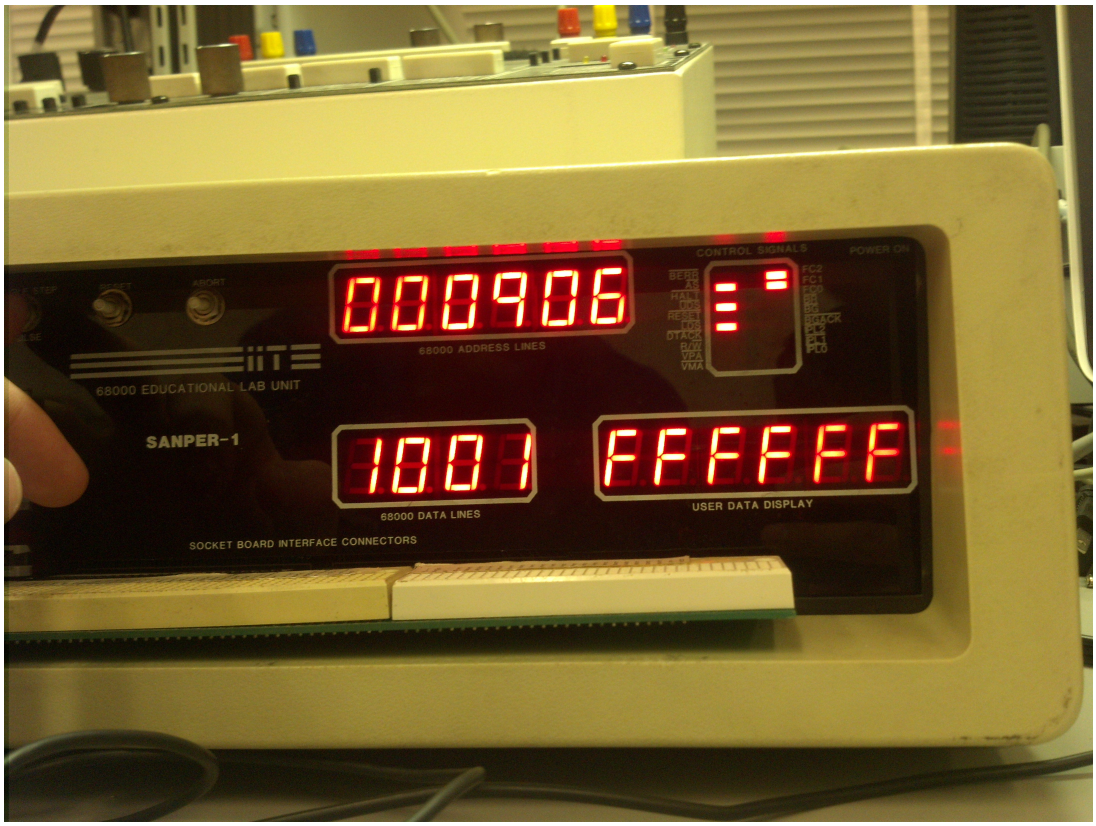
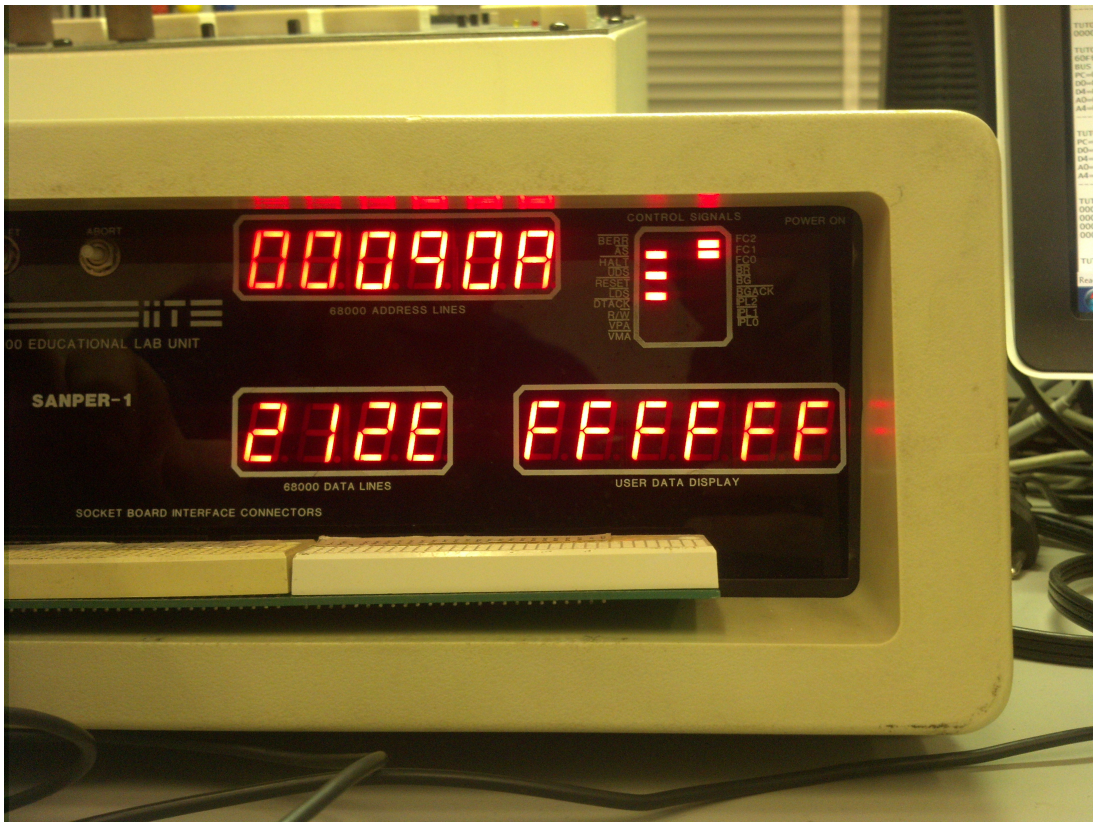
68000 EDUCATIONAL LAB UNIT
SANPER-1
00AA
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS


000906
68000 ADDRESS LINES
CONTROL SIGNALS
POWER ON
68000 EDUCATIONAL LAB UNIT
SANPER-1
1001
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS


RESET
ABORT
68000 EDUCATIONAL LAB UNIT
SANPER-1
000908
68000 ADDRESS LINES
CONTROL SIGNALS
POWER ON
BERR
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
IPL2
IPL1
IPL0
60F6
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS


