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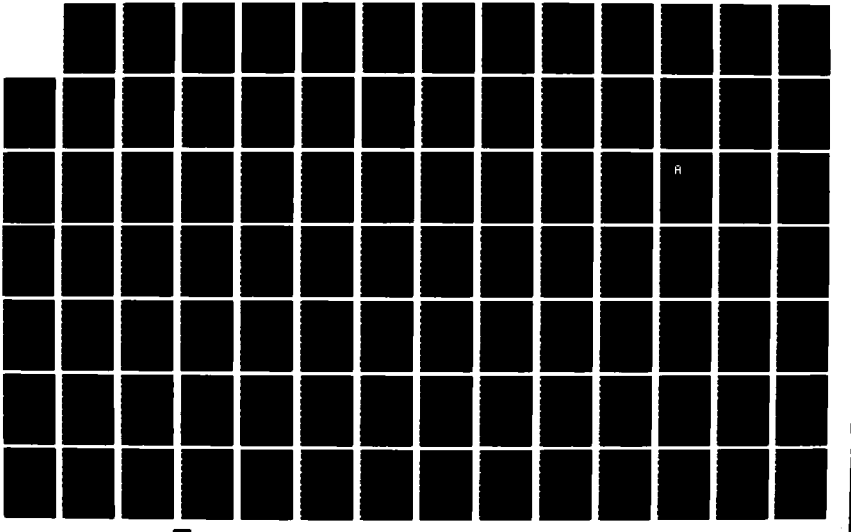

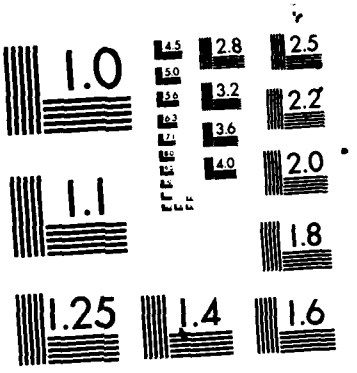

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFIT/CI/NR 86- 179T	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* A Low Cost Video Display System Using The Motorola 6811 Single-Chip Microcomputer		5. TYPE OF REPORT & PERIOD COVERED THESIS/DISSERTATION 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Kevin Eugene Williams		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS AFIT STUDENT AT: The University of Texas		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 1986 13. NUMBER OF PAGES 162
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASS 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

APPROVED FOR PUBLIC RELEASE: IAW AFR 190-1

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

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A LOW COST VIDEO DISPLAY SYSTEM USING THE MOTOROLA 6811 SINGLE-CHIP MICROCOMPUTER

by

KEVIN EUGENE WILLIAMS, B.S.E.E.

THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE IN ENGINEERING

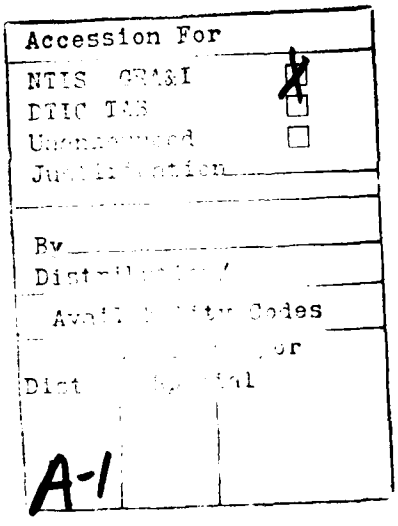
THE UNIVERSITY OF TEXAS AT AUSTIN

August 1986

Acknowledgments

I would like to thank Dr. G. J. Lipovski for providing me with many ideas and suggestions throughout the course of this thesis.

July 18, 1986 Kevin E. Williams



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Chapter One

Introduction

1.1 Background

In 1972, Intel introduced the first central processing unit contained entirely on one chip, the 4004. [TANN84] Since then, continual improvements in semiconductor technology have enabled manufacturers to pack more and more components on a single chip. Now, in addition to the central processing unit, RAM, ROM, and peripheral devices can also be put on a single chip. This combination of central processing unit, RAM, ROM, and peripheral devices on a one chip is termed a *single chip microcomputer* [BAER80]. One of the most powerful single chip microcomputers available today is the Motorola 6811 (hereafter referred to as M6811).

The M6811 is the latest in the Motorola 68xx series of microprocessors-microcomputers. The M6811 features include an extended 6800 instruction set, 8K bytes of ROM, 512 bytes of EEPROM, 256 bytes of RAM, a 16-bit timer system, a serial communications interface (SCI), a serial peripheral interface (SPI), an eight channel analog-to-digital converter, and two 8-bit general purpose I/O ports. [MOT85A]

To help designers develop applications for the M6811, Motorola produced an evaluation module board. This board allows designers to develop hardware and software for an M6811 based system. A monitor called Bit Users Fast Friendly Aid to Logical Operation (BUFFALO) is resident in the 8K ROM of the board's M6811.

The monitor can be used via a terminal or host computer. BUFFALO also includes a debugger and a one line assembler/disassembler. [MOT85B]

Obviously the M6811 can be used in a variety of applications such as instrumentation and control systems. In the academic world, the M6811 can be used as a learning tool in an undergraduate level microprocessor class. However, developing an application using the M6811 requires the evaluation module board and a terminal as previously described. Consequently, acquiring the number of evaluation module boards and terminals to equip a microprocessor lab would be very costly. Also, students would be limited to working in the lab as very few students have the financial resources needed to acquire their own evaluation module board and terminal. In order to make the M6811 available for program development at a low cost, a different display method is needed.

Fortunately, as it will be shown in this thesis, the M6811 itself is capable of video signal generation. Indeed, the primary reason the M6811 was chosen for this project was because of its on-board SPI. It is the SPI which generates the high serial data rate necessary for a video display.

1.2 Purpose of Thesis

The purpose of this thesis was to design a low cost video display system using the M6811. The video display system accepts input from a keyboard and generates a composite video signal to display that data on an ordinary television set. The existing BUFFALO monitor was modified to work with this display system. The BUFFALO software along with the keyboard and video display software resides in the 8K ROM of the M6811. Students will use the available RAM and

EEPROM for developing their programs. Furthermore, the low cost video display system is easily transported and usable with an ordinary television set instead of an expensive terminal. Thus, a student working on an experiment can take the system home and use a regular television to work at home.

Low cost implies a minimal system and indeed one objective was to keep the number of components in the system to an absolute minimum. Thus, an external CRT controller, which would also require external memory, was not used to generate the video signals.

1.3 Organization of Thesis

The following is a brief overview of the organization of this thesis. In Chapter Two, a more detailed discussion of M6811 is given. Then, in Chapter Three the keyboard scanning and decoding algorithms along with the hardware are explained. Chapter Four discusses how the M6811 is used to generate the video signal. Chapter Five details how the modified BUFFALO monitor works with the keyscan/video display software and contains a summary of the modifications made to the original BUFFALO monitor. Chapter Six is a brief summary. Appendix A is a user's guide to the modified BUFFALO monitor. Appendix B contains the hardware schematics. Appendix C explains how to use a different keyboard with the system. Finally, Appendix D is a complete software listing. This software listing includes the modified BUFFALO monitor along with the keyscan/video display software.

Chapter Two

The Motorola 6811 Single-Chip Microcomputer

The purpose of this chapter is to explain the M6811 features and architecture. Only those features of the M6811 used by the display system will be covered in depth. The majority of the information in this chapter was extracted from [MOT85A].

2.1 General Description

The M6811 is a single-chip microcomputer manufactured by Motorola, Inc. It provides on-chip memory of 8K bytes of ROM, 512 bytes of EEPROM and 256 bytes of static RAM. In addition, the following on-chip functions are provided:

a) an 8 channel analog-to-digital converter

b) a serial communications interface (SCI)

c) a serial peripheral interface (SPI)

d) a pulse accumulator

e) an 8 bit bidirectional port

f) an 8 bit output port

g) a timer system which includes 3 input capture lines and 5 output compare lines

2.2 Register Set

The registers available to the programmer are shown in Figure 2-1. The following is a brief discussion of these registers:

Accumulators A and B: These are general purpose registers used to hold operands and results of arithmetic operations or data manipulations. These two accumulators can be concatenated in a single 16-bit accumulator called the D accumulator.

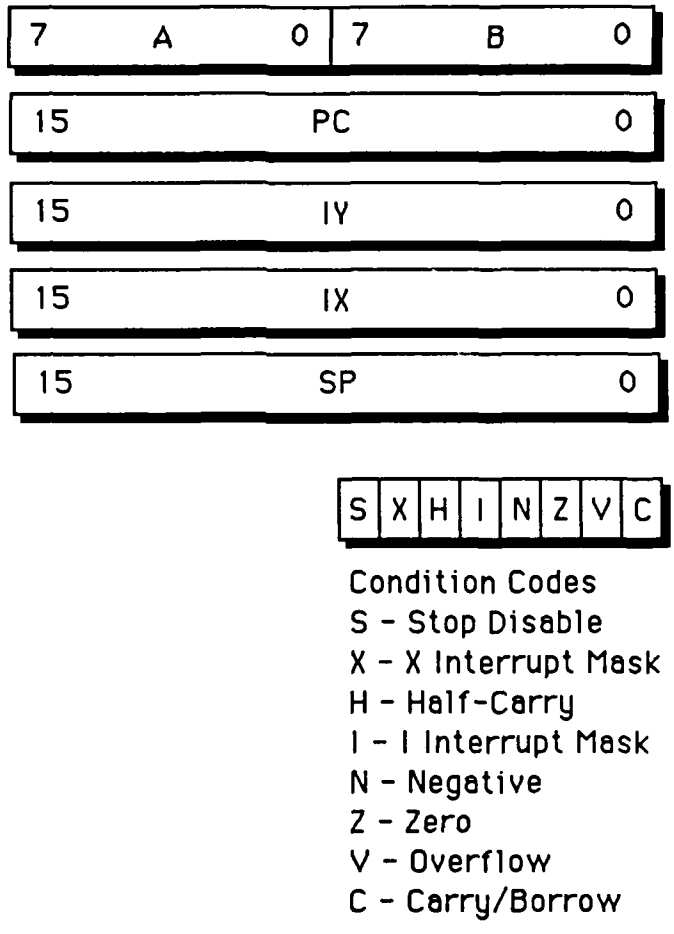


FIGURE 2 - 1. M6811 Registers

Index Registers IX and IY: These registers are used for indexed addressing. The 16-bit value in the index register is added to an 8-bit offset to compute

the effective address. The index registers can also be used as counters or temporary storage registers. The IY register operations require one more byte of machine code than the IX operations. Also, the IY operations require one more cycle of execution time.

Stack Pointer SP: This 16-bit register contains the address of the next free location on the stack. The stack operates on a last-in-first-out basis. When a byte is added (pushed) onto the stack, the byte is stored at address contained in the SP, then the SP is decremented. Conversely, when a byte is removed (pulled) from the stack, the SP is incremented, then the byte is retrieved from the address contained in the SP.

Program Counter PC: The program counter is a 16-bit register that contains the address of the next instruction to be executed.

Condition Code Register CCR: The condition code register is an 8-bit register in which each bit signifies the results of the instruction just executed. These bits can be individually tested by a program and a specific action can be taken as a result of the test.

2.3 Instruction Set

The M6811 instruction set is a superset of the M6800. There are 91 new opcodes available in the M6811. Among the enhancements of the M6811 instruction

set are addition of 16 by 16 divide instructions, STOP and WAIT instructions, and bit manipulation instructions.

2.4 Addressing Modes

The M6811 has six addressing modes. These modes are as follows:

1) Immediate - the actual operand is contained in the byte(s) immediately following the opcode.
2) Direct - the single byte following the opcode is assumed to be the least significant byte of the address of the operand. The most significant byte is assumed to be 00.
3) Extended - The two bytes following the opcode are the address of the operand.
4) Indexed - the X or Y register is used to calculate the effective address of the operand. An 8-bit unsigned offset is added to the index register.
5) Inherent - the operand is a register and is identified in the opcode.
6) Relative - used for branch instructions. If the branch condition is true, an 8-bit signed quantity is added to the program counter to form the effective branch address. If the branch condition is false, then the program continues with the next instruction.

2.5 Operating Modes

The M6811 can be operated either the single chip mode or the expanded multiplexed mode. In the expanded multiplexed mode, the M6811 can communicate with an external address and data bus. This allows the M6811 to access external

memory and peripheral devices. In the single chip mode, the external address and data buses are not used. For this thesis, the single chip mode will be used.

2.6 Interrupts

The M6811 supports both external and internal hardware interrupts. There are seventeen internal hardware interrupts and one software interrupt. A hardware priority circuit determines resolution of simultaneous interrupts. One of the interrupts may be elevated the highest priority in the resolution circuit.

When an unmasked interrupt occurs, a vector address for that interrupt is fetched from the internal ROM. All the registers are saved (except the SP) and control is passed to the vector address.

2.7 On-Chip Peripheral Devices

The following is a brief description of the on-chip peripheral devices on the M6811:

1) Parallel I/O: There are two ports available for general purpose I/O. Each bit in these ports may be configured as either input or output. One additional port is available for output only.
2) Serial Peripheral Interface: This device is used by keyboard decode/video signal generation software. Since it is the main device used for this thesis, it will be discussed is some detail in section 2.7.
3) Serial Communications Interface: This device provides full duplex, asynchronous communication capability. It may be set up in many

different configurations to allow it to communicate with a variety of systems.

4) Analog-to-Digital Converter: This device is an 8-channel multiplexed-input successive approximation A/D converter. The user connects a high and low reference to pins on the M6811. The digitized value of the input analog signal will be a value between 0 and $FF. This value is ratiometric with respect to the high and low reference voltages.

5) Programmable Timer: The M6811 has a 16-bit free running counter, three input compare registers, and five output compare registers. The free running counter can be used by reading the most significant byte of the counter. The least significant byte is placed in a buffer. The input compare registers latch the value of the counter when an edge is detected on the associated input compare pin. The output compare registers compare the value stored in their associated register with the counter. The user specifies which actions are taken when a match occurs, such as generating an interrupt.

2.8 Serial Peripheral Interface

The SPI is the device used to read the keyboard and generate the signal to build a composite video signal. Subsequent chapters of this thesis will make reference to the SPI, so it is important to understand the details of this device. For an extremely detailed explanation of the SPI, see [GALL84].

The SPI allows full duplex, synchronous bit transfers at clock rates of up to 1.05 MHz. The SPI may be operated as a master or slave, but will only operate in

the master mode for this thesis. Figure 2-2 shows a block diagram of the SPI as a master connected to a slave. Later, it will be shown the "slave" is actually the hardware interface with the keyboard.

As Figure 2-2, shows there are three signals associated with the SPI. The first of these is the MOSI line. MOSI is short for Master Out - Slave In. There is a register in the SPI called the Serial Peripheral Data I/O Register (SPDR). When a

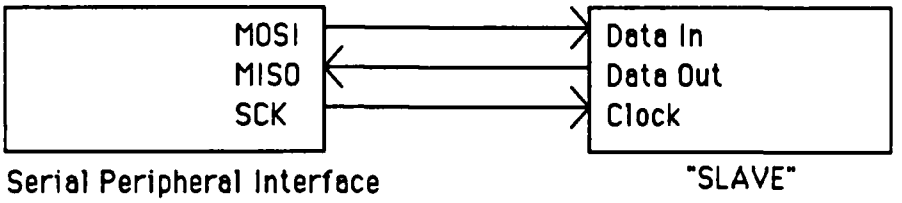


Figure 2 - 2. Master-Slave Relationship

byte of data is written to the SPDR the data is output on the MOSI line serially with the most significant bit sent first. The MISO, or Master In - Slave Out, is an input the SPI. It used by the slave to send a byte of data in serial form to the SPI. Thus, full duplex operation of the SPI is achieved via the MOSI and MISO lines. When a byte of data is written to the SPDR and shifted out on the MOSI line, the slave starts sending its byte of data on the MISO line. In essence, the master and slave exchange a byte of data. The synchronization for this transfer is the SCK line. This clock signal is activated when the byte is written to the SPDR and deactivated after the last bit of the byte has been sent.

There is another signal associated with the SPI that is not shown. It is called the Slave Select line. If the M6811 is used in a system in which several devices can

control the bus, the Slave Select line is used by the mode fault circuitry to detect bus conflicts. However, in this thesis, the M6811 is the only device that can ever be the "master". Therefore the mode fault circuit is not needed in this application and the Slave Select line is used as an output line.

Besides the SPDR, there are three other registers associated with the SPI system. They are the Serial Peripheral Control Register (SPCR), the Serial Peripheral Status Register (SPSR), and the Port D Data Direction Register (DDRD). Figure 2-3 illustrates these registers. The SPCR is used to initialize the SPI and set its operating parameters. The SPSR indicates the completion of data transfer between the master and slave. The SPIF bit of the SPSR is set to one upon completion of a transfer. No further transfers of data will be allowed until this bit is cleared. To clear the SPIF bit, the SPSR must be read followed by either a read from or write to the SPDR. The SPSR also tells if a write collision occurred or a mode fault was detected. A write collision is caused by trying to write to the SPDR while a transfer is taking place. Finally, the DDRD is used to connect the SPI signals to the port D pins as inputs or outputs. A one configures the pin as an output and a zero makes it an input. (Note the TxD and RxD bits are part of the SCI which also uses the port D pins.)

SPIE	SPE	DWOM	MSTR	CPOL	CPHA	SPR1	SPR2	SPCR

SPIE - if set, SPI interrupts are allowed
SPE - if set, SPI system connected to external pins
DWOM - if set, SPI pins function as open drain outputs
MSTR - if set, SPI is the master device
CPOL,CPHA - detemine polarity and phase of SCK
SPR1,SPR2 - select baud rate of SCK

SPIF	WCOL		MODF					SPSR

SPIF - set upon completion of data transfer
WCOL - if set, write collision occurred
MODF - if set, a multi-master conflict occurred

		$\overline{SS}$	SCK	MOSI	MISO	TxD	RxD	DDRD

Figure 2-3. SPI associated registers

Chapter Three

Keyboard Scan and Decoding

This purpose of this chapter is to describe how the M6811 is used to scan and decode a keyboard. The hardware used to interface the keyboard to the M6811 is described. The algorithm used to scan and decode the keyboard is presented.

3.1 Keyboard Discussion

A keyboard is simply a matrix of switches. When a single keyboard key is depressed, a unique row and column of the matrix are connected. Finding out which column and row are connected when a key is depressed is the heart of decoding a keyboard. How this decoding is done will be discussed shortly.

There are currently two types of keyboards, the encoded keyboard and the non-encoded keyboard. The encoded keyboard has the necessary hardware to decode the keyboard and supply the ASCII code of the depressed key. The non-encoded keyboard is nothing more than a matrix of rows and columns. All of the decoding must be done in software. The extra hardware required for the encoded keyboard makes it more expensive than the non-encoded keyboard. [ZAKS81] Because of its lower cost, a non-encoded keyboard will be used for this project.

Use of a non-encoded keyboard will require software to accomplish several tasks. These tasks include the following:

-- Debouncing the keyboard.

-- Identifying the row and column of the depressed key.

-- Generating the ASCII code of the depressed key.

-- Handling multiple-key depression.

3.1.1 Debouncing

Debouncing is required because there is an oscillation period ("bouncing") of 10 to 20 milliseconds before a switch contact stabilizes. [LIPO80] [ZAKS81] This happens when the switch transitions from open to closed and visa versa. To debounce the keyboard in software, a delay of 10 - 20 milliseconds is required. When a key has been depressed and detected by the software, the 10 - 20 millisecond delay is invoked. After the delay, the keyboard is checked again. If the same key is depressed, we have a valid key depression. In this system, the keyboard is sampled every 16.67 milliseconds. This 16.67 milliseconds corresponds to the time it takes to display one frame of video data. Thus, the keyboard is sampled once every frame during non-display periods. To get a valid key depression, the same key must be depressed for two successive samples.

3.1.2 Key Identification

To identify the depressed key, the row and column of the depressed key must be identified. In this system, a "walking zero" algorithm is used to identify the row and column. This algorithm is presented in detail in Section 3.3.

3.1.3 Generating the ASCII Code

There are a couple of different ways to generate the ASCII code for a depressed key. One way is to derive the code mathmatically. Generally, this will require a certain arrangement of the keyboard matrix. A second method is to use a

lookup table. In this method, the row and column of the depressed key are used to generate an offset into a lookup table which contains the ASCII codes. This lookup table method is used in this system for one important reason - using a lookup table allows a different keyboard to be used. Then only the lookup table need be modified when a different keyboard is used. If the mathmatical method had been used, then the program section that computes the code would have to be changed when a different keyboard is used. With the program in the ROM section of the M6811, changing the program is not a viable option. Thus, the lookup table is the best option for ASCII code generation in this system.

3.1.4 Multiple Key Depression

The simplest way to deal with multiple key depression is to wait until one key is released before attempting to decode the keyboard again. In other words, once a key has been depressed and decoded don't try to decode the keyboard again until there are no keys being depressed. While this method would not be good for high speed typing, it is suitable for this system. This is because any input line to the monitor will usually consist of fewer than 10 keystrokes. This method also has the added benefit of requiring less software to implement.

3.2 Keyboard Hardware Design

The M6811 provides two different ways to design and implement the keyboard hardware. One way is to use two of the 8-bit parallel I/O ports. One of the ports would be connected to the columns of the keyboard matrix and the other would be connected to the rows. This method offers the advantage of simplicity in

terms of both hardware and software at the expense of tying up two of the M6811's 8-bit I/O ports. The second method is to use the SPI. Obviously, this method will require external hardware and more software. But it has the advantage of not tying up two 8-bit I/O ports. It is felt that keeping the two 8-bit I/O ports available for student projects is more important than using them for keyboard scanning. In addition, since it is already being used for video signal generation, using the SPI for the keyboard scanning optimizes its use. For these reasons the SPI will be used for the keyboard scanning along with some external hardware.

3.2.1 Keyboard Hardware

Refer to the keyboard hardware schematic, Figure 3-1, for the following discussion. The interface between the SPI and the keyboard matrix consists of a 74LS164 8-bit parallel-out serial shift register and a 74LS165 8-bit parallel-load shift register. The 74LS164 outputs are connected to the columns of the keyboard matrix, while the parallel inputs to the 74LS165 are connected to the rows of the keyboard matrix. The MOSI output from the SPI is connected to the serial input A of the 74LS164 and the serial output of the 74LS165 is input to the MISO pin of the SPI. The SCK output from the SPI is connected to the clock input for both chips. Notice the master-slave relationship between the keyboard hardware and the SPI. There are pullup resistors connected to the parallel inputs of the 74LS165. This guarantees a logic "1" is presented to the parallel inputs if no key is depressed on the keyboard. Note the SS line of the SPI is connected to the load/shift input of the 74LS165. This line will be used to tell the 74LS165 when to latch the data present on the rows of the keyboard.

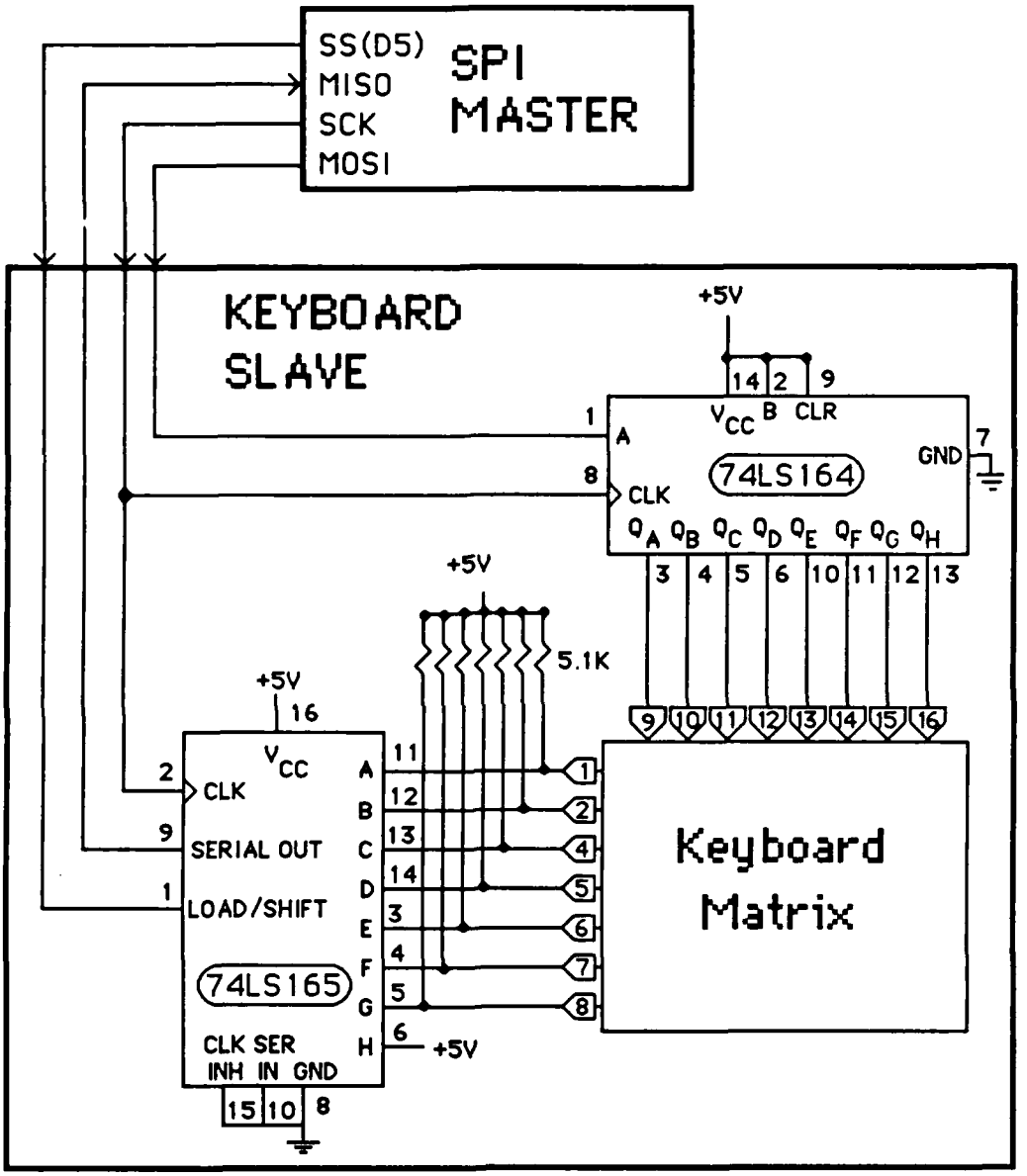


Figure 3-1 Keyboard Hardware

It was pointed out earlier that the SS line could be used as a general purpose output if the mode fault circuit was not needed. Since the mode fault circuit is not needed (because there can only be one master in this system) the SS line is used as an output. Hereafter, this line will be referred to as the D5 line (pin 5 of port D) because it is functioning as a general purpose output line, not as a slave select input line. The keyboard is from a Radio Shack Color Computer. This keyboard has an 8 column by 7 row matrix. Since there are only 7 rows, the H input to the 74LS165 is tied high to make sure the walking zero algorithm works properly. The hardware and software can easily be modified to use a different keyboard and this is described in Appendix C.

3.2.2 Keyboard Hardware Operation

The following is a discussion of how the keyboard hardware is designed to operate. The software writes a one byte pattern to the SPDR. The action of writing the pattern to the SPDR initiates the serial transfer of the byte on the MOSI line. The SCK synchronizes the transfer with the 74LS164. Upon completion of the transfer, the pattern is now present on the columns of the keyboard. This is how the patterns are set up on the columns of the keyboard. Recall that the SPI also receives a byte of data on its MISO line. We have already seen the MISO line is connected to the serial output of the 74LS165. So at the same time the bit pattern is sent to the 74LS164 for the column pattern, a byte representing the row pattern is received from the 74LS165. The row pattern must be loaded into the 74LS165 shift register by sending an active low load pulse to the 74LS165. This is done in software by pulsing the D5 line. Thus, the hardware allows the keyboard to be scanned by

sending column patterns to and receiving row patterns from the keyboard hardware interface.

3.3 Keyboard Scan and Decoding

This section presents the algorithm used to scan and decode the keyboard. The software program listing is located in Appendix D. The algorithm uses what is known as a "row scanning" technique. [LIPO80] [ZAKS81] In row scanning, a pattern is presented on the columns. The first pattern consists of a zero in the least significant bit (bit 0) and ones in all the other bits. After this pattern is presented on the columns, the row pattern is latched and read. If the value of the row pattern is $FF (all ones), then no key along the least significant bit 's column has been depressed. The next pattern is sent to the 74LS164. However, this pattern is different. This zero is now shifted into bit 1 with all other bits set to one. The row pattern is read and again checked against $FF. If it is not $FF, then a key has been depressed in the bit 1 column. The column of the depressed key is known and the row can be found from the row pattern. With this information, the corresponding ASCII value is found in a lookup table. Notice that if no key is depressed in the bit 1 column, then the zero would be shifted into bit 2 and the process would repeat until bit 7 is reached. Thus, we have a "walking zero" algorithm as the zero in the column pattern walks through the byte. Once the bit 7 pattern has been sent, all the columns have been scanned. If no key has been depressed, then the keyboard is not scanned again for another 16.67 milliseconds. The 16.67 milliseconds corresponds to time it takes for display of one frame of a video signal.

3.3.1 Keyboard Scan

The flowchart for the keyboard scan is shown in Figure 3-2. At the start of the keyboard scan the variables COLCNT and ROWCNT are initialized to zero. These two variables are used to hold the column count and row count respectively. Then accumulator A is initialized with the first column pattern value of $FE (1111 1110). This first pattern is sent and at the same time a meaningless byte is received from the 74LS165. The 74LS165 data inputs are latched by pulsing the load line of the 74LS165 via the D5 pin of the M6811. The 74LS165 now has a valid row pattern latched into it. The carry bit is set and a ROLA instruction is executed. Accumulator A now has the value $FC (1111 1101). This second column pattern is sent at the same time the first row pattern is received. The received row pattern is compared with $FF to determine if a key is depressed. If a key is depressed, then the row pattern value will not be equal to $FF and control will jump to the decode routine. If no key is depressed, then the value of COLCNT will be incremented by one. This is to keep track of the value of the column being examined for key depression so it can be decoded later. Now, the carry bit is set and a ROLA is executed. The carry bit is then checked to see if it is zero. This is done to see if all the column patterns have been sent. If the carry bit is not zero, then the program will loop back as shown in Figure 3-2 to repeat the process. Eventually, after the eight column patterns have been sent, the carry bit will be zero. There is still one row pattern to retrieve from the 74LS165. This is done by sending a load pulse to the 74LS165 and then writing an arbitrary byte to the SPDR. The value of the byte sent this time is unimportant because we are not concerned with setting up a valid pattern

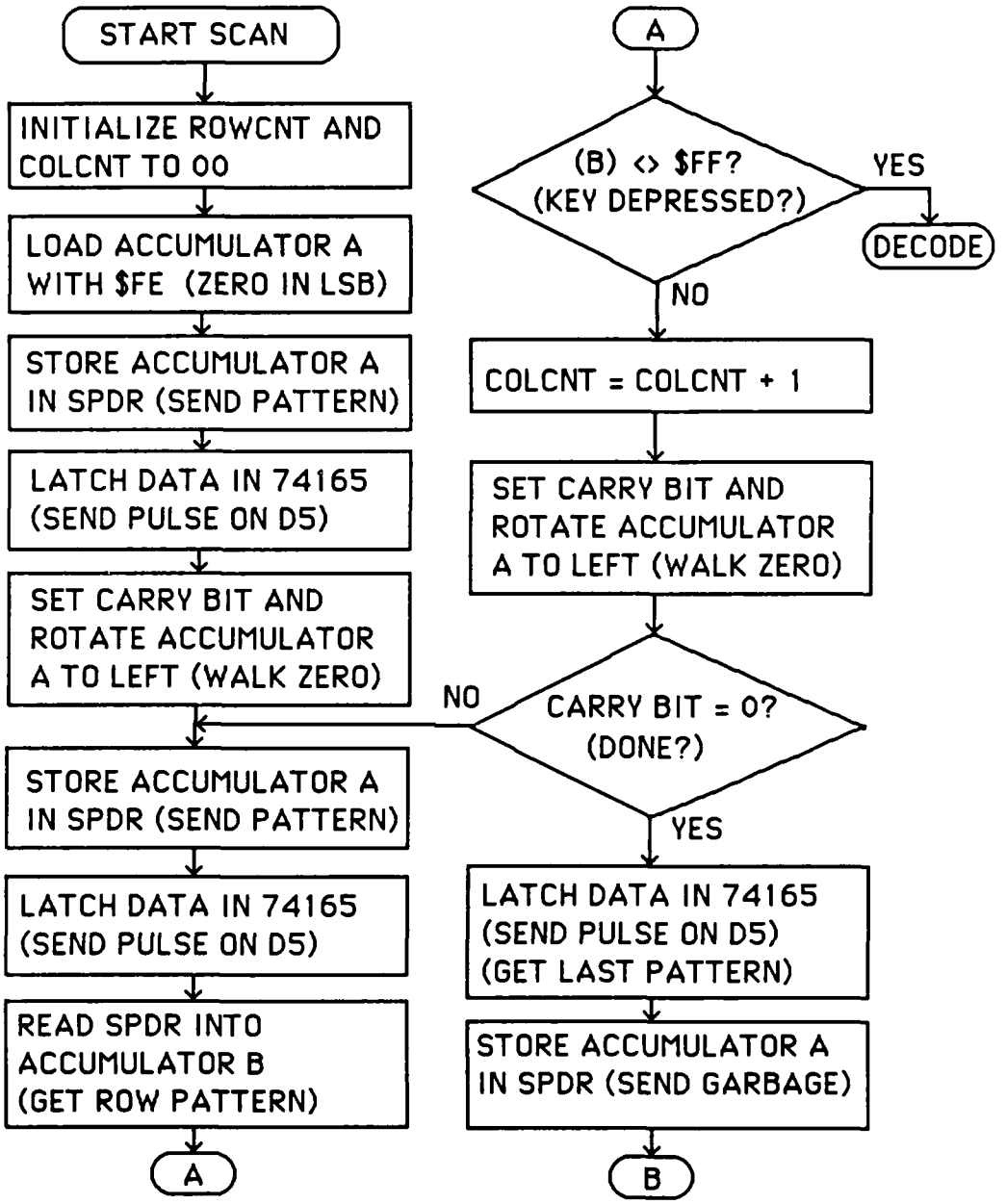
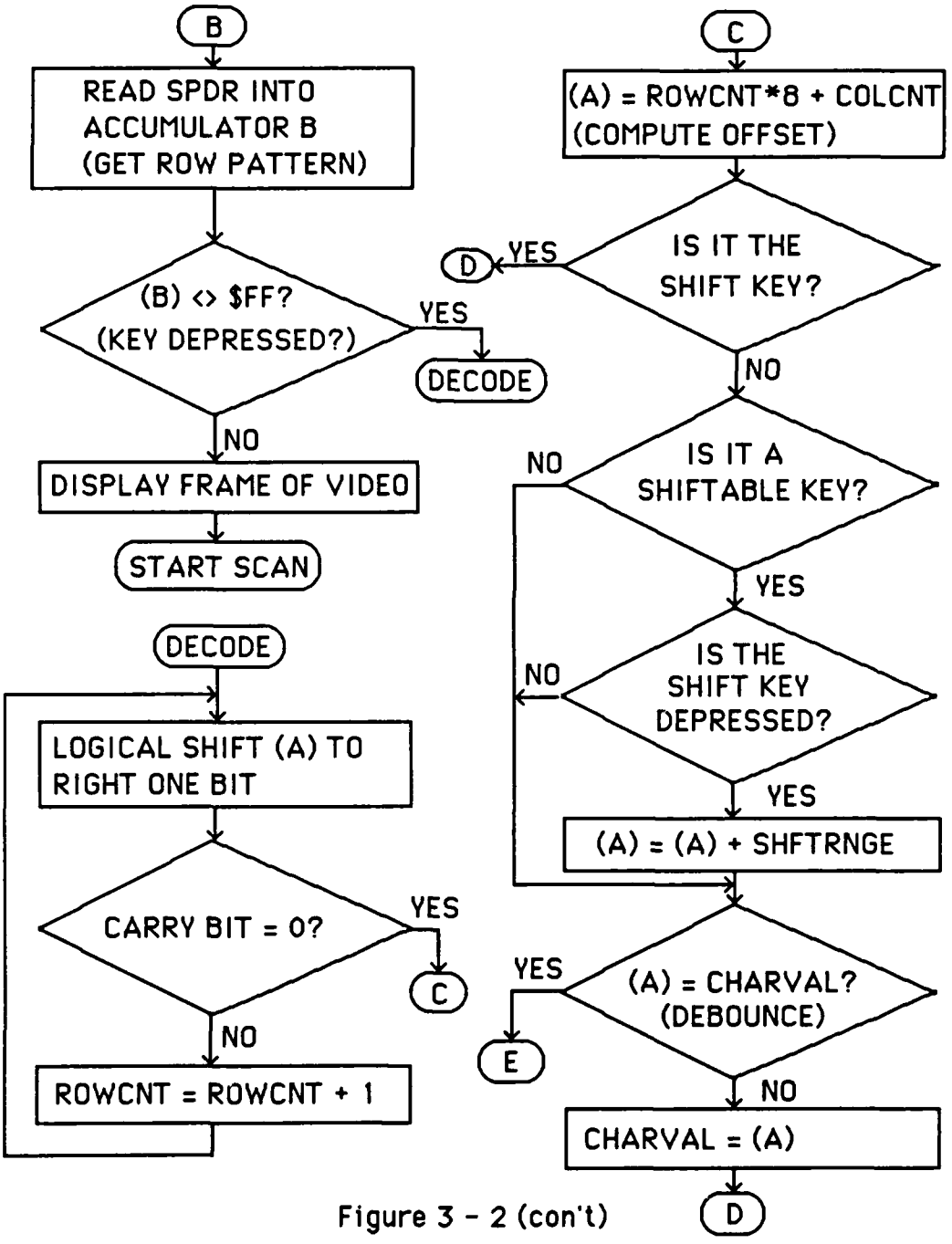


Figure 3-2. Keyboard Scan and Decode Flowchart



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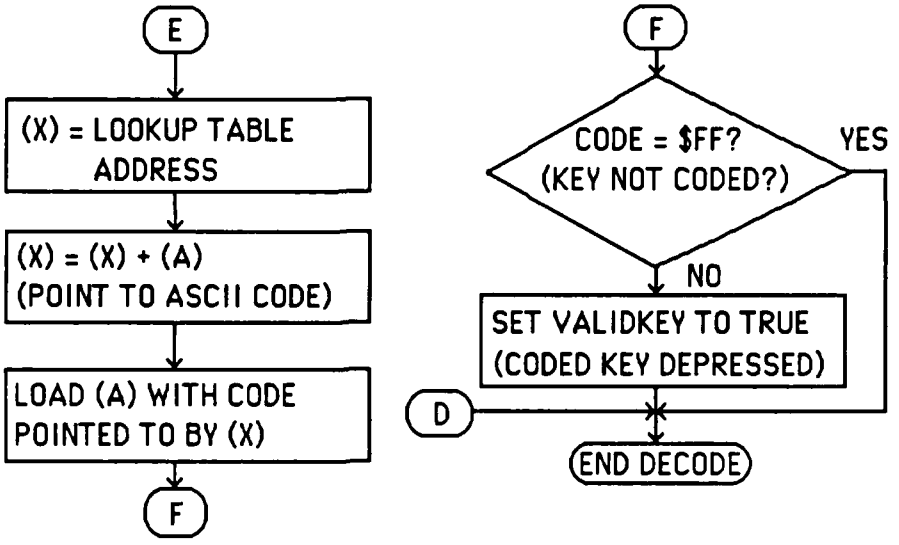


Figure 3 - 2 (con't)

on the columns but rather only interested in getting the last row pattern from the 74LS165. The last row pattern is checked for a key depression. If there is no key depression the decode routine is skipped; if there is a key depression, then the decode routine is executed.