00 1001
68000 ADDRESS LINES
CONTROL SIGNALS
POWER ON
68000 EDUCATIONAL LAB UNIT
SANPER-1
60AA
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS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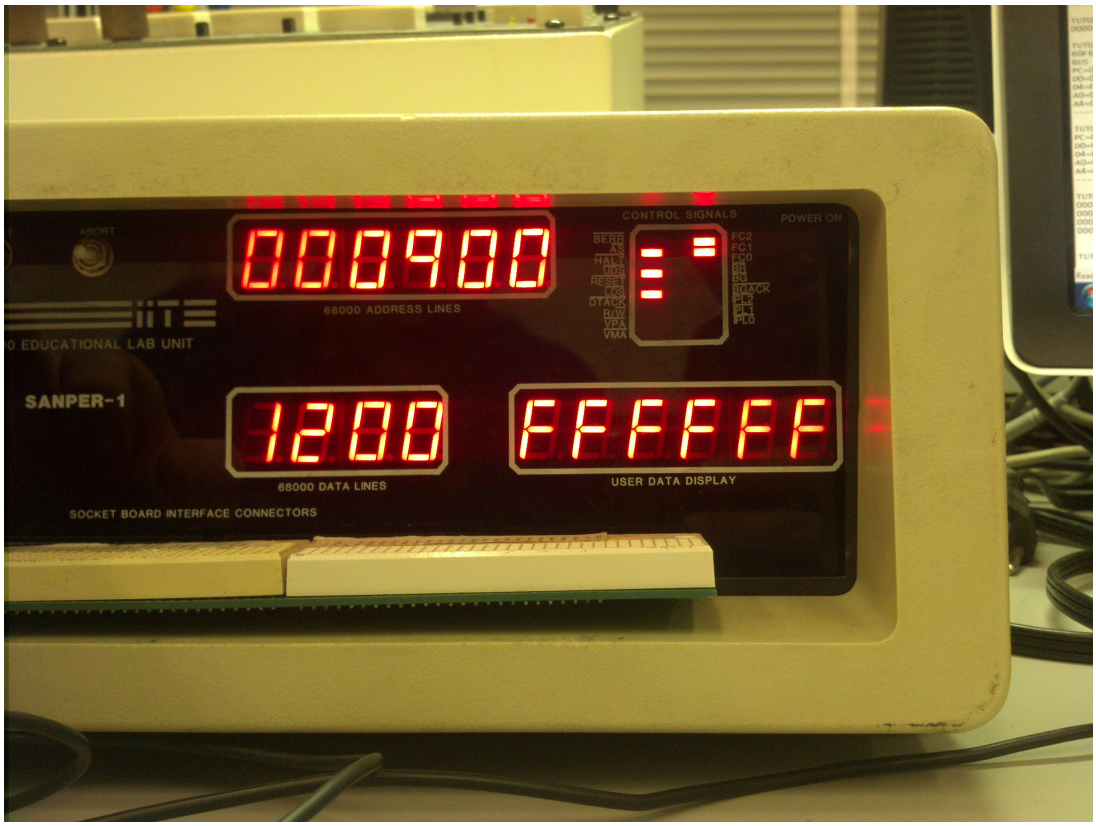
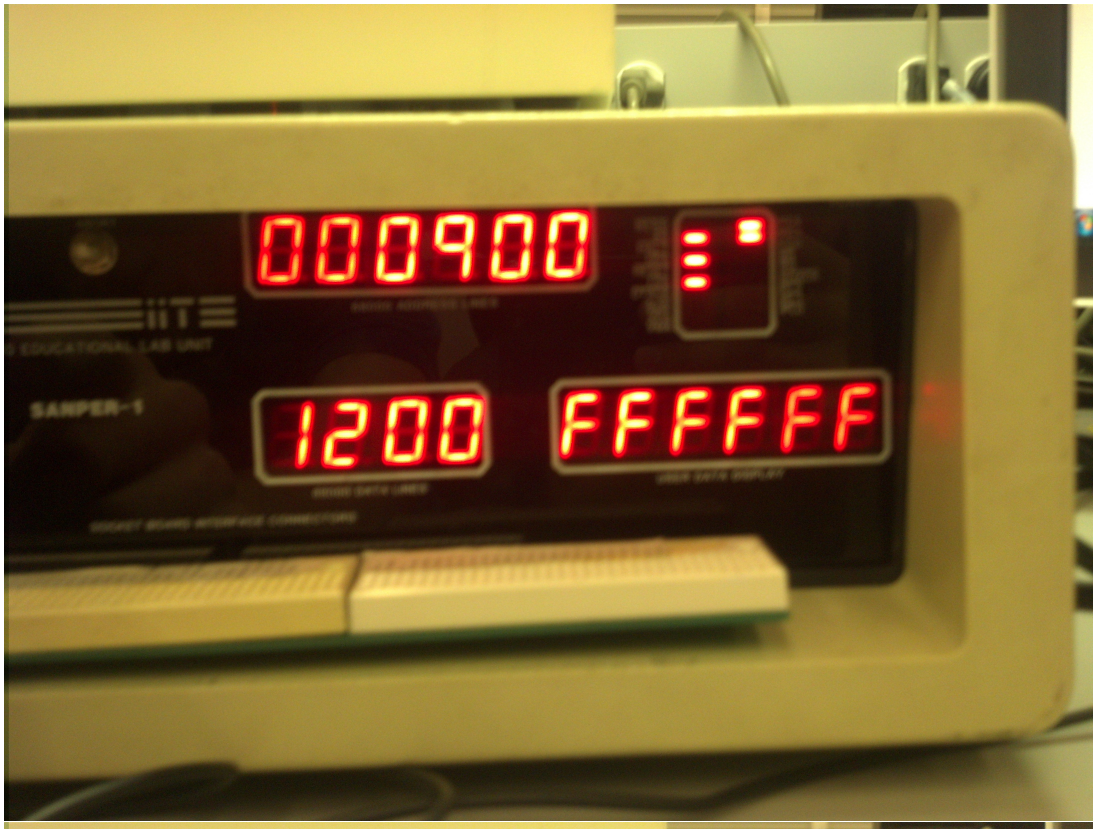
68000 ADDRESS LINES
CONTROL SIGNALS
POWER ON
BERR
AS
HALT
DDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
00 EDUCATIONAL LAB UNIT
SANPER-1
212E
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS


ABORT
iiT
EDUCATIONAL LAB UNIT
SANPER-1
000900
68000 ADDRESS LINES
CONTROL SIGNALS
POWER ON
BERR
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
1200
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS

5.2.3 Table 1.4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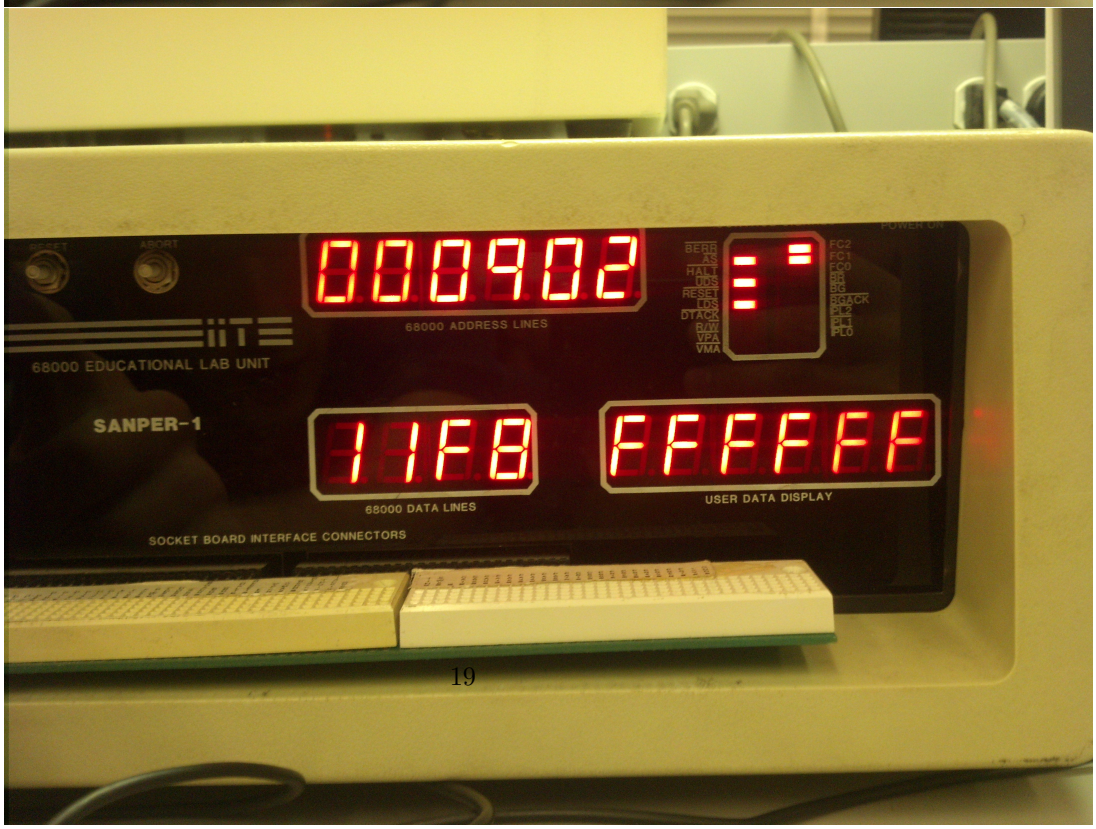
1200
FFFFFF
SANPER-1