3.3.2 Keyboard Decoding

The decoding flowchart is also depicted in Figure 3-2. In order for the decode routine to be entered, a key depression must have been detected by the scan routine. At this point, the column number of the depressed key is contained in COLCNT, and the row pattern is contained in accumulator B. The first thing to do is translate the row pattern into a row number. This is accomplished by executing a LSRB and checking the carry bit for a zero. If the carry bit is not zero, then the value of ROWCNT is incremented by one and the loop is repeated until the carry bit

is zero. Once the zero is reached, the correct row number value is in ROWCNT.

The value of ROWCNT is multiplied by 8 and added to the value of COLCNT. This value is first checked to see if it is the shift key. If it is, then only the shift key is down. This is because the shift key is the last key on the matrix; it has the highest value for 8 * ROWCNT + COLCNT. If it is not the shift key, then the value is checked to see if it a shiftable key. If the value falls in the shiftable range, then the shift key is checked to see if it is depressed. This is done be sending a pattern to the 74164 which contains a zero in the column the shift key is located. The row pattern is latched and retrieved. This pattern is checked to see if there is a zero in the row the shift key is located. If the shift key is depressed, then the constant SHFTRNGE is added to the computed value. This new value is now compared with the value of CHARVAL. CHARVAL contains the computed value of the of the last decoded key. The purpose of this comparison is to debounce the keyboard by requiring the same value for a decoded key on two successive keyboard scans 16.67 milliseconds apart. If the comparison fails, then the computed value becomes the new value of CHARVAL and the decode routine is exited.

If there is a match between the computed value and CHARVAL, then the only computation left is to load index register X with the value of the starting address of the lookup table and add to it the computed offset. The ASCII code is loaded into accumulator A. Finally, the code is checked against $FF. The value $FF is used in the lookup table to indicate an unimplemented key. If the value of the code is not $FF, then the flag VALIDKEY is set to true to indicate a valid key has been

depressed and properly decoded. At this point, program control returns to the caller. The caller now has the ASCII code of the depressed key in accumulator A.

Chapter Four

Video Signal Generation Using the M6811

This chapter explains how the M6811 is used to generate the signals necessary for a composite video signal. First, there is a brief introduction to cathode ray tube (CRT) signal timing requirements. This is followed by a presentation of the algorithm used to generate the video and synchronization signals. The integration of the keyboard software with the video software is also described.

4.1 CRT Theory and Timing

The purpose of this section is to give a brief introduction to CRT theory and the signal timing requiriments for the CRT's found in unmodified black-and-white television sets. For a more detailed explanation of CRT theory and timing, the reader may consult [KANE80], [LANC78], and [HERR72]

A CRT consists of an evacuated glass tube with a fluorescent coating on the inner surface of its rectangular screen and an electron gun positioned opposite the screen. The electron gun emits an electron beam which strikes the fluorescent screen producing a phosphor dot on the screen. The point where the electron beam strikes the screen is controlled by electromagnetically deflecting the electron beam. The intensity of the electron beam can also be controlled. This allows various shades of grey to be displayed on a black-and-white television.

The internal circuitry of a television automatically moves the electron beam in a set pattern or scan. In raster-scan televisions, the electron beam starts in the upper left corner of the screen. The beam moves to the right until it reaches the right side of

of the screen. When it reaches this point, the beam quickly moves back to the left side of the screen. This horizontal movement of the beam back to the right side of the screen is called horizontal retrace. The beam has also moved down very slightly in the vertical plane. This process continues until the beam reaches the lower right corner of the screen. After reaching the lower right corner of the screen the beam returns, called vertical retrace, to the upper right corner and the same process continues.

The frequency of the horizontal and vertical scans is preset. In the United States, the horizontal frequency is 15,750 Hz. In other words, the electron beam makes 15,750 traversals, or lines, across the screen every second. The vertical frequency is 60 Hz. Thus, the electron beam goes from top to bottom in 1/60 th of a second (called a frame). This means there are 262.5 lines (15750÷60) displayed as the electron beam moves from top to bottom 60 times every second. Unfortunately, not all of these 262.5 lines are usable for display. It takes about 20 horizontal lines of time to accomplish the vertical retrace. In addition, unless the television is of high quality, some of the horizontal lines will be either partially or completely out of view near the top and bottom of the screen.

The CRT requires three signals in order to produce a picture. These three signals consist of the vertical synchronization pulses, the horizontal synchronization pulses, and the video signal. The vertical and horizontal synchronization pulses do not drive the vertical and horizontal scans, but rather they synchronize with the CRT circuitry. This allows some variation in the signals provided to the television. This means the horizontal synchronization pulse, called HSYNC, can be varied somewhat but should be maintained within +5 to -10% of the 15,750 Hz frequency.

[KANE80] The HSYNC pulse width is typically between 5 -10 μs. The vertical synchronization pulse, called VSYNC, requires a much higher accuracy. If the VSYNC pulse is not maintained within .01% of 60 Hz, a hum bar will cross the screen about every 10 seconds. [LANC78] The VSYNC pulse width is typically 3 horizontal lines long (about 200 μs). Finally, the video signal controls the intensity of the CRT's electron beam. The higher the voltage of the video signal, the brighter the phosphor spot the electron beam produces. When all three of these signals are combined into a single signal, the single signal is called a composite video signal.

4.2 Video Generation Software Design

There are two possible directions to take in the design of the video generation software. One is an interrupt-driven design. In this design, the video generation software interrupts the BUFFALO monitor every 1/60 th of a second to display a frame of video data. This design uses one of the on-board counters to generate an interrupt when it is time to display a frame of video. In addition, external hardware is required to generate the synchronization signals. This design was attempted but proved unsuccessful because of difficulties synchronizing the timing. A second design was made which did not use interrupts. This design makes the video generation software a subroutine. The subroutine is called by the BUFFALO monitor whenever it needs data from the user or needs to display data for the user. This design does not need to use one of the on-board counters and does not need external hardware to generate the synchronziation signals. The subroutine design does not suffer from the timing synchronization problems encountered with the interrupt-driven design. This is because once the subroutine is invoked it starts the

timing from that point. Then it is merely a matter of counting machine cycles to ensure the timing is done properly. When the BUFFALO monitor has program control, the CRT screen will be blank. However, the BUFFALO monitor processes most commands so quickly that the user does not even notice the CRT going blank. The remainder of this chapter will explain the aspects of this design and how it works.

4.3 Screen Display Format Design

The screen display format consists of 5 character rows with 6 characters per row. This provides a 30 character display - more than enough for any possible input to the BUFFALO monitor. This format was not arbitrarily chosen. It was driven by the interaction of three factors: the speed of serial transfer from the SPI, the time required for the software to lookup the font patterns, and the use of as little of the on-board RAM as possible.

The amount of data that can be displayed on a CRT screen is directly related to the speed at which a serial bit stream can be generated. The serial bit stream consists of the "1" s and "0" s to be displayed on the screen. With a 2 MHz E clock, the maximum rate of serial transfer from the SPI is 1 MHz. A 1 MHz serial bit rate is not fast enough to provide anything close to a high resolution display. Recall that there are 15750 horizontal lines and 60 frames of data displayed every second. This results in one line of data displayed in 63.5 μs, of which 5-10 μs is used for the horizontal retrace and about 10 μs is spent in a "non-viewable" area. This leaves about 40 μs for display of video data. If each character takes 8 bits to display horizontally, only 5 characters could be displayed on a line. In this system, a

technique is used to make the effective width only 6 bits wide. (see section 4.5) Therefore 6 characters can be displayed in 36 μs.

To determine how many rows of 6 characters can be displayed recall there are about 260 horizontal lines displayed every 16.67 ms. However, some of these lines are used during vertical retrace and others are not displayed on viewable portion of the screen. In this system, a total of 160 horizontal lines are used for display of data. Using a 5 by 7 font one might think 20 character rows (160 ÷ 8) could be displayed. However, it is impractical to display 20 rows of 6 characters in this system for three reasons. First, it would require 120 bytes, almost half the on-board RAM, be set aside for a character buffer. Secondly, there are not enough machine cycles in a horizontal line display time to enable the software to lookup all the display patterns. (This reason in itself rules out a 20 by 6 display) Finally, there is no need for a display this size when working with the BUFFALO monitor. The number of character rows for display has been set at 5. Each character row consists of 32 horizontal lines. Each scanline of a character is displayed for 4 horizontal lines. This scheme also allows enough time for the software to do all the font pattern lookups.

Each character of the font consists of 8 bytes. The font for the character "A" along with its corresponding bit pattern is shown is Figure 4-1. A "1" displays a white dot on the CRT while a "0" results in a black dot.

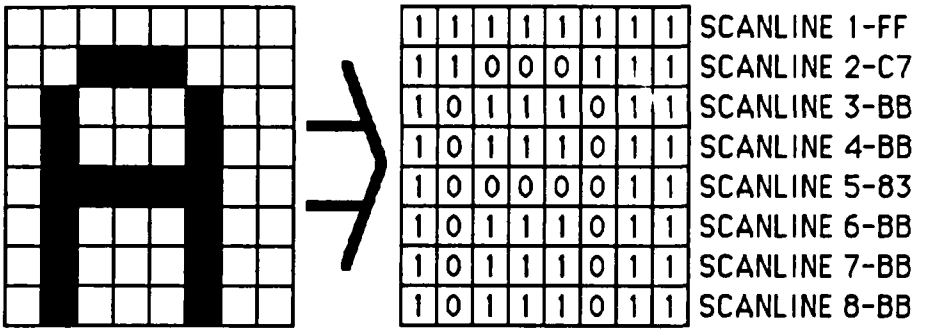
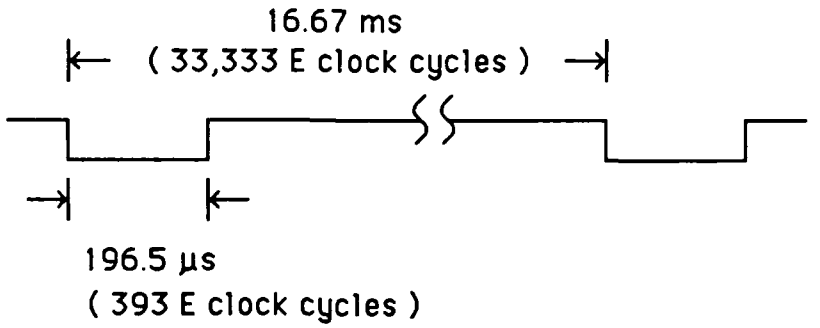


Figure 4 - 1. Sample Font and Bit Pattern

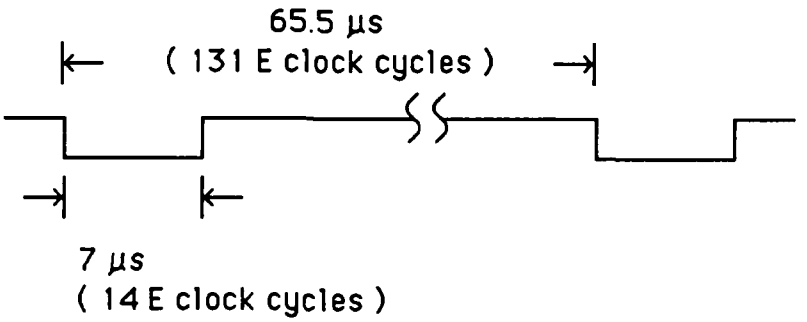
4.4 Synchronization Pulse Timing and Generation

This section explains the exact timing for the vertical and horizontal synchronization pulses used in the system. All values for the E clock cycles are based on a 2 MHz E clock.

The VSYNC pulse timing is shown in Figure 4-2a. The pulse width is 196.5 μs and the frequency is 60 Hz. The VSYNC pulse width corresponds to exactly three horizontal line times. From the start of one frame to the start of the next takes 16.67 ms which equates to 33,333 E clock cycles. The HSYNC pulse timing is shown in Figure 4-2b. The pulse width is 7 μs and the frequency is 1/65.5 μs or 15,267 Hz. The HSYNC pulse frequency is slightly different from the 15,750 Hz standard but it is still within timing tolerances. This slower frequency is a result of needing more clock cycles per horizontal line in order to accomplish all the



(a) VSYNC pulse timing



(b) HSYNC pulse timing

Figure 4 - 2. Synchronization Pulse Timing

necessary tasks in the display software. A side effect of the slower HSYNC frequency is a reduction in the number of horizontal lines per frame. Instead of 262.5 lines per frame, there are now 15267/60 or 254.5 lines per frame.

The generation of the VSYNC and HSYNC pulses is quite simple. Both VSYNC and HSYNC pulses are output on the D5 pin. This results in a composite synchronization pulse signal. When it time for a pulse to be output, a "0" is written to bit 5 of port D. After an appropriate delay for the pulse width a "1" is written to

bit 5 of port D. As stated earlier, the video generation software is called as a subroutine. The subroutine begins by outputing a VSYNC pulse. All syncronization timing starts from this point and HSYNC and VSYNC pulses are output at the proper times.

4.5 Video Signal Generation

This section explains the algorithm used to generate the video signal. The characters are represented in a 30-byte character buffer by their ASCII code (the characters are placed in the buffer by the BUFFALO monitor which will be discussed in Chapter 5). A 6-byte display buffer contains the font patterns to be displayed. There are two problems to solve in order to translate the ASCII codes in the character buffer into a proper video data signal. First, the patterns corresponding to ASCII codes in the character buffer have to be looked up in the font table and placed in the display buffer. Second, the patterns have to be displayed at exactly the right time every frame. These two problems will have to be solved in most any display system design. However, in addition to these problems, another problem surfaced while designing the solution for the M6811.

This additional problem was the result of the slow speed of the SPI. Because the SPSR has to be read after completion of a byte transfer, patterns cannot be continually sent to the SPDR for transfer. A pattern must be sent, the SPSR must be read after the transfer is complete, then another pattern may be sent. Not only does this reduce the number of characters that can be displayed on a horizontal line, but it also results in large gaps between characters on the CRT screen. This means only 3 or 4 characters could be displayed on the screen and these characters would

have significant gaps between them. To solve this problem a unique solution was devised.

The solution involves displaying half the characters in the character buffer during one frame followed by the other half of the characters the next frame. Figure 4-3 illustrates the timing relationships between the even and odd frame horizontal lines. The address of CHARBUFF is considered the first "even" character address, CHARBUFF+2 is the address of the second "even" character, etc. Likewise, CHARBUFF+1 is the first "odd" character address, CHARBUFF+3 is

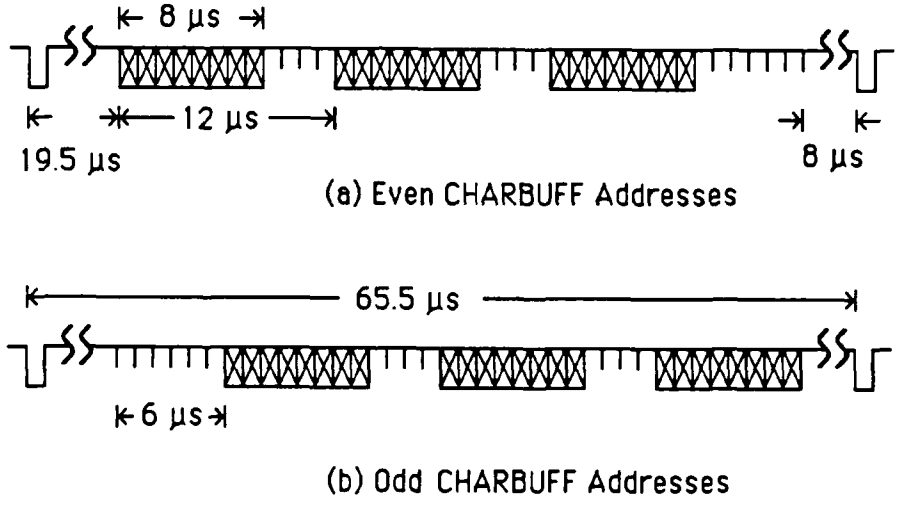


Figure 4 - 3. Even-Odd Frame Character Timing

the second "odd" character address, and so on. Three character patterns are displayed during each line with 12 µs spacing separating the start of each character pattern. The 1 MHz SPI speed means each pattern takes 8 µs of time to display. The timing of the frames is the same except that during an "odd" frame the character patterns are delayed by 6 µs. This 6 µs difference between the two frames is

accomplished by checking the variable FIELD. Based on the value of FIELD, 6 μs of code is executed either before or after the active display time. There is one drawback of this scheme. Because the effective frame rate is reduced to 30 Hz, there is a slight but perceptible flicker of the display. However, the increased effective bandwidth achieved with this scheme outweighs the slight flicker of the display.

Also note the effective width of the characters is now only 6 bits. This is because of the overlap of the two frames. The last two bits of "even" characters occupy the same location as the first two bits of the "odd" characters. This makes the space between two characters on the screen appear to be only one bit wide.

This solution is integrated with the solution to two previously stated problems and the resulting algorithm is detailed in by flowchart in Figure 4-4. Before beginning the discussion of the flowchart it is important to make a point about its structure. One of the more difficult tasks in designing this section of the software was getting all the tasks accomplished in the available time per horizontal line. Also, it was a goal to keep the overall size of the program to a minimum because of the limited amout of ROM. To keep program size down meant designing repetitive loops wherever possible under constraint of the limited machine cycles available per horizontal line. Add to all of this the complication of generating "even and odd" frames and the problem is not trivial. The reader may wonder why the video generation software (see Appendix D) looks disjointed or instructions seem "out-of-place". This is because of all of these requirements and constraints. While the software may look disjointed and instructions may appear "out-of-place", it has to be in order to take advantage of every machine cycle.

4.5.1 Discussion of Video Signal Generation Flowchart

Refer to Figure 4-4 for the following discussion. The following is a list of the symbolic names used in the flowchart and their functions:

SYMBOLIC NAME	FUNCTION
CHARBUFF	Address of first character in the 30-byte character buffer
DISPBUFF	Address of first display pattern in the 6-byte display buffer
FONTABLE	Address of first pattern in the font table
READBUFF	Used to save address of first character of each character row
SCANLINE	Used to hold value of current scanline
SLCNT	Used to control number of times the same scanline is displayed
DISPTR	Holds address of next position in display buffer to be filled
FIELD	Used to indicate whether odd or even frame is displayed

At the start of every display frame, the first task accomplished is to toggle the FIELD variable. This ensures the display alternates between odd and even frame displays. Then the variables used by the routine are initialized. In addition, the first three locations of the display buffer are initialized to $FF. Note that this is permitted because the first scan line of every character is $FF. Index register Y and READBUFF are initialized to point to CHARBUFF-1+FIELD. Thus, FIELD is used to point Y at either the "odd" or "even" character addresses. The (-1) is necessary because Y is incremented by one during the HSYNC pulse. DISPTR is

initialized to DISPBUFF+2 as is index register X. The reason for this will become apparent shortly.

Next, a repetitive loop is entered. This loop will execute until SLCNT reaches 0. Since SLCNT is initialized to 3, it will execute three times. After the HSYNC pulse is output and index register Y is incremented, FIELD is checked. If FIELD is "1" (odd frame), then a 6 μs section of code is executed. This 6 μs of code consists of looking up a pattern pointed to by index register X and placing it in the display buffer address pointed to by DISPTR. Note that the first time through the loop DISPTR and index register X are pointing at the same location - DISPBUFF+2. So the first time through the loop DISPBUFF+2 is written back to itself. This will not be the case on subsequent passes through the loop as index register X will then point to a new pattern in the font table. Next, an ASCII code is retrieved from the character buffer address pointed at by index register Y. The first time through the loop the content of either CHARBUFF or CHARBUFF+1 is retrieved based on the value of FIELD. The value of DISPTR is incremented to point at DISPBUFF+3. It is now time to send the first pattern, located in DISPBUFF, via the SPI by writing to the SPDR. While this transmission is taking place, the ASCII code that was just looked up is multiplied by 8. Now it is time to send the second pattern, located in DISPBUFF+1. During this transmission, the value of SCANLINE is added to the value of FONTABLE-$100 and this is added to ASCII*8. The reason for adding FONTABLE-$100 is because the first entry in the font table is a space character, ASCII code $20. Since 8*$20 = $100, $100 must be subtracted from FONTABLE to get the correct offset. Figure 4-5 shows computation of the font table address graphically.

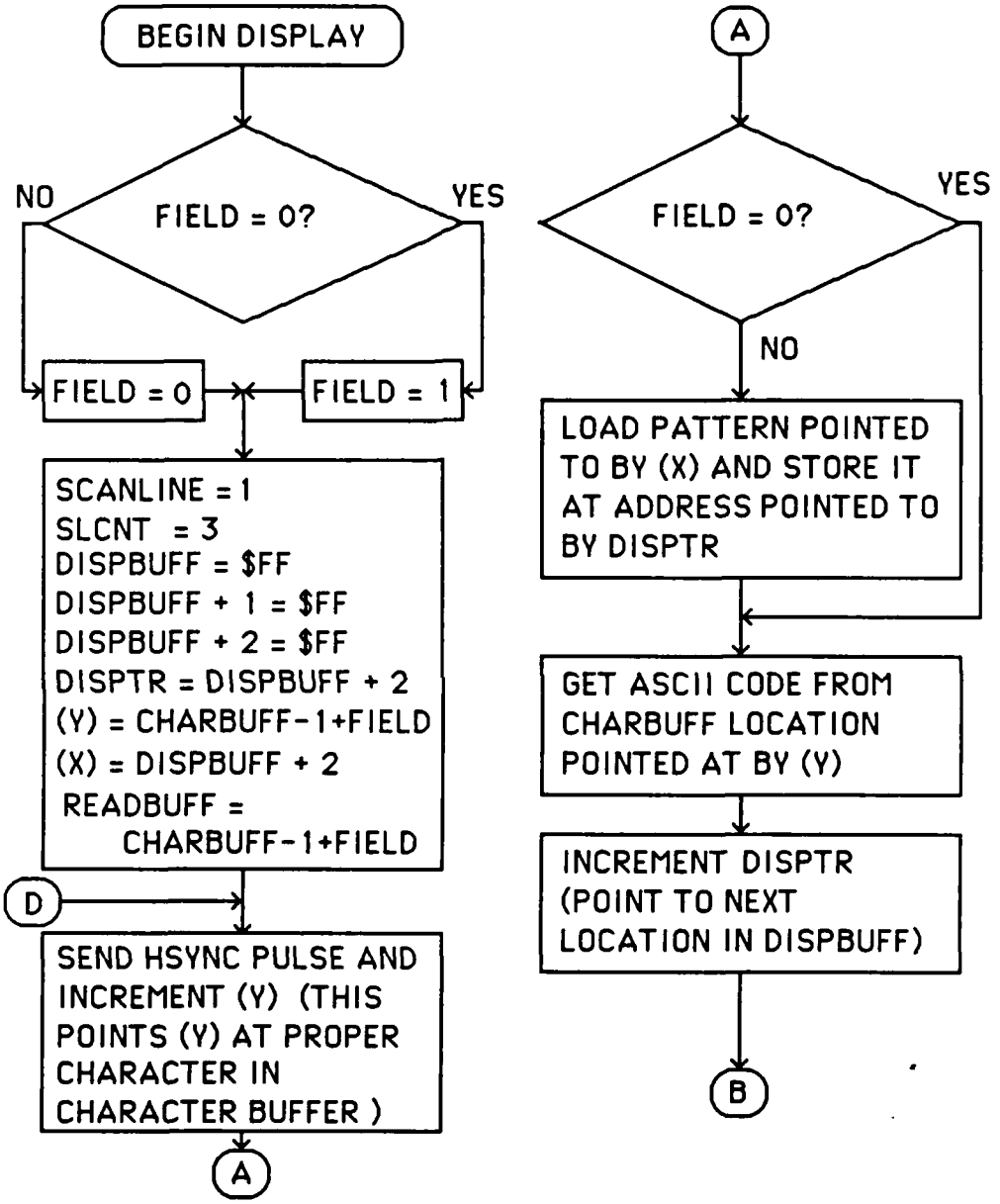


Figure 4-4. Video Display Flowchart

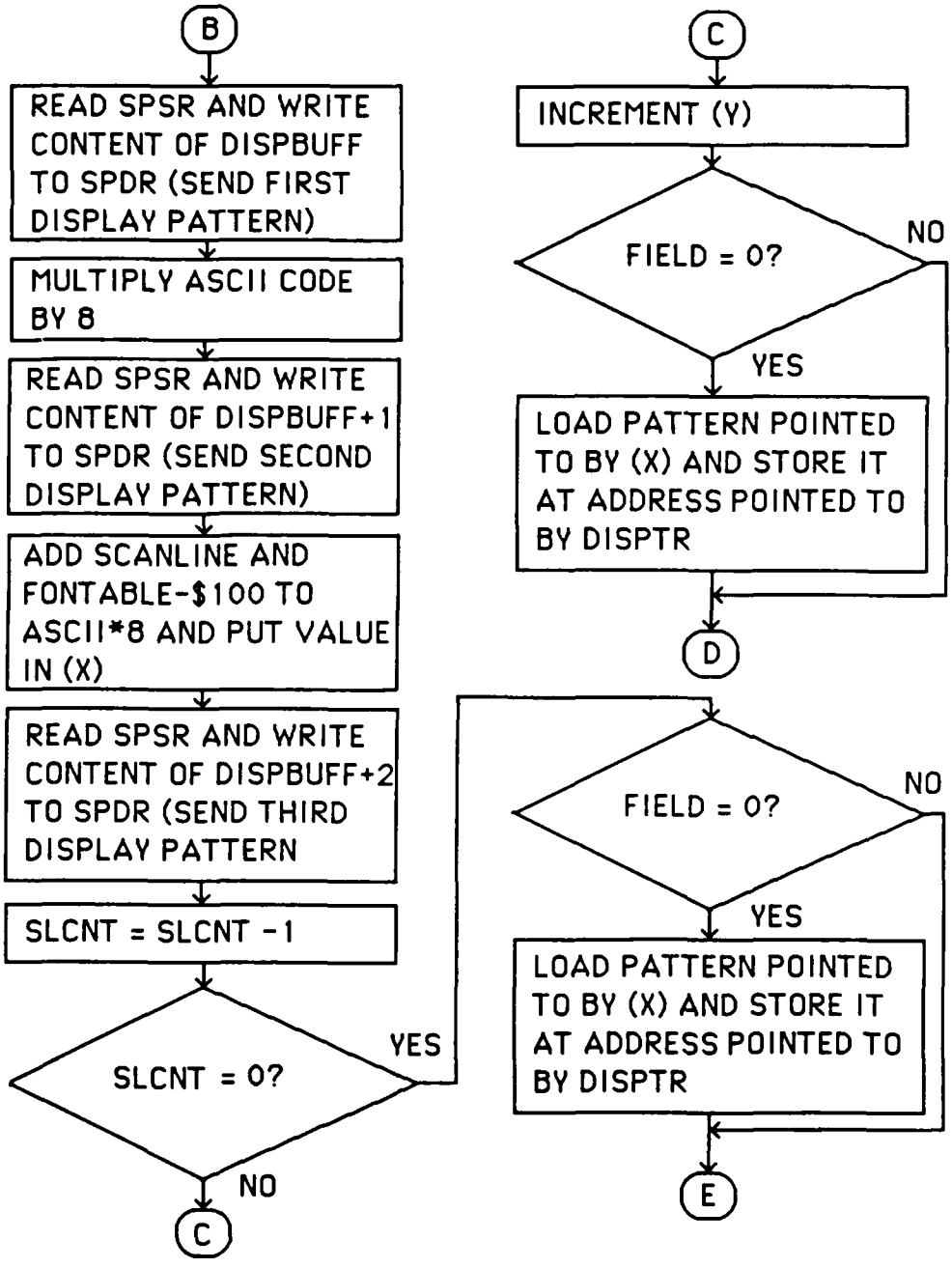


Figure 4-4. (Cont'd)

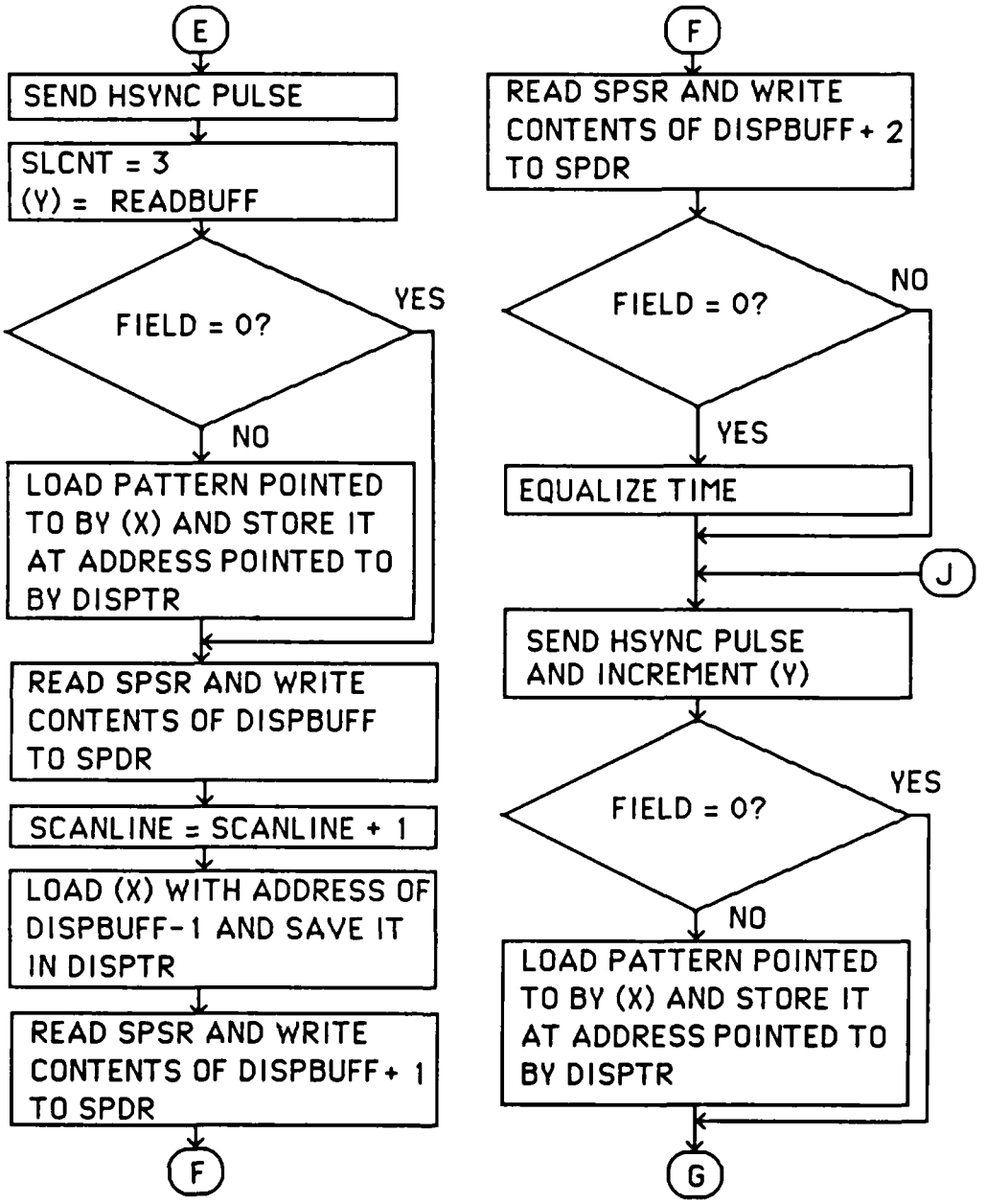


Figure 4-4. (Cont'd)