000902
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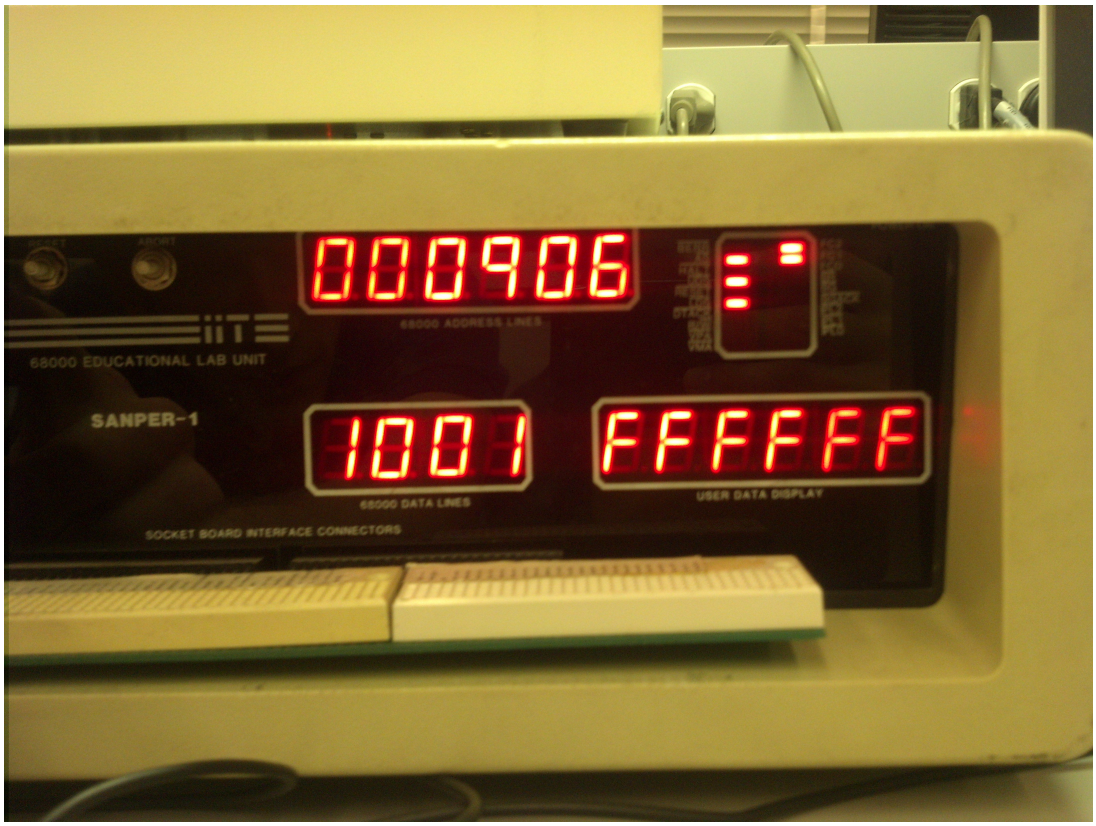
SANPER-1
11F8
FFFFFF
68000 DATA LINES
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS


RESET
ABORT
000904
68000 ADDRESS LINES
iiT
68000 EDUCATIONAL LAB UNIT
SANPER-1
1000
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS


000906
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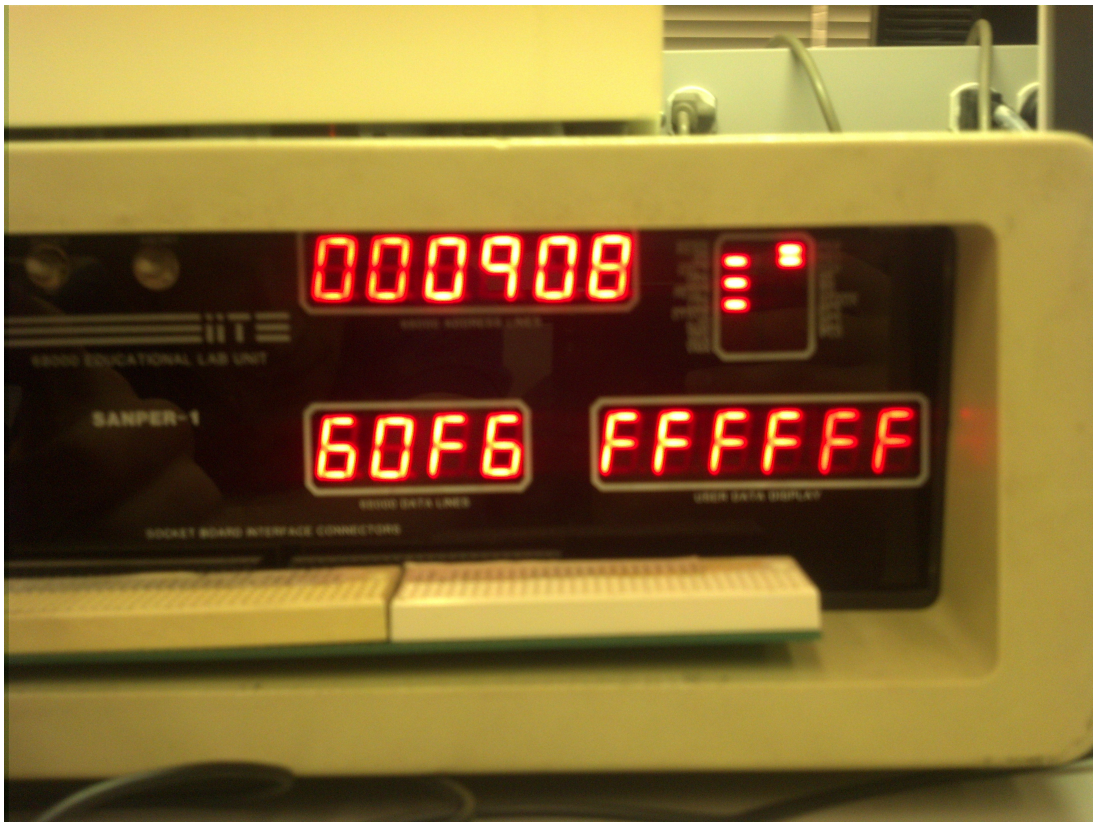
68000 EDUCATIONAL LAB UNIT
SANPER-1
1001
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS


001000
68000 ADDRESS LINES
iiT
68000 EDUCATIONAL LAB UNIT
SANPER-1
AA01
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS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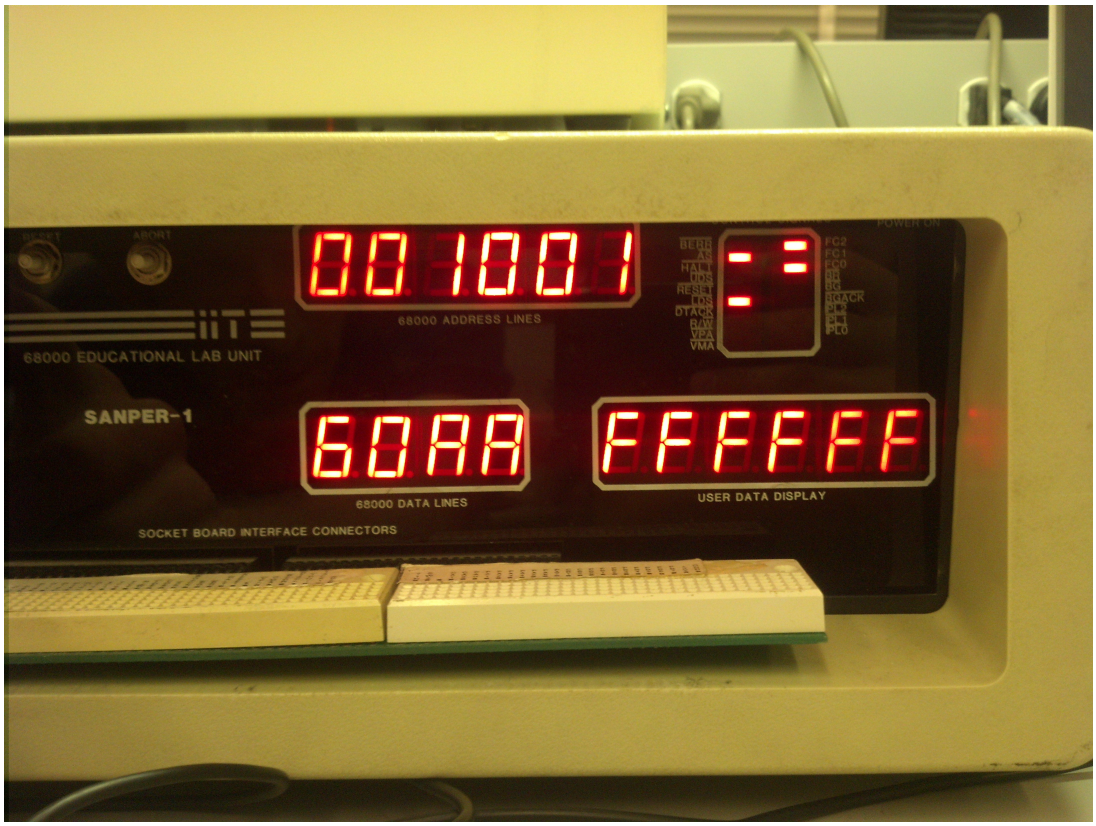
FFFFFF
SANPER-1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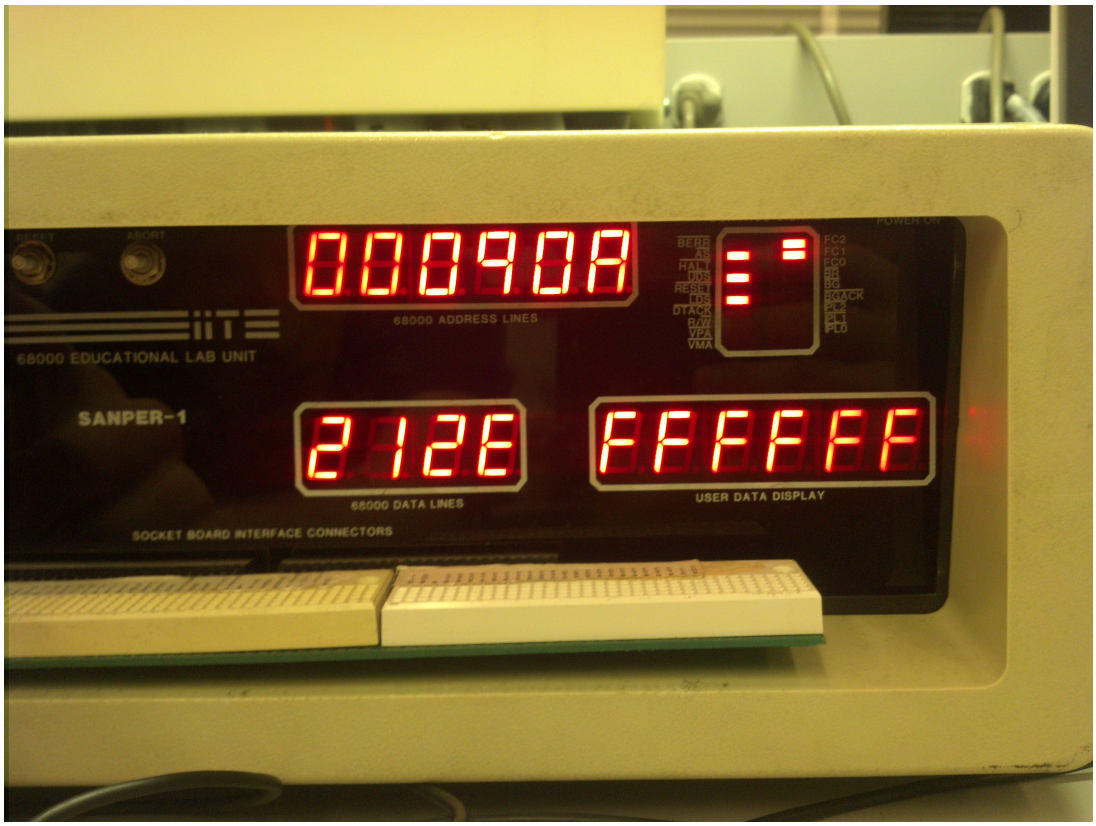
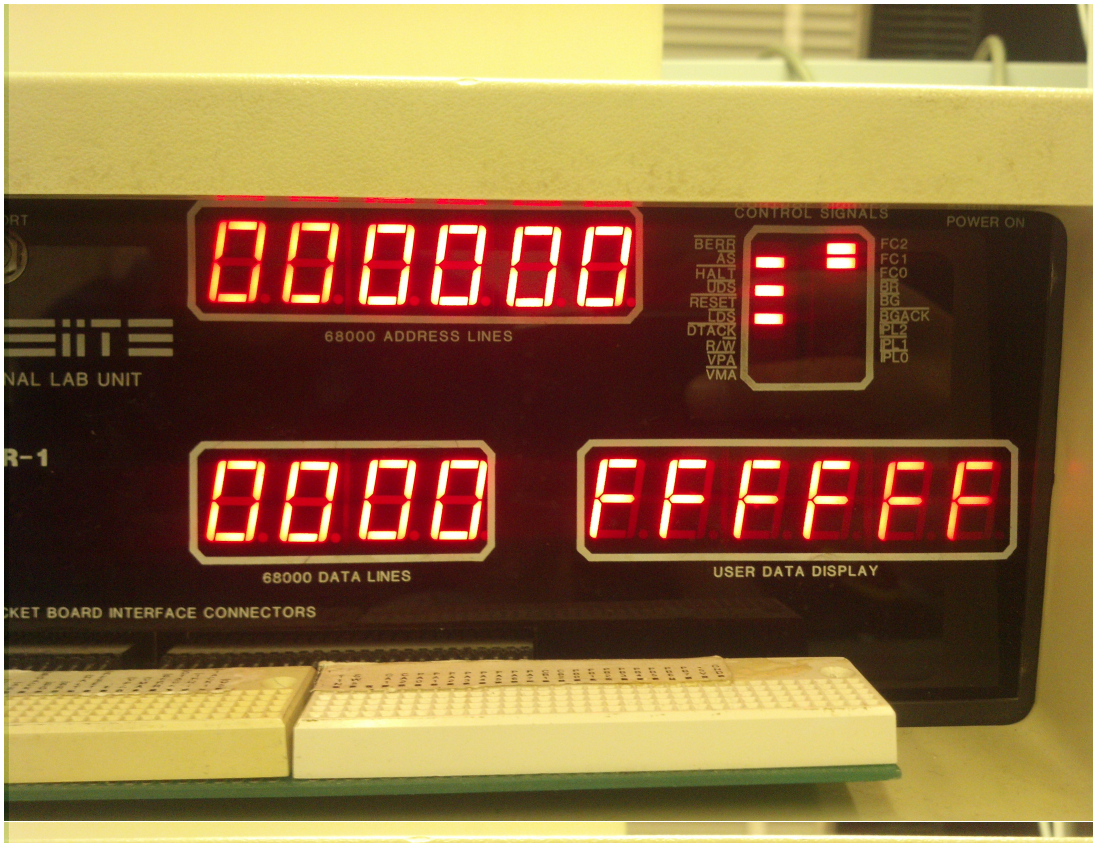
68000 DATA LINES
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS


000908
68000 ADDRESS LINES
68000 EDUCATIONAL LAB UNIT
SANPER-1
212E
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
SOCKET BOARD INTERFACE CONNECTORS