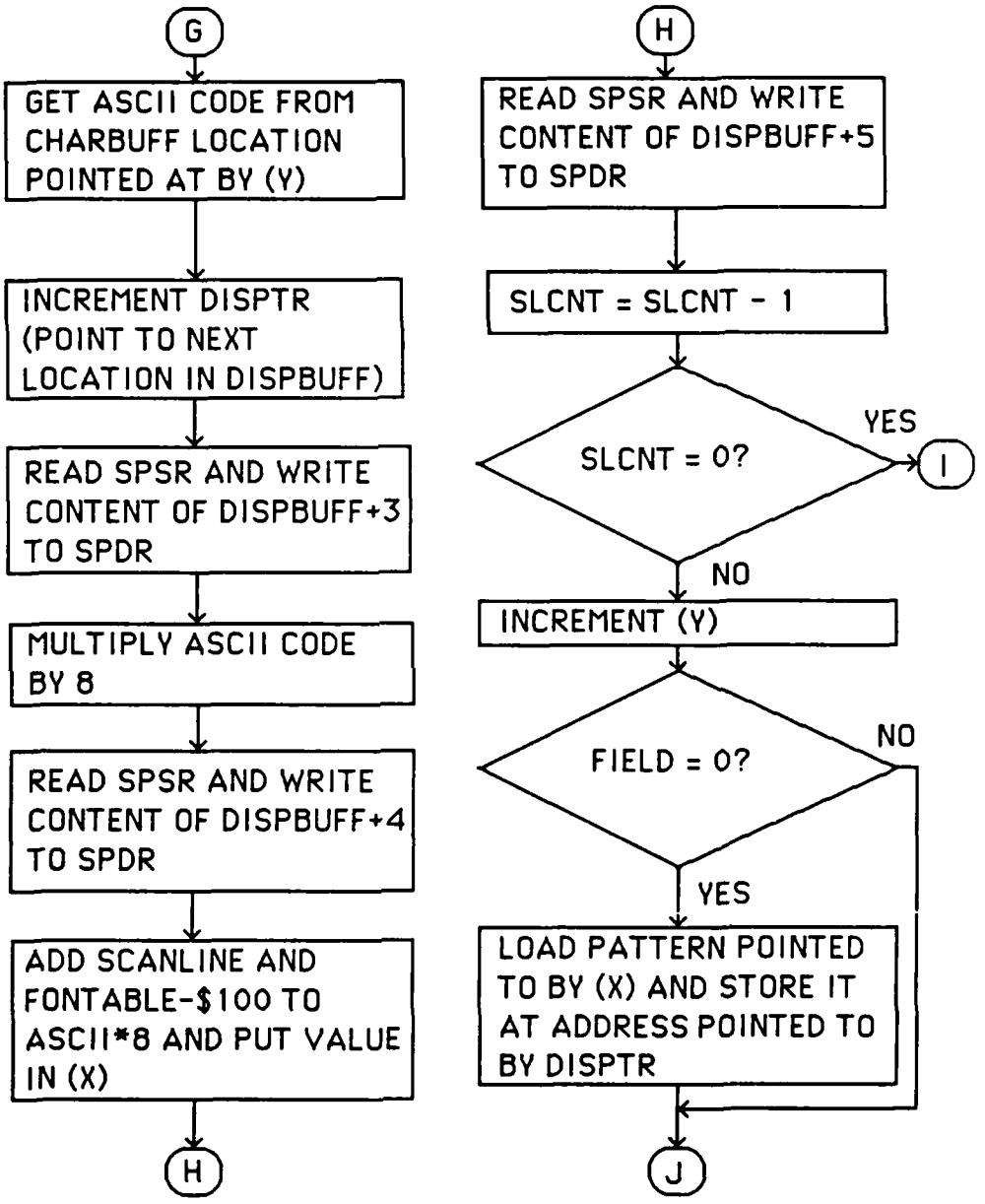


Figure 4-4. (Cont'd)

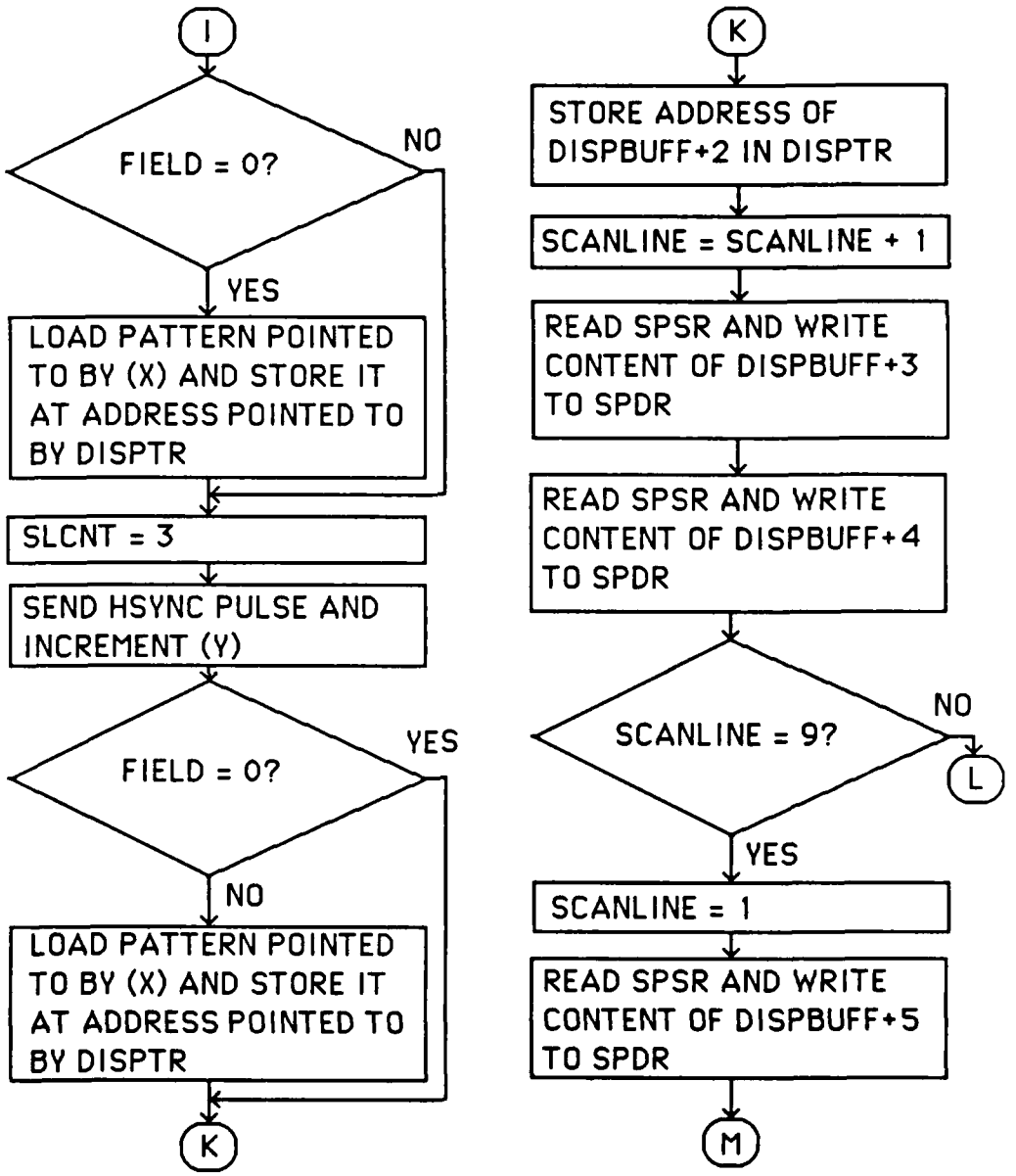


Figure 4-4. (Cont'd)

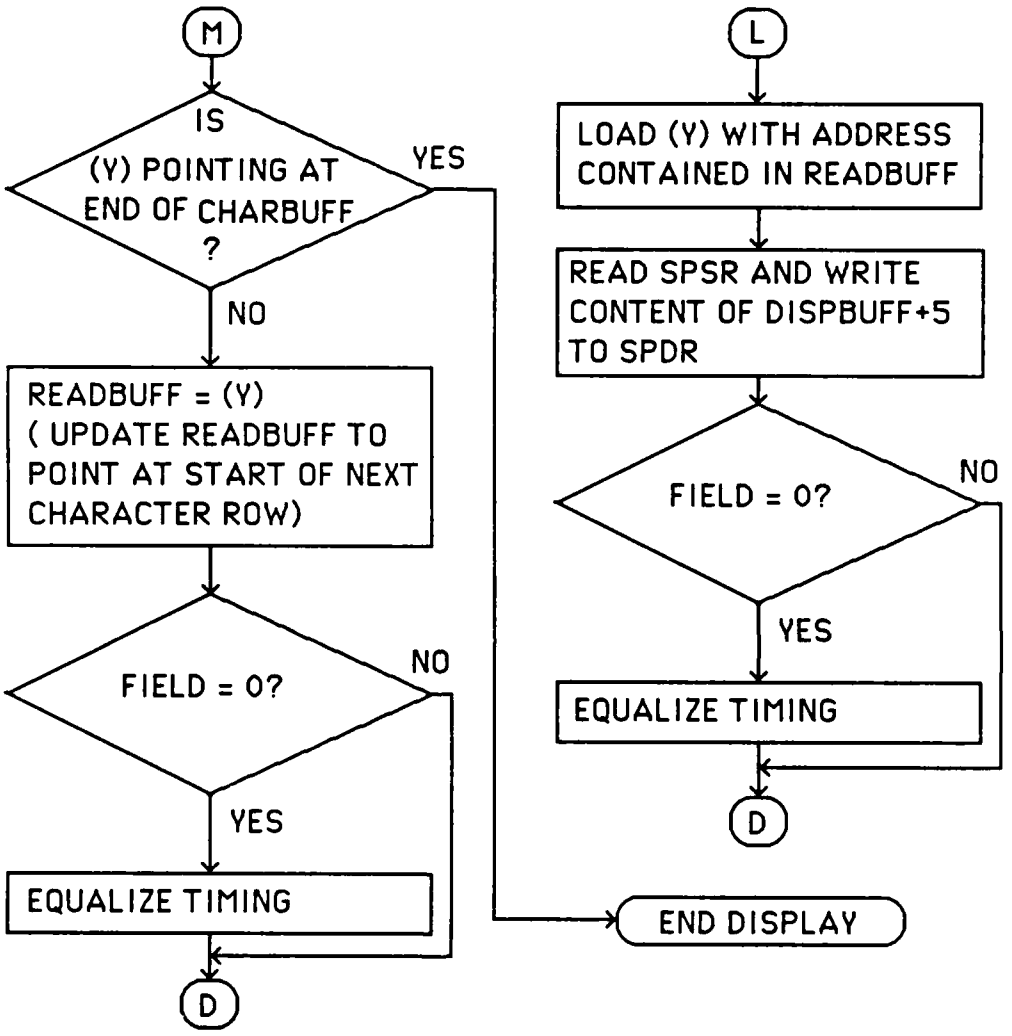


Figure 4-4. (Cont'd)

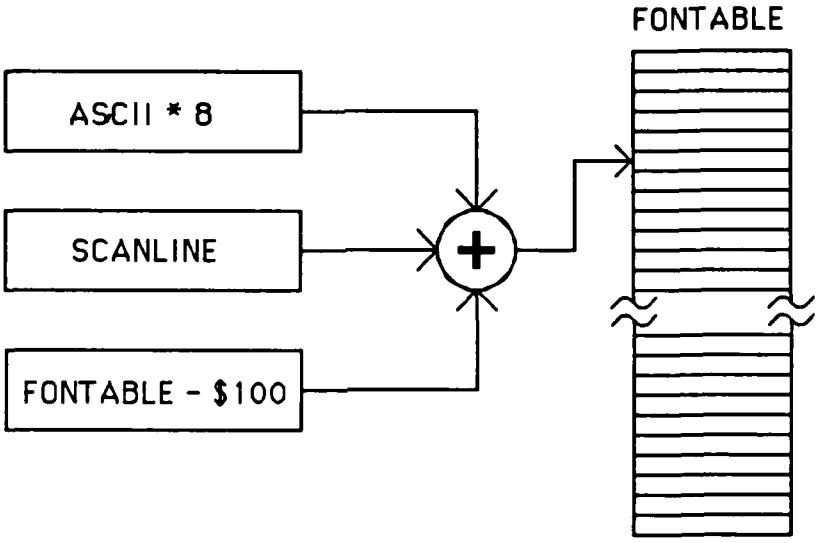


Figure 4 - 5. Computing Font Table Address

Index register X now contains the address of the desired display pattern for the given ASCII code and scanline. Again it is time to send another pattern, this time the content of DISPBUFF+2. The value of SLCNT is decremented by one and checked to see if it is zero. If it isn't, then index register Y is incremented by one and FIELD is checked. Note the same 6 µs section of code is executed except the condition for executing it is opposite of that for executing it at the start of the loop. This illustrates how the "odd" and "even" frames are shifted with respect to each other by 6 µs. If FIELD does equal "0" here, then index register X points at a display pattern and DISPTR points at DISPBUFF+3. Thus the first byte in the second half of the display buffer has been filled. The program loops back to generation of the HSYNC pulse and incrementing of index register Y. Index register Y has now been

incremented by 2 since the last iteration of the loop. It now points to the next "even" or "odd" address in the character buffer. The same process is repeated until the value of SLCNT reaches "0".

When SLCNT reaches "0", the first three horizontal lines of the first character scanline have been displayed. As the loop is exited, there is still one more pattern to be looked up and placed in DISPBUFF+5 (pointed at by DISPTR). When this accomplished is based on the value of FIELD. Again, this is necessary in order to maintain the proper timing relationships. The fourth and last horizontal line of the scanline is output. At the same time, SLCNT is reinitialized to 3, index register Y is reloaded with the address contained in READBUFF (this points Y back to the start of the same character row in the character buffer). The value of SCANLINE is incremented by one so the proper patterns are looked up. DISPTR is reset to DISPBUFF-1.

The next loop is exactly the same as the first loop with a couple of exceptions. Instead of sending the patterns in DISPBUFF through DISPBUFF+2, the patterns in DISPBUFF+3 through DISPBUFF+5 are sent. Furthermore, because DISPTR starts at DISPBUFF-1 instead of DISPBUFF+2, the new patterns are placed in DISPBUFF through DISPBUFF+2. This loop will also continue until SLCNT reaches "0".

Once again, one more horizontal line must be displayed to complete the scanline. In addition to reinitializing SLCNT to 3, setting DISPTR to DISBUFF+2, and incrementing SCANLINE, some further checks have to be made. The first additional check that has to be made at this point is to see if all the scanlines for the current character row have been displayed. This is done by checking if SCANLINE

is equal to 9. If it isn't, then index register Y is loaded with address contained in READBUFF, the pattern in DISPBUFF+5 is sent, and program control jumps back to the start of the first loop to display the next scanline. If SCANLINE is equal to 9, then the end of the current character row has been reached. SCANLINE is reset to 1 in anticipation of the start of the next character row. But before the next character row can start, a check must be made to see if all the character rows have been displayed. This is done by checking to see if the value in index register Y is pointing past the end of the character buffer. If it is, then all the rows have been displayed and the active display portion of the frame is complete. If index register Y is not pointing past the end of the character buffer, then it is pointing at the first character of the next row to be displayed. This address is saved in READBUFF for future reference and control passes to the first loop. The entire process repeats until all the rows have been displayed.

The software code is extremely "well tuned". Every instruction is where it is because of the required timing control. Any attempt to modify to code would be extremely tedious and difficult because the timing relationships must be maintained.

4.6 Video/Keyboard Software Integration

This section explains how the video display software is integrated with the keyboard scan and decode software. The modified BUFFALO monitor calls the display software as a subroutine. This subroutine will display the contents of CHARBUFF on the CRT until a key on the keyboard is depressed and decoded. The subroutine will then return the ASCII code of the depressed key in accumulator

A. The BUFFALO monitor will decide what it wants to do with the code. This will be discussed in detail in Chapter 5.

The algorithms for the the keyboard scan/decode and video signal generation have already been presented. Figure 4-6 is a flowchart showing how the two algorithms are integrated together. When BUFFALO calls the subroutine, a VSYNC pulse is output to start the timing of the video signal. The first task accomplished is to check the VALIDKEY variable. If VALIDKEY is true, then the keyboard is checked for no key depression. This prevents rapid repetition of the same key and requires one key be released before another may be depressed. If VALIDKEY is false, or is made false after checking for no key depression, then the keyboard scan and decode routine is executed as previously described. If an implemented key is decoded, then the subroutine is exited. The value of the ASCII code is returned to BUFFALO in accumulator A.

While the keyboard scan and decode is taking place, HSYNC pulses must be emitted at the right time to synchronize with the CRT. The keyscan software uses these HSYNC pulses as load pulses to the 74165. These HSYNC pulses must occur at the appropriate times, so the keyscan software is written around the timing of these pulses. Recall from the explanation of the keyboard scan/decode algorithm that patterns are sent to the keyboard columns until a key depression is detected or all patterns have been sent. This means the number of HSYNC pulses required for the keyboard scan is not known beforehand. However, the number of blank lines required before the start of the active display period is known. This number, referred to as BLKLINES in the software listing, is loaded into index register Y. Every time an HSYNC pulse is generated during the keyboard scan and decode, this

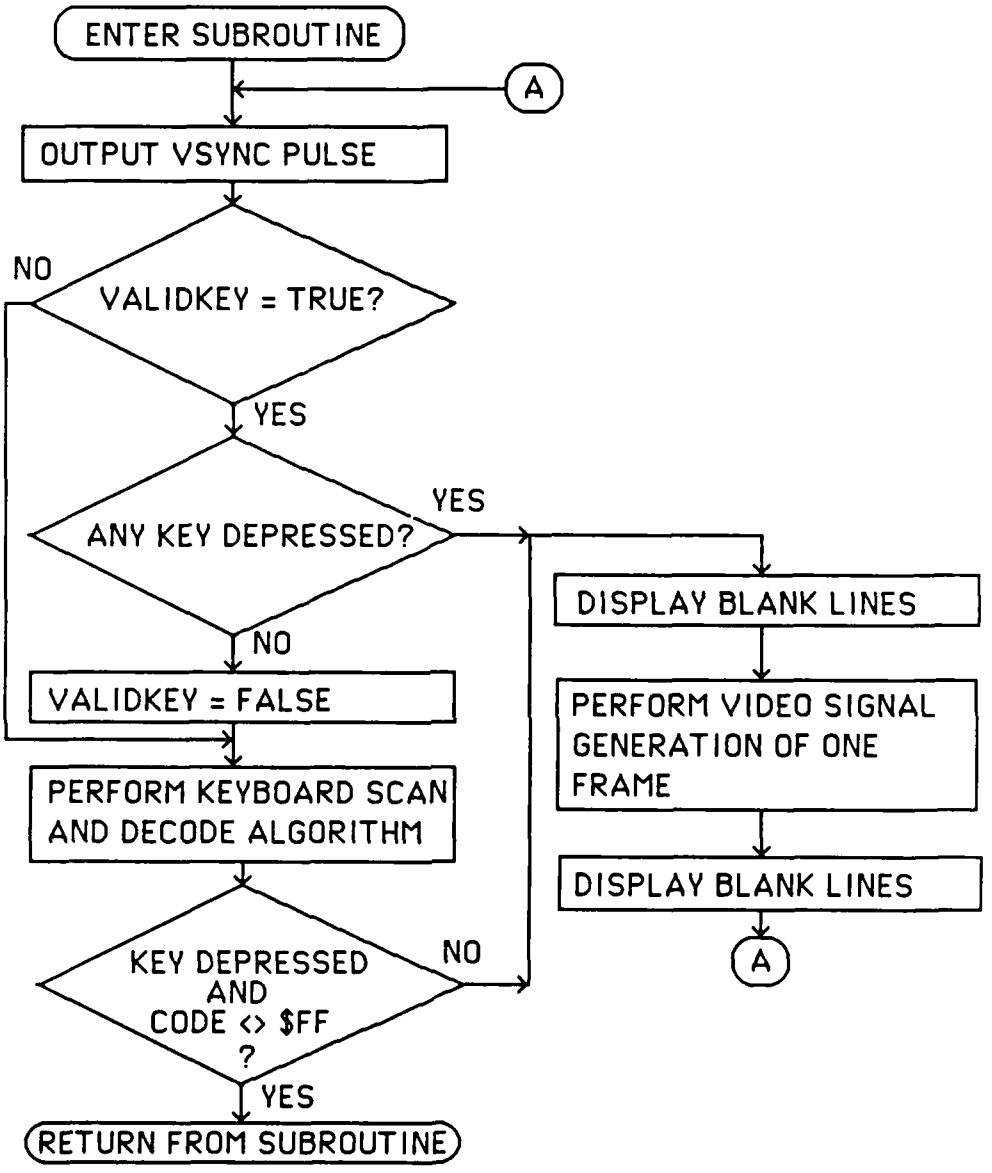


Figure 4 - 6. Keyboard/Video Subroutine Flowchart

value is decremented by one. Thus, upon completion of the scan/decode, index register Y has the number of blank lines that still have to be generated. This number of blank lines is generated prior to beginning the active display period.

The active display period is executed as previously described and more blank lines are displayed to complete the frame. Recall the total number of lines in this design is 254.5 with the active display period requiring 160 horizontal lines. Three line times are used for the VSYNC pulse, 44 lines are used prior to the active display period, and the remainder of the lines are displayed after the active display period. Then the entire process repeats starting with the VSYNC pulse.

4.7 Generating a Composite Video Signal

While some special monitors may have separate inputs for synchronization and video signals, most commercial television sets require an RF modulated composite video signal. In order to get a composite video signal, a simple circuit is used to mix the synchronization signals and the video data. This circuit is shown in Figure 4-7.

The circuit uses two open collector output exclusive NOR gates of a 74266 chip. When the voltage on the MOSI line is low, the current is shunted through the upper 220 Ω resistor resulting in a low voltage on the output line. When the voltage on the MOSI line is high, the diode is forward biased resulting in a voltage increase across the lower 220 Ω resistor. The synchronization pulses arrive on the D5 line. When the D5 line goes low, the output of the gate goes low resulting in a low

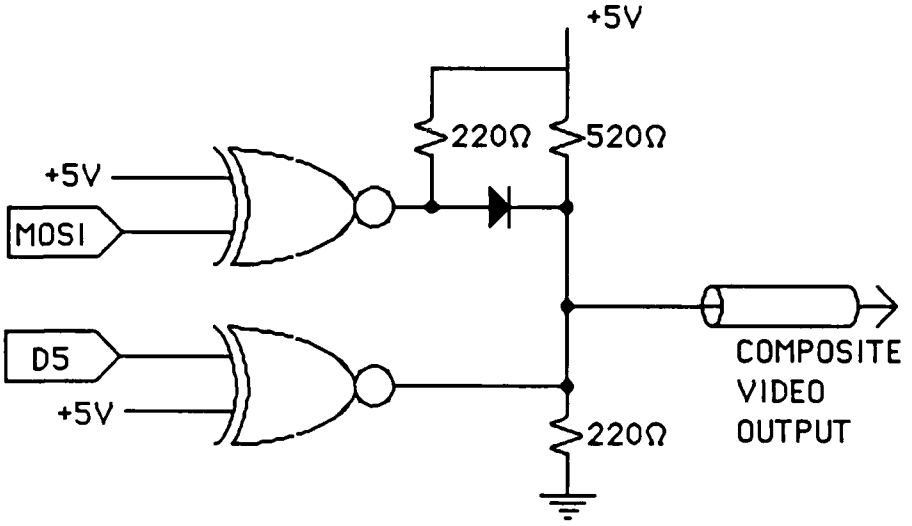


Figure 4 - 7. Composite Video Circuit

voltage at the output of the circuit. Thus, when the D5 line is pulsed low for the HSYNC and VSYNC pulses, the electron beam voltage is essentially at ground (black).

If the television has a direct composite video input, the output of this circuit can be used directly. If there is no direct composite video input, the output of this circuit must be input to an RF modulator and the output of the modulator connected to the television.

Chapter Five

The Modified BUFFALO Monitor

This chapter explains the operation of the modified BUFFALO monitor. First, the determination of the I/O device is explained. This is followed by a presentation of how data in input to and output from the modified BUFFALO monitor. Finally, a summary of the changes to the original BUFFALO monitor is presented. A complete software listing of the modified BUFFALO monitor can be found in Appendix D.

5.1 Determining the I/O Device

Originally, the BUFFALO monitor was designed to accomplish I/O via the onboard SCI, an external ACIA, or a an external DUART. Since this system operates only in the single-chip mode, no external ACIA or DUART may be used. However, the onboard SCI may still be used for I/O. Thus, the option to use the system with a terminal is retained.

The flowchart in Figure 5-1 depicts how BUFFALO detemines which device is going to be used for I/O. Both the SPI and SCI are initialized. A variable called IODEV is used to indicate which device will be used. If IODEV is 0, then the SCI is the I/O device. If IODEV is 1, then the SPI is the I/O device. The I/O drivers use IODEV to determine which set of routines to call for I/O processing. Modified BUFFALO will continue to poll both devices until input is received. The first device to respond will be the device used for I/O. The device not used for I/O is available for user software.

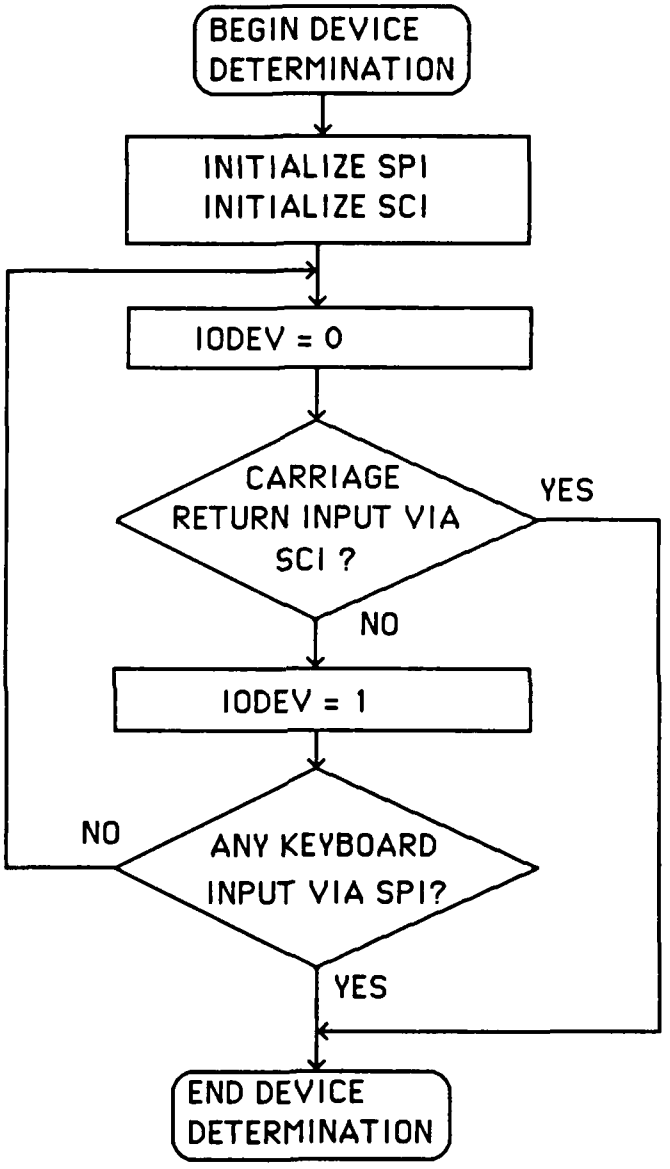


Figure 5-1. Determining the I/O Device

5.2 Data Input to BUFFALO

In order to process commands, BUFFALO must assemble a command line. It assembles this command line by calling the input I/O driver. The input I/O driver checks the value of IODEV to determine which set of routines to use to get a character. If IODEV = 1, then the keyscan/video display subroutine is called and the ASCII character code is returned in accumulator A. If IODEV = 0, then the SCI input routines are called and the ASCII character code is also returned in accumulator A. BUFFALO checks this code to see if it a backspace, carriage return, or control character. If it isn't, then the character is placed in the character buffer. This is the same 30-byte character buffer as previously described. BUFFALO will continue to call the input driver for more input until a carriage return or control character is encountered. Once a carriage return is entered, BUFFALO assumes a command has been entered. The available commands are explained in Appendix A.

At this point, the character buffer contains the command and any possible arguments. A command table is searched to see if the entered command matches any of the BUFFALO commands. If it does, then BUFFALO calls the command task as a subroutine. The task is accomplished and the user can enter another command. If the command entered does not match any of the commands in the command table, then an error message is displayed and the user can try again.

5.3 Data Output from BUFFALO

The output of data from the modified BUFFALO monitor when using the SCI device is straightforward and unchanged from the original version of

BUFFALO. However, when the device is the SPI, several changes had to be made. This section will discuss those changes.

Many of the BUFFALO commands display some type of data such as contents of memory location or register contents. When using the SPI for I/O, the output data must be put in the 30-byte character buffer for display using the keyscan/video display subroutine. The actual process of putting the characters into the buffer is transparent to the commands. The command software sends its output to the output driver. The output driver calls the output routines which in turn put the data in the character buffer. The amount of the data in the character buffer is kept track of so that if the buffer becomes full, the filling of the character buffer is halted and the user is shown the data in the buffer. This is done by calling the keyscan/video display subroutine when the buffer is full. The user can view the data until a key is depressed on the keyboard. The character buffer is then filled with the rest of the data, if any, and the process continues. The output data is formatted for the 5 line by 6 character display.

5.4 Summary of Changes to the BUFFALO Monitor

This section summarizes the major changes made to the original BUFFALO 2.2 monitor. In addition to the changes discussed in sections 5.1 through 5.3, the following changes were made to the original BUFFALO 2.2 monitor:

1) The assembler/disassembler was changed so that EEPROM locations could be assembled/disassembled. In addition, when the assembler/disassembler is expecting input, a "." prompt will be displayed instead of the ">" prompt.

2) The Go, Call, and Proceed commands were changed so that in all three cases each instruction is traced instead of inserting SWI's for breakpoints. After each instruction is traced, the program counter is checked to see if it matches one of the breakpoints. This was done to extend the life of the EEPROM because the EEPROM is only good for 400 erasures.

3) A command called EX was added so real time applications could be run. The EX command allows the user to run a program without tracing through the program.

4) The LOAD command was changed to get data from only the SCI. The LOAD command will only work when the SCI is the I/O device.

5) The original BUFFALO 2.2 had dedicated RAM locations for every interrupt vector. This was changed to reduce the amount of RAM used for interrupt vectors. The user supplies a number corresponding to a particular interrupt and the address of the interrupt handler. There is a routine in ROM which is entered when an interrupt is generated. This routine checks the user vector number against the type of interrupt which occurred to determine if the user has an interrupt handler for the particular interrupt. If it does, then contol passes to the interrupt handler. If it doesn't, then an RTI is executed.

Chapter Six

Summary

This thesis has presented a low cost video display system using the M6811 single chip microcomputer. The design of the software algorithms and the hardware necessary to implement the system have been presented and discussed. The system has been built and meets its desired objective of providing a low cost display system that students can use to learn about the M6811.

In the course of the design, several problems had to be overcome. One major problem was the limited speed of the SPI. The design of an "interlaced" display with half of the characters displayed during each alternating frame allowed an increased effective bandwidth at the expense of a tolerable flicker of the display. In addition, because of the limit of 8K of onboard ROM, the display software had to be optimized to use repetitive loops whenever possible to reduce overall program size. This allowed the display software along with the BUFFALO monitor to fit within the limits of the 8K of onboard ROM. Because of the strict timing requirements of the video signals, the software had to well "tuned". Every clock cycle had to counted to ensure the right output was generated at the right time. While not extremely difficult in nature, this process was very tedious.

Finally, this thesis has shown the viability of using the M6811 to read a keyboard and generate the necessary signals to produce a composite video signal. Hopefully, the system will provide an excellent learning tool for undergraduate students studying microprocessors.

Appendix A

A User's Guide to the Modified BUFFALO Monitor

This appendix contains information necessary to user the modified BUFFALO monitor with the low cost video display system.

A.1 System Startup

When the system is powered up, the television screen will consist of a series of lines across the screen. Press the RETURN key on the keyboard and the prompt "BUFFALO 2.2" will be displayed. Now press any key and the BUFFALO prompt ,">", will be displayed. Commands may be entered any time the ">" prompt is displayed.

A.2 Available Memory for Programs

Care must be taken when entering data into the memory. If certain locations are altered, the monitor will crash.

The following memory locations are available:

RAM	**00A1 - 00FF**	**95 bytes**
EEPROM	**B648 - B7FF**	**440 bytes**

Thus, there are 535 bytes available for program development. Be sure to use the above memory locations.

A.3 Interrupt Routines

The M6811 has a vector for each possible interrupt located at upper addresses of the 8K ROM. Since the vectors for almost all of these interrupts are not known beforehand, a method had to be devised to allow the user to specify the address of the interrupt handler.

There are two vectors available in RAM for the user interrupt handlers. The modified BUFFALO monitor checks these two vectors to determine if the user has interrupt handler for the interrupt. The user supplies the vector number and address in the designated RAM locations. These are the designated RAM locations for vector number and address:

Vector Number 1 - Vector Number: 0095 Address: 0096

Vector Number 2 - Vector Number: 0098 Address: 0099

The Vector Numbers and their associated interrupts are as follows:

Vector Number	Interrupt
1	SCI
2	SPI
3	Pulse Accumulator Input Edge
4	Pulse Accumulator Overflow
5	Timer Overflow
6	Timer Output Compare 4
7	Timer Output Compare 3

8	Timer Output Compare 2
9	Timer Output Compare 1
10	Timer Input Compare 3
11	Timer Input Compare 2
12	Timer Input Compare 1
13	Real Time Interrupt
14	IRQ
15	XIRQ
16	Illegal Opcode Trap
17	COP Failure
18	COP Clock Monitor Fail

As an example, suppose a program has an interrupt handler routine for the Timer Output Compare 3 located at address B70E. The number 7 would be loaded into either of the two Vector Number locations and the address B70E would be loaded into the associated address location. If Vector Number 1 were used, then the vector memory locations would look like:

0095 - 07

0096 - B7

0097 - 0E

When an interrupt from the Timer Output Compare 3 is generated, the interrupt handler at B70E will be executed.

In addtion , there are two dedicated interrupts for the Timer Output Compare 5 and the Software Interrupt. Each of these requires 3 bytes and are located as follows:

Timer Output Compare 5: 009B

Software Interrupt: 009E

In order to use these, the JMP opcode ($7E) is placed in the first byte and the address of the interrupt handler is placed in the last two bytes.

A.4 Modified BUFFALO Commands

In keeping with Motorola documentation, the command line format is as follows:

><command>[<parameters>] [RETURN]

where:

SYMBOL	FUNCTION
>	BUFFALO monitor prompt
<command>	Command mnemonic
<parameters>	Expression or address
[<parameters>]	Optional parameters
[RETURN]	RETURN keyboard key depressed

General Information:

1. Fields are separated by at least one space.

2. All numbers are interpreted as hexadecimal. Do not use a $ to precede hexadecimal numbers.
3. A maximum of 28 characters may be entered on a command line. If more characters are entered then the error message "Too Long" will be displayed.
4. The BREAK key will abort a command.

The following is a list of the commands, their function, and page number:

ASM ASSEMBLER/DISASSEMBLER

This command allows the user to assemble and disassemble code one line at a time. The format for the command is as follows:

ASM <address> [RETURN]

The <address> is the address of the first byte of the line to be disassembled. After the RETURN key has been depressed, the mnemonic along with the arguments (if any) will be displayed on the screen. The disassembled line will be displayed on the screen until the user depresses any key. The screen will then be clear except for a "." prompt displayed in the upper left corner of the display. The "." prompt indicates BUFFALO is waiting for an input line to assemble. If no input is needed, type [RETURN] and the next line will be disassembled and displayed. To terminate the ASM, depress the BREAK key.

Notes:

- a '#' preceding an argument indicates immediate addressing
- arguments must be separated by a space
- a ',' indicates indexed addressing and the next character must be X or Y

Subcommands (entered at the end of the command line):

[RETURN] - Disassembles the next opcode. If there was no assembly input, the next opcode is retrieved from the disassembler.

[LINE FEED] - Same as [RETURN] except if there is no assembly input, the <address> is incremented and this new address is disassembled.

[UP ARROW] - same as [LINE FEED] except <address> is decremented.

[BACK SLASH] (/) - reassembles current <address>.

BR Breakpoint Set

This command allows breakpoints to be put into the breakpoint table. The following is the command format for this command:

BR [<address>] [RETURN]

If <address> is provided, it is placed in the breakpoint table if the table is not full and the contents of the updated breakpoint table are displayed. If all four entries in the breakpoint table are used, then the message "FULL" will be displayed and the breakpoint will not be entered in the table. If <address> is not provided then the contents of the breakpoint table will be displayed. More than one address may be provided on the command line, but once the table has four entries, no further addresses will be entered into the table and the "FULL" message will be displayed.