5.2.4 Reset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CONTROL SIGNALS
POWER ON
BERR
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
0000
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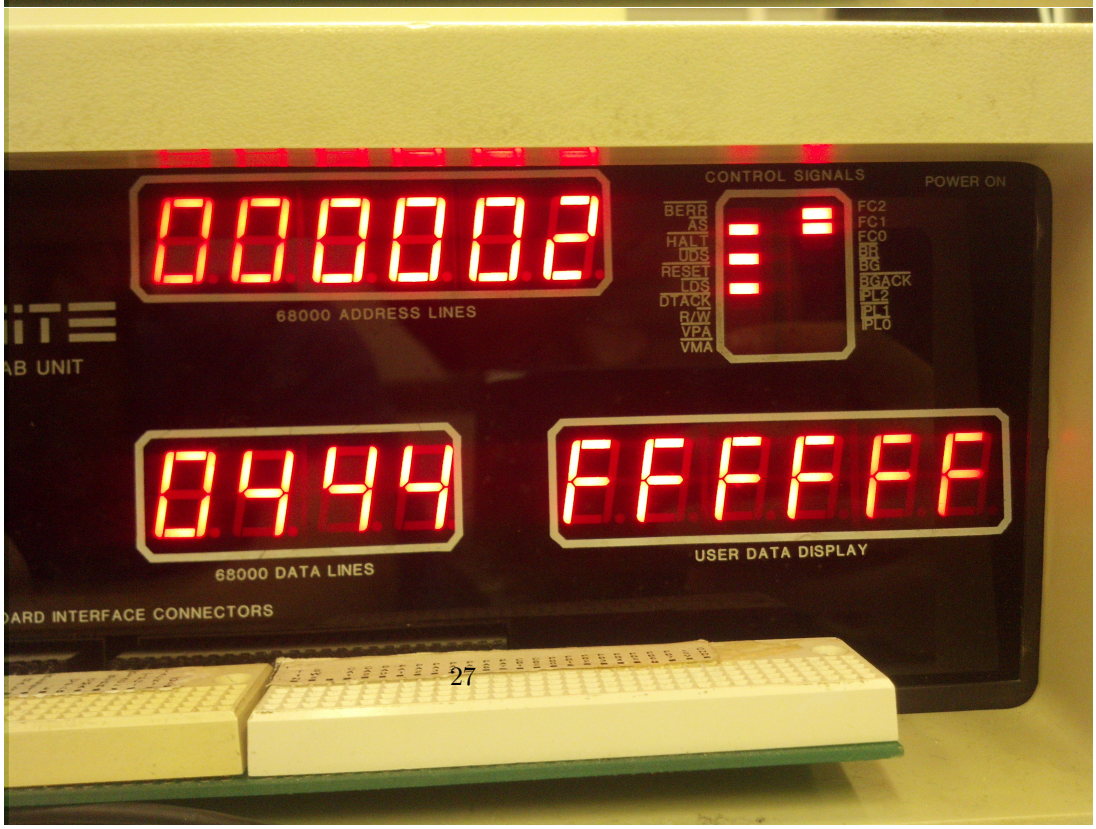
FFFFFF
USER DATA DISPLAY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CONTROL SIGNALS
POWER ON
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AS
HALT
UDS
RESET
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DTACK
R/W
VPA
VMA
FC2
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BR
BG
BGACK
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IPL1
IPL0
0449
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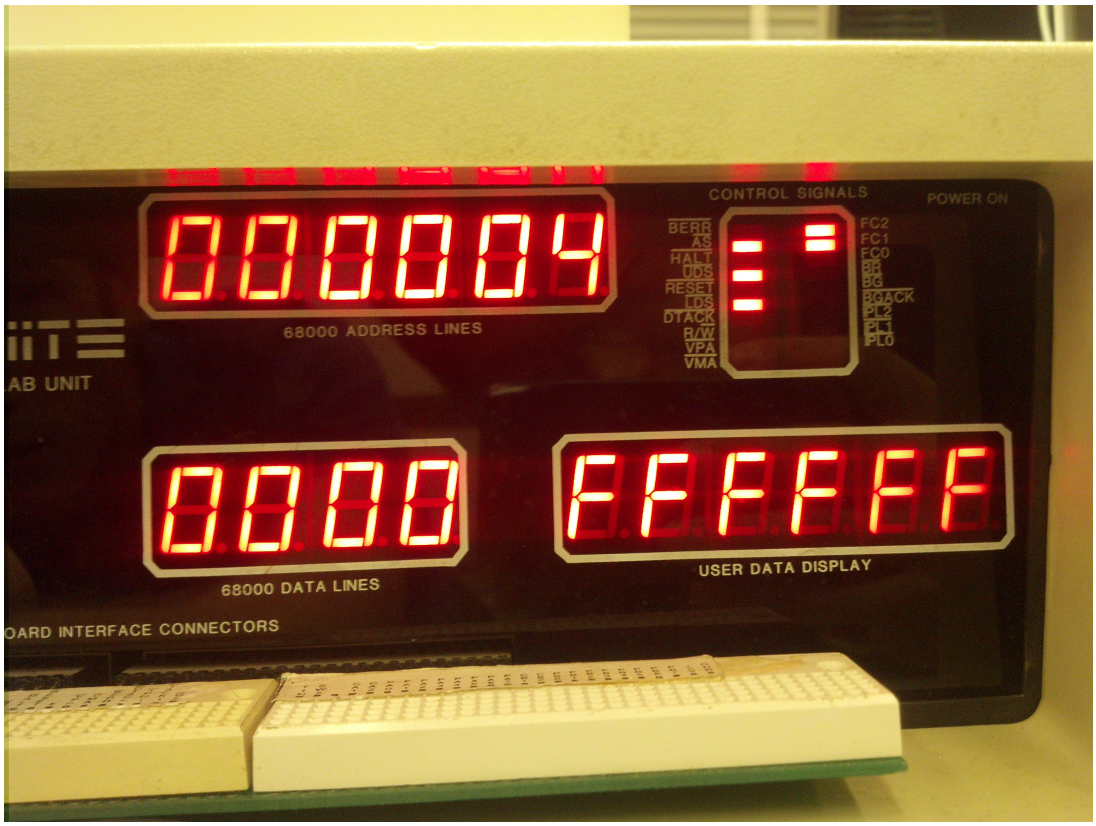
FFFFFF
USER DATA DISPLAY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CONTROL SIGNALS
POWER ON
BERR
AS
HALT
UDS
RESET
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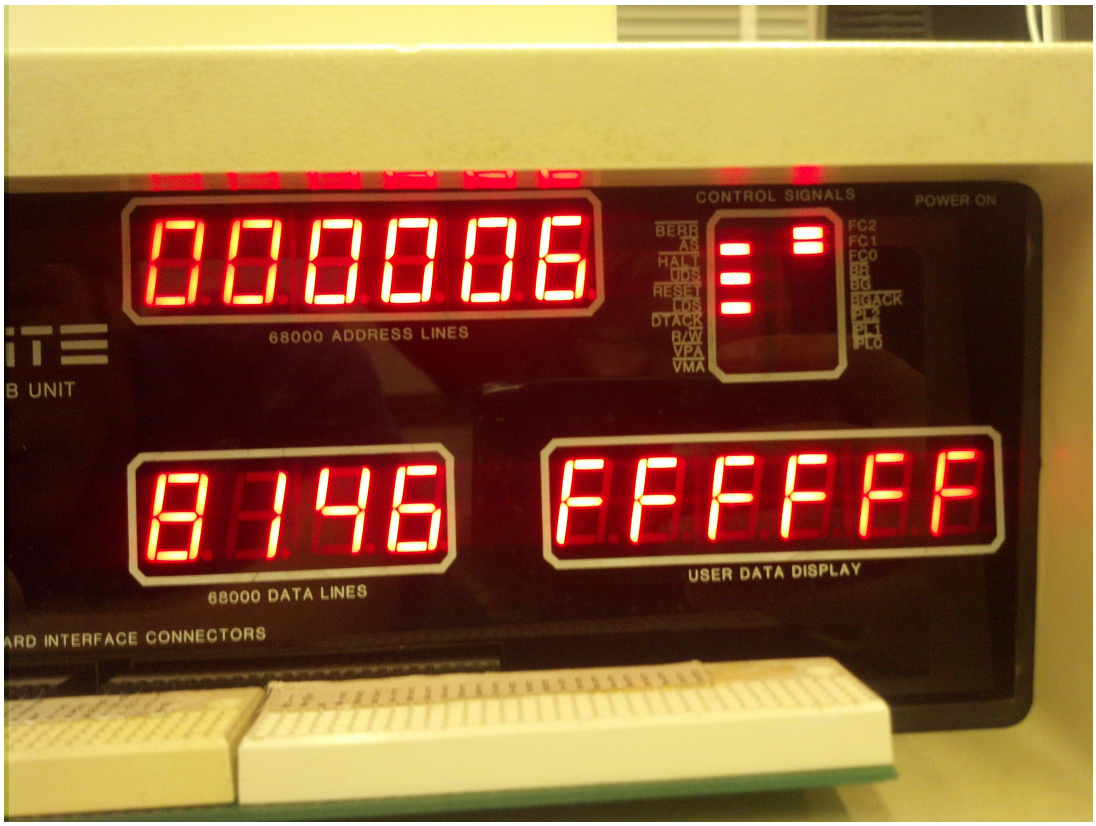
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
AB UNIT
0000
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
OARD INTERFACE CONNECTORS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DTACK
R/W
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VMA
FC2
FC1
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IPL1
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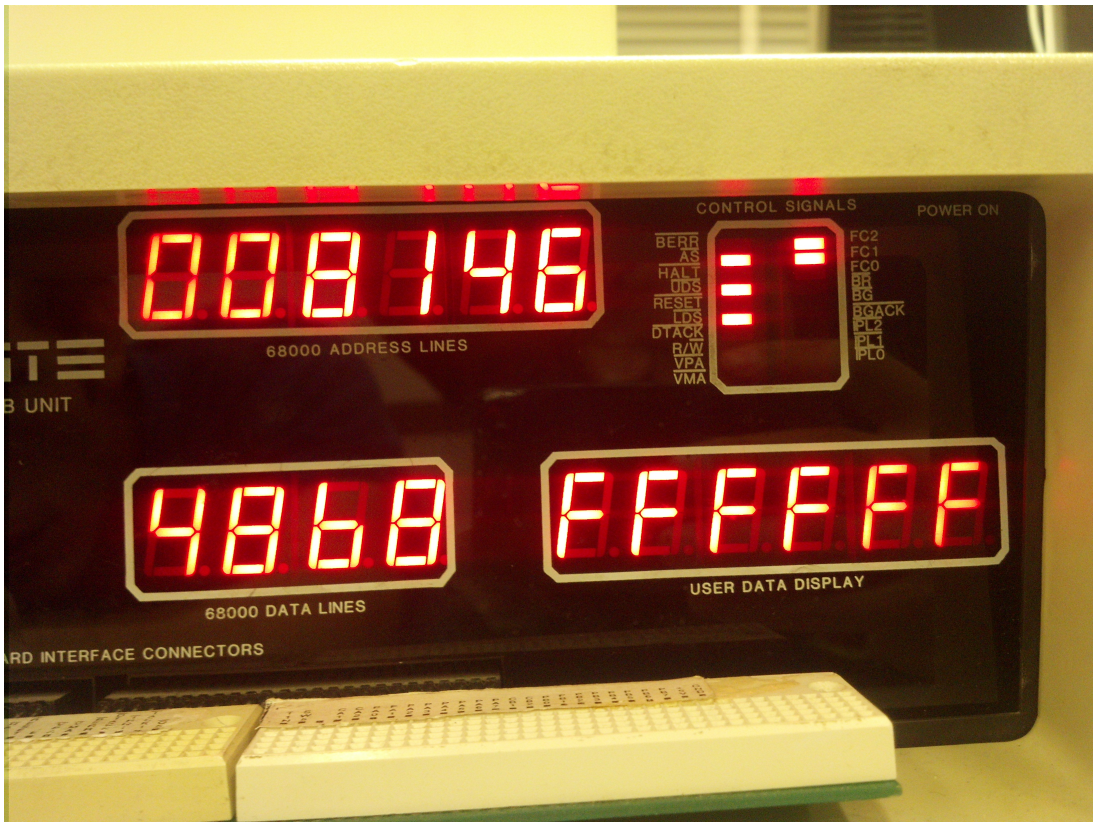
CONTROL SIGNALS
POWER ON
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R/W
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VMA
FC2
FC1
FC0
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BG
BGACK
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IPL1
IPL0
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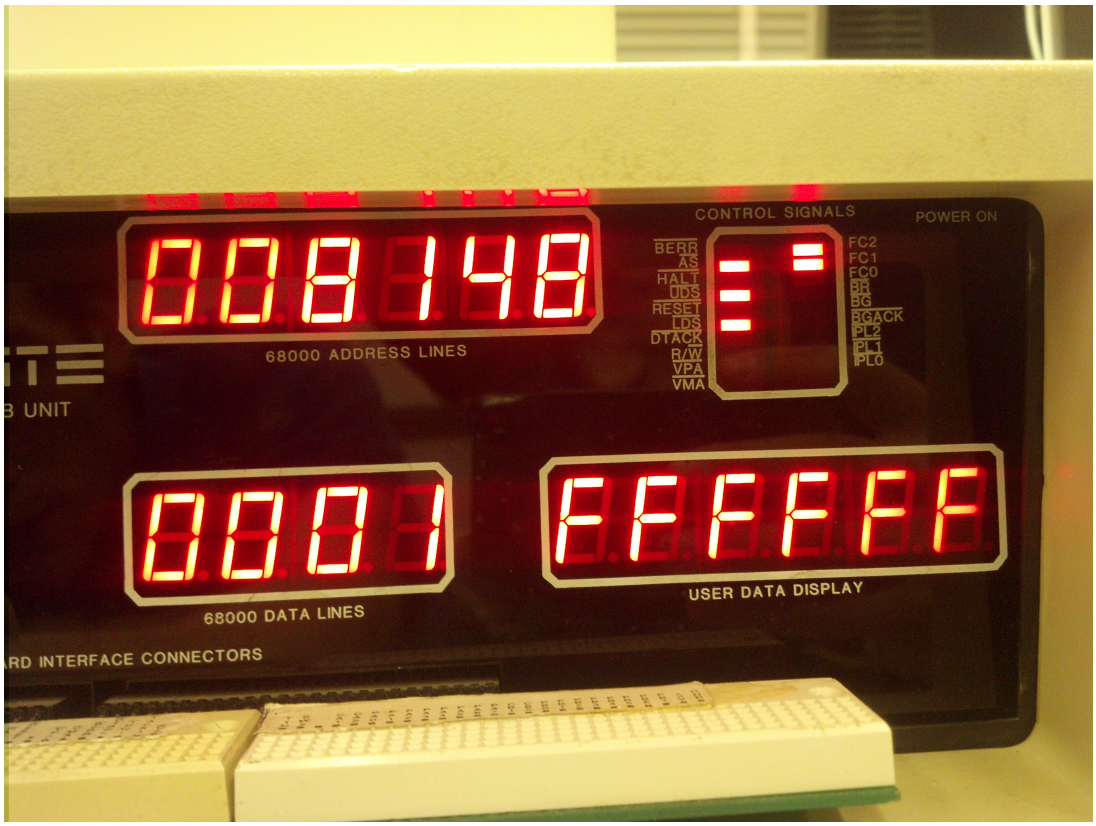
68000 DATA LINES
USER DATA DISPLAY
B UNIT
ARD INTERFACE CONNECTORS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UDS
RESET
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DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
0001
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
B UNIT
RD INTERFACE CONNECTORS