BR - Remove Breakpoint

This command removes breakpoints from the breakpoint table. The following is the command line format:

BR -[<address>] [RETURN]

If <address> is provided, and it is in the breakpoint table, the address is removed from the table. Just as with BR, multiple addresses may be entered on a single command line (each address must be preceded by a "-"). If no <address> is provided, then all the breakpoints in the table will be removed.

CALL Call Subroutine

This command allows the user to call a subroutine. Control will return to the monitor when either a RTS or breakpoint is encountered. The command line format is as follows:

CALL [<address>] [RETURN]

If <address> is not supplied, then the user's PC value is used as the starting address. Like the Go command, Call will not work properly with a real time application such as timing external events.

EX Execute Program

This command allows the user to execute a program without breakpoints or the limitations of the GO command. This command should be used when attempting to run a real time application or an application which must get precise event timing. The GO command will ruin any attempt to accurately time events. The command line format is as follows:

EX [<address>] [RETURN]

If <address> is not supplied, then the user's PC value is used as the starting address.

G Go execute program

This command executes a user's program. It will return control to BUFFALO if a breakpoint is encountered. This command works by invoking the TRACE command until a breakpoint is encountered. Thus, any program that relies on timing events will not work properly. Therefore, use the EX command when

precise timing is required. The command line format for this command is as follows:

G [<address>] [RETURN]

If <address> is not provided, then execution begins at the current value of the Program Counter.

HELP Display commands

This command displays the commands available in the BUFFALO monitor. The command line is as follows:

HELP [RETURN]

LOAD Load program

Load allows a user program to be downloaded to the 6811. This command only works when using a computer with a communications software application such as a Macintosh with MacTerminal. This command will not work with the CRT display. The following is the command line format:

LOAD [RETURN]

After the command is entered, BUFFALO waits for an S-record format file to be sent (for more information on S-record format see [MOT85B]). In MacTerminal, the SEND FILE command is used to send the file to BUFFALO. The baud rate of the terminal must be set at 600 for proper operation. This is because the data may occupy the EEPROM and it takes about 10 ms to program one byte in the EEPROM.

MD Memory Display

This command permits display of a block of memory. The command line format is as follows:

MD [<address1>][<address2>] [RETURN]

This command will display the contents of memory starting at <address1> up to and including <address2>. If <address2> is not specified, then 128 bytes starting at <address1> will be displayed. If neither <address1> or <address2> are specified, then 128 bytes starting at the default memory pointer location will be displayed. Depressing the BREAK key will abort the MD command.

MM Memory Modify

This command allows the contents of a memory location to be modified. The command line format is as follows:

MM [<address>] [RETURN]

If <address> is not supplied, then the default memory pointer location will be opened for display and modification. If <address> is supplied, then the contents of <address> will be opened for display and modification. If data is entered, the contents of the location are updated to reflect the new data. There are several subcommands associated with the command. These subcommands are entered after the data, if any, is entered.

[RETURN] - Closes the current location and opens the next address.

[-] (minus sign) - Closes the current location and opens the previous address.

[=] (equal sign) - Reopens the current location.

[.] (period) - Closes the current location and exits the memory modify command.

If an attempt is made to modify a ROM location, then BUFFALO will display the message "ROM-". A shortcut to enter the MM mode is to enter "/" when the BUFFALO prompt is displayed. This will open the default memory pointer location. As always, depressing BREAK will abort the command.

MV Move Memory Block

This command allows a block of memory to be moved from one location to another. The command line format is as follows:

MV <source1> <source2> [<destination>] [RETURN]

This would move a block of memory starting at <source1> and ending at <source2> to <destination>. Both <source1> and <source2> must be supplied or an error message will be displayed. If <destination> is not supplied, then the block will be moved up one byte. When using the CRT display system, the screen may go blank because of the length of time required to move blocks to the EEPROM.

P Proceed from breakpoint

This command allows the user to proceed from a breakpoint. It is used after Go or Trace to continue execution of a program. The command line format is as follows:

P [RETURN]

RD Register Display

This command displays the contents of user's CPU registers. The command line format is as follows:

RD [RETURN]

RM Register Modify

This command displays the contents of the CPU registers and allows the user to modify the contents. The command line is as follows:

RM [<register name>] [RETURN]

The allowable register names are P, Y, X, A, B, C, S. If no <register name> is specified, then the first register is opened - the program counter P. The user may then change the value of the register. There are two subcommands:

[RETURN] - Opens the next register.

[.] (period) - Exits the register modify command.

The value of a register is changed only if data is entered before a subcommand.

T Trace

This command allows the user to trace through a program. The command line format is as follows:

T [<count>] [RETURN]

If <count> is not specified, only one instruction will be traced. If <count> is specified, then the trace command will be invoked <count> times. After each instruction has been traced, the contents of the registers are displayed. The BREAK key may be used to abort the command.

A.5 Debugging with the Modified BUFFALO Monitor

Debugging with the modified BUFFALO monitor is very much the same as debugging with any other monitor. The user can set breakpoints and Go or Trace through the program. However, because of the limited number of times the EEPROM may be erased (about 400), SWI instructions are not used to set breakpoints. This way SWI's are not written and erased every time a Go, Proceed, or Call command is used. Instead, each instruction is traced and the Program Counter is checked to see if a breakpoint is hit. This will present no problem to the user unless a real time application is being designed. In this case, such as counting clock cycles between events, the Trace, Go, Call, and Proceed commands will give invalid results to the user. To run a program in real time use the EX command.

Appendix B

Hardware Schematics

This appendix contains the hardware schematic for the low cost video display system.

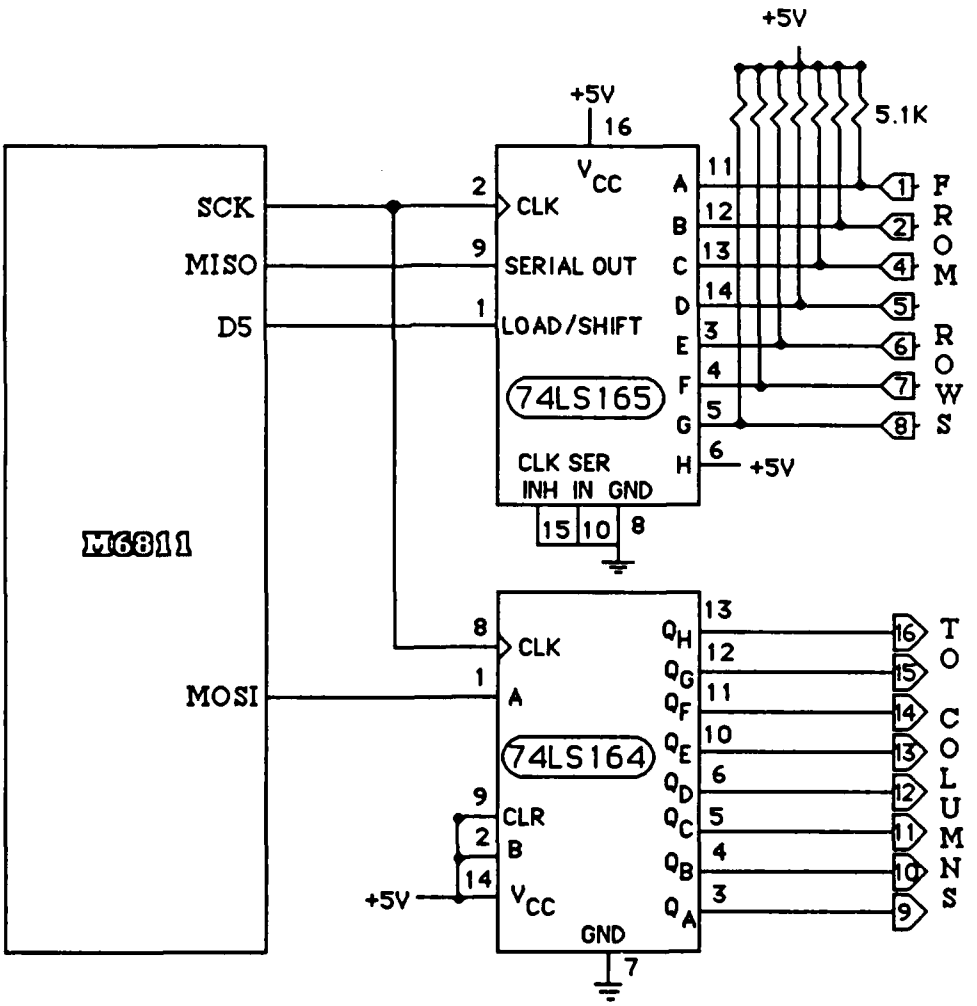


Figure B-1 Keyboard Interface

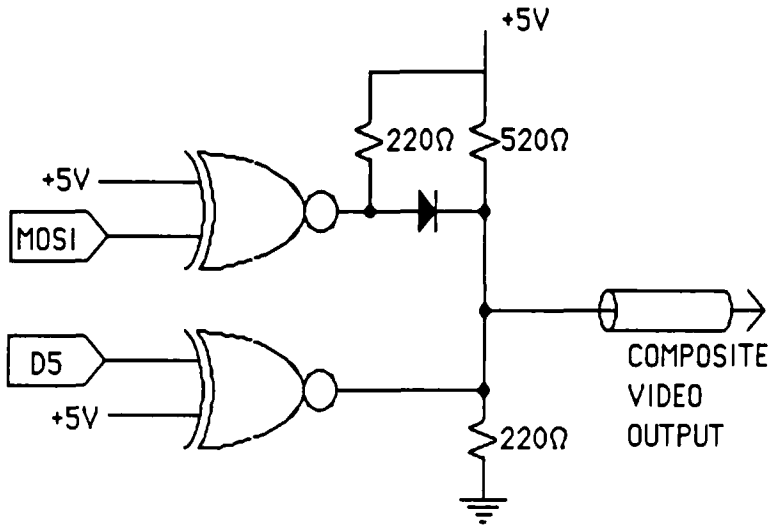


Figure B - 2. Composite Video Circuit

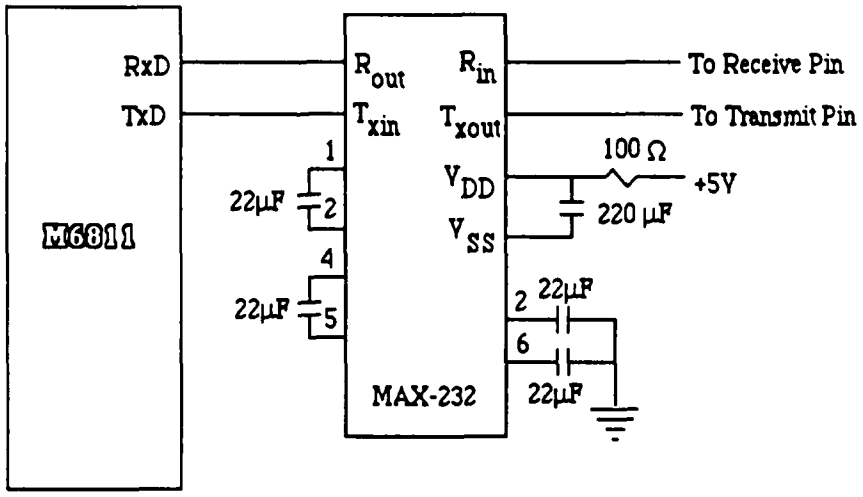


Figure B - 3. RS-232 Circuit

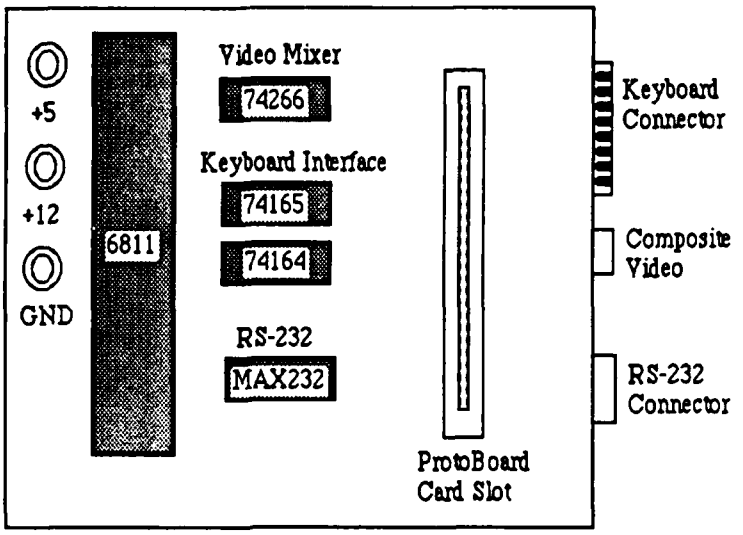


Figure B - 4. Possible Experiment Board Layout

Appendix C

Using a Different Keyboard

In order to provide the system with more flexibility, the capability to use a different keyboard is provided. There are two requirements for a replacement, non-encoded keyboard: it can have a matrix no larger than 8 X 8 and the shift key must result in the largest value for 8 * ROWCNT + COLCNT (i.e. the shift key must be connected to the most significant bit on the column and the most significant bit on the row). This section describes the changes to the software to use a different keyboard.

The keyboard lookup table is located in the first part of the EEPROM memory area starting at address $B600. The first six locations are used to define the characteristics of the keyboard. These values are needed by the decoding routines. These locations and names of these six values are as follows:

Address	Name	Purpose
$B600	SHIFTKEY	Defines the matrix value of the shift key
$B601	SHIFTLOW	Defines the matrix value of first shiftable key
$B602	SHIFTHI	Defines the matrix value of the last shiftable key
$B603	SHFTCOLP	Defines the column pattern for the shift key
$B604	SHFTROWP	Defines the row pattern for the shift key
$B605	SHFTRNGE	Defines the offset added for a shifted key
$B606	TABLE	Start of keyboard lookup table

The best way to illustrate these how these values are determined is by showing how the values for the present keyboard are determined.

As stated earlier, the keyboard used in the system is from a Radio Shack Color Computer . The schematic for the keyboard is shown in Figure C-1. The keyboard consists of a 7 row by 8 column matrix. Note the shift key is in the lower right corner of the matrix. It is connected to the most significant bit of the column pattern and its row line is, in essence, connected to the most significant bit of the row pattern. Each key position has a value associated with it. Starting in the upper left corner, the key has a matrix value of 0. The key to its right has a value of 1, and so on, until the end of the first row is reached with a value of 7. The next key after 7 is the start of the second row. Thus, for this keyboard the SHIFTKEY has a matrix value of 55.

The next characteristics are SHIFTLOW, SHIFTHI, and SHFTRNGE. There are no lower case letters in the display font, so there is no need to use the shift key with the alphabetic characters. This means the first shiftable key is the 1 key. Its matrix value is 33 (4*8 + 1) Thus, SHIFTLOW has a value of 33.. Similarly, the last shiftable key value, SHIFTHI, is 47. To find SHFTRNGE, notice the last key (exclude the shift key) has matrix value 50. The shifted ASCII codes must begin in the table after the value for matrix key 50. To point at the shifted value, an offset of 18 (51 - 33) must be added to the unshifted value. Therefore, SHFTRNGE is set at 18. This scheme results in minimum memory used for the lookup table.

The final two characteristics are SHFTCOLP and SHFTROWP. These values are necessary to check for shift key depression when another key has been depressed. The value for SHFTCOLP consists of a zero in the column of the shift

key and ones in the rest of the bits. For this keyboard, the value of SHFTCOLP is $7F (0111 1111). The value for SHFTROWP is the complement of a zero in the row of the shift key with ones in the other bits. For this keyboard, the value is the complement of $BF (1011 1111). This value is $40 (0100 0000).

The table of ASCII codes starts at address $B606. This address is referred to as TABLE in the software. The table starts with the ASCII code for @ and continues with A, B, C, D, E, F, G, H, I, and so on until the BRK code. Immediately following the BRK ASCII code are the ASCII codes for the shiftable keys, starting with ! and ending with ?.

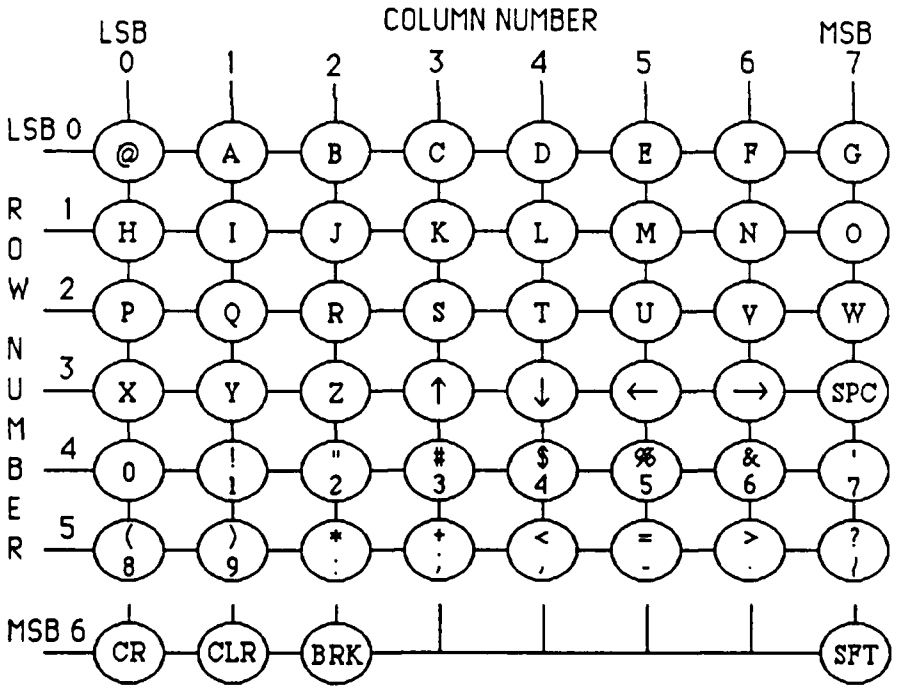


Figure C - 1. Radio Shack Keyboard Schematic

One final note about using a different keyboard. Be sure any unused inputs to the 74LS165 are tied high, not low. This is a must for the keyboard decoding software to work properly. For example, if the new keyboard only has six row lines then the G and H inputs to the 74LS165 must be tied high.

Appendix D

Software Listing

This appendix contains the software listing. The entire modified BUFFALO 2.2 monitor is included for reference. The keyscan/video display software is under the name VIDEO and starts at line 3499. The portions of the original BUFFALO 2.2 monitor are reprinted courtesy of Motorola, Inc. The following routines were written to support the video display system:

Name	Line Number
INITLP	0120
CRTBKSPC	0318
INITCRT	0353
OUTCRT	0415
CRTSTRG	0491
CLRBUFF	0507
HORPULSE	0525
EX	1512
VIDEO	3499
FONTABLE	3960
VECTCHK	4238

```
0001                    ********************************************************
0002                    ************ SYMBOLIC DEFINITIONS ***************
0003                    ********************************************************
0004
0005  0000              RAMBS       EQU   $0          start of RAM
0006  1000              REGBS       EQU   $1000       start of register set
0007  E000              PGMSTRT     EQU   $E000       start of ROM
0008  1008              PORTD       EQU   REGBS+$08   port D I/O register
0009  1009              DDRD        EQU   REGBS+$09   data dir reg for port D
0010  100A              PORTE       EQU   REGBS+$0A   port e
0011  100E              TCNT        EQU   REGBS+$0E   timer count
0012  101E              TOC5        EQU   REGBS+$1E   oc5 reg
0013  1020              TCTL1       EQU   REGBS+$20   timer control 1
0014  1022              TMSK1       EQU   REGBS+$22   timer mask 1
0015  1023              TFLG1       EQU   REGBS+$23   timer flag 1
0016  1024              TMSK2       EQU   REGBS+$24   timer mask 2
0017  1028              SPCR        EQU   REGBS+$28   SPI Control Register
0018  1029              SPSR        EQU   REGBS+$29   SPI Status Register
0019  102A              SPDR        EQU   REGBS+$2A   SPI Data Register
0020  102B              BAUD        EQU   REGBS+$2B   SCI baud reg
0021  102C              SCCR1       EQU   REGBS+$2C   SCI control1 reg
0022  102D              SCCR2       EQU   REGBS+$2D   SCI control2 reg
0023  102E              SCSR        EQU   REGBS+$2E   SCI status reg
0024  102F              SCDAT       EQU   REGBS+$2F   SCI data reg
0025  1039              OPTION      EQU   REGBS+$39   option reg
0026  103A              COPRST      EQU   REGBS+$3A
0027  103B              PPROG       EQU   REGBS+$3B   ee prog reg
0028  103C              HPRIO       EQU   REGBS+$3C   hprio reg
0029  103F              CONFIG      EQU   REGBS+$3F   config register
0030  001E              BUFFLEN     EQU   30          buffer holds 30 chars
0031  0004              EOT         EQU   $04         end of transmission
0032  0008              BACKSPCE    EQU   $08         ASCII backspace
0033  0018              CTLX        EQU   $18         control x
0034  0002              CTLA        EQU   $02
0035  0017              CTLW        EQU   $17
0036  007F              DEL         EQU   $7F         abort
0037  003F              SWI         EQU   $3F
0038  000D              CRETURN     EQU   $0D         ASCII carriage return
0039  0018              KEYBREAK    EQU   CTLX
0040  0020              SPACE       EQU   $20         ASCII space
0041  003E              PROMPT      EQU   '>'
0042  0020              SSHIGH      EQU   $20
0043  00DF              SSLOW       EQU   $DF
0044  003A              DDRDINIT    EQU   $3A
0045  005C              CTRLINIT    EQU   $5C
0046  002C              BLKLINES    EQU   44          # of blank lines which
0047                    *                             comprise the V Front porch
0048  005A              TOTBLKS     EQU   90          # blank lines per frame
0049  0003              SLINES      EQU   3
0050  0008              MAXROWS     EQU   8           # of keyboard rows
0051                    *-------------------------------------------
```

```
0052                    *          RAM STORAGE DEFINITIONS
0053                    *-----------------------------------------
0054  0000                        ORG   $0          start at RAM location 0
0055  0000              VALIDKEY  RMB   1          1 = good key decoded
0056  0001              IODEV     RMB   1          0=SCI : 1=SPI
0057  0002              CHARPTR   RMB   1          CHARBUFF pointer
0058  0003              READBUFF  RMB   2
0059  0005              CHARBUFF  RMB   BUFFLEN    char buff holds 30 chars
0060  0023              ENDBUFF   EQU   *
0061  0023              DISPTR    RMB   2          DISPBUF pointer
0062  0025              DISPBUFF  RMB   6          double line display buffer
0063  002B              FIELD     RMB   1          0=even frame : 1 = odd
0064  002C              SLCNT     RMB   1          # of H lines per scan line
0065  002D                        RMB   20         user stack area
0066  0041              USTACK    RMB   30         monitor stack area
0067  005F              STACK     RMB   1
0068  0060              COMBUFF   RMB   8          command buffer
0069  0068              SHFTREG   RMB   2
0070  006A              BRKTABL   RMB   8
0071  0072              REGS      RMB   9
0072  007B              SP        RMB   2
0073  007D              AUTOLF    RMB   1
0074  007E              COUNT     RMB   1
0075  007F              PTRMEM    RMB   2
0076  0081              PTR0      RMB   2
0077  0083              PTR1      RMB   2
0078  0085              PTR2      RMB   2
0079  0087              PTR3      RMB   2
0080  0089              PTR4      RMB   2
0081  008B              PTR5      RMB   2
0082  008D              PTR6      RMB   2
0083  008F              PTR7      RMB   2
0084  0091              TMP1      RMB   1
0085  0092              TMP2      RMB   1
0086  0093              TMP3      RMB   1
0087  0094              TMP4      RMB   1
0088
0089                    *++++++ INTERRUPT VECTORS +++++++
0090  0095              VECTR1    RMB   1          user vector number 1
0091  0096              VJMP1     RMB   2          user vector number 1 address
0092  0098              VECTR2    RMB   1          user vector number 2
0093  0099              VJMP2     RMB   2          user vector number 2 address
0094  009B              VOC5      RMB   3          vector for OC5 interrupt
0095  009E              VSWIIN    RMB   3          vector for SWIIN
0096  0101              USERRAM   EQU   *          start of user RAM
0097
0098
0099
0100
0101                    **************************
0102                    *    INITIALIZATION      *
```

```
0103                        ************************
0104  E000                              ORG   PGMSTRT
0105  E000  86 93                       LDAA  #$93
0106  E002  B7 10 39                    STAA  OPTION
0107  E005  4F                          CLRA
0108  E006  B7 10 24                    STAA  TMSK2
0109  E009  8E 00 5F                    LDS   #STACK      monitor sp
0110  E00C  CE 00 41                    LDX   #USTACK
0111  E00F  DF 7B                       STX   SP          default user sp
0112  E011  86 D0                       LDAA  #$D0
0113  E013  97 7A                       STAA  REGS+8      default ccr
0114  E015  BD E3 6C                    JSR   BPCLR       clear breakpoints
0115  E018  7F 00 7D                    CLR   AUTOLF
0116  E01B  7C 00 7D                    INC   AUTOLF      auto cr/lf = on
0117                        * initialize devices
0118  E01E  BD E1 85                    JSR   INITCRT     initialize crt system
0119  E021  BD E3 CC                    JSR   ONSCI       initialize SCI system
0120  E024  7F 00 01      INITLP        CLR   IODEV       (0 = SCI)
0121  E027  BD E1 41                    JSR   INPUT       read SCI
0122  E02A  81 0D                       CMPA  #CRETURN    check for carriage return
0123  E02C  27 0A                       BEQ   SIGNON      found device - the SCI
0124  E02E  7C 00 01                    INC   IODEV       (1 = SPI)
0125  E031  BD E1 98                    JSR   CRTCHK      check for a key
0126  E034  81 00                       CMPA  #0
0127  E036  27 EC                       BEQ   INITLP      no input from SPI;try again
0128  E038  CE E4 85      SIGNON        LDX   #MSG1
0129  E03B  BD E2 08                    JSR   OUTSTRG
0130
0131                        *++++++++++++++++++++++++++++++++++++++++
0132                        *++++   Main Loop - Gets input from user  ++++
0133                        *++++        Assembles a command line     ++++
0134                        *++++++++++++++++++++++++++++++++++++++++
0135
0136  E03E  8E 00 5F      MAIN          LDS   #STACK      initialize monitor stack
0137  E041  BD E1 F7                    JSR   OUTCRLF
0138  E044  BD E2 4E                    JSR   CLRBUFF     clear buffer for use by CRT
0139  E047  86 3E                       LDAA  #PROMPT     prompt user
0140  E049  BD E1 76                    JSR   OUTPUT      send it to device
0141  E04C  BD E1 37      MAIN10        JSR   INCHAR      get character from user
0142  E04F  CE 00 05                    LDX   #CHARBUFF
0143  E052  D6 02                       LDAB  CHARPTR
0144  E054  3A                          ABX               offset into buffer
0145  E055  81 18                       CMPA  #CTLX       abort?
0146  E057  27 E5                       BEQ   MAIN        yes - restart
0147  E059  81 08                       CMPA  #BACKSPCE   backspace?
0148  E05B  26 10                       BNE   MAIN20
0149  E05D  96 01                       LDAA  IODEV       Is I/O device SPI or SCI?
0150  E05F  27 05                       BEQ   MAIN11
0151  E061  BD E1 64                    JSR   CRTBKSPC
0152  E064  20 E6                       BRA   MAIN10
0153  E066  7A 00 02      MAIN11        DEC   CHARPTR
```

```
0154  E069  2D D3          BLT   MAIN
0155  E06B  20 DF          BRA   MAIN10
0156  E06D  81 0D  MAIN20  CMPA  #CRETURN     carriage return?
0157  E06F  26 14          BNE   MAIN30 no
0158  E071  7D 00 01       TST   IODEV
0159  E074  26 07          BNE   MAIN21
0160  E076  5D             TSTB
0161  E077  27 C5          BEQ   MAIN
0162  E079  A7 00          STAA  0,X
0163  E07B  20 22          BRA   COMM0
0164  E07D  C1 02  MAIN21  CMPB  #2           any characters in the buffer?
0165  E07F  27 BD          BEQ   MAIN         no - start over
0166  E081  A7 00          STAA  0,X          put cr into buffer
0167  E083  20 1A          BRA   COMM0        parse input
0168  E085  7D 00 01  MAIN30  TST   IODEV
0169  E088  26 05          BNE   MAIN35
0170  E08A  A7 00          STAA  0,X
0171  E08C  5C             INCB
0172  E08D  D7 02          STAB  CHARPTR
0173  E08F  C1 1E  MAIN35  CMPB  #BUFFLEN
0174  E091  2D 08          BLT   MAIN40
0175  E093  CE E4 97       LDX   #MSG3
0176  E096  BD E2 08       JSR   OUTSTRG
0177  E099  20 A3          BRA   MAIN
0178  E09B  81 2D  MAIN40  CMPA  #'/'
0179  E09D  26 AD          BNE   MAIN10
0180
0181                *+++++++++++++++++++++++++++++++++++++++
0182                *++++Parse out and evaluate the command line++++
0183                *+++++++++++++++++++++++++++++++++++++++
0184
0185  E09F  4F      COMM0   CLRA
0186  E0A0  97 91           STAA  TMP1
0187  E0A2  97 68           STAA  SHFTREG
0188  E0A4  97 69           STAA  SHFTREG+1
0189  E0A6  5F              CLRB
0190  E0A7  CE 00 05        LDX   #CHARBUFF    point (X) at input buffer
0191  E0AA  96 01           LDAA  IODEV
0192  E0AC  27 01           BEQ   COMM01
0193  E0AE  08              INX                point (X) past prompt char
0194  E0AF  DF 81   COMM01  STX   PTR0         save pointer
0195  E0B1  BD E3 8D        JSR   WSKIP        find first character
0196  E0B4  BD E3 78  COMM1   JSR   RDBUFF      read from buffer
0197  E0B7  CE 00 60        LDX   #COMBUFF
0198  E0BA  3A              ABX
0199  E0BB  BD E2 74        JSR   UPCASE       convert to upper case
0200  E0BE  A7 00           STAA  0,X          put in command buffer
0201  E0C0  81 0D           CMPA  #$0D
0202  E0C2  27 35           BEQ   SRCH         jump if cr
0203  E0C4  BD E3 9B        JSR   WCHEK
0204  E0C7  27 30           BEQ   SRCH         jump if wspac
```

```
0205  E0C9  BD E3 7F          JSR   INCBUFF     move buffer pointer
0206  E0CC  5C               INCB
0207  E0CD  C1 08            CMPB  #$8
0208  E0CF  2F 09            BLE   COMM2
0209  E0D1  CE E4 97          LDX   #MSG3       "long"
0210  E0D4  BD E2 08          JSR   OUTSTRG
0211  E0D7  7E E0 3E          JMP   MAIN
0212  E0DA  81 2F     COMM2   CMPA  #'/'
0213  E0DC  26 16            BNE   COMM4       jump if not "/"
0214  E0DE  7D 00 91          TST   TMP1
0215  E0E1  26 08            BNE   COMM3       jump if not enabled
0216  E0E3  D7 7E            STAB  COUNT
0217  E0E5  CE E5 0D          LDX   #MSLASH
0218  E0E8  7E E1 32          JMP   EXEC        execute "/"
0219  E0EB  CE E4 AF  COMM3   LDX   #MSG8       "command?"
0220  E0EE  BD E2 08          JSR   OUTSTRG
0221  E0F1  7E E0 3E          JMP   MAIN
0222  E0F4  BD E2 7F  COMM4   JSR   HEXBIN
0223  E0F7  20 BB            BRA   COMM1
0224
0225                  ********************************************
0226                  * Search tables for command.  At this point,
0227                  * COMBUFF holds the command field to be executed,
0228                  * and B = # of characters in the command field.
0229                  * The command table holds the whole command name
0230                  * but only the first n characters of the command
0231                  * must match what is in COMBUFF where n is the
0232                  * number of characters entered by the user.
0233                  ********************************************
0234
0235  E0F9  D7 7E     SRCH    STAB  COUNT       size of command entered
0236  E0FB  CE E4 27          LDX   #COMTABL    pointer to table
0237  E0FE  DF 83             STX   PTR1        pointer to next entry
0238  E100  DE 83     SRCH1   LDX   PTR1
0239  E102  18 CE 00 60       LDY   #COMBUFF    pointer to command buffer
0240  E106  E6 00             LDAB  0,X
0241  E108  C1 FF             CMPB  #$FF
0242  E10A  26 09             BNE   SRCH2
0243  E10C  CE E4 91          LDX   #MSG2       "command not found"
0244  E10F  BD E2 08          JSR   OUTSTRG
0245  E112  7E E0 3E          JMP   MAIN
0246  E115  3C       SRCH2   PSHX              compute next table entry
0247  E116  CB 03             ADDB  #$3
0248  E118  3A                ABX
0249  E119  DF 83              STX   PTR1
0250  E11B  38                 PULX
0251  E11C  5F                 CLRB
0252  E11D  5C       SRCHLP   INCB              match characters loop
0253  E11E  A6 01              LDAA  1,X         read table
0254  E120  18 A1 00           CMPA  0,Y         compare to combuff
0255  E123  26 DB              BNE   SRCH1       try next entry
```

```
0256  E125  08              INX             move pointers
0257  E126  18 08           INY
0258  E128  D1 7E           CMPB  COUNT
0259  E12A  2D F1           BLT   SRCHLP    loop countu1 times
0260  E12C  DE 83           LDX   PTR1
0261  E12E  09              DEX
0262  E12F  09              DEX
0263  E130  EE 00           LDX   0,X       jump address from table
0264  E132  AD 00  EXEC     JSR   0,X       call task as subroutine
0265  E134  7E E0 3E        JMP   MAIN
0266
0267                *******************************
0268                * INCHAR() - this routine waits for input
0269                *   from the SCI or SPI
0270                *******************************
0271
0272  E137  BD E1 41 INCHAR  JSR   INPUT
0273  E13A  4D               TSTA
0274  E13B  27 FA            BEQ   INCHAR
0275  E13D  BD E1 76         JSR   OUTPUT    echo character in (A)
0276  E140  39      INCHAR10 RTS
0277
0278                ***********************************
0279                * INPUT() - this routine calls the specific
0280                *  routine to read the SPI or SCI. It also
0281                *  disarms the COP. The character is
0282                *  returned in register A.
0283                ***********************************
0284
0285  E141  86 55    INPUT   LDAA  #$55
0286  E143  B7 10 3A         STAA  COPRST
0287  E146  86 AA            LDAA  #$AA
0288  E148  B7 10 3A         STAA  COPRST
0289  E14B  96 01            LDAA  IODEV
0290  E14D  26 04            BNE   INPUT1
0291  E14F  BD E1 57         JSR   INSCI
0292  E152  39               RTS
0293  E153  BD F9 EB  INPUT1 JSR   VIDEO
0294  E156  39               RTS
0295
0296                ****************************************
0297                * INSCI() - get input from the SCI. Data received
0298                *  is returned in register A.
0299                ****************************************
0300
0301  E157  B6 10 2E  INSCI  LDAA  SCSR
0302  E15A  84 20            ANDA  #$20
0303  E15C  27 05            BEQ   INSCI1
0304  E15E  B6 10 2F         LDAA  SCDAT
0305  E161  84 7F            ANDA  #$7F
0306  E163  39       INSCI1  RTS
```

```
0307
0308                    ****************************************
0309                    * CRTBKSPC() - this routine is used when a backspace
0310                    *  character is received from the SPI. Updates the
0311                    *  CHARPTR and erases the appropriate data in the
0312                    *  CHARBUFF. On entry X points to next free
0313                    *  location in CHARBUFF. X-1 points to a backspace
0314                    *  character, and X-2 has the data to be erased
0315                    *  Destroys: A,B,X
0316                    ****************************************
0317
0318  E164  86 20       CRTBKSPC    LDAA  #SPACE
0319  E166  09                      DEX                   decrement pointer
0320  E167  A7 00                   STAA  0,X             put space in previous loc
0321  E169  CB FE                   ADDB  #-2             decrement offset by two
0322  E16B  27 05                   BEQ   BACKSP1
0323  E16D  09                      DEX
0324  E16E  A7 00                   STAA  0,X             put space in old location
0325  E170  20 01                   BRA   BACKSP2
0326  E172  5C          BACKSP1     INCB
0327  E173  D7 02        BACKSP2     STAB  CHARPTR         update pointer
0328  E175  39                      RTS
0329
0330                    ****************************************
0331                    * OUTPUT(a) - this routine outputs the character in
0332                    *  A to the either the SCI or SPI. On exit, A still has
0333                    *  the character.
0334                    ****************************************
0335
0336  E176  37          OUTPUT      PSHB
0337  E177  D6 01                   LDAB  IODEV
0338  E179  26 05                   BNE   OUTPUT1
0339  E17B  BD E3 DB                JSR   OUTSCI
0340  E17E  20 03                   BRA   OUTPUT4
0341  E180  BD E1 D5    OUTPUT1     JSR   OUTCRT
0342  E183  33          OUTPUT4     PULB
0343  E184  39                      RTS
0344
0345                    ****************************************
0346                    * initcrt() - this routine initializes the
0347                    *  SPI and configures port D. Pord D must
0348                    *  be configured before the SPI is initialized
0349                    *  or the SPI will lock up, thinking it has had
0350                    *  a write collision.
0351                    ****************************************
0352                    * initialize DDRD
0353  E185  86 3A       INITCRT     LDAA  #DDRDINIT
0354  E187  B7 10 09                STAA  DDRD
0355                    * initialize D5 to a logic one
0356  E18A  B6 10 08                LDAA  PORTD
0357  E18D  8A 20                   ORAA  #SSHIGH         set bit 5 to ZERO
```

```
0358  E18F  B7 10 08                STAA  PORTD
0359                  * Configure the SPCR
0360  E192  86 5C                   LDAA  #CTRLINIT     Bit pattern into SPCR
0361  E194  B7 10 28                STAA  SPCR
0362  E197  39                      RTS
0363
0364                  ********************************************
0365                  * crtchk() - this routine checks for a key depression
0366                  *  via the SPI. If a key is depressed then A is returned
0367                  *  with the value 1, else A is 0.
0368                  ********************************************
0369
0370  E198  86 FE     CRTCHK        LDAA  #$FE          first pattern
0371  E19A  F6 10 29                LDAB  SPSR          clear spi flags
0372  E19D  B7 10 2A                STAA  SPDR          send first pattern
0373  E1A0  36                      PSHA                save A
0374  E1A1  3D                      MUL                 kill time
0375  E1A2  32                      PULA                restore A
0376  E1A3  BD E2 63                JSR   HORPULSE      latch data
0377  E1A6  F6 10 29  CRTCHK0       LDAB  SPSR
0378  E1A9  0D                      SEC
0379  E1AA  49                      ROLA
0380  E1AB  24 12                   BCC   CRTCHK1       all patterns have been sent
0381  E1AD  B7 10 2A                STAA  SPDR
0382  E1B0  36                      PSHA                save A
0383  E1B1  3D                      MUL                 kill time
0384  E1B2  32                      PULA                restore A
0385  E1B3  BD E2 63                JSR   HORPULSE
0386  E1B6  F6 10 2A                LDAB  SPDR
0387  E1B9  C1 FF                   CMPB  #$FF
0388  E1BB  26 10                   BNE   CRTCHK2
0389  E1BD  20 E7                   BRA   CRTCHK0
0390  E1BF  B7 10 2A  CRTCHK1       STAA  SPDR          need to check last pattern
0391  E1C2  3D                      MUL                 kill time
0392  E1C3  3D                      MUL                 kill time
0393  E1C4  F6 10 2A                LDAB  SPDR          get last pattern
0394  E1C7  C1 FF                   CMPB  #$FF
0395  E1C9  26 02                   BNE   CRTCHK2
0396  E1CB  4F                      CLRA
0397  E1CC  39                      RTS                 return with a=0; no key
0398  E1CD  81 00     CRTCHK2       CMPA  #0            check for nothing connected
0399  E1CF  26 01                   BNE   CRTCHK3
0400  E1D1  39                      RTS                 returns with a=0; no key
0401  E1D2  86 01     CRTCHK3       LDAA  #1
0402  E1D4  39                      RTS                 key depressed
0403
0404                  ********************************************
0405                  * OUTCRT(a) - this routine is called if the SPI is the
0406                  *  external device. The character in A is put in the
0407                  *  CHARBUFF and the CHARPTR is updated. If there is
0408                  *  no room in CHARBUFF, then the routine calls VIDEO
```