00814A
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CONTROL SIGNALS
POWER ON
BERR
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
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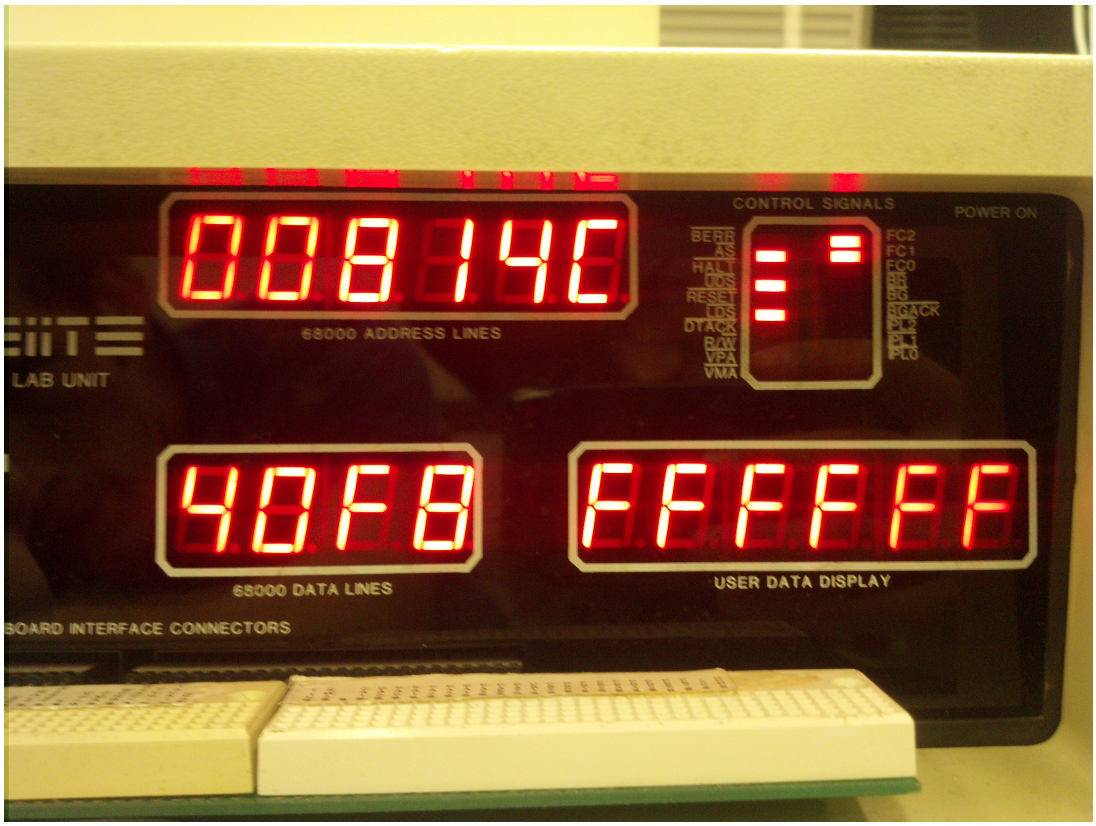
BR
BG
BGACK
B UNIT
0406
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
ARD INTERFACE CONNECTORS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AS
HALT
UDS
RESET
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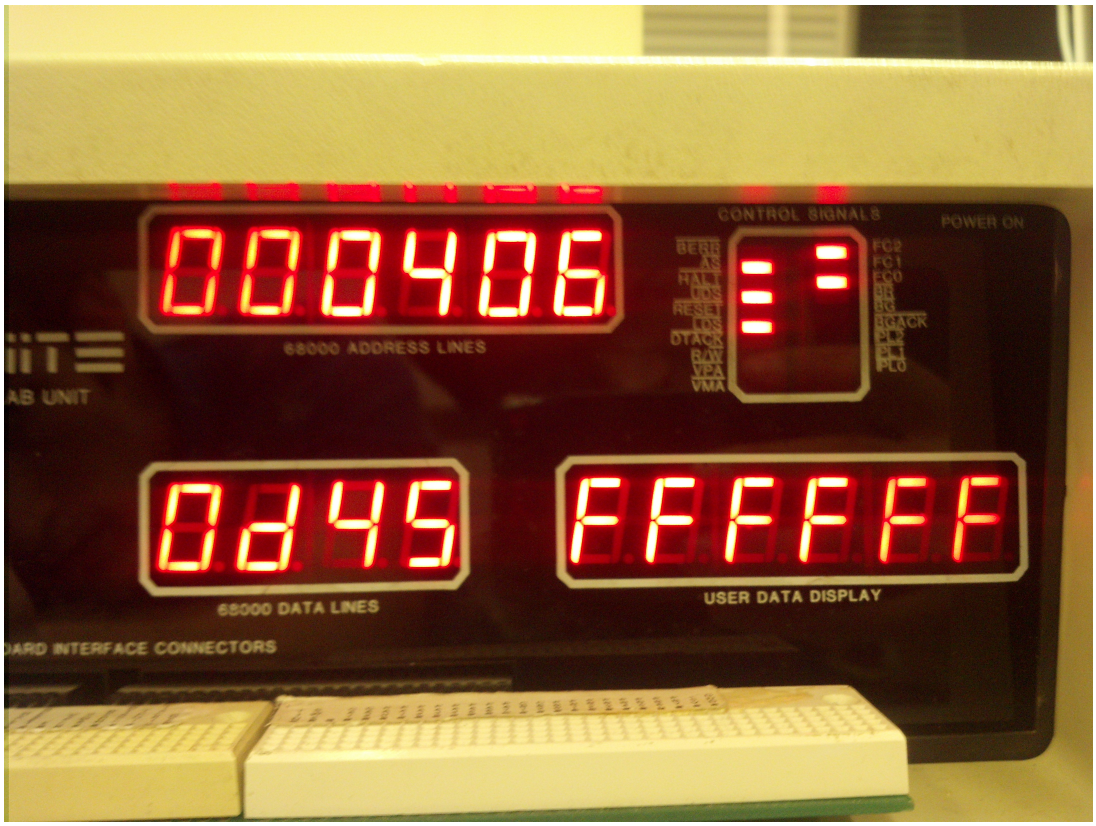
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
LAB UNIT
40F8
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
BOARD INTERFACE CONNECTORS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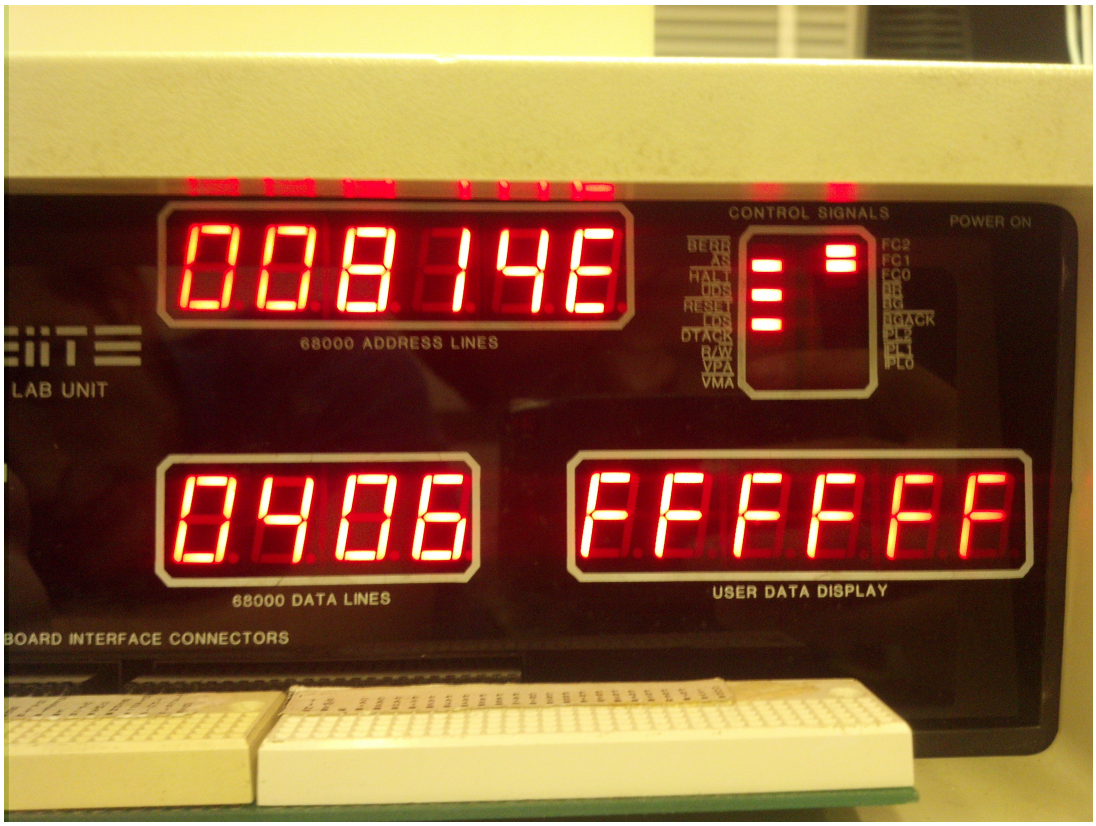
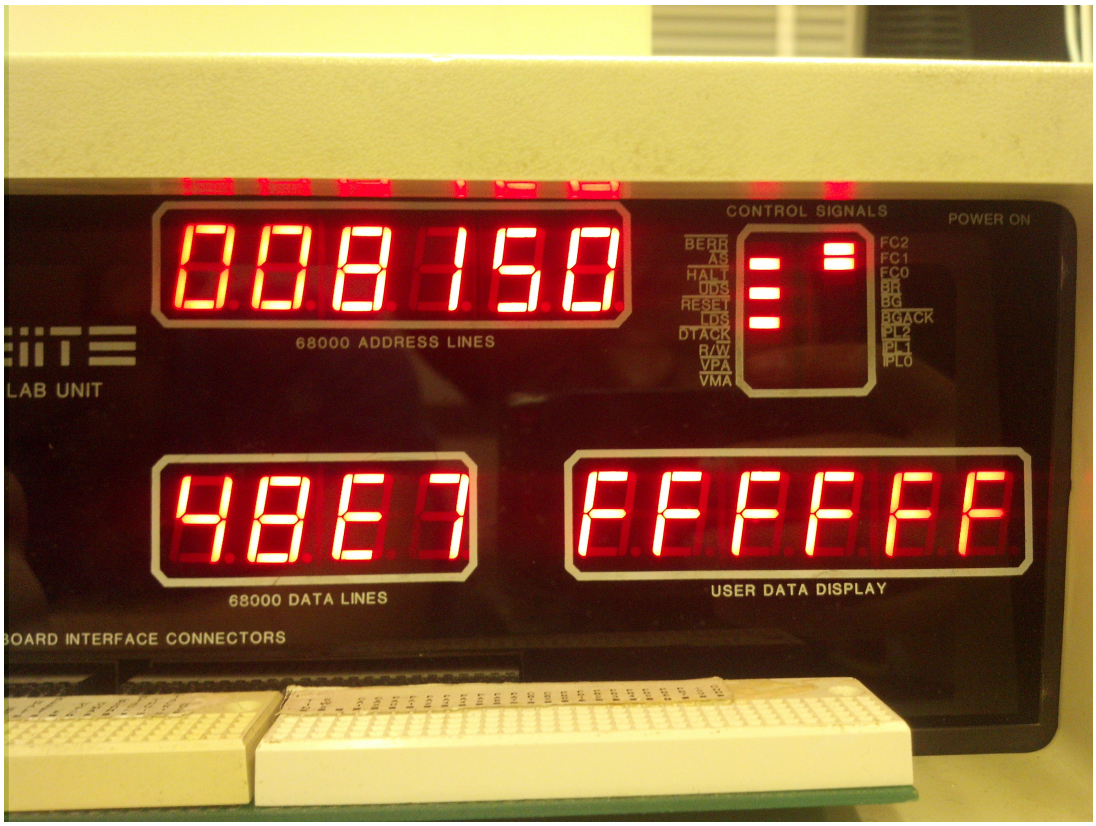
POWER ON
BERR
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
0d45
68000 DATA LINES
FFFFFF
USER DATA DISPLAY