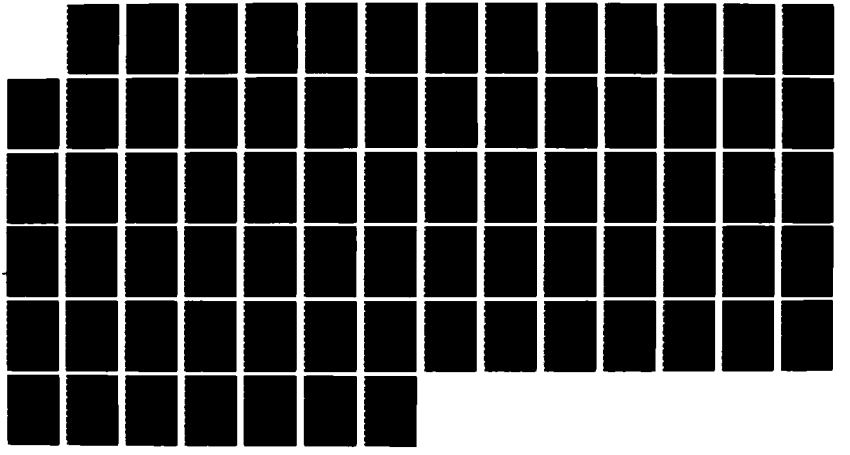
```
0409                    * which will display the contents of CHARBUFF and wait
0410                    * for the user to hit any key. The CHARBUFF will be emptied
0411                    * and the data in A placed in CHARBUFF. A still contains the
0412                    * character data upon exit. Destroys B.
0413                    ************************************************
0414
0415  E1D5  3C          OUTCRT      PSHX                 save (X)
0416  E1D6  D6 02                   LDAB  CHARPTR        get pointer
0417  E1D8  C1 E1                   CMPB  #BUFFLEN       buffer full?
0418  E1DA  27 0B                   BEQ   OUTCRT1        yes-display data
0419  E1DC  CE 00 05                LDX   #CHARBUFF      no-put data in buffer
0420  E1DF  3A                      ABX
0421  E1E0  A7 00                   STAA  0,X            put character in buffer
0422  E1E2  7C 00 02                INC   CHARPTR
0423  E1E5  20 0E                   BRA   OUTCRT2
0424  E1E7  36          OUTCRT1     PSHA                 save (A)
0425  E1E8  BD F9 EB                JSR   VIDEO          display data;wait for keyentry
0426  E1EB  BD E2 4E                JSR   CLRBUFF        clean out buffer
0427  E1EE  C6 01                   LDAB  #1             reset pointer
0428  E1F0  D7 02                   STAB  CHARPTR        save it
0429  E1F2  32                      PULA                 get character
0430  E1F3  97 05                   STAA  CHARBUFF       put character in buffer
0431  E1F5  38          OUTCRT2     PULX                 restore (X)
0432  E1F6  39                      RTS
0433
0434                    ************************************************
0435                    * OUTCRLF() - output a carriage return and linefeed.
0436                    * Returns A containing an ASCII carriage return.
0437                    ************************************************
0438
0439  E1F7  7D 00 01    OUTCRLF     TST   IODEV
0440  E1FA  26 0B                   BNE   OUTCRLF1
0441  E1FC  86 0D                   LDAA  #CRETURN
0442  E1FE  BD E1 76                JSR   OUTPUT
0443  E201  4F                      CLRA
0444  E202  BD E1 76                JSR   OUTPUT
0445  E205  86 0D                   LDAA  #CRETURN
0446  E207  39          OUTCRLF1    RTS
0447
0448                    ********************************************
0449                    * OUTSTRG() - this routine calls an SPI or SCI routine
0450                    * to output a string of of characters.
0451                    ********************************************
0452
0453  E208  BD E1 F7    OUTSTRG     JSR   OUTCRLF
0454  E20B  36          OUTSTRG0    PSHA
0455  E20C  96 01                   LDAA  IODEV
0456  E20E  26 0E                   BNE   OUTSTRG1
0457  E210  BD E2 1A                JSR   SCISTRG
0458  E213  20 03                   BRA   OUTSTRG2
0459  E215  BD E2 35    OUTSTRG1    JSR   CRTSTRG
```

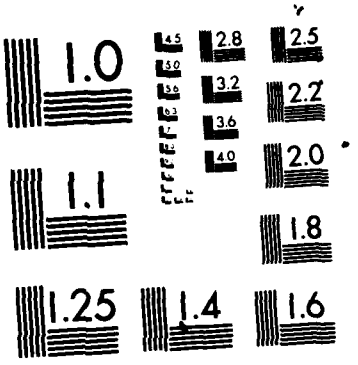
```
0460  E218  32          OUTSTRG2    PULA
0461  E219  39                      RTS
0462
0463                    ************************************************
0464                    *SCISTRG() - output a string of ASCII bytes starting at x
0465                    * until an end of text to the SCI. X is updated to the EOT
0466                    * character.
0467                    ************************************************
0468
0469  E21A  A6 00       SCISTRG     LDAA 0,X
0470  E21C  81 04                   CMPA #EOT
0471  E21E  27 14                   BEQ  SCISTRG2
0472  E220  BD E1 76                JSR  OUTPUT
0473  E223  08                      INX
0474  E224  BD E1 41                JSR  INPUT
0475  E227  27 F1                   BEQ  SCISTRG
0476  E229  81 17                   CMPA #CTLW
0477  E22B  26 ED                   BNE  SCISTRG
0478  E22D  BD E1 41    SCISTRG1    JSR  INPUT
0479  E230  27 FB                   BEQ  SCISTRG1
0480  E232  20 E6                   BRA  SCISTRG
0481  E234  39          SCISTRG2    RTS
0482
0483                    ************************************************
0484                    * CRTSTRG()- output string of ASCII bytes starting at x until
0485                    * end of text to SPI. X is updated to the eot character.
0486                    * It then will continue send characters to output() until the eot
0487                    *  is reached. The routine will then wait for any key to be
0488                    *  depressed by the user. Destroys A.
0489                    ************************************************
0490
0491  E235  BD E2 4E    CRTSTRG     JSR  CLRBUFF     clear the character buffer
0492  E238  A6 00       CRTSTRG0    LDAA 0,X         get character
0493  E23A  81 04                   CMPA #EOT        end of text?
0494  E23C  27 09                   BEQ  CRTSTRG1    yes - display message
0495  E23E  BD E2 74                JSR  UPCASE      make sure it is upper case
0496  E241  BD E1 76                JSR  OUTPUT      put character in buffer
0497  E244  08                      INX              point to next character
0498  E245  20 F1                   BRA  CRTSTRG0    get next character
0499  E247  BD E2 41    CRTSTRG1    JSR  INPUT       wait for input from user
0500  E24A  BD E2 4E                JSR  CLRBUFF     clean out the buffer
0501  E24D  39                      RTS
0502                    ************************************************
0503                    * clrbuff() - This routine fills CHARBUFF with ASCII space
0504                    *  characters and resets CHARPTR to zero.
0505                    ************************************************
0506
0507  E24E  3C          CLRBUFF     PSHX             save registers
0508  E24F  36                      PSHA
0509  E250  CE 00 05                LDX  #CHARBUFF
0510  E253  86 20                   LDAA #$20
```

```
0511  E255  A7 00     ANOTHER   STAA  0,X
0512  E257  08                 INX
0513  E258  8C 00 23            CPX   #CHARBUFF+BUFFLEN  buffer clear?
0514  E25B  26 F8                BNE   ANOTHER
0515  E25D  7F 00 02            CLR   CHARPTR      reset pointer
0516  E260  32                  PULA               restore registers
0517  E261  38                  PULX
0518  E262  39                  RTS
0519                ********************************************
0520                * horpulse() - this routine outputs a pulse on the D5 pin.
0521                *  The pulse width is 14 E clocks (7 µs with 2 mhz E clock)
0522                *  Destroys B.
0523                ********************************************
0524
0525  E263  F6 10 08  HORPULSE  LDAB  PORTD
0526  E266  C4 DF               ANDB               #SSLOW
0527  E268  F7 10 08            STAB  PORTD
0528  E26B  8F                  XGDX               kill time
0529  E26C  8F                  XGDX               kill time
0530  E26D  01                  NOP                kill time
0531  E26E  CA 20               ORAB               #SSHIGH
0532  E270  F7 10 08            STAB  PORTD
0533  E273  39                  RTS
0534
0535                ************************************
0536                * UPCASE(a) - If the contents of A is alpha,
0537                * returns a converted to uppercase.
0538                ************************************
0539
0540  E274  81 61     UPCASE    CMPA  #'a'
0541  E276  2D 06               BLT   UPCASE1      jump if < a
0542  E278  81 7A               CMPA  #'z'
0543  E27A  2E 02               BGT   UPCASE1      jump if > z
0544  E27C  80 20               SUBA  #$20         convert
0545  E27E  39        UPCASE1   RTS
0546
0547                ****************************************
0548                *  HEXBIN(a) - Convert the ASCII character in a
0549                * to binary and shift into shftreg. Returns value
0550                * in tmp1 incremented if a is not hex.
0551                ****************************************
0552
0553  E27F  36        HEXBIN    PSHA
0554  E280  37                  PSHB
0555  E281  3C                  PSHX
0556  E282  BD E2 74            JSR   UPCASE       convert to upper case
0557  E285  81 30               CMPA  #'0'
0558  E287  2D 22               BLT   HEXNOT       jump if a < $30
0559  E289  81 39               CMPA  #'9'
0560  E28B  2F 0A               BLE   HEXNMB       jump if 0-9
0561  E28D  81 41               CMPA  #'A'
```

```
0562  E28F  2D 1A          BLT   HEXNOT    jump if $39> a <$41
0563  E291  81 46          CMPA  #'F'
0564  E293  2E 16          BGT   HEXNOT    jump if a > $46
0565  E295  8B 09          ADDA  #$9       convert $A-$F
0566  E297  84 0F  HEXNMB   ANDA  #$0F      convert to binary
0567  E299  CE 00 68        LDX   #SHFTREG
0568  E29C  C6 04           LDAB  #4
0569  E29E  68 01  HEXSHFT  ASL   1,X       2 byte shift through
0570  E2A0  69 00           ROL   0,X       carry bit
0571  E2A2  5A              DECB
0572  E2A3  2E F9           BGT   HEXSHFT   shift 4 times
0573  E2A5  AA 01           ORAA  1,X
0574  E2A7  A7 01           STAA  1,X
0575  E2A9  20 03           BRA   HEXRTS
0576  E2AB  7C 00 91 HEXNOT  INC   TMP1      indicate not hex
0577  E2AE  38       HEXRTS  PULX
0578  E2AF  33               PULB
0579  E2B0  32               PULA
0580  E2B1  39               RTS
0581
0582                 ******************************************
0583                 * BUFFARG() - Build a hex argument from the
0584                 * contents of the input buffer. Characters are
0585                 * converted to binary and shifted into shftreg
0586                 * until a non-hex character is found. On exit
0587                 * shftreg holds the last four digits read, count
0588                 * holds the number of digits read, ptrbuff points
0589                 * to the first non-hex character read, and A holds
0590                 * that first non-hex character.
0591                 ******************************************
0592
0593  E2B2  7F 00 91 BUFFARG CLR   TMP1      not hex indicator
0594  E2B5  7F 00 7E         CLR   COUNT     # or digits
0595  E2B8  7F 00 68         CLR   SHFTREG
0596  E2BB  7F 00 69         CLR   SHFTREG+1
0597  E2BE  BD E3 8D         JSR   WSKIP
0598  E2C1  BD E3 78 BUFFLP  JSR   RDBUFF     read char
0599  E2C4  BD E2 7F         JSR   HEXBIN
0600  E2C7  7D 00 91         TST   TMP1
0601  E2CA  26 08            BNE   BUFFRTS   jump if not hex
0602  E2CC  7C 00 7E         INC   COUNT
0603  E2CF  BD E3 7F         JSR   INCBUFF    move buffer pointer
0604  E2D2  20 ED            BRA   BUFFLP
0605  E2D4  39       BUFFRTS RTS
0606
0607                 ******************************************
0608                 * TERMARG() - Build a hex argument from the
0609                 * terminal. Characters are converted to binary
0610                 * and shifted into shftreg until a non-hex character
0611                 * is found. On exit shftreg holds the last four
0612                 * digits read, count holds the number of digits
```

AD-A172 963 A LOW COST VIDEO DISPLAY SYSTEM USING THE MOTOROLA 6811 2/2
SINGLE-CHIP MICROCOMPUTER(U) AIR FORCE INST OF TECH
WRIGHT-PATTERSON AFB OH K E WILLIAMS AUG 86
UNCLASSIFIED AFIT/CI/NR-86-179T F/G 9/2 NL





```
0613                        * read, and A holds the first non-hex character.
0614                        ******************************************
0615
0616  E2D5  7F 00 7E  TERMARG   CLR   COUNT
0617  E2D8  7F 00 68            CLR   SHFTREG
0618  E2DB  7F 00 69            CLR   SHFTREG+1
0619  E2DE  BD E1 37  TERM0     JSR   INCHAR
0620  E2E1  81 18               CMPA  #CTLX
0621  E2E3  27 04               BEQ   TERM1       jump if controlx
0622  E2E5  81 7F               CMPA  #DEL
0623  E2E7  26 03               BNE   TERM2       jump if not delete
0624  E2E9  7E E0 3E  TERM1     JMP   MAIN        abort
0625  E2EC  7F 00 91  TERM2     CLR   TMP1        hex indicator
0626  E2EF  BD E2 7F            JSR   HEXBIN
0627  E2F2  7D 00 91            TST   TMP1
0628  E2F5  26 05               BNE   TERM3       jump if not hex
0629  E2F7  7C 00 7E            INC   COUNT
0630  E2FA  20 E2               BRA   TERM0
0631  E2FC  39        TERM3     RTS
0632
0633                        ************************************
0634                        *  CHGBYT() - If shftreg is not empty, put
0635                        * contents of shftreg at address in X.  If X
0636                        * is an address in EEPROM then program it.
0637                        ************************************
0638
0639  E2FD  7D 00 7E  CHGBYT    TST   COUNT
0640  E300  27 60               BEQ   CHGBYT4     jump if shftreg empty
0641  E302  96 69               LDAA  SHFTREG+1
0642  E304  A7 00     CHGBYT0   STAA  0,X         attempt to write
0643  E306  A6 00               LDAA  0,X
0644  E308  91 69               CMPA  SHFTREG+1
0645  E30A  27 45               BEQ   CHGBYT3     jump if it worked
0646  E30C  8C 10 3F            CPX   #CONFIG
0647  E30F  27 0A               BEQ   CHGBYT1     jump if config reg
0648  E311  8C B6 00            CPX   #$B600
0649  E314  25 3B               BLO   CHGBYT3     jump if not EE
0650  E316  8C B7 FF            CPX   #$B7FF
0651  E319  22 36               BHI   CHGBYT3     jump if not EE
0652  E31B  A6 00     CHGBYT1   LDAA  0,X
0653  E31D  81 FF               CMPA  #$FF
0654  E31F  27 15               BEQ   CHGBYT2     jump if already erased
0655  E321  86 16               LDAA  #$16        do byte erase
0656  E323  B7 10 3B            STAA  PPROG
0657  E326  86 FF               LDAA  #$FF
0658  E328  A7 00               STAA  0,X
0659  E32A  86 17               LDAA  #$17
0660  E32C  B7 10 3B            STAA  PPROG
0661  E32F  8D 32               BSR   CHGWAIT
0662  E331  86 00               LDAA  #$00
0663  E333  B7 10 3B            STAA  PPROG       end of byte erase
```

```
0664  E336  96 69       CHGBYT2   LDAA  SHFTREG+1
0665  E338  81 FF                 CMPA  #$FF
0666  E33A  27 15                 BEQ   CHGBYT3     jump if no need to program
0667  E33C  86 02                 LDAA  #$02        do byte program
0668  E33E  B7 10 3B              STAA  PPROG
0669  E341  96 69                 LDAA  SHFTREG+1
0670  E343  A7 00                 STAA  0,X
0671  E345  86 03                 LDAA  #$03
0672  E347  B7 10 3B              STAA  PPROG
0673  E34A  8D 17                 BSR   CHGWAIT
0674  E34C  86 00                 LDAA  #$00
0675  E34E  B7 10 3B              STAA  PPROG       end of byte program
0676  E351  A6 00       CHGBYT3   LDAA  0,X
0677  E353  91 69                 CMPA  SHFTREG+1
0678  E355  27 0B                 BEQ   CHGBYT4
0679  E357  3C                    PSHX
0680  E358  CE E4 AA              LDX   #MSG6       "rom"
0681  E35B  BD E2 08              JSR   OUTSTRG
0682  E35E  BD E1 F7              JSR   OUTCRLF
0683  E361  38                    PULX
0684  E362  39          CHGBYT4   RTS
0685
0686  E363  3C          CHGWAIT   PSHX              delay 10 ms
0687  E364  CE 0D AC              LDX   #3500
0688  E367  09          CHGWAIT1  DEX
0689  E368  26 FD                 BNE   CHGWAIT1
0690  E36A  38                    PULX
0691  E36B  39                    RTS
0692
0693                    ********************************
0694                    * BPCLR() - Clear all entries in the
0695                    * table of breakpoints.
0696                    ********************************
0697
0698  E36C  CE 00 6A    BPCLR     LDX   #BRKTABL
0699  E36F  C6 08                 LDAB  #8
0700  E371  6F 00       BPCLR1    CLR   0,X
0701  E373  08                    INX
0702  E374  5A                    DECB
0703  E375  2E FA                 BGT   BPCLR1      loop 8 times
0704  E377  39                    RTS
0705
0706                    ************************************
0707                    * RDBUFF() - Read the character in CHARBUFF
0708                    * pointed at by ptrbuff into A. Returns ptrbuff
0709                    * unchanged.
0710                    ************************************
0711
0712  E378  3C          RDBUFF    PSHX
0713  E379  DE 81                 LDX   PTR0
0714  E37B  A6 00                 LDAA  0,X
```

```
0715  E37D  38              PULX
0716  E37E  39              RTS
0717
0718                        ****************************************
0719                        * INCBUFF(), DECBUFF() - Increment or decrement
0720                        * ptrbuff.
0721                        ****************************************
0722
0723  E37F  3C        INCBUFF     PSHX
0724  E380  DE 81               LDX   PTR0
0725  E382  08                 INX
0726  E383  20 04               BRA   INCDEC
0727  E385  3C        DECBUFF     PSHX
0728  E386  DE 81               LDX   PTR0
0729  E388  09                 DEX
0730  E389  DF 81      INCDEC      STX   PTR0
0731  E38B  38                 PULX
0732  E38C  39                 RTS
0733
0734                        ****************************************
0735                        * WSKIP() - Read from the CHARBUFF until a
0736                        * non whitespace (space, comma, tab) character
0737                        * is found. Returns ptrbuff pointing to the
0738                        * first non-whitespace character and a holds
0739                        * that character.
0740                        ****************************************
0741
0742  E38D  BD E3 78  WSKIP       JSR   RDBUFF      read character
0743  E390  BD E3 9B              JSR   WCHEK
0744  E393  26 05                 BNE   WSKIP1      jump if not wspc
0745  E395  BD E3 7F              JSR   INCBUFF     move pointer
0746  E398  20 F3                 BRA   WSKIP       loop
0747  E39A  39        WSKIP1      RTS
0748
0749                        ********************************
0750                        * WCHEK(a) - Returns z=1 if a holds a
0751                        * whitespace character, else z=0.
0752                        ********************************
0753  E39B  81 2C     WCHEK       CMPA  #$2C        comma
0754  E39D  27 06                 BEQ   WCHEK1
0755  E39F  81 20                 CMPA  #$20        space
0756  E3A1  27 02                 BEQ   WCHEK1
0757  E3A3  81 09                 CMPA  #$09        tab
0758  E3A5  39        WCHEK1      RTS
0759
0760                        ****************************************
0761                        * DCHEK(a) - Returns Z=1 if a = whitespace
0762                        * or carriage return or period. Else returns z=0.
0763                        ****************************************
0764
0765  E3A6  BD E3 9B  DCHEK       JSR   WCHEK
```

```
0766  E3A9  27 06          BEQ   DCHEK1      jump if whitespace
0767  E3AB  81 0D          CMPA  #$0D
0768  E3AD  27 02          BEQ   DCHEK1
0769  E3AF  81 2E          CMPA  #'.'
0770  E3B1  39       DCHEK1 RTS
0771
0772                  ****************************************
0773                  * CHKABRT() - Checks for a control x or delete
0774                  * from the terminal. If found, the stack is
0775                  * reset and the control is transferred to main.
0776                  * Note that this is an abnormal termination.
0777                  *  If the input from the terminal is a control W
0778                  * then this routine keeps waiting until any other
0779                  * character is read.
0780                  ****************************************
0781
0782  E3B2  BD E1 41 CHKABRT JSR   INPUT
0783  E3B5  27 14          BEQ   CHK4        jump if no input
0784  E3B7  81 17          CMPA  #CTLW
0785  E3B9  26 05          BNE   CHK2        jump in not cntlw
0786  E3BB  BD E1 41 CHKABRT1 JSR  INPUT
0787  E3BE  27 FB          BEQ   CHKABRT1    jump if no input
0788  E3C0  81 7F    CHK2  CMPA  #DEL
0789  E3C2  27 04          BEQ   CHK3        jump if delete
0790  E3C4  81 18          CMPA  #CTLX
0791  E3C6  26 03          BNE   CHK4        jump if not control x
0792  E3C8  7E E0 3E CHK3  JMP   MAIN        abort
0793  E3CB  39       CHK4  RTS               return
0794
0795                  ************************************
0796                  * onsci() - initialize the SCI for 600 baud
0797                  * at 8 mhz extal.
0798                  ************************************
0799  E3CC  86 34    ONSCI LDAA  #$34
0800  E3CE  B7 10 2B       STAA  BAUD
0801  E3D1  4F             CLRA
0802  E3D2  B7 10 2C       STAA  SCCR1
0803  E3D5  86 0C          LDAA  #$0C
0804  E3D7  B7 10 2D       STAA  SCCR2
0805  E3DA  39             RTS
0806
0807                  ************************************
0808                  * OUTSCI() - Output A to sci. IF autolf = 1,
0809                  *          cr and lf sent as crlf.
0810                  ************************************
0811
0812  E3DB  7D 00 7D OUTSCI TST   AUTOLF
0813  E3DE  27 10          BEQ   OUTSCI2     jump if autolf=0
0814  E3E0  8D 0E          BSR   OUTSCI2
0815  E3E2  81 0D          CMPA  #$0D
0816  E3E4  26 04          BNE   OUTSCI1
```

```
0817  E3E6  86 0A          LDAA  #$0A          if cr, send lf
0818  E3E8  20 06          BRA   OUTSCI2
0819  E3EA  81 0A  OUTSCI1  CMPA  #$0A
0820  E3EC  26 0E          BNE   OUTSCI3
0821  E3EE  86 0D          LDAA  #$0D          if lf, send cr
0822  E3F0  F6 10 2E OUTSCI2 LDAB  SCSR         read status
0823  E3F3  C5 80          BITB  #$80
0824  E3F5  27 F9          BEQ   OUTSCI2       loop until tdre=1
0825  E3F7  84 7F          ANDA  #$7F          mask parity
0826  E3F9  B7 10 2F       STAA  SCDAT         send character
0827  E3FC  39    OUTSCI3  RTS
0828
0829                *************************************
0830                * OUTRHLF(), OUTLHLF(), OUTA()
0831                *Convert A from binary to ASCII and output.
0832                *Contents of A are destroyed..
0833                *************************************
0834
0835  E3FD  44    OUTLHLF  LSRA              shift data to right
0836  E3FE  44             LSRA
0837  E3FF  FF             LSRA
0838  E400  44             LSRA
0839  E401  84 0F OUTRHLF  ANDA  #$0F         mask top half
0840  E403  8B 30          ADDA  #$30         convert to ascii
0841  E405  81 39          CMPA  #$39
0842  E407  2F 02          BLE   OUTA         jump if 0-9
0843  E409  8B 07          ADDA  #$07         convert to hex A-F
0844  E40B  BD E1 76 OUTA   JSR   OUTPUT       output character
0845  E40E  39              RTS
0846
0847                ****************************************
0848                * OUT1BYT(x) - Convert the byte at X to two
0849                *ASCII characters and output. Return X pointing
0850                *to next byte.
0851                ****************************************
0852
0853  E40F  36    OUT1BYT  PSHA
0854  E410  A6 00          LDAA  0,X            get data in a
0855  E412  36             PSHA                 save copy
0856  E413  8D E8          BSR   OUTLHLF        output left half
0857  E415  32             PULA                 retrieve copy
0858  E416  8D E9          BSR   OUTRHLF        output right half
0859  E418  32             PULA
0860  E419  08             INX
0861  E41A  39             RTS
0862
0863                ****************************************
0864                * OUT1BSP(x), OUT2BSP(x) - Output 1 or 2 bytes
0865                *at x followed by a space. Returns x pointing to
0866                *next byte.
0867                ****************************************
```

```
0868
0869  E41B  BD E4 0F  OUT2BSP     JSR   OUT1BYT     do first byte
0870  E41E  BD E4 0F  OUT1BSP     JSR   OUT1BYT     do next byte
0871  E421  86 20     OUTSPAC     LDAA  #$20        output a space
0872  E423  BD E1 76               JSR   OUTPUT
0873  E426  39                    RTS
0874
0875                  *** COMMAND TABLE ***
0876  E427            COMTABL     EQU   *
0877  E427  03                    FCB   3
0878  E428  41 53 4D              FCC   'ASM'
0879  E42B  EE EE                 FDB   #ASSEM
0880  E42D  02                    FCB   2
0881  E42E  42 52                 FCC   'BR'
0882  E430  EC B2                 FDB   #BREAK
0883  E432  04                    FCB   4
0884  E433  42 55 4C 4B           FCC   'BULK'
0885  E437  EA FD                 FDB   #BULK
0886  E439  07                    FCB   7
0887  E43A  42 55 4C 4B 41 4C 4C  FCC   'BULKALL'
0888  E441  EB 02                 FDB   #BULKALL
0889  E443  04                    FCB   4
0890  E444  43 41 4C 4C           FCC   'CALL'
0891  E448  EB 2F                 FDB   #CALL
0892  E44A  02                    FCB   2
0893  E44B  4D 44                 FCC   'MD'
0894  E44D  E6 29                 FDB   #DUMP
0895  E44F  01                    FCB   1
0896  E450  47                    FCC   'G'
0897  E451  EB 66                 FDB   #GO
0898  E453  02                    FCB   2
0899  E454  45 58                 FCC   'EX'
0900  E456  EB 89                 FDB   #EX
0901  E458  04                    FCB   4
0902  E459  48 45 4C 50           FCC   'HELP'
0903  E45D  E7 CF                 FDB   #HELP
0904  E45F  02                    FCB   2           LENGTH OF COMMAND
0905  E460  4D 4D                 FCC   'MM'        ASCII COMMAND
0906  E462  E4 F5                 FDB   #MEMORY     COMMAND ADDRESS
0907  E464  02                    FCB   2
0908  E465  4D 56                 FCC   'MV'
0909  E467  E5 7A                 FDB   #MOVE
0910  E469  01                    FCB   1
0911  E46A  50                    FCC   'P'
0912  E46B  EB A8                 FDB   #PROCEED
0913  E46D  02                    FCB   2
0914  E46E  52 44                 FCC   'RD'
0915  E470  E7 5B                 FDB   #REGISTER
0916  E472  01                    FCB   1
0917  E473  54                    FCC   'T'
0918  E474  EB AF                 FDB   #TRACE
```

```
0919  E476  04                        FCB   4
0920  E477  4C 4F 41 44               FCC   'LOAD'
0921  E47B  ED 69                     FDB   #LOAD
0922  E47D  04                        FCB   4
0923  E47E  56 45 52 46               FCC   'VERF'
0924  E482  ED 61                     FDB   #VERIFY
0925  E484  FF                        FCB   -1              end of table
0926
0927                      *** TEXT TABLES ***
0928  E485  42 55 46 46  MSG1         FCC   'BUFFALO 2.2'
0929  E490  04                        FCB   EOT
0930  E491  57 68 61 74MSG2           FCC                   'What?'
0931  E496  04                        FCB   EOT
0932  E497  54 6F 6F 20  MSG3         FCC   'Too Long'
0933  E49F  04                        FCB   EOT
0934  E4A0  46 76 6C 6CMSG4           FCC                   'Full'
0935  E4A4  04                        FCB   EOT
0936  E4A5  4F 70 2D 20MSG5           FCC                   'Op- '
0937  E4A9  04                        FCB   EOT
0938  E4AA  72 6F 6D 2DMSG6           FCC                   'rom-'
0939  E4AE  04                        FCB   EOT
0940  E4AF  43 6F 6D 6DMSG8           FCC                   'Command?'
0941  E4B7  04                        FCB   EOT
0942  E4B8  42 61 64 20  MSG9         FCC                   'Bad argument'
0943  E4C4  04                        FCB   EOT
0944  E4C5  64 6F 6E 65  MSG11        FCC                   'done'
0945  E4C9  04                        FCB   EOT
0946  E4CA  63 68 65 63  MSG12        FCC                   'checksum error'
0947  E4D8  04                        FCB   EOT
0948  E4D9  65 72 72 6F  MSG13        FCC                   'error addr '
0949  E4E4  04                        FCB   EOT
0950  E4E5  4E 4F 54 20  MSG14        FCC                   'NOT IN SPI MODE'
0951  E4F4  04                        FCB   EOT
0952
0953                      ********************************************
0954                      *  MEMORY [<addr>]
0955                      *  [<addr>]/
0956                      * Opens memory and allows user to modify the
0957                      * contents at <addr> or the last opened location.
0958                      *   Subcommands:
0959                      * [<data>]<cr> - Close current location and OPEN NEXT.
0960                      * [<data>]<-> - Close current and open previous.
0961                      * [<data>]<.> - Close current and EXIT.
0962                      * [<data>]<=> - Reopen current location.
0963                      *    The contents of the current location is only
0964                      * changed if valid data is entered before each
0965                      * subcommand.
0966                      ********************************************
0967
0968  E4F5  BD E3 8D  MEMORY       JSR   WSKIP
0969  E4F8  81 0D                  CMPA  #$D
```

```
0970  E4FA  27 1A          BEQ   MEM1        jump if cr
0971  E4FC  BD E2 B2       JSR   BUFFARG
0972  E4FF  BD E3 8D       JSR   WSKIP
0973  E502  81 0D          CMPA  #$D
0974  E504  27 07          BEQ   MSLASH      jump if cr
0975  E506  CE E4 B8       LDX   #MSG9       "bad argument"
0976  E509  BD E2 08       JSR   OUTSTRG
0977  E50C  39             RTS
0978  E50D  7A 00 7E  MSLASH DEC  COUNT
0979  E510  27 04          BEQ   MEM1        jump if no argument
0980  E512  DE 68          LDX   SHFTREG
0981  E514  DF 7F          STX   PTRMEM      update "current location"
0982  E516  BD E1 F7  MEM1  JSR   OUTCRLF
0983  E519  BD E2 4E       JSR   CLRBUFF     if dev = SPI then clr buffer
0984  E51C  CE 00 7F  MEM2  LDX   #PTRMEM
0985  E51F  BD E4 1B       JSR   OUT2BSP     output address
0986  E522  DE 7F    MEM3  LDX   PTRMEM
0987  E524  BD E4 21       JSR   OUTSPAC
0988  E527  BD E4 1E       JSR   OUT1BSP     output contents
0989  E52A  C6 03          LDAB  #3
0990  E52C  BD E4 21  MEM35 JSR   OUTSPAC     output 3 spaces
0991  E52F  5A             DECB
0992  E530  26 FA          BNE   MEM35
0993  E532  86 3E          LDAA  #PROMPT     output prompt character
0994  E534  BD E1 76       JSR   OUTPUT
0995  E537  7F 00 68       CLR   SHFTREG
0996  E53A  7F 00 69       CLR   SHFTREG+1
0997  E53D  BD E2 D5  MEM4  JSR   TERMARG
0998  E540  BD E2 74       JSR   UPCASE
0999  E543  DE 7F          LDX   PTRMEM
1000  E545  81 0D          CMPA  #CRETURN
1001  E547  27 15          BEQ   MEMSP       jump if CR
1002  E549  81 2D          CMPA  #'-'
1003  E54B  27 1A          BEQ   MEMUA       jump if MINUS SIGN
1004  E54D  81 3D          CMPA  #'='
1005  E54F  27 1F          BEQ   MEMSL       jump if =
1006  E551  81 2E          CMPA  #'.'
1007  E553  27 21          BEQ   MEMCR       jump if PERIOD
1008  E555  CE E4 AF       LDX   #MSG8       "command?"
1009  E558  BD E2 08       JSR   OUTSTRG
1010  E55B  7E E5 16       JMP   MEM1
1011  E55E  BD E2 FD  MEMSP JSR   CHGBYT
1012  E561  08             INX
1013  E562  DF 7F          STX   PTRMEM
1014  E564  7E E5 16       JMP   MEM1        output contents
1015  E567  BD E2 FD  MEMUA JSR   CHGBYT
1016 E56A  09             DEX
1017 E56B  DF 7F          STX   PTRMEM
1018 E56D  7E E5 16       JMP   MEM1        output cr, addr, contents
1019  E570  BD E2 FD  MEMSL JSR   CHGBYT
1020 E573  7E E5 16       JMP   MEM1        output cr, addr, contents
```

```
1021  E576  BD E2 FD  MEMCR     JSR   CHGBYT
1022  E579  39                 RTS                 exit task
1023
1024                  **********************************
1025                  *  move <src1> <src2> [<dest>] - move
1026                  *block at <src1> to <src2> to <dest>.
1027                  *  Moves block 1 byte up if no <dest>.
1028                  **********************************
1029
1030  E57A  BD E2 B2  MOVE      JSR   BUFFARG
1031  E57D  7D 00 7E            TST   COUNT
1032  E580  27 2D               BEQ   MOVERR        jump if no arg
1033  E582  BD E3 9B            JSR   WCHEK
1034  E585  26 28               BNE   MOVERR        jump if no delim
1035  E587  DE 83               LDX   SHFTREG       src1
1036  E589  DF 83               STX   PTR1
1037  E58B  BD E2 B2            JSR   BUFFARG
1038  E58E  7D 00 7E            TST   COUNT
1039  E591  27 1C               BEQ   MOVERR        jump if no arg
1040  E593  BD E3 A6            JSR   DCHEK
1041  E596  26 17               BNE   MOVERR        jump if no delim
1042  E598  DE 68               LDX   SHFTREG       src2
1043  E59A  DF 85               STX   PTR2
1044  E59C  BD E2 B2            JSR   BUFFARG
1045  E59F  BD E3 8D            JSR   WSKIP
1046  E5A2  81 0D               CMPA  #$0D
1047  E5A4  26 09               BNE   MOVERR        jump if not cr
1048  E5A6  7D 00 7E            TST   COUNT
1049  E5A9  27 0B               BEQ   MOVE1         jump if no arg
1050  E5AB  DE 68               LDX   SHFTREG       dest
1051  E5AD  20 0A               BRA   MOVE2
1052  E5AF  CE E4 B8  MOVERR    LDX   #MSG9         "bad argument"
1053  E5B2  BD E2 08            JSR   OUTSTRG
1054  E5B5  39                  RTS
1055  E5B6  DE 83     MOVE1     LDX   PTR1
1056  E5B8  08                  INX                 default dest
1057  E5B9  DF 87     MOVE2     STX   PTR3
1058  E5BB  DE 87               LDX   PTR3          dest
1059  E5BD  9C 83               CPX   PTR1          src1
1060  E5BF  23 2C               BLS   MOVE3         jump if dest =< src1
1061  E5C1  9C 85               CPX   PTR2          src2
1062  E5C3  22 28               BHI   MOVE3         jump if dest > src2
1063  E5C5  DC 85               LDD   PTR2
1064  E5C7  93 83               SUBD  PTR1
1065  E5C9  D3 87               ADDD  PTR3
1066  E5CB  DD 87               STD   PTR3          dest = dest+(src2-src1)
1067  E5CD  DE 85               LDX   PTR2
1068  E5CF  A6 00     MOVELP1   LDAA  0,X           char at src2
1069  E5D1  3C                  PSHX
1070  E5D2  DE 87               LDX   PTR3
1071  E5D4  8C B6 00            CPX   #$B600        jump if not eeprom
```

```
1072  E5D7  25 08           BLO   MOVEA
1073  E5D9  8C B7 FF        CPX   #$B7FF        jump if not eeprom
1074  E5DC  22 03           BHI   MOVEA
1075  E5DE  BD E6 0D        JSR   MOVPROG      program eeprom
1076  E5E1  A7 00   MOVEA   STAA  0,X          dest
1077  E5E3  09              DEX
1078  E5E4  DF 87           STX   PTR3
1079  E5E6  38              PULX
1080  E5E7  09              DEX
1081  E5E8  9C 83           CPX   PTR1
1082  E5EA  24 E3           BHS   MOVELP1      loop src2-src1 times
1083  E5EC  39              RTS
1084  E5ED  DE 83   MOVE3   LDX   PTR1         srce1
1085  E5EF  A6 00   MOVELP2 LDAA  0,X
1086  E5F1  3C              PSHX
1087  E5F2  DE 87           LDX   PTR3         dest
1088  E5F4  8C B6 00        CPX   #$B600       jump if not eeprom
1089  E5F7  25 08           BLO   MOVEB
1090  E5F9  8C B7 FF        CPX   #$B7FF       jump if not eeprom
1091  E5FC  22 03           BHI   MOVEB
1092  E5FE  BD E6 0D        JSR   MOVPROG      program eeprom
1093  E601  A7 00   MOVEB   STAA  0,X
1094  E603  08              INX
1095  E604  DF 87           STX   PTR3
1096  E606  38              PULX
1097  E607  08              INX
1098  E608  9C 85           CPX   PTR2
1099  E60A  23 E3           BLS   MOVELP2      loop src2-src1 times
1100  E60C  39              RTS
1101
1102                ******************************************
1103                * MOVPROG - Program eeprom location in X with
1104                *     data in A.
1105                ******************************************
1106
1107  E60D  37      MOVPROG PSHB
1108  E60E  3C              PSHX
1109  E60F  C6 02           LDAB  #$02
1110  E611  F7 10 3B        STAB  PPROG        set eelat
1111  E614  A7 00           STAA  0,X
1112  E616  C6 03           LDAB  #$03
1113  E618  F7 10 3B        STAB  PPROG        set pgm
1114  E61B  CE 08 00        LDX   #$0800
1115  E61E  09      MOVEDLY DEX
1116  E61F  26 FD           BNE   MOVEDLY      delay 12 ms
1117  E621  C6 00           LDAB  #$00
1118  E623  F7 10 3B        STAB  PPROG
1119  E626  38              PULX
1120  E627  33              PULB
1121  E628  39              RTS
1122
```

```
1123                    ****************************************
1124                    * dump [<addr1> [<addr2>]] - Dump memory
1125                    *  in 16 byte lines from <addr1> to <addr2>.
1126                    *  Default starting address is "current
1127                    *  location" and default number of lines is 8.
1128                    ****************************************
1129
1130  E629  DE 7F       DUMP        LDX   PTRMEM     current location
1131  E62B  DF 83                   STX   PTR1       default start
1132  E62D  C6 80                   LDAB  #$80
1133  E62F  3A                      ABX
1134  E630  DF 85                   STX   PTR2       default end
1135  E632  BD E3 8D                JSR   WSKIP
1136  E635  81 0D                   CMPA  #$D
1137  E637  27 39                   BEQ   DUMP1      jump - no arguments
1138  E639  BD E2 B2                JSR   BUFFARG    read argument
1139  E63C  7D 00 7E                TST   COUNT
1140  E63F  27 2A                   BEQ   DUMPERR    jump if no argument
1141  E641  BD E3 A6                JSR   DCHEK
1142  E644  26 25                   BNE   DUMPERR    jump if delimiter
1143  E646  DE 68                   LDX   SHFTREG
1144  E648  DF 83                   STX   PTR1
1145  E64A  C6 80                   LDAB  #$80
1146  E64C  3A                      ABX
1147  E64D  DF 85                   STX   PTR2       default end address
1148  E64F  BD E3 8D                JSR   WSKIP
1149  E652  81 0D                   CMPA  #$D
1150  E654  27 1C                   BEQ   DUMP1      jump - 1 argument
1151  E656  BD E2 B2                JSR   BUFFARG    read argument
1152  E659  7D 00 7E                TST   COUNT
1153  E65C  27 0D                   BEQ   DUMPERR    jump if no argument
1154  E65E  BD E3 8D                JSR   WSKIP
1155  E661  81 0D                   CMPA  #$0D
1156  E663  26 06                   BNE   DUMPERR    jump if not cr
1157  E665  DE 68                   LDX   SHFTREG
1158  E667  DF 85                   STX   PTR2
1159  E669  20 07                   BRA   DUMP1      jump - 2 arguments
1160  E66B  CE E4 B8    DUMPERR     LDX   #MSG9      "bad argument"
1161  E66E  BD E2 08                JSR   OUTSTRG
1162  E671  39                      RTS
1163  E672  DC 83       DUMP1       LDD   PTR1
1164  E674  DD 7F                   STD   PTRMEM     new current location
1165  E676  C4 F0                   ANDB  #$F0
1166  E678  DD 83                   STD   PTR1       start dump at 16 byte bound
1167  E67A  D6 01       DUMPLP      LDAB  IODEV      check device (0=SCI,1=SPI)
1168  E67C  27 17                   BEQ   DUMPSCI    if device=SCI take branch
1169  E67E  BD E6 DF                JSR   SCREEN     output first screen of data
1170  E681  DC 83                   LDD   PTR1       get base address
1171  E683  C3 00 08                ADDD  #8         compute new address
1172  E686  DD 83                   STD   PTR1       save new address
1173  E688  BD E6 DF                JSR   SCREEN     output  screen of 8 bytes
```

```
1174  E68B  DC 83          LDD   PTR1
1175  E68D  83 00 08       SUBD  #8
1176  E690  DD 83          STD   PTR1
1177  E692  7E E6 C4       JMP   DUMP45      the same code as the SCI.
1178  E695  BD E1 F7  DUMPSCI  JSR  OUTCRLF
1179  E698  CE 00 83       LDX   #PTR1
1180  E69B  BD E4 1B       JSR   OUT2BSP     first address
1181  E69E  DE 83          LDX   PTR1        base address
1182  E6A0  5F             CLRB              loop counter
1183  E6A1  BD E4 1E  DUMPDAT  JSR  OUT1BSP  hex value loop
1184  E6A4  5C             INCB
1185  E6A5  C1 10          CMPB  #$10
1186  E6A7  2D F8          BLT   DUMPDAT     loop 16 times
1187  E6A9  5F             CLRB              loop counter
1188  E6AA  DE 83     DUMPASC  LDX  PTR1     base address
1189  E6AC  3A             ABX
1190  E6AD  A6 00          LDAA  0,X         ascii value loop
1191  E6AF  81 20          CMPA  #$20
1192  E6B1  25 04          BLO   DUMP3       jump if non printable
1193  E6B3  81 7A          CMPA  #$7A
1194  E6B5  23 02          BLS   DUMP4       jump if printable
1195  E6B7  86 20     DUMP3    LDAA  #$20     space for non printables
1196  E6B9  BD E1 76  DUMP4    JSR   OUTPUT   output ascii value
1197  E6BC  5C             INCB
1198  E6BD  C1 10          CMPB  #$10
1199  E6BF  2D E9          BLT   DUMPASC     loop 16 times
1200  E6C1  BD E3 B2       JSR   CHKABRT     check abort or wait
1201  E6C4  DC 83     DUMP45   LDD   PTR1
1202  E6C6  C3 00 10       ADDD  #$10        point to next 16 byte bound
1203  E6C9  DD 83          STD   PTR1        update ptr1
1204  E6CB  1A 93 85       CPD   PTR2
1205  E6CE  22 0E          BHI   DUMP5       quit if ptr1 > ptr2
1206  E6D0  1A 83 00 00    CPD   #$00        check wraparound at $ffff
1207  E6D4  26 A4          BNE   DUMPLP      jump - no wraparound
1208  E6D6  DC 85          LDD   PTR2
1209  E6D8  1A 83 FF F0    CPD   #$FFF0
1210  E6DC  25 9C          BLO   DUMPLP      upper bound not at top
1211  E6DE  39        DUMP5    RTS           quit
1212
1213                  ************************************************
1214                  * screen() - this subroutine outputs 8 bytes of data is sequence
1215                  * starting at the address in PTR1. Data is formatted for
1216                  * the CRT screen.
1217                  ************************************************
1218
1219  E6DF  BD E2 4E  SCREEN   JSR   CLRBUFF    clear display buffer
1220  E6E2  CE 00 83       LDX   #PTR1
1221  E6E5  BD E4 1B       JSR   OUT2BSP     output address
1222  E6E8  BD E4 21       JSR   OUTSPAC     for screen format
1223  E6EB  DE 83          LDX   PTR1        base address
1224  E6ED  5F             CLRB              loop counter
```

```
1276  E749  08              INX
1277  E74A  81 53           CMPA  #'S'        s is last register
1278  E74C  26 F8           BNE   RPRI1       jump if not done
1279  E74E  7D 00 01        TST   IODEV
1280  E751  27 06           BEQ   RPR2
1281  E753  BD E1 37        JSR   INCHAR      display data and wait
1282  E756  BD E2 4E        JSR   CLRBUFF
1283  E759  38       RPR2    PULX
1284  E75A  39              RTS
1285
1286                 ****************************************
1287                 * register [<name>] - prints the user regs
1288                 *and opens them for modification. <name> is
1289                 *the first register opened (default = P).
1290                 * Subcommands:
1291                 * [<nn>]<cr> Opens the next register.
1292                 * [<nn>]<.>   Return.
1293                 *  The register value is only changed if
1294                 *  <nn> is entered before the subcommand.
1295                 ****************************************
1296
1297  E75B  CE E6 FA  REGISTER  LDX   #REGLIST
1298  E75E  BD E3 8D            JSR   WSKIP       a = first char of arg
1299  E761  BD E2 74            JSR   UPCASE      convert to upper case
1300  E764  81 0D               CMPA  #$D
1301  E766  27 1E               BEQ   REG4        jump if no argument
1302  E768  A1 00       REG1    CMPA              0,X
1303  E76A  27 0E               BEQ   REG3
1304  E76C  E6 00               LDAB  0,X
1305  E76E  08                  INX
1306  E76F  C1 53               CMPB  #'S'
1307  E771  26 F5               BNE   REG1        jump if not "s"
1308  E773  CE E4 B8    REG2    LDX   #MSG9       "bad argument"
1309  E776  BD E2 08            JSR   OUTSTRG
1310  E779  39                  RTS
1311  E77A  3C          REG3    PSHX
1312  E77B  BD E3 7F            JSR   INCBUFF
1313  E77E  BD E3 8D            JSR   WSKIP       next char after arg
1314  E781  81 0D               CMPA  #$D
1315  E783  38                  PULX
1316  E784  26 ED               BNE   REG2        jump if not cr
1317  E786  BD E7 3F    REG4    JSR   RPRINT      print all registers
1318  E789  BD E1 F7    REG5    JSR   OUTCRLF
1319  E78C  BD E2 4E    REG51   JSR   CLRBUFF
1320  E78F  BD E7 0F            JSR   RPRNT1      print reg name
1321  E792  86 3E               LDAA  #PROMPT
1322  E794  BD E1 76            JSR   OUTPUT      output prompt character
1323  E797  BD E2 D5            JSR   TERMARG     read subcommand
1324  E79A  BD E3 A6            JSR   DCHEK
1325  E79D  27 07               BEQ   REG6        jump if delimiter
1326  E79F  CE E4 B8            LDX   #MSG9       "bad argument"
```

```
1327  E7A2  BD E2 08          JSR   OUTSTRG
1328  E7A5  39               RTS
1329  E7A6  36        REG6   PSHA
1330  E7A7  3C               PSHX
1331  E7A8  7D 00 7E         TST   COUNT
1332  E7AB  27 14            BEQ   REG8          jump if no input
1333  E7AD  E6 07            LDAB  7,X           get reg offset
1334  E7AF  A6 0E            LDAA  14,X          byte size
1335  E7B1  CE 00 72         LDX   #REGS         user registers
1336  E7B4  3A               ABX
1337  E7B5  4D               TSTA
1338  E7B6  27 05            BEQ   REG7          jump if 1 byte reg
1339  E7B8  96 68            LDAA  SHFTREG
1340  E7BA  A7 00            STAA  0,X           put in top byte
1341  E7BC  08               INX
1342  E7BD  96 69     REG7   LDAA  SHFTREG+1
1343  E7BF  A7 00            STAA  0,X           put in bottom byte
1344  E7C1  38        REG8   PULX
1345  E7C2  32               PULA
1346  E7C3  E6 00            LDAB  0,X           CHECK FOR REGISTER S
1347  E7C5  C1 53            CMPB  #'S'
1348  E7C7  27 05            BEQ   REG9          jump if "s"
1349  E7C9  08               INX                 point to next register
1350  E7CA  81 2E            CMPA                #'.'
1351  E7CC  26 BB            BNE   REG5          jump if not period
1352  E7CE  39        REG9   RTS
1353
1354                  ****************************************
1355                  * help - List BUFFALO commands to terminal.
1356                  ****************************************
1357  E7CF  CE E7 D6  HELP   LDX   #HELPMSG1
1358  E7D2  BD E2 08         JSR   OUTSTRG       print screen
1359  E7D5  39               RTS
1360
1361  E7D6  2A 20 4D 65HELPMSG1  FCC             '* Memory commands *'
1362  E7E9  0D               FCB   #$0D
1363  E7EA  4D 44 20 28      FCC   'MD           (<addr1> (<addr2>)) memory
                                                 dump.
1364                               MV            <s1> <s2> (<d>) block move.'
1365  E82F  0D               FCB   #$0D
1366  E830  4D 4D 20 28      FCC   'MM           (<addr>)
                                                 Open memory location.
1367                                             Subcommands:'
1368  E85F  0D               FCB   #$0D
1369  E860  3C 3D 3E 20      FCC                 '<=> open same address. <->
                                                 open
1370                                             previous address.'
1371  E894  0D               FCB   #$0D
1372  E895  3C 63 72 3E      FCC                 '<cr> open next address. <sp>
                                                 open
1373                                             next address.'
```

```
1374  E8C7  0D                  FCB   #$0D
1375  E8C8 20 20 20 20          FCC                ' <.> quit.'
1376  E8D6  0D                  FCB   #$0D
1377  E8D7  41 53 4D 20         FCC                'ASM (<addr>) line
                                                   assembler/disassembler.
1378                                               Subcommands:'
1379  E90D  0D                  FCB   #$0D
1380  E90E  3C 3D 3E 20         FCC                '<=> do same address. <-> do
1381                                               previous address.'
1382  E93D  0D                  FCB   #$0D
1383  E93E  3C 63 72 3E         FCC                '<cr> do next opcode. <.>
                                                   quit.'
1384  E95F  0D                  FCB   #$0D
1385  E960  2A 20 43 6F         FCC                '* Code execution commands *'
1386  E97B  0D                  FCB   #$0D
1387  E97C  42 52 4B 20         FCC   'BRK         (-)(<addr>) Set up breakpoint
                                                   table.'
1388  E9A5  0D                  FCB   #$0D
1389  E9A6  52 44 20 28         FCC   'RD          (p,y,x,a,b,c,s) Open user
                                                   registers.'
1390  E9CE  0D                  FCB   #$0D
1391  E9CF  47 20 28 3C         FCC   'G           (<addr>) execute user code with
1392                                               breakpoints.'
1393  E9FE  0D                  FCB   #$0D
1394  E9FF  45 58 20 3C         FCC   'EX          (<addr>) execute user code
1395                                               (no breakpoints).'
1396  EA2E  0D                  FCB   #$0D
1397  EA2F  43 41 4C 4C         FCC   'CALL        (<addr>) Call user subroutine.'
1398  EA53  0D                  FCB   #$0D
1399  EA54  54 20 28 3C         FCC   'T           (<n>) Trace n instructions.
1400                                   P           continue executing.'
1401  EA8B  0D                  FCB   #$0D
1402  EA8C  2A 20 4F 74               FCC          '* Other useful commands *'
1403  EA A5  0D                 FCB   #$0D
1404  EAA6  42 55 4C 4B         FCC   'BULK        Erase the eeprom.    BULKALL
1405                                               Erase eeprom and config.'
1406  EAE5  0D                  FCB   #$0D
1407  EAE6  43 4E 54 4C         FCC                'CNTLX or DEL  Abort.'
1408  EAFB  0D                  FCB   #$0D
1409  EAFC  04                  FCB   4
1410
1411                    ************************************
1412                    * bulk - Bulk erase the eeprom except the
1413                    *config register.
1414                    ************************************
1415
1416  EAFD  7F 00 92    BULK    CLR   TMP2