00814E
68000 ADDRESS LINES
CONTROL SIGNALS
POWER ON
BERR
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
LAB UNIT
0406
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
BOARD INTERFACE CONNECTORS


00B150
68000 ADDRESS LINES
CONTROL SIGNALS
POWER ON
BERR
AS
HALT
UDS
RESET
LDS
DTACK
R/W
VPA
VMA
FC2
FC1
FC0
BR
BG
BGACK
IPL2
IPL1
IPL0
LAB UNIT
4BE7
68000 DATA LINES
FFFFFF
USER DATA DISPLAY
BOARD INTERFACE CONNECTORS

5.3 Terminal Output

```
TUTOR  1.3 > G $1000
PHYSICAL ADDRESS=00001000

ILLEGAL INSTRUCTION
PC=00000900 SR=2718=.S7XN... US=7FFF605F SS=00000786
D0=FFFF3FFF D1=FFFF1FFF D2=FFFF7FFF D3=FFFF1FDB
D4=FFFF7FFF D5=FFFF0B3B D6=7FFF7FFF D7=FFFF212F
A0=FFFF3FFF A1=00001234 A2=7FDF7FFF A3=FFFF032B
A4=FFFF2FFF A5=FFFF3FFF A6=7FFF7BBF A7=00000786
--------------------000900    4954                DC.W    $4954

TUTOR  1.3 > MD $1000
001000    AA 00 11 FC 00 AA 10 00  60 00 F8 F6 0E 8B 6F 9F  *..|.*..`.xv..o.

TUTOR  1.3 > MD $900
000900    49 54 20 57 4F 52 4B 53  20 21 21 1F 0D 4E 0F 0F  IT WORKS !!..N..

TUTOR  1.3 > .PC 1000

TUTOR  1.3 > T
PHYSICAL ADDRESS=00001000

1010 TRAP ERROR
PC=00001000 SR=A718=TS7XN... US=7FFF605F SS=00000786
D0=FFFF3FFF D1=FFFF1FFF D2=FFFF7FFF D3=FFFF1FDB
D4=FFFF7FFF D5=FFFF0B3B D6=7FFF7FFF D7=FFFF212F
A0=FFFF3FFF A1=00001234 A2=7FDF7FFF A3=FFFF032B
A4=FFFF2FFF A5=FFFF3FFF A6=7FFF7BBF A7=00000786
--------------------001000    AA00                DC.W    $AA00

TUTOR  1.3 :> .
WHAT

TUTOR  1.3 >MM $1000;DI
WHAT

TUTOR  1.3 > MM $100;DI
000100    0000                DC.W    $0000 ?.


TUTOR  1.3 > MM $1000;DI
WHAT

TUTOR  1.3 >  MM $1000;DI
001000    AA00                DC.W    $AA.0 ?


TUTOR  1.3 > MM $1000;DI
WHAT

TUTOR  1.3 >  MM $1000;DI
001000    4FF82000            LEA.L   $2000,A7
001004    2A7C00000900        MOVE.L  #$900,A5
00100A    2C7C0000090B        MOVE.L  #$90B,A6
001010    1E3C00F3            MOVE.B  #243,D7
001014    4E4E                TRAP    #14
001016    1E3C00F1            MOVE.B  #241,D7
00101A    4E4E                TRAP    #14
00101C    1E3C00E3            MOVE.B  #227,D7
001020    4E4E                TRAP    #14
001022    60E0                BRA     $1004
001024    F0F4                DC.W    $F0F4 ?.


TUTOR  1.3 > G $1000
PHYSICAL ADDRESS=00001000
IT WORKS !!

IT WORKS !!
```