1417  EB00  20 06               BRA   BULK1
1418
1419                    ************************************
1420                    * bulkall - Bulk erase the eeprom and the
```

```
1421                        *config register.
1422                        ***********************************
1423
1424  EB02  7F 00 92  BULKALL   CLR   TMP2
1425  EB05  7C 00 92            INC   TMP2
1426  EB08  36        BULK1     PSHA
1427  EB09  86 06               LDAA  #$06
1428  EB0B  B7 10 3B            STAA  PPROG       set eelat, erase bits
1429  EB0E  86 FF               LDAA  #$FF
1430  EB10  7D 00 92            TST   TMP2
1431  EB13  26 05               BNE   BULK2       jump if config
1432  EB15  B7 B6 00            STAA  $B600       write to $b600
1433  EB18  20 03               BRA   BULK3
1434  EB1A  B7 10 3F  BULK2     STAA  CONFIG
1435  EB1D  86 07     BULK3     LDAA  #$07
1436  EB1F  B7 10 3B            STAA  PPROG
1437  EB22  3C                  PSHX
1438  EB23  CE 0F A0            LDX   #4000       4000*5~
1439  EB26  09        BULKDLY   DEX               2~
1440  EB27  26 FD               BNE   BULKDLY     3~
1441  EB29  38                  PULX
1442  EB2A  7F 10 3B            CLR   PPROG
1443  EB2D  32                  PULA
1444  EB2E  39                  RTS
1445
1446                        ***********************************
1447                        *  call [<addr>] - Execute a jsr to addr or
1448                        *user's pc value. Return to monitor by rts
1449                        *or breakpoint.
1450                        ***********************************
1451
1452  EB2F  BD E3 8D  CALL      JSR   WSKIP
1453  EB32  81 0D               CMPA  #$D
1454  EB34  27 15               BEQ   CALL3       jump if no arg
1455  EB36  BD E2 B2            JSR   BUFFARG
1456  EB39  BD E3 8D            JSR   WSKIP
1457  EB3C  81 0D               CMPA  #$D
1458  EB3E  27 07               BEQ   CALL2       jump if cr
1459  EB40  CE E4 B8            LDX   #MSG9       "bad argument"
1460  EB43  BD E2 08            JSR   OUTSTRG
1461  EB46  39                  RTS
1462  EB47  DE 68     CALL2     LDX   SHFTREG
1463  EB49  DF 72               STX   REGS        pc = <addr>
1464  EB4B  DE 7B     CALL3     LDX   SP
1465  EB4D  09                  DEX               user stack pointer
1466  EB4E  CC EB 5D            LDD   #RETURN     return address
1467  EB51  ED 00               STD   0,X
1468  EB53  09                  DEX
1469  EB54  DF 7B               STX   SP          new user stack pointer
1470  EB56  C6 02               LDAB  #2          (2=CALL)
1471  EB58  D7 92               STAB  TMP2        flag for breakpoints
```

```
1472  EB5A  7E EB D4                JMP   TRACE3        pickup trace command
1473
1474                        ********************************
1475                        * return() - Return here from rts after
1476                        * call command.
1477                        ********************************
1478
1479  EB5D  BD E1 F7  RETURN        JSR   OUTCRLF
1480  EB60  BD E7 3F                JSR   RPRINT        print user registers
1481  EB63  7E E0 3E                JMP   MAIN
1482
1483                        ***************************************
1484                        * go [<addr>] - Execute starting at <addr> or
1485                        *user's pc value. Executes an rti to user code.
1486                        *Returns to monitor via a breakpoint.
1487                        ***************************************
1488
1489  EB66  BD E3 8D  GO            JSR   WSKIP
1490  EB69  81 0D                   CMPA  #$0D
1491  EB6B  27 15                   BEQ   GO2           jump if no arg
1492  EB6D  BD E2 B2                JSR   BUFFARG
1493  EB70  BD E3 8D                JSR   WSKIP
1494  EB73  81 0D                   CMPA  #$0D
1495  EB75  27 07                   BEQ   GO1           jump if cr
1496  EB77  CE E4 B8                LDX   #MSG9         "bad argument"
1497  EB7A  BD E2 08                JSR   OUTSTRG
1498  EB7D  39                      RTS
1499  EB7E  DE 68     GO1           LDX   SHFTREG
1500  EB80  DF 72                   STX   REGS          pc = <addr>
1501  EB82  C6 03     GO2           LDAB  #3            (0=T,1=P,2=CALL,3=G)
1502  EB84  D7 92                   STAB  TMP2
1503  EB86  7E EB D4                JMP   TRACE3        do trace
1504
1505                        ************************
1506                        * execute [<addr>] - executes
1507                        * user program starting at <addr>
1508                        * or user's pc if no <addr> supplied.
1509                        * No breakpoints are inserted.
1510                        ************************
1511
1512  EB89  BD E3 8D  EX            JSR   WSKIP
1513  EB8C  81 0D                   CMPA  #$0D
1514  EB8E  27 15                   BEQ   EX2           jump if no arg
1515  EB90  BD E2 B2                JSR   BUFFARG
1516  EB93  BD E3 8D                JSR   WSKIP
1517  EB96  81 0D                   CMPA  #$0D
1518  EB98  27 07                   BEQ   EX1           jump if cr
1519  EB9A  CE E4 B8                LDX   #MSG9         "bad argument"
1520  EB9D  BD E2 08                JSR   OUTSTRG
1521  EBA0  39                      RTS
1522  EBA1  DE 68     EX1           LDX   SHFTREG
```

```
1523  EBA3  DF 72                STX   REGS          pc = <addr>
1524  EBA5  7E EC 4E  EX2        JMP   RESTACK
1525
1526                  ************************************
1527                  *  proceed - Same as go except it ignores
1528                  *a breakpoint at the first opcode.  Calls
1529                  *trace once and then go.
1530                  ************************************
1531
1532  EBA8  C6 01     PROCEED    LDAB  #1             (0=T,1=P,2=CALL,3=G)
1533  EBAA  D7 92                STAB  TMP2
1534  EBAC  7E EB D4             JMP   TRACE3
1535
1536                  ****************************************
1537                  *  trace <n> - Trace n instructions starting
1538                  *at user's pc value.  n is a hex number less than
1539                  *$FF (defaults to 1).
1540                  ****************************************
1541
1542  EBAF  7F 00 94  TRACE      CLR   TMP4
1543  EBB2  7C 00 94             INC   TMP4           default counttl = 1
1544  EBB5  5F                   CLRB                 (0=T,1=P,2=CALL,3=G)
1545  EBB6  D7 92                STAB  TMP2
1546  EBB8  BD E3 8D             JSR   WSKIP
1547  EBBB  81 0D                CMPA  #$0D
1548  EBBD  27 15                BEQ   TRACE3         jump if cr
1549  EBBF  BD E2 B2             JSR   BUFFARG
1550  EBC2  BD E3 8D             JSR   WSKIP
1551  EBC5  81 0D                CMPA  #$0D
1552  EBC7  27 07                BEQ   TRACE1         jump if cr
1553  EBC9  CE E4 B8             LDX   #MSG9          "bad argument"
1554  EBCC  BD E2 08             JSR   OUTSTRG
1555  EBCF  39                   RTS
1556  EBD0  96 69     TRACE1     LDAA  SHFTREG+1      n
1557  EBD2  97 94                STAA  TMP4
1558  EBD4  B6 10 20  TRACE3     LDAA  TCTL1
1559  EBD7  97 85                STAA  PTR2           save user mode/level
1560  EBD9  84 FC                ANDA  #$FC
1561  EBDB  B7 10 20             STAA  TCTL1          disable oc5 output
1562  EBDE  B6 10 22             LDAA  TMSK1
1563  EBE1  97 86                STAA  PTR2+1         save user int masks
1564  EBE3  7F 10 24             CLR   TMSK2          disable tof and pac ints
1565  EBE6  DE 9C                LDX   VOC5+1
1566  EBE8  DF 89                STX   PTR4           save user's vector
1567  EBEA  86 7E                LDAA  #$7E           jmp opcode
1568  EBEC  97 9B                STAA  VOC5
1569  EBEE  CE EC 0E             LDX   #TRACEIN
1570  EBF1  DF 9C                STX   VOC5+1         monitor oc5 vector
1571  EBF3  96 7A                LDAA  REGS+8         user ccr
1572  EBF5  84 EF                ANDA  #$EF           clear i bit
1573  EBF7  97 7A                STAA  REGS+8
```

```
1574  EBF9  C6 57          LDAB  #87          cycles to end of rti
1575  EBFB  FE 10 0E       LDX   TCNT         timer count value
1576  EBFE  3A             ABX                3~ \
1577  EBFF  FF 10 1E       STX   TOC5         oc5 match register  5~ \
1578  EC02  86 08          LDAA  #$08        2~ \
1579  EC04  B7 10 23       STAA  TFLG1        clear oc5 int flag    4~  \
1580  EC07  B7 10 22       STAA  TMSK1        enable oc5 int   4~   / 86~
1581  EC0A  0E             CLI                2~ /
1582  ECOB  7E EC 4E       JMP   RESTACK      execute an rti   66~ /
1583
1584                  ********************************
1585                  * tracein - return from toc5 interrupt.
1586                  ********************************
1587
1588  EC0E  0F        TRACEIN  SEI
1589  EC0F  7F 10 22          CLR   TMSK1      disable timer ints
1590  EC12  30                TSX
1591  EC13  8E 00 5F          LDS   #STACK
1592  EC16  BD EC 67          JSR   SAVSTACK   save user regs
1593  EC19  DE 89             LDX   PTR4
1594  EC1B  DF 9C             STX   VOC5+1
1595  EC1D  7D 00 01          TST   IODEV
1596  EC20  26 03             BNE   TRACEIN1
1597  EC22  BD E3 B2          JSR   CHKABRT    check for abort
1598  EC25  D6 92     TRACEIN1 LDAB TMP2
1599  EC27  27 17             BEQ   TRACE9     jump if trace command
1600  EC29  C1 01             CMPB  #1         proceed command?
1601  EC2B  26 03             BNE   TRACEIN2   no.
1602  EC2D  7E EB 82          JMP   GO2        yes-pickup go command
1603  EC30  BD EC 89  TRACEIN2 JSR  BRPTCHK    check for breakpt (call or go)
1604  EC33  DE 72             LDX   REGS       get user pc
1605  EC35  8C EB 5D          CPX   #RETURN    see if we reached RTS
1606  EC38  27 03             BEQ   TRACEIN3   yes - return control
1607  EC3A  7E EB D4          JMP   TRACE3     no - trace another instruction
1608  EC3D  7E EB 5D  TRACEIN3 JMP  RETURN
1609  EC40  BD E1 F7  TRACE9  JSR   OUTCRLF    print registers for
1610  EC43  BD E7 3F          JSR   RPRINT     trace only.
1611  EC46  7A 00 94          DEC   TMP4
1612  EC49  22 89             BHI   TRACE3     jump if counttl >= 0
1613  EC4B  7E E0 3E          JMP   MAIN       return to monitor
1614
1615                  ************************************
1616                  * restack() - Restore user stack and
1617                  *execute an RTI. Extended addressing forced
1618                  *to ensure count value for trace.
1619                  ************************************
1620
1621  EC4E  BE 00 7B  RESTACK  LDS   >SP       stack pointer
1622  EC51  FE 00 72           LDX   >REGS
1623  EC54  3C                PSHX             pc
1624  EC55  FE 00 74           LDX   >REGS+2
```

```
1625  EC58  3C          PSHX            y
1626  EC59  FE 00 76    LDX   >REGS+4
1627  EC5C  3C          PSHX            x
1628  EC5D  FC 00 78    LDD   >REGS+6
1629  EC60  36          PSHA            a
1630  EC61  37          PSHB            b
1631  EC62  B6 00 7A    LDAA  >REGS+8
1632  EC65  36          PSHA            ccr
1633  EC66  3B    RESTACK1  RTI
1634
1635              ***************************************************
1636              * savstack() - Save user's registers. If originating command
1637              * is CALL, then don't update the user's pc.
1638              ***************************************************
1639
1640  EC67  A6 00 SAVSTACK  LDAA  0,X
1641  EC69  97 7A         STAA  REGS+8      ccr
1642  EC6B  EC 01         LDD   1,X
1643  EC6D  97 79         STAA  REGS+7      b
1644  EC6F  D7 78         STAB  REGS+6      a
1645  EC71  EC 03         LDD   3,X
1646  EC73  DD 76         STD   REGS+4      x
1647  EC75  EC 05         LDD   5,X
1648  EC77  DD 74         STD   REGS+2      y
1649  EC79  96 92         LDAA  TMP2        check to see if call command
1650  EC7B  81 02         CMPA  #2
1651  EC7D  27 04         BEQ   SAVST1      yes- then don't change pc
1652  EC7F  EC 07         LDD   7,X
1653  EC81  DD 72         STD   REGS        pc
1654  EC83  C6 08 SAVST1  LDAB  #8
1655  EC85  3A            ABX
1656  EC86  DF 7B         STX   SP          stack pointer
1657  EC88  39            RTS
1658
1659              ****************************
1660              * BRPTCHK() - checks to see if
1661              *  a breakpoint has been reached
1662              ****************************
1663
1664  EC89  3C    BRPTCHK   PSHX            save (X)
1665  EC8A  5F              CLRB            offset into breakpoint table
1666  EC8B  CE 00 6A BRPTCHK1 LDX #BRKTABL  point to table
1667  EC8E  3A              ABX             add offset
1668  EC8F  EE 00           LDX   0,X       get breakpoint
1669  EC91  9C 72           CPX   REGS      see if it matches user PC
1670  EC93  27 08           BEQ   BRPTCHK2
1671  EC95  CB 02           ADDB  #2        point to next entry in table
1672  EC97  C1 06           CMPB  #6        done with search?
1673  EC99  2F F0           BLE   BRPTCHK1  no-check next entry
1674  EC9B  38              PULX            restore (X)
1675  EC9C  39              RTS             no match found-return
```

```
1676  EC9D  D6 92     BRPTCHK2  LDAB  TMP2
1677  EC9F  C1 02               CMPB  #2          call command?
1678  ECA1  26 06               BNE   BPHIT1      no
1679  ECA3  DE 7B               LDX   SP          remove return address
1680  ECA5  08                  INX
1681  ECA6  08                  INX
1682  ECA7  DF 7B               STX   SP
1683  ECA9  BD E1 F7  BPHIT1    JSR   OUTCRLF
1684  ECAC  BD E7 3F            JSR   RPRINT      display registers
1685  ECAF  7E E0 3E            JMP   MAIN        return to monitor
1686
1687                  ****************************************
1688                  *  break [-][<addr>] . . .
1689                  * Modifies the breakpoint table.  More than
1690                  *one argument can be entered on the command
1691                  *line but the table will hold only 4 entries.
1692                  *4 types of arguments are implied above:
1693                  * break         Prints table contents.
1694                  * break <addr>  Inserts <addr>.
1695                  * break -<addr> Deletes <addr>.
1696                  * break -       Clears all entries.
1697                  ****************************************
1698
1699  ECB2  BD E3 8D  BREAK     JSR   WSKIP
1700  ECB5  81 0D               CMPA  #$0D
1701  ECB7  26 04               BNE   BRKDEL      jump if not cr
1702  ECB9  BD ED 2D            JSR   BPRINT      print table
1703  ECBC  39                  RTS
1704  ECBD  81 2D     BRKDEL    CMPA  #'-'
1705  ECBF  26 31               BNE   BRKDEF      jump if not -
1706  ECC1  BD E3 7F            JSR   INCBUFF
1707  ECC4  BD E3 78            JSR   RDBUFF
1708  ECC7  BD E3 A6            JSR   DCHEK
1709  ECCA  26 06               BNE   BRKDEL1     jump if not delimeter
1710  ECCC  BD E3 6C            JSR   BPCLR       clear table
1711  ECCF  7E EC B2            JMP   BREAK       do next argument
1712  ECD2  BD E2 B2  BRKDEL1   JSR   BUFFARG     get address to delete
1713  ECD5  BD E3 A6            JSR   DCHEK
1714  ECD8  27 07               BEQ   BRKDEL2     jump if delimeter
1715  ECDA  CE E4 B8            LDX   #MSG9       "bad argument"
1716  ECDD  BD E2 08            JSR   OUTSTRG
1717  ECE0  39                  RTS
1718  ECE1  BD ED 4C  BRKDEL2   JSR   BPSRCH      look for addr in table
1719  ECE4  5D                  TSTB
1720  ECE5  2B 08               BMI   BRKDEL3     jump if not found
1721  ECE7  CE 00 6A            LDX   #BRKTABL
1722  ECEA  3A                  ABX
1723  ECEB  6F 00               CLR   0,X         clear entry
1724  ECED  6F 01               CLR   1,X
1725  ECEF  7E EC B2  BRKDEL3   JMP   BREAK       do next argument
1726  ECF2  BD E2 B2  BRKDEF    JSR   BUFFARG     get argument
```

```
1727  ECF5  BD E3 A6          JSR   DCHEK
1728  ECF8  27 07             BEQ   BRKDEF1     jump if delimiter
1729  ECFA  CE E4 B8          LDX   #MSG9       "bad argument"
1730  ECFD  BD E2 08          JSR   OUTSTRG
1731  ED00  39                RTS
1732  ED01  BD ED 4C  BRKDEF1 JSR   BPSRCH      look for entry in table
1733  ED04  5D                TSTB
1734  ED05  2C AB             BGE   BREAK       jump if already in table
1735  ED07  DE 68             LDX   SHFTREG
1736  ED09  7F 00 68          CLR   SHFTREG
1737  ED0C  7F 00 69          CLR   SHFTREG+1
1738  ED0F  3C                PSHX
1739  ED10  BD ED 4C          JSR   BPSRCH      look for 0 entry
1740  ED13  38                PULX
1741  ED14  5D                TSTB
1742  ED15  2A 0A             BPL   BRKDEF3     jump if table not full
1743  ED17  CE E4 A0          LDX   #MSG4       "full"
1744  ED1A  BD E2 08          JSR   OUTSTRG
1745  ED1D  BD ED 2D          JSR   BPRINT
1746  ED20  39                RTS
1747  ED21  18 CE 00 6A BRKDEF3 LDY  #BRKTABL
1748  ED25  18 3A             ABY
1749  ED27  CD EF 00          STX   0,Y         put new entry in
1750  ED2A  7E EC B2          JMP   BREAK       do next argument
1751
1752                  **********************************
1753                  * bprint() - print the contents of the table.
1754                  **********************************
1755
1756  ED2D  BD E1 F7  BPRINT  JSR   OUTCRLF
1757  ED30  BD E2 4E          JSR   CLRBUFF     clear display buffer
1758  ED33  CE 00 6A          LDX   #BRKTABL
1759  ED36  C6 04             LDAB  #4
1760  ED38  BD E4 1B  BPRINT1 JSR   OUT2BSP
1761  ED3B  BD E4 21          JSR   OUTSPAC     for formatting
1762  ED3E  5A                DECB
1763  ED3F  2E F7             BGT   BPRINT1     loop 4 times
1764  ED41  D6 01             LDAB  IODEV
1765  ED43  27 06             BEQ   BPRINT2
1766  ED45  BD F9 EB          JSR   VIDEO       display until user hits key
1767  ED48  BD E2 4E          JSR   CLRBUFF
1768  ED4B  39        BPRINT2 RTS
1769
1770                  **********************************
1771                  * bpsrch() - search table for address in
1772                  * shftreg. Returns b = index to entry or
1773                  * b = -1 if not found.
1774                  **********************************
1775
1776  ED4C  5F        BPSRCH  CLRB
1777  ED4D  CE 00 6A  BPSRCH1 LDX   #BRKTABL
```

```
1778  ED50  3A                ABX
1779  ED51  EE 00             LDX   0,X          get table entry
1780  ED53  9C 68             CPX   SHFTREG
1781  ED55  26 01             BNE   BPSRCH2      jump if no match
1782  ED57  39                RTS
1783  ED58  5C          BPSRCH2  INCB
1784  ED59  5C                INCB
1785  ED5A  C1 06             CMPB  #$6
1786  ED5C  2F EF             BLE   BPSRCH1      loop 4 times
1787  ED5E  C6 FF             LDAB  #$FF
1788  ED60  39                RTS
1789                *************************************
1790                *  load(ptrbuff[]) - Load s1/s9 records from
1791                *host to memory. Ptrbuff[] points to string in
1792                *input buffer which is a command to output s1/s9
1793                *records from the host ("cat filename" for unix).
1794                *   Returns error and address if it can't write
1795                *to a particular location.
1796                *************************************
1797                *  verify(ptrbuff[]) - Verify memory from load
1798                *command.  Ptrbuff[] is same as for load.
1799                *************************************
1800
1801  ED61  7F 00 92    VERIFY   CLR   TMP2
1802  ED64  7C 00 92             INC   TMP2         flagt1 = 1 = verify
1803  ED67  20 03                BRA   LOAD1
1804  ED69  7F 00 92    LOAD     CLR   TMP2         flagt1 = 0 = load
1805
1806  ED6C  7D 00 01    LOAD1    TST   IODEV
1807  ED6F  27 07                BEQ   LOAD1A
1808  ED71  CE E4 E5             LDX   #MSG14       'NOT USING SCI'
1809  ED74  BD E2 08             JSR   OUTSTRG
1810  ED77  39                   RTS
1811  ED78  BD E3 8D    LOAD1A   JSR   WSKIP
1812  ED7B  81 0D                CMPA  #$0D
1813  ED7D  27 07                BEQ   LOAD5A
1814  ED7F  CE E4 B8             LDX   #MSG9        bad argument
1815  ED82  BD E2 08             JSR   OUTSTRG
1816  ED85  39                   RTS
1817  ED86  7F 00 7D    LOAD5A   CLR   AUTOLF
1818  ED89  BD E3 B2    LOAD5    JSR   CHKABRT
1819  ED8C  81 02                CMPA  #CTLA
1820  ED8E  26 04                BNE   LOAD6
1821  ED90  7C 00 7D             INC   AUTOLF
1822  ED93  39                   RTS
1823  ED94  BD E1 41    LOAD6    JSR   INPUT        read SCI
1824  ED97  4D                   TSTA
1825  ED98  27 EF                BEQ   LOAD5        jump if no input
1826  ED9A  81 53                CMPA  #'S'
1827  ED9C  26 EB                BNE   LOAD5        jump if not S
1828  ED9E  BD E1 41    LOAD7    JSR   INPUT
```

```
1829  EDA1  4D                  TSTA
1830  EDA2  27 FA               BEQ   LOAD7       jump if no input
1831  EDA4  81 39               CMPA  #'9
1832  EDA6  26 0F               BNE   LOAD8       jump if not S9
1833  EDA8  BD EE 0D            JSR   BYTE
1834  EDAB  D6 69               LDAB  SHFTREG+1   b = byte count
1835  EDAD  BD EE 0D  LOAD75    JSR   BYTE
1836  EDB0  5A                  DECB
1837  EDB1  26 FA               BNE   LOAD75      loop until end of record
1838  EDB3  7C 00 7D            INC   AUTOLF      turn on autolf
1839  EDB6  39                  RTS               all done return normally
1840  EDB7  81 31       LOAD8   CMPA  #'1'
1841  EDB9  26 CE               BNE   LOAD5       jump if not S1
1842  EDBB  7F 00 94            CLR   TMP4        clear checksum
1843  EDBE  BD EE 0D            JSR   BYTE
1844  EDC1  D6 69               LDAB  SHFTREG+1
1845  EDC3  C0 02               SUBB  #$2         b = byte count
1846  EDC5  BD EE 0D            JSR   BYTE
1847  EDC8  BD EE 0D            JSR   BYTE
1848  EDCB  DE 68               LDX   SHFTREG     x = base address
1849  EDCD  09                  DEX
1850  EDCE  BD EE 0D  LOAD10    JSR   BYTE        get next byte
1851  EDD1  08                  INX
1852  EDD2  5A                  DECB              check byte count
1853  EDD3  27 23               BEQ   LOAD12      if 0, go do checksum
1854  EDD5  96 69               LDAA  SHFTREG+1
1855  EDD7  7D 00 92            TST   TMP2
1856  EDDA  26 03               BNE   LOAD11      jump if verify
1857  EDDC  BD E3 04            JSR   CHGBYT0     put byte into memory
1858  EDDF  A1 00       LOAD11  CMPA  0,X         verify ram location
1859  EDE1  27 EB               BEQ   LOAD10      jump if ram ok
1860  EDE3  DF 87               STX   PTR3        save error address
1861  EDE5  7C 00 7D            INC   AUTOLF      turn on autolf
1862  EDE8  BD E1 F7            JSR   OUTCRLF
1863  EDEB  CE E4 D9            LDX   #MSG13      "error addr"
1864  EDEE  BD E2 08            JSR   OUTSTRG
1865  EDF1  CE 00 87            LDX   #PTR3
1866  EDF4  BD E4 1B            JSR   OUT2BSP     address
1867  EDF7  39                  RTS
1868  EDF8  96 94       LOAD12  LDAA  TMP4
1869  EDFA  4C                  INCA              do checksum
1870  EDFB  26 03               BNE   LOAD13      jump if s1 record okay
1871  EDFD  7E ED 89            JMP   LOAD5
1872  EE00  7C 00 7D   LOAD13   INC   AUTOLF
1873  EE03  BD E1 F7            JSR   OUTCRLF
1874  EE06  CE E4 CA            LDX   #MSG12      "checksum error"
1875  EE09  BD E2 08            JSR   OUTSTRG
1876  EE0C  39                  RTS
1877
1878                    ********************************
1879                    * byte() - Read 2 ascii bytes and
```

```
1880                        *convert to one hex byte. Returns byte
1881                        *shifted into shftreg and added to tmp4.
1882                        ********************************
1883
1884  EE0D  37              BYTE        PSHB
1885  EE0E  3C                          PSHX
1886  EE0F  BD E1 41        BYTE0       JSR   INPUT       (1st byte)
1887  EE12  4D                          TSTA
1888  EE13  27 FA                       BEQ   BYTE0       loop until input
1889  EE15  BD E2 7F                    JSR   HEXBIN
1890  EE18  BD E1 41        BYTE1       JSR   INPUT       read host (2nd byte)
1891  EE1B  4D                          TSTA
1892  EE1C  27 FA                       BEQ   BYTE1       loop until input
1893  EE1E  BD E2 7F                    JSR   HEXBIN
1894  EE21  96 69                       LDAA  SHFTREG+1
1895  EE23  9B 94                       ADDA  TMP4
1896  EE25  97 94                       STAA  TMP4        add to checksum
1897  EE27  38                          PULX
1898  EE28  33                          PULB
1899  EE29  39                          RTS
1900
1901  0000                  PAGE1       EQU   $00         values for page opcodes
1902  0018                  PAGE2       EQU   $18
1903  001A                  PAGE3       EQU   $1A
1904  00CD                  PAGE4       EQU   $CD
1905  0000                  IMMED       EQU   $0          addressing modes
1906  0001                  INDX        EQU   $1
1907  0002                  INDY        EQU   $2
1908  0003                  LIMMED      EQU   $3          (long immediate)
1909  0004                  OTHER       EQU   $4
1910
1911                        *** Rename variables for assem/disassem ***
1912  0092                  AMODE       EQU   TMP2        addressing mode
1913  0093                  YFLAG       EQU   TMP3
1914  0094                  PNORM       EQU   TMP4        page for normal opcode
1915  007F                  OLDPC       EQU   PTRMEM
1916  0083                  PC          EQU   PTR1        program counter
1917  0085                  PX          EQU   PTR2        page for x indexed
1918  0086                  PY          EQU   PTR2+1      page for y indexed
1919  0087                  BASEOP      EQU   PTR3        base opcode
1920  0088                  CLASS       EQU   PTR3+1      class
1921  0089                  DISPC       EQU   PTR4        pc for disassembler
1922  008B                  BRADDR      EQU   PTR5        relative branch offset
1923  008D                  MNEPTR      EQU   PTR6        pointer to table for dis
1924  008F                  ASSCOMM     EQU   PTR7        subcommand for assembler
1925
1926                        *** Error messages for assembler ***
1927  EE2A  EE 3C           MSGDIR      FDB   #MSGA1      message table index
1928  EE2C  EE 53                       FDB   #MSGA2
1929  EE2E  EE 6B                       FDB   #MSGA3
1930  EE30  EE 7A                       FDB   #MSGA4
```

```
1931  EE32  EE 87                FDB   #MSGA5
1932  EE34  EE 9A                FDB   #MSGA6
1933  EE36  EE B2                FDB   #MSGA7
1934  EE38  EE CD                FDB   #MSGA8
1935  EE3A  EE DA                FDB   #MSGA9
1936  EE3C  49 6D 6D 65MSGA1     FCC   'Immediate mode illegal'
1937  EE52  04                   FCB   EOT
1938  EE53  45 72 72 6F  MSGA2   FCC   'Error in mnemonic table'
1939  EE6A  04                   FCB   EOT
1940  EE6B  49 6C 6C 65MSGA3     FCC   'Illegal bit op'
1941  EE79  04                   FCB   EOT
1942  EE7A  42 61 64 20  MSGA4   FCC   'Bad argument'
1943  EE86  04                   FCB   EOT
1944  EE87  4D 6E 65 6DMSGA5     FCC   'Mnemonic not found'
1945  EE99  04                   FCB   EOT
1946  EE9A  55 6E 6B 6EMSGA6     FCC   'Unknown addressing mode'
1947  EEB1  04                   FCB   EOT
1948  EEB2  49 6E 64 65  MSGA7   FCC   'Indexed addressing assumed'
1949  EECC  04                   FCB   EOT
1950  EECD  53 79 6E 74  MSGA8   FCC   'Syntax error'
1951  EED9  04                   FCB   EOT
1952  EEDA  42 72 61 6E  MSGA9   FCC   'Branch out of range'
1953  EEED  04                   FCB   EOT
1954  EEEE              ASSEM    EQU   *
1955  EEEE  CE 00 00             LDX   #RAMBS
1956  EEF1  DF 7F                STX   OLDPC
1957  EEF3  BD E3 8D             JSR   WSKIP
1958  EEF6  81 0D                CMPA  #$0D
1959  EEF8  27 15                BEQ   ASSLOOP     jump if no argument
1960  EEFA  BD E2 B2             JSR   BUFFARG
1961  EEFD  BD E3 8D             JSR   WSKIP
1962  EF00  81 0D                CMPA  #$0D
1963  EF02  27 07                BEQ   ASSEM1      jump if argument ok
1964  EF04  CE EE 7A             LDX   #MSGA4      "bad argument"
1965  EF07  BD E2 08             JSR   OUTSTRG
1966  EF0A  39                   RTS
1967  EF0B  DE 68        ASSEM1  LDX   SHFTREG
1968  EF0D  DF 7F                STX   OLDPC
1969
1970  EF0F  DE 7F        ASSLOOP LDX   OLDPC
1971  EF11  DF 83                STX   PC
1972  EF13  BD E1 F7             JSR   OUTCRLF
1973  EF16  BD E2 4E             JSR   CLRBUFF     clear display buffer
1974  EF19  CE 00 83             LDX   #PC
1975  EF1C  BD E4 1B             JSR   OUT2BSP     output the address
1976  EF1F  BD E4 21             JSR   OUTSPAC     formatting
1977  EF22  BD F7 57             JSR   DISASSM     disassemble opcode
1978  EF25  BD E1 F7             JSR   OUTCRLF
1979  EF28  7D 00 01             TST   IODEV       check device type
1980  EF2B  27 03                BEQ   ASSLOOP1    if SCI take branch
1981  EF2D  BD F9 EB             JSR   VIDEO       wait for input
```

```
1982  EF30  BD E4 21  ASSLOOP1  JSR   OUTSPAC
1983  EF33  BD E4 21           JSR   OUTSPAC
1984  EF36  BD E4 21           JSR   OUTSPAC
1985  EF39  BD E4 21           JSR   OUTSPAC
1986  EF3C  BD E2 4E           JSR   CLRBUFF
1987  EF3F  BD EF D8           JSR   READLN    read input for assembly
1988  EF42  97 8F              STAA  ASSCOMM
1989  EF44  81 5E              CMPA  #'^'
1990  EF46  27 09              BEQ   ASSLP0    jump if up arrow
1991  EF48  81 2F              CMPA  #'/'
1992  EF4A  27 05              BEQ   ASSLP0    jump if slash
1993  EF4C  81 00              CMPA  #$00
1994  EF4E  26 04              BNE   ASSLP1    jump if none of above
1995  EF50  39                 RTS             return if bad input
1996  EF51  BD E1 F7  ASSLP0   JSR   OUTCRLF
1997  EF54  7D 00 01  ASSLP1   TST   IODEV
1998  EF57  26 0F              BNE   ASSLP01   format for SPI
1999  EF59  BD E4 21           JSR   OUTSPAC
2000  EF5C  BD E4 21           JSR   OUTSPAC
2001  EF5F  BD E4 21           JSR   OUTSPAC
2002  EF62  BD E4 21           JSR   OUTSPAC
2003  EF65  BD E4 21           JSR   OUTSPAC
2004  EF68  BD F0 33  ASSLP01  JSR   PARSE
2005  EF6B  C1 05              CMPB  #$5
2006  EF6D  2F 08              BLE   ASSLP2    jump if mnemonic <= 5 chars
2007  EF6F  CE EE 87           LDX   #MSGA5    "mnemonic not found"
2008  EF72  BD E2 08           JSR   OUTSTRG
2009  EF75  20 2F              BRA   ASSLP5
2010  EF77                     ASSLP2  EQU   *
2011  EF77  C1 00              CMPB  #$0
2012  EF79  27 2E              BEQ   ASSLP10   jump if no input
2013  EF7B  BD F0 74           JSR   MSRCH
2014  EF7E  96 88              LDAA  CLASS
2015  EF80  81 FF              CMPA  #$FF
2016  EF82  26 08              BNE   ASSLP3
2017  EF84  CE EE 87           LDX   #MSGA5    "mnemonic not found"
2018  EF87  BD E2 08           JSR   OUTSTRG
2019  EF8A  20 1A              BRA   ASSLP5
2020  EF8C  BD F0 AC  ASSLP3   JSR   DOOP
2021  EF8F  81 00              CMPA  #$00
2022  EF91  26 07              BNE   ASSLP4    jump if doop error
2023  EF93  CE 00 00           LDX   #$00
2024  EF96  DF 89              STX   DISPC     indicate good assembly
2025  EF98  20 0F              BRA   ASSLP10
2026  EF9A  4A        ASSLP4   DECA            a = error message index
2027  EF9B  16                 TAB
2028  EF9C  CE EE 2A           LDX   #MSGDIR
2029  EF9F  3A                 ABX
2030  EFA0  3A                 ABX
2031  EFA1  EE 00              LDX   0,X
2032  EFA3  BD E2 08           JSR   OUTSTRG   output error message
```

```
2033  EFA6  7F 00 8F  ASSLP5     CLR   ASSCOMM     error command
2034  EFA9            ASSLP10    EQU   *
2035  EFA9  96 8F                LDAA  ASSCOMM
2036  EFAB  81 5E                CMPA  #'^'
2037  EFAD  26 07                BNE   ASSLP11     jump if not up arrow
2038  EFAF  DE 7F                LDX   OLDPC
2039  EFB1  09                   DEX
2040  EFB2  DF 7F                STX   OLDPC       back up
2041  EFB4  20 1F                BRA   ASSLP15
2042  EFB6  81 0A     ASSLP11    CMPA  #$0A
2043  EFB8  27 04                BEQ   ASSLP12     jump if linefeed
2044  EFBA  81 0D                CMPA  #$0D
2045  EFBC  26 17                BNE   ASSLP15     jump if not cr
2046  EFBE  DE 89     ASSLP12    LDX   DISPC
2047  EFC0  26 06                BNE   ASSLP13     jump if dispc != 0
2048  EFC2  DE 83                LDX   PC
2049  EFC4  DF 7F                STX   OLDPC
2050  EFC6 20 0D                 BRA   ASSLP15
2051  EFC8  81 0A     ASSLP13    CMPA  #$0A
2052  EFCA  26 05                BNE   ASSLP14     jump if not linefeed
2053  EFCC  DE 7F                LDX   OLDPC
2054  EFCE  08                   INX
2055  EFCF  DF 89                STX   DISPC
2056  EFD1  DE 89     ASSLP14    LDX   DISPC
2057  EFD3  DF 7F                STX   OLDPC
2058  EFD5  7E EF 0F  ASSLP15    JMP   ASSLOOP
2059
2060
2061                             ****************************************
2062                             * readln() --- Read input from terminal into buffer
2063                             * until a command character is read (cr,lf,/,^).
2064                             * If more chars are typed than the buffer will hold,
2065                             * the extra characters are overwritten on the end.
2066                             *  On exit: b=number of chars read, a=0 if quit,
2067                             * else a=next command.
2068                             ****************************************
2069
2070  EFD8  BD E2 4E  READLN     JSR   CLRBUFF
2071  EFDB  86 2E                LDAA  #'.'
2072  EFDD  BD E1 76             JSR   OUTPUT      output asm prompt character
2073  EFE0  BD E1 37  RLN1       JSR   INCHAR
2074  EFE3  BD E2 74             JSR   UPCASE
2075  EFE6  CE 00 05             LDX   #CHARBUFF
2076  EFE9  D6 02                LDAB  CHARPTR
2077  EFEB  3A                   ABX
2078  EFEC  81 7F                CMPA  #DEL        Delete
2079  EFEE  27 41                BEQ   RLNQUIT
2080  EFF0  81 18                CMPA  #CTLX       Control X
2081  EFF2  27 3D                BEQ   RLNQUIT
2082  EFF4  81 02                CMPA  #CTLA       Control A
2083  EFF6  27 39                BEQ   RLNQUIT
```

```
2084  EFF8  81 03          CMPA  #$03        Control C
2085  EFFA  27 35          BEQ   RLNQUIT
2086  EFFC  81 04          CMPA  #$04        Control D
2087  EFFE  27 31          BEQ   RLNQUIT
2088  F000  81 08          CMPA  #$08        backspace
2089  F002  26 11          BNE   RLN2
2090  F004  7D 00 01       TST   IODEV
2091  F007  27 05          BEQ   RDLN10
2092  F009  BD E1 64       JSR   CRTBKSPC    backspace on CHARBUFF
2093  F00C  20 D2          BRA   RLN1        get another character
2094  F00E  7A 00 02 RDLN10 DEC   CHARPTR
2095  F011  2C CD          BGE   RLN1
2096  F013  20 C3          BRA   READLN      start over
2097  F015  7D 00 01 RLN2   TST   IODEV
2098  F018  26 05          BNE   RLN21
2099  F01A  A7 00          STAA  0,X         put char in buffer
2100  F01C  5C             INCB              point to next pos in buffer
2101  F01D  D7 02          STAB  CHARPTR     update pointer
2102  F01F  C1 1E RLN21    CMPB  #BUFFLEN    max buffer length
2103  F021  2D 08          BLT   RLN3        jump if buffer not full
2104  F023  CE E4 97       LDX   #MSG3       'too long'
2105  F026  BD E2 08       JSR   OUTSTRG
2106  F029  20 AD          BRA   READLN
2107  F02B  BD F0 65 RLN3   JSR   ASSCHEK     check for subcommand
2108  F02E  26 B0          BNE   RLN1
2109  F030  39             RTS
2110  F031  4F    RLNQUIT  CLRA              quit
2111  F032  39             RTS               return
2112
2113                       ******************************************
2114                       * parse() -parse out the mnemonic from CHARBUFF
2115                       * to COMBUFF. on exit: b=number of chars parsed.
2116                       ******************************************
2117
2118  F033  86 20  PARSE   LDAA  #$20
2119  F035  97 63          STAA  COMBUFF+3
2120  F037  CE 00 05       LDX   #CHARBUFF   initialize buffer ptr
2121  F03A  7D 00 01       TST   IODEV
2122  F03D  27 01          BEQ   PARS1
2123  F03F  08             INX               adjust pointer if SPI
2124  F040  DF 81  PARS1   STX   PTR0
2125  F042  BD E3 8D       JSR   WSKIP       find first character
2126  FO45  5F             CLRB
2127  F046  BD E3 78 PARSLP JSR   RDBUFF      read character
2128  F049  BD E3 7F       JSR   INCBUFF
2129  F04C  BD E3 9B       JSR   WCHEK
2130  F04F  27 13          BEQ   PARSRT      jump if whitespace
2131  F051  BD F0 65       JSR   ASSCHEK
2132  F054  27 0E          BEQ   PARSRT      jump if end of line
2133  F056  BD E2 74       JSR   UPCASE      convert to upper case
```

```
2134  F059  CE 00 60          LDX   #COMBUFF
2135  F05C  3A                ABX
2136  F05D  A7 00             STAA  0,X          store in combuff
2137  F05F  5C                INCB
2138  F060  C1 05             CMPB  #$5
2139  F062  2F E2             BLE   PARSLP       loop 6 times
2140  F064  39        PARSRT  RTS
2141
2142                  ******************************
2143                  * asschek() -perform compares for
2144                  * cr, lf, ^, /
2145                  ******************************
2146
2147  F065  81 0A     ASSCHEK CMPA  #$0A         linefeed
2148  F067  27 0A             BEQ   ASSCHK1
2149  F069  81 0D             CMPA  #$0D         carriage ret
2150  F06B  27 06             BEQ   ASSCHK1
2151  F06D  81 5E             CMPA  #'^'         up arrow
2152  F06F  27 02             BEQ   ASSCHK1
2153  F071  81 2F             CMPA  #'/'         slash
2154  F073  39        ASSCHK1 RTS
2155
2156                  ***************************************************
2157                  * msrch() --- Search MNETABL for mnemonic in COMBUFF.
2158                  *stores base opcode at baseop and class at class.
2159                  * Class = FF if not found.
2160                  ***************************************************
2161
2162  F074  CE F3 D8  MSRCH   LDX   #MNETABL    pointer to mnemonic table
2163  F077  18 CE 00 60       LDY   #COMBUFF     pointer to string
2164  F07B  20 03             BRA   MSRCH1
2165  F07D            MSNEXT  EQU   *
2166  F07D  C6 06             LDAB  #6
2167  F07F  3A                ABX                point to next table entry
2168  F080  A6 00     MSRCH1  LDAA  0,X          read table
2169  F082  81 04             CMPA  #EOT
2170  F084  26 05             BNE   MSRCH2       jump if not end of table
2171  F086  86 FF             LDAA  #$FF
2172  F088  97 88             STAA  CLASS        FF = not in table
2173  F08A  39                RTS
2174  F08B  18 A1 00  MSRCH2  CMPA  0,Y          op[0] = tabl[0] ?
2175  F08E  26 ED             BNE   MSNEXT
2176  F090  A6 01             LDAA  1,X
2177  F092  18 A1 01          CMPA  1,Y          op[1] = tabl[1] ?
2178  F095  26 E6             BNE   MSNEXT
2179  F097  A6 02             LDAA  2,X
2180  F099  18 A1 02          CMPA  2,Y          op[2] = tabl[2] ?
2181  F09C  26 DF             BNE   MSNEXT
2182  F09E  A6 03             LDAA  3,X
2183  F0A0  18 A1 03          CMPA  3,Y          op[2] = tabl[2] ?
2184  F0A3  26 D8             BNE   MSNEXT
```

```
2185  F0A5  EC 04              LDD   4,X          opcode, class
2186  F0A7  97 87              STAA  BASEOP
2187  F0A9  D7 88              STAB  CLASS
2188  F0AB  39                 RTS
2189
2190                  ****************************************
2191                  ** doop(baseop,class) — process mnemonic.
2192                  ** on exit: a=error code corresponding to error
2193                  **                    messages.
2194                  ****************************************
2195
2196  F0AC            DOOP      EQU   *
2197  F0AC  86 04               LDAA  #OTHER
2198  F0AE  97 92               STAA  AMODE        mode
2199  F0B0  7F 00 93            CLR   YFLAG
2200  F0B3  DE 81               LDX   PTR0
2201  F0B5  8C 00 23  DOPLP1    CPX   #ENDBUFF     (end of buffer)
2202  F0B8  27 1B               BEQ   DOOP1        jump if end of buffer
2203  F0BA  EC 00               LDD   0,X          read 2 chars from buffer
2204  F0BC  08                  INX                move pointer
2205  F0BD  81 2C               CMPA  #','
2206  F0BF  26 F4               BNE   DOPLP1
2207  F0C1  C1 59               CMPB  #'Y'         look for ",y"
2208  F0C3  26 06               BNE   DOPLP2
2209  F0C5  86 02               LDAA  #INDY
2210  F0C7  97 92               STAA  AMODE
2211  F0C9  20 0A               BRA   DOOP1
2212  F0CB  C1 58     DOPLP2    CMPB  #'X'         look for ",x"
2213  F0CD  26 06               BNE   DOOP1        jump if not x
2214  F0CF  86 01               LDAA  #INDX
2215  F0D1  97 92               STAA  AMODE
2216  F0D3  20 00               BRA   DOOP1
2217  F0D5  BD E3 8D  DOOP1     JSR   WSKIP
2218  F0D8  81 23               CMPA  #'#'         look for immediate mode
2219  F0DA  26 07               BNE   DOOP2
2220  F0DC  BD E3 7F            JSR   INCBUFF      point at argument
2221  F0DF  86 00               LDAA  #IMMED
2222  F0E1  97 92               STAA  AMODE
2223  F0E3  D6 88     DOOP2     LDAB  CLASS
2224  F0E5  C1 02               CMPB  #P2INH
2225  F0E7  26 03               BNE   DOSW1
2226  F0E9  7E F1 4A            JMP   DOP2I
2227  F0EC  C1 01     DOSW1     CMPB  #INH
2228  F0EE  26 03               BNE   DOSW2
2229  F0F0  7E F1 4F            JMP   DOINH
2230  F0F3  C1 05     DOSW2     CMPB  #REL
2231  F0F5  26 03               BNE   DOSW3
2232  F0F7  7E F1 56            JMP   DOREL
2233  F0FA  C1 08     DOSW3     CMPB  #LIMM
2234  F0FC  26 03               BNE   DOSW4
2235  F0FE  7E F1 85            JMP   DOLIM
```

```
2236  F101  C1 07       DOSW4    CMPB  #NIMM
2237  F103  26 03                BNE   DOSW5
2238  F105  7E F1 8F             JMP   DONOI
2239  F108  C1 03       DOSW5    CMPB  #GEN
2240  F10A  26 03                BNE   DOSW6
2241  F10C  7E F1 98             JMP   DOGENE
2242  F10F  C1 04       DOSW6    CMPB  #GRP2
2243  F111  26 03                BNE   DOSW7
2244  F113  7E F1 A6             JMP   DOGRP
2245  F116  C1 15       DOSW7    CMPB  #CPD
2246  F118  26 03                BNE   DOSW8
2247  F11A  7E F1 D8             JMP   DOCPD
2248  F11D  C1 10       DOSW8    CMPB  #XNIMM
2249  F11F  26 03                BNE   DOSW9
2250  F121  7E F1 F9             JMP   DOXNOI
2251  F124  C1 09       DOSW9    CMPB  #XLIMM
2252  F126  26 03                BNE   DOSW10
2253  F128  7E F2 02             JMP   DOXLI
2254  F12B  C1 12       DOSW10   CMPB  #YNIMM
2255  F12D  26 03                BNE   DOSW11
2256  F12F  7E F2 1A             JMP   DOYNOI
2257  F132  C1 11       DOSW11   CMPB  #YLIMM
2258  F134  26 03                BNE   DOSW12
2259  F136  7E F2 23             JMP   DOYLI
2260  F139  C1 13       DOSW12   CMPB  #BTB
2261  F13B  26 03                BNE   DOSW13
2262  F13D  7E F2 42             JMP   DOBTB
2263  F140  C1 14       DOSW13   CMPB  #SETCLR
2264  F142  26 03                BNE   DODEF
2265  F144  7E F2 42             JMP   DOSET
2266  F147  86 02       DODEF    LDAA  #$2
2267  F149  39                   RTS
2268  F14A  86 18       DOP2I    LDAA  #PAGE2
2269  F14C  BD F3 CB             JSR   EMIT
2270  F14F  96 87       DOINH    LDAA  BASEOP
2271  F151  BD F3 CB             JSR   EMIT
2272  F154  4F                   CLRA
2273  F155  39                   RTS
2274  F156  BD F3 AD    DOREL    JSR   ASSARG
2275  F159  81 04                CMPA  #$04
2276  F15B  26 01                BNE   DOREL1     jump if arg ok
2277  F15D  39                   RTS
2278  F15E  DC 68       DOREL1   LDD   SHFTREG    get branch address
2279  F160  DE 83                LDX   PC         get program counter
2280  F162  08                   INX
2281  F163  08                   INX              point to end of opcode
2282  F164  DF 8B                STX   BRADDR
2283  F166  93 8B                SUBD  BRADDR     calculate offset
2284  F168  DD 8B                STD   BRADDR     save result
2285  F16A  1A 83 00 7F          CMPD  #$7F       in range ?
2286  F16E  23 09                BLS   DOREL2     jump if in range
```

```
2287  F170  1A 83 FF 80          CMPD  #$FF80
2288  F174  24 03                BHS   DOREL2      jump if in range
2289  F176  86 09                LDAA  #$09        'Out of range'
2290  F178  39                   RTS
2291  F179  97 87       DOREL2   LDAA  BASEOP
2292  F17B  BD F3 CB             JSR   EMIT        emit opcode
2293  F17E  96 8C                LDAA  BRADDR+1
2294  F180  BD F3 CB             JSR   EMIT        emit offset
2295  F183  4F                   CLRA              normal return
2296  F184  39                   RTS
2297  F185  96 92       DOLIM    LDAA  AMODE
2298  F187  81 00                CMPA  #IMMED
2299  F189  26 04                BNE   DONOI
2300  F18B  86 03                LDAA  #LIMMED
2301  F18D  97 92                STAA  AMODE
2302  F18F  96 92       DONOI    LDAA  AMODE
2303  F191  81 00                CMPA  #IMMED
2304  F193  26 03                BNE   DOGENE      jump if not immediate
2305  F195  86 01                LDAA  #$1         "immediate mode illegal"
2306  F197  39                   RTS
2307  F198  86 00       DOGENE   LDAA  #PAGE1
2308  F19A  97 94                STAA  PNORM
2309  F19C  97 85                STAA  PX
2310  F19E  86 18                LDAA  #PAGE2
2311  F1A0  97 86                STAA  PY
2312  F1A2  BD F2 DE             JSR   DOGEN
2313  F1A5  39                   RTS
2314  F1A6  96 92       DOGRP    LDAA  AMODE
2315  F1A8  81 02                CMPA  #INDY
2316  F1AA  26 09                BNE   DOGRP1
2317  F1AC  86 18                LDAA  #PAGE2
2318  F1AE  BD F3 CB             JSR   EMIT
2319  F1B1  86 01                LDAA  #INDX
2320  F1B3  97 92                STAA  AMODE
2321  F1B5              DOGRP1   EQU   *
2322  F1B5  96 92                LDAA  AMODE
2323  F1B7  81 01                CMPA  #INDX
2324  F1B9  26 04                BNE   DOGRP2
2325  F1BB  BD F3 7E             JSR   DOINDEX
2326  F1BE  39                   RTS
2327  F1BF              DOGRP2   EQU   *
2328  F1BF  96 87                LDAA  BASEOP
2329  F1C1  8B 10                ADDA  #$10
2330  F1C3  BD F3 CB             JSR   EMIT
2331  F1C6  BD F3 AD             JSR   ASSARG
2332  F1C9  81 04                CMPA  #$04
2333  F1CB  27 0A                BEQ   DOGRPRT     jump if bad arg
2334  F1CD  DC 68                LDD   SHFTREG     extended address
2335  F1CF  BD F3 CB             JSR    EMIT
2336  F1D2  17                   TBA
2337  F1D3  BD F3 CB             JSR   EMIT
```

```
2338  F1D6  4F                    CLRA
2339  F1D7  39          DOGRPRT   RTS
2340  F1D8  96 92       DOCPD     LDAA  AMODE
2341  F1DA  81 00                 CMPA  #IMMED
2342  F1DC  26 04                 BNE   DOCPD1
2343  F1DE  86 03                 LDAA  #LIMMED
2344  F1E0  97 92                 STAA  AMODE
2345  F1E2  96 92       DOCPD1    LDAA  AMODE
2346  F1E4  81 02                 CMPA  #INDY
2347  F1E6  26 03                 BNE   DOCPD2
2348  F1E8  7C 00 93              INC   YFLAG
2349  F1EB  86 1A       DOCPD2    LDAA  #PAGE3
2350  F1ED  97 94                 STAA  PNORM
2351  F1EF  97 85                 STAA  PX
2352  F1F1  86 CD                 LDAA  #PAGE4
2353  F1F3  97 86                 STAA  PY
2354  F1F5  BD F2 DE              JSR   DOGEN
2355  F1F8  39                    RTS
2356  F1F9  96 92       DOXNOI    LDAA  AMODE
2357  F1FB  81 00                 CMPA  #IMMED
2358  F1FD  26 03                 BNE   DOXLI
2359  F1FF  86 01                 LDAA  #$1         "immediate mode illegal"
2360  F201  39                    RTS
2361  F202  96 92       DOXLI     LDAA  AMODE
2362  F204  81 00                 CMPA  #IMMED
2363  F206  26 04                 BNE   DOXLI1
2364  F208  86 03                 LDAA  #LIMMED
2365  F20A  97 92                 STAA  AMODE
2366  F20C  86 00       DOXLI1    LDAA  #PAGE1
2367  F20E  97 94                 STAA  PNORM
2368  F210  97 85                 STAA  PX
2369  F212  86 CD                 LDAA  #PAGE4
2370  F214  97 86                 STAA  PY
2371  F216  BD F2 DE              JSR   DOGEN
2372  F219  39                    RTS
2373  F21A  96 92       DOYNOI    LDAA  AMODE
2374  F21C  81 00                 CMPA  #IMMED
2375  F21E  26 03                 BNE   DOYLI
2376  F220  86 01                 LDAA  #$1         "immediate mode illegal"
2377  F222  39                    RTS
2378  F223  96 92       DOYLI     LDAA  AMODE
2379  F225  81 02                 CMPA  #INDY
2380  F227  26 03                 BNE   DOYLI1
2381  F229  7C 00 93              INC   YFLAG
2382  F22C  81 00       DOYLI1    CMPA  #IMMED
2383  F22E  26 04                 BNE   DOYLI2
2384  F230  86 03                 LDAA  #LIMMED
2385  F232  97 92                 STAA  AMODE
2386  F234  86 18       DOYLI2    LDAA  #PAGE2
2387  F236  97 94                 STAA  PNORM
2388  F238  97 86                 STAA  PY
```

```
2389  F23A  86 1A          LDAA  #PAGE3
2390  F23C  97 85          STAA  PX
2391  F23E  BD F2 DE       JSR   DOGEN
2392  F241  39             RTS
2393  F242          DOBTB   EQU   *
2394  F242  BD F2 B8 DOSET  JSR   BITOP
2395  F245  81 00          CMPA  #$00
2396  F247  26 03          BNE   DOSET1
2397  F249  86 03          LDAA  #$3       "illegal bit op"
2398  F24B  39             RTS
2399  F24C  96 92  DOSET1   LDAA  AMODE
2400  F24E  81 02          CMPA  #INDY
2401  F250  26 09          BNE   DOSET2
2402  F252  86 18          LDAA  #PAGE2
2403  F254  BD F3 CB       JSR   EMIT
2404  F257  86 01          LDAA  #INDX
2405  F259  97 92          STAA  AMODE
2406  F25B  96 87  DOSET2   LDAA  BASEOP
2407  F25D  BD F3 CB       JSR   EMIT
2408  F260  BD F3 AD       JSR   ASSARG
2409  F263  81 04          CMPA  #$04
2410  F265  26 01          BNE   DOSET22   jump if arg ok
2411  F267  39             RTS
2412  F268  96 69  DOSET22  LDAA  SHFTREG+1 index offset
2413  F26A  BD F3 CB       JSR   EMIT
2414  F26D  96 92          LDAA  AMODE
2415  F26F  81 01          CMPA  #INDX
2416  F271  26 06          BNE   DOSET3
2417  F273  BD E3 7F       JSR   INCBUFF
2418  F276  BD E3 7F       JSR   INCBUFF
2419  F279  BD F3 AD DOSET3 JSR   ASSARG
2420  F27C  81 04          CMPA  #$04
2421  F27E  26 01          BNE   DOSET33   jump if arg ok
2422  F280  39             RTS
2423  F281  96 69  DOSET33  LDAA  SHFTREG+1 mask
2424  F283  BD F3 CB       JSR   EMIT
2425  F286  96 88          LDAA  CLASS
2426  F288  81 14          CMPA  #SETCLR
2427  F28A  26 02          BNE   DOSET4
2428  F28C  4F             CLRA
2429  F28D  39             RTS
2430  F28E  BD F3 AD DOSET4 JSR   ASSARG
2431  F291  81 04          CMPA  #$04
2432  F293  26 01          BNE   DOSET5    jump if arg ok
2433  F295  39             RTS
2434  F296  DE 83  DOSET5   LDX   PC        program counter
2435  F298  08             INX              point to next inst
2436  F299  DF 8B          STX   BRADDR     save pc value
2437  F29B  DC 68          LDD   SHFTREG    get branch address
2438  F29D  93 8B          SUBD  BRADDR
      calculate offset
```

```
2439  F29F  1A 83 00 7F            CMPD #$7F
2440  F2A3  23 0D                  BLS  DOSET6      jump if in range
2441  F2A5  1A 83 FF 80            CMPD #$FF80
2442  F2A9  24 07                  BHS  DOSET6      jump if in range
2443  F2AB  4F                     CLRA
2444  F2AC  BD F3 CB               JSR  EMIT
2445  F2AF  86 09                  LDAA #$09        'out of range'
2446  F2B1  39                     RTS
2447  F2B2  17          DOSET6     TBA              offset
2448  F2B3  BD F3 CB               JSR  EMIT
2449  F2B6  4F                     CLRA
2450  F2B7  39                     RTS
2451
2452                    ********************************************
2453                    ** bitop(baseop,amode,class) --- adjust opcode on bit
2454                    **     manipulation instructions. Returns opcode in a
2455                    **     or a = 0 if error
2456                    ********************************************
2457
2458  F2B8  96 92       BITOP      LDAA AMODE
2459  F2BA  D6 88                  LDAB CLASS
2460  F2BC  81 01                  CMPA #INDX
2461  F2BE  26 01                  BNE  BITOP1
2462  F2C0  39                     RTS
2463  F2C1  81 02       BITOP1     CMPA #INDY
2464  F2C3  26 01                  BNE  BITOP2      jump not indexed
2465  F2C5  39                     RTS
2466  F2C6  C1 14       BITOP2     CMPB #SETCLR
2467  F2C8  26 07                  BNE  BITOP3      jump not bset,bclr
2468  F2CA  96 87                  LDAA BASEOP      get opcode
2469  F2CC  80 08                  SUBA #8
2470  F2CE  97 87                  STAA BASEOP
2471  F2D0  39                     RTS
2472  F2D1  C1 13       BITOP3     CMPB #BTB
2473  F2D3  26 07                  BNE  BITOP4      jump not bit branch
2474  F2D5  96 87                  LDAA BASEOP      get opcode
2475  F2D7  80 0C                  SUBA #12
2476  F2D9  97 87                  STAA BASEOP
2477  F2DB  39                     RTS
2478  F2DC  4F          BITOP4     CLRA             0 = fatal bitop
2479  F2DD  39                     RTS
2480
2481                    ********************************************
2482                    ** dogen(baseop,mode,pnorm,px,py) - process
2483                    ** general addressing modes. Returns a = error #.
2484                    ********************************************
2485
2486  F2DE  96 92       DOGEN      LDAA AMODE
2487  F2E0  81 03                  CMPA #LIMMED
2488  F2E2  27 13                  BEQ  DOGLIM
2489  F2E4  81 00                  CMPA #IMMED
```

```
2490  F2E6  27 2C          BEQ   DOGIMM
2491  F2E8  81 02          CMPA  #INDY
2492  F2EA  27 41          BEQ   DOGINDY
2493  F2EC  81 01          CMPA  #INDX
2494  F2EE  27 4C          BEQ   DOGINDX
2495  F2F0  81 04          CMPA  #OTHER
2496  F2F2  27 57          BEQ   DOGOTH
2497  F2F4  86 06  DOGDEF   LDAA  #$06       unknown addre...
2498  F2F6  39             RTS
2499  F2F7  96 94  DOGLIM   LDAA  PNORM
2500  F2F9  BD F3 C3       JSR   EPAGE
2501  F2FC  96 87  DOGLIM1  LDAA  BASEOP
2502  F2FE  BD F3 CB       JSR   EMIT
2503  F301  BD F3 AD       JSR   ASSARG     get next argument
2504  F304  81 04          CMPA  #$04
2505  F306  26 01          BNE   DOGLIM2    jump if arg ok
2506  F308  39             RTS
2507  F309  DC 68  DOGLIM2  LDD   SHFTREG
2508  F30B  BD F3 CB       JSR   EMIT
2509  F30E  17             TBA
2510  F30F  BD F3 CB       JSR   EMIT
2511  F312  4F             CLRA
2512  F313  39             RTS
2513  F314  96 94  DOGIMM   LDAA  PNORM
2514  F316  BD F3 C3       JSR   EPAGE
2515  F319  96 87          LDAA  BASEOP
2516  F31B  BD F3 CB       JSR   EMIT
2517  F31E  BD F3 AD       JSR   ASSARG
2518  F321  81 04          CMPA  #$04
2519  F323  26 01          BNE   DOGIMM1    jump if arg ok
2520  F325  39             RTS
2521  F326  96 69  DOGIMM1  LDAA  SHFTREG+1
2522  F328  BD F3 CB       JSR   EMIT
2523  F32B  4F             CLRA
2524  F32C  39             RTS
2525  F32D  96 86  DOGINDY  LDAA  PY
2526  F32F  BD F3 C3       JSR   EPAGE
2527  F332  96 87          LDAA  BASEOP
2528  F334  8B 20          ADDA  #$20
2529  F336  97 87          STAA  BASEOP
2530  F338  BD F3 7E       JSR   DOINDEX
2531  F33B  39             RTS
2532  F33C  96 85  DOGINDX  LDAA  PX
2533  F33E  BD F3 C3       JSR   EPAGE
2534  F341  96 87          LDAA  BASEOP
2535  F343  8B 20          ADDA  #$20
2536  F345  97 87          STAA  BASEOP
2537  F347  BD F3 7E       JSR   DOINDEX
2538  F34A  39             RTS
2539  F34B  BD F3 AD DOGOTH JSR   ASSARG
2540  F34E  81 04          CMPA  #$04
```

```
2541  F350  26 01          BNE   DOGOTH0     jump if arg ok
2542  F352  39             RTS
2543  F353  96 94  DOGOTH0  LDAA  PNORM
2544  F355  BD F3 C3       JSR   EPAGE
2545  F358  96 7E          LDAA  COUNT
2546  F35A  81 02          CMPA  #$2
2547  F35C  2E 0E          BGT   DOGOTH1
2548  F35E  96 87          LDAA  BASEOP
2549  F360  8B 10          ADDA  #$10        direct mode opcode
2550  F362  BD F3 CB       JSR   EMIT
2551  F365  96 69          LDAA  SHFTREG+1
2552  F367  BD F3 CB       JSR   EMIT
2553  F36A  4F             CLRA
2554  F36B  39             RTS
2555  F36C  96 87  DOGOTH1  LDAA  BASEOP
2556  F36E  8B 30          ADDA  #$30        extended mode opcode
2557  F370  BD F3 CB       JSR   EMIT
2558  F373  DC 68          LDD   SHFTREG
2559  F375  BD F3 CB       JSR   EMIT
2560  F378  17             TBA
2561  F379  BD F3 CB       JSR   EMIT
2562  F37C  4F             CLRA
2563  F37D  39             RTS
2564
2565                ****************************************
2566                ** doindex(op) --- handle all wierd stuff for
2567                **  indexed addressing. Returns a = error number.
2568                ****************************************
2569
2570  F37E  96 87  DOINDEX  LDAA  BASEOP
2571  F380  BD F3 CB       JSR   EMIT
2572  F383  BD F3 AD       JSR   ASSARG
2573  F386  81 04          CMPA  #$04
2574  F388  26 01          BNE   DOINDX0     jump if arg ok
2575  F38A  39             RTS
2576  F38B  81 2C  DOINDX0  CMPA  #','
2577  F38D  27 03          BEQ   DOINDX1
2578  F38F  86 08          LDAA  #$08        "syntax error"
2579  F391  39             RTS
2580  F392  BD E3 7F  DOINDX1  JSR  INCBUFF
2581  F395  BD E3 78       JSR   RDBUFF
2582  F398  81 59          CMPA  #'Y'
2583  F39A  27 0A          BEQ   DOINDX2
2584  F39C  81 58          CMPA  #'X'
2585  F39E  27 06          BEQ   DOINDX2
2586  F3A0  FE EE B2       LDX   MSGA7       "index addr assumed"
2587  F3A3  BD E2 08       JSR   OUTSTRG
2588  F3A6  96 69  DOINDX2  LDAA  SHFTREG+1
2589  F3A8  BD F3 CB       JSR   EMIT
2590  F3AB  4F             CLRA
2591  F3AC  39             RTS
```

```
2592
2593                    ****************************************
2594                    ** assarg(); - get argument. Returns a = 4 if bad
2595                    ** argument, else a = first non hex char.
2596                    ****************************************
2597
2598  F3AD  BD E2 B2    ASSARG      JSR   BUFFARG
2599  F3B0  BD F0 65                JSR   ASSCHEK     check for command
2600  F3B3  27 05                   BEQ   ASSARG1     jump if ok
2601  F3B5  BD E3 9B                JSR   WCHEK       check for whitespace
2602  F3B8  26 06                   BNE   ASSARG2     jump if not ok
2603  F3BA  7D 00 7E    ASSARG1     TST   COUNT
2604  F3BD  27 01                   BEQ   ASSARG2     jump if no argument
2605  F3BF  39                      RTS
2606  F3C0  86 04       ASSARG2     LDAA  #$04        bad argument
2607  F3C2  39                      RTS
2608
2609                    ****************************
2610                    ** epage(a) --- emit page prebyte
2611                    ****************************
2612
2613  F3C3  81 00       EPAGE       CMPA  #PAGE1
2614  F3C5  27 03                   BEQ   EPAGRT      jump if page 1
2615  F3C7  BD F3 CB                JSR   EMIT
2616  F3CA  39          EPAGRT      RTS
2617
2618                    ****************************
2619                    * emit(a) --- emit contents of a
2620                    ****************************
2621
2622  F3CB  DE 83       EMIT        LDX   PC
2623  F3CD  97 69                   STAA  SHFTREG+1   so CHGBYT0 works
2624  F3CF  BD E3 04                JSR   CHGBYT0     put data in memory
2625  F3D2  BD E4 1E                JSR   OUT1BSP
2626  F3D5  DF 83                   STX   PC
2627  F3D7  39                      RTS
2628
2629                                                  *Mnemonic table for hc11 line
                                                      assembler
2630  0000              NULL        EQU   $0          nothing
2631  0001              INH         EQU   $1          inherent
2632  0002              P2INH       EQU   $2          page 2 inherent
2633  0003              GEN         EQU   $3          general addressing
2634  0004              GRP2        EQU   $4          group 2
2635  0005              REL         EQU   $5          relative
2636  0006              IMM         EQU   $6          immediate
2637  0007              NIMM        EQU   $7          general except for immediate
2638  0008              LIMM        EQU   $8          2 byte immediate
2639  0009              XLIMM       EQU   $9          longimm for x
2640  0010              XNIMM       EQU   $10         no immediate for x
2641  0011              YLIMM       EQU   $11         longimm for y
```

```
2642  0012                YNIMM     EQU   $12          no immediate for y
2643  0013                BTB       EQU   $13          bit test and branch
2644  0014                SETCLR    EQU   $14          bit set or clear
2645  0015                CPD       EQU   $15          compare d
2646  0016                BTBD      EQU   $16          bit test and branch direct
2647  0017                SETCLRD   EQU   $17          bit set or clear direct
2648
2649                      ************************************************
2650                      *  mnetabl - includes all '11 mnemonics, base opcodes,
2651                      * and type of instruction. The assembler search routine
2652                      *depends on 4 characters for each mnemonic so that 3 char
2653                      *mnemonics are extended with a space and 5 char mnemonics
2654                      *are truncated.
2655                      ************************************************
2656  F3D8                MNETABL   EQU   *
2657  F3D8  41 42 41 20           FCC   'ABA '       Mnemonic
2658  F3DC  1B                    FCB   $1B          Base opcode
2659  F3DD  01                    FCB   INH          Class
2660  F3DE  41 42 58 20           FCC   'ABX '
2661  F3E2  3A                    FCB   $3A
2662  F3E3  01                    FCB   INH
2663  F3E4  41 42 59 20           FCC   'ABY '
2664  F3E8  3A                    FCB   $3A
2665  F3E9  02                    FCB   P2INH
2666  F3EA  41 44 43 41           FCC   'ADCA'
2667  F3EE  89                    FCB   $89
2668  F3EF  03                    FCB   GEN
2669  F3F0  41 44 43 42           FCC   'ADCB'
2670  F3F4  C9                    FCB   $C9
2671  F3F5  03                    FCB   GEN
2672  F3F6  41 44 44 41           FCC   'ADDA'
2673  F3FA  8B                    FCB   $8B
2674  F3FB  03                    FCB   GEN
2675  F3FC  41 44 44 42           FCC   'ADDB'
2676  F400  CB                    FCB   $CB
2677  F401  03                    FCB   GEN
2678  F402  41 44 44 44           FCC   'ADDD'
2679  F406  C3                    FCB   $C3
2680  F407  08                    FCB   LIMM
2681  F408  41 4E 44 41           FCC   'ANDA'
2682  F40C  84                    FCB   $84
2683  F40D  03                    FCB   GEN
2684  F40E  41 4E 44 42           FCC   'ANDB'
2685  F412  C4                    FCB   $C4
2686  F413  03                    FCB   GEN
2687  F414  41 53 4C 20           FCC   'ASL '
2688  F418  68                    FCB   $68
2689  F419  04                    FCB   GRP2
2690  F41A  41 53 4C 41           FCC   'ASLA'
2691  F41E  48                    FCB   $48
2692  F41F  01                    FCB   INH
```

```
2693  F420  41 53 4C 42      FCC   'ASLB'
2694  F424  58               FCB   $58
2695  F425  01               FCB   INH
2696  F426  41 53 4C 44      FCC   'ASLD'
2697  F42A  05               FCB   $05
2698  F42B  01               FCB   INH
2699  F42C  41 53 52 20      FCC   'ASR '
2700  F430  67               FCB   $67
2701  F431  04               FCB   GRP2
2702  F432  41 53 52 41      FCC   'ASRA'
2703  F436  47               FCB   $47
2704  F437  01               FCB   INH
2705  F438  41 53 52 42      FCC   'ASRB'
2706  F43C  57               FCB   $57
2707  F43D  01               FCB   INH
2708  F43E  42 43 43 20      FCC   'BCC '
2709  F442  24               FCB   $24
2710  F443  05               FCB   REL
2711  F444  42 43 4C 52      FCC   'BCLR'
2712  F448  1D               FCB   $1D
2713  F449  1F               FCB   SETCLR
2714  F44A  42 43 53 20      FCC   'BCS '
2715  F44E  25               FCB   $25
2716  F44F  05               FCB   REL
2717  F450  42 45 51 20      FCC   'BEQ '
2718  F454  27               FCB   $27
2719  F455  05               FCB   REL
2720  F456  42 47 45 20      FCC   'BGE '
2721  F45A  2C               FCB   $2C
2722  F45B  05               FCB   REL
2723  F45C  42 47 54 20      FCC   'BGT '
2724  F460  2E               FCB   $2E
2725  F461  05               FCB   REL
2726  F462  42 48 49 20      FCC   'BHI '
2727  F466  22               FCB   $22
2728  F467  05               FCB   REL
2729  F468  42 48 53 20      FCC   'BHS '
2730  F46C  24               FCB   $24
2731  F46D  05               FCB   REL
2732  F46E  42 49 54 41      FCC   'BITA'
2733  F472  85               FCB   $85
2734  F473  03               FCB   GEN
2735  F474  42 49 54 42      FCC   'BITB'
2736  F478  C5               FCB   $C5
2737  F479  03               FCB   GEN
2738  F47A  42 4C 45 20      FCC   'BLE '
2739  F47E  2F               FCB   $2F
2740  F47F  05               FCB   REL
2741  F480  42 4C 4F 20      FCC   'BLO '
2742  F484  25               FCB   $25
2743  F485  05               FCB   REL
```

```
2744  F486  42 4C 53 20        FCC   'BLS '
2745  F48A  23                 FCB   $23
2746  F48B  05                 FCB   REL
2747  F48C  42 4C 54 20        FCC   'BLT '
2748  F490  2D                 FCB   $2D
2749  F491  05                 FCB   REL
2750  F492  42 4D 49 20        FCC   'BMI '
2751  F496  2B                 FCB   $2B
2752  F497  05                 FCB   REL
2753  F498  42 4E 45 20        FCC   'BNE '
2754  F49C  26                 FCB   $26
2755  F49D  05                 FCB   REL
2756  F49E  42 50 4C 20        FCC   'BPL '
2757  F4A2  2A                 FCB   $2A
2758  F4A3  05                 FCB   REL
2759  F4A4  42 52 41 20        FCC   'BRA '
2760  F4A8  20                 FCB   $20
2761  F4A9  05                 FCB   REL
2762  F4AA  42 52 43 4C        FCC   'BRCL'      (BRCLR)
2763  F4AE  1F                 FCB   $1F
2764  F4AF  13                 FCB   BTB
2765  F4B0  42 52 4E 20        FCC   'BRN '
2766  F4B4  21                 FCB   $21
2767  F4B5  05                 FCB   REL
2768  F4B6  42 52 53 45        FCC   'BRSE'      (BRSET)
2769  F4BA  1E                 FCB   $1E
2770  F4BB  13                 FCB   BTB
2771  F4BC  42 53 45 54        FCC   'BSET'
2772  F4C0  1C                 FCB   $1C
2773  F4C1  14                 FCB   SETCLR
2774  F4C2  42 53 52 20        FCC   'BSR '
2775  F4C6  8D                 FCB   $8D
2776  F4C7  05                 FCB   REL
2777  F4C8  42 56 43 20        FCC   'BVC '
2778  F4CC  28                 FCB   $28
2779  F4CD  05                 FCB   REL
2780  F4CE  42 56 53 20        FCC   'BVS '
2781  F4D2  29                 FCB   $29
2782  F4D3  05                 FCB   REL
2783  F4D4  43 42 41 20        FCC   'CBA '
2784  F4D8  11                 FCB   $11
2785  F4D9  01                 FCB   INH
2786  F4DA  43 4C 42 20        FCC   'CLC '
2787  F4DE  0C                 FCB   $0C
2788  F4DF  01                 FCB   INH
2789  F4E0  43 4C 49 20        FCC   'CLI '
2790  F4E4  0E                 FCB   $0E
2791  F4E5  01                 FCB   INH
2792  F4E6  43 4C 52 20        FCC   'CLR '
2793  F4EA  6F                 FCB   $6F
2794  F4EB  04                 FCB   GRP2
```

```
2795  F4EC  43 4C 52 41      FCC   'CLRA'
2796  F4F0  4F               FCB   $4F
2797  F4F1  01               FCB   INH
2798  F4F2  43 4C 52 42      FCC   'CLRB'
2799  F4F6  5F               FCB   $5F
2800  F4F7  01               FCB   INH
2801  F4F8  43 4C 56 20      FCC   'CLV '
2802  F4FC  0A               FCB   $0A
2803  F4FD  01               FCB   INH
2804  F4FE  43 4D 50 41      FCC   'CMPA'
2805  F502  81               FCB   $81
2806  F503  03               FCB   GEN
2807  F504  43 4D 50 42      FCC   'CMPB'
2808  F508  C1               FCB   $C1
2809  F509  03               FCB   GEN
2810  F50A  43 4F 4D 20      FCC   'COM '
2811  F50E  63               FCB   $63
2812  F50F  04               FCB   GRP2
2813  F510  43 4F 4D 41      FCC   'COMA'
2814  F514  43               FCB   $43
2815  F515  01               FCB   INH
2816  F516  43 4F 4D 42      FCC   'COMB'
2817  F51A  53               FCB   $53
2818  F51B  01               FCB   INH
2819  F51C  43 50 44 20      FCC   'CPD '
2820  F520  83               FCB   $83
2821  F521  15               FCB   CPD
2822  F522  43 50 58 20      FCC   'CPX '
2823  F526  8C               FCB   $8C
2824  F527  09               FCB   XLIMM
2825  F528  43 50 59 20      FCC   'CPY '
2826  F52C  8C               FCB   $8C
2827  F52D  11               FCB   YLIMM
2828  F52E  44 41 41 20      FCC   'DAA '
2829  F532  19               FCB   $19
2830  F533  01               FCB   INH
2831  F534  44 45 43 20      FCC   'DEC '
2832  F538  6A               FCB   $6A
2833  F539  04               FCB   GRP2
2834  F53A  44 45 43 41      FCC   'DECA'
2835  F53E  4A               FCB   $4A
2836  F53F  01               FCB   INH
2837  F540  44 45 42 42      FCC   'DECB'
2838  F544  5A               FCB   $5A
2839  F545  01               FCB   INH
2840  F546  44 45 53 20      FCC   'DES '
2841  F54A  34               FCB   $34
2842  F54B  01               FCB   INH
2843  F54C  44 45 58 20      FCC   'DEX '
2844  F550  09               FCB   $09
2845  F551  01               FCB   INH
```

```
2846  F552  44 45 59 20      FCC   'DEY '
2847  F556  09               FCB   $09
2848  F557  02               FCB   P2INH
2849  F558  45 4F 52 41      FCC   'EORA'
2850  F55C  88               FCB   $88
2851  F55D  03               FCB   GEN
2852  F55E  45 4F 52 42      FCC   'EORB'
2853  F562  C8               FCB   $C8
2854  F563  03               FCB   GEN
2855  F564  46 44 49 56      FCC   'FDIV'
2856  F568  03               FCB   $03
2857  F569  01               FCB   INH
2858  F56A  49 44 49 56      FCC   'IDIV'
2859  F56E  02               FCB   $02
2860  F56F  01               FCB   INH
2861  F570  49 4E 43 20      FCC   'INC '
2862  F574  6C               FCB   $6C
2863  F575  04               FCB   GRP2
2864  F576  49 4E 43 41      FCC   'INCA'
2865  F57A  4C               FCB   $4C
2866  F57B  01               FCB   INH
2867  F57C  49 4E 43 42      FCC   'INCB'
2868  F580  5C               FCB   $5C
2869  F581  01               FCB   INH
2870  F582  49 4E 53 20      FCC   'INS '
2871  F586  31               FCB   $31
2872  F587  01               FCB   INH
2873  F588  49 4E 58 20      FCC   'INX '
2874  F58C  08               FCB   $08
2875  F58D  01               FCB   INH
2876  F58E  49 4E 59 20      FCC   'INY '
2877  F592  08               FCB   $08
2878  F593  02               FCB   P2INH
2879  F594  4A 4D 50 20      FCC   'JMP '
2880  F598  6E               FCB   $6E
2881  F599  04               FCB   GRP2
2882  F59A  4A 53 52 20      FCC   'JSR '
2883  F59E  8D               FCB   $8D
2884  F59F  07               FCB   NIMM
2885  F5A0  4C 44 41 41      FCC   'LDAA'
2886  F5A4  86               FCB   $86
2887  F5A5  03               FCB   GEN
2888  F5A6  4C 44 41 42      FCC   'LDAB'
2889  F5AA  C6               FCB   $C6
2890  F5AB  03               FCB   GEN
2891  F5AC  4C 44 44 20      FCC   'LDD '
2892  F5B0  CC               FCB   $CC
2893  F5B1  08               FCB   LIMM
2894  F5B2  4C 44 53 20      FCC   'LDS '
2895  F5B6  8E               FCB   $8E
2896  F5B7  08               FCB   LIMM
```

```
2897  F5B8  4C 44 58 20     FCC   'LDX '
2898  F5BC  CE              FCB   $CE
2899  F5BD  09              FCB   XLIMM
2900  F5BE  4C 44 59 20     FCC   'LDY '
2901  F5C2  CE              FCB   $CE
2902  F5C3  11              FCB   YLIMM
2903  F5C4  4C 53 4C 20     FCC   'LSL '
2904  F5C8  68              FCB   $68
2905  F5C9  04              FCB   GRP2
2906  F5CA  4C 53 4C 41     FCC   'LSLA'
2907  F5CE  48              FCB   $48
2908  F5CF  01              FCB   INH
2909  F5D0  4C 53 4C 42     FCC   'LSLB'
2910  F5D4  58              FCB   $58
2911  F5D5  01              FCB   INH
2912  F5D6  4C 53 4C 44     FCC   'LSLD'
2913  F5DA  05              FCB   $05
2914  F5DB  01              FCB   INH
2915  F5DC  4C 53 52 20     FCC   'LSR '
2916  F5E0  64              FCB   $64
2917  F5E1  04              FCB   GRP2
2918  F5E2  4C 53 52 41     FCC   'LSRA'
2919  F5E6  44              FCB   $44
2920  F5E7  01              FCB   INH
2921  F5E8  4C 53 52 42     FCC   'LSRB'
2922  F5EC  54              FCB   $54
2923  F5ED  01              FCB   INH
2924  F5EE  4C 53 53 44     FCC   'LSRD'
2925  F5F2  04              FCB   $04
2926  F5F3  01              FCB   INH
2927  F5F4  4D 55 4C 20     FCC   'MUL '
2928  F5F8  3D              FCB   $3D
2929  F5F9  01              FCB   INH
2930  F5FA  4E 45 47 20     FCC   'NEG '
2931  F5FE  60              FCB   $60
2932  F5FF  04              FCB   GRP2
2933  F600  4E 45 47 41     FCC   'NEGA'
2934  F604  40              FCB   $40
2935  F605  01              FCB   INH
2936  F606  4E 45 47 42     FCC   'NEGB'
2937  F60A  50              FCB   $50
2938  F60B  01              FCB   INH
2939  F60C  4E 4F 50 20     FCC   'NOP '
2940  F610  01              FCB   $01
2941  F611  01              FCB   INH
2942  F612  4F 52 41 41     FCC   'ORAA'
2943  F616  8A              FCB   $8A
2944  F617  03              FCB   GEN
2945  F618  4F 52 41 42     FCC   'ORAB'
2946  F61C  CA              FCB   $CA
2947  F61D  03              FCB   GEN
```

```
2948  F61E  50 53 48 41     FCC   'PSHA'
2949  F622  36              FCB   $36
2950  F623  01              FCB   INH
2951  F624  50 53 48 42     FCC   'PSHB'
2952  F628  37              FCB   $37
2953  F629  01              FCB   INH
2954  F62A  50 53 48 58     FCC   'PSHX'
2955  F62E  3C              FCB   $3C
2956  F62F  01              FCB   INH
2957  F630  50 53 48 59     FCC   'PSHY'
2958  F634  3C              FCB   $3C
2959  F635  02              FCB   P2INH
2960  F636  50 55 4C 41     FCC   'PULA'
2961  F63A  32              FCB   $32
2962  F63B  01              FCB   INH
2963  F63C  50 55 4C 42     FCC   'PULB'
2964  F640  33              FCB   $33
2965  F641  01              FCB   INH
2966  F642  50 55 4C 58     FCC   'PULX'
2967  F646  38              FCB   $38
2968  F647  01              FCB   INH
2969  F648  50 55 4C 59     FCC   'PULY'
2970  F64C  38              FCB   $38
2971  F64D  02              FCB   P2INH
2972  F64E  52 4F 4C 20     FCC   'ROL '
2973  F652  69              FCB   $69
2974  F653  04              FCB   GRP2
2975  F654  52 4F 4C 41     FCC   'ROLA'
2976  F658  49              FCB   $49
2977  F659  01              FCB   INH
2978  F65A  52 4F 4C 42     FCC   'ROLB'
2979  F65E  59              FCB   $59
2980  F65F  01              FCB   INH
2981  F660  52 4F 52 20     FCC   'ROR '
2982  F664  66              FCB   $66
2983  F665  04              FCB   GRP2
2984  F666  52 4F 52 41     FCC   'RORA'
2985  F66A  46              FCB   $46
2986  F66B  01              FCB   INH
2987  F66C  52 4F 52 42     FCC   'RORB'
2988  F670  56              FCB   $56
2989  F671  01              FCB   INH
2990  F672  52 54 49 20     FCC   'RTI '
2991  F676  3B              FCB   $3B
2992  F677  01              FCB   INH
2993  F678  52 54 53 20     FCC   'RTS '
2994  F67C  39              FCB   $39
2995  F67D  01              FCB   INH
2996  F67E  53 42 41 20     FCC   'SBA '
2997  F682  10              FCB   $10
2998  F683  01              FCB   INH
```

```
2999  F684  53 42 43 41     FCC  'SBCA'
3000  F688  82              FCB  $82
3001  F689  03              FCB  GEN
3002  F68A  53 42 43 42     FCC  'SBCB'
3003  F68E  C2              FCB  $C2
3004  F68F  03              FCB  GEN
3005  F690  53 45 43 20     FCC  'SEC '
3006  F694  0D              FCB  $0D
3007  F695  01              FCB  INH
3008  F696  53 45 49 20     FCC  'SEI '
3009  F69A  0F              FCB  $0F
3010  F69B  01              FCB  INH
3011  F69C  53 45 56 20     FCC  'SEV '
3012  F6A0  0B              FCB  $0B
3013  F6A1  01              FCB  INH
3014  F6A2  53 54 41 41     FCC  'STAA'
3015  F6A6  87              FCB  $87
3016  F687  07              FCB  NIMM
3017  F6A8  53 54 41 42     FCC  'STAB'
3018  F6AC  C7              FCB  $C7
3019  F6AD  07              FCB  NIMM
3020  F6AE  53 54 44 20     FCC  'STD '
3021  F6B2  CD              FCB  $CD
3022  F6B3  07              FCB  NIMM
3023  F6B4  53 54 4F 50     FCC  'STOP'
3024  F6B8  CF              FCB  $CF
3025  F6B9  01              FCB  INH
3026  F6BA  53 54 53 20     FCC  'STS '
3027  F6BE  BF              FCB  $8F
3028  F6BF  07              FCB  NIMM
3029  F6C0  53 54 58 20     FCC  'STX '
3030  F6C4  CF              FCB  $CF
3031  F6C5  10              FCB  XNIMM
3032  F6C6  53 54 59 20     FCC  'STY '
3033  F6CA  CF              FCB  $CF
3034  F6CB  12              FCB  YNIMM
3035  F6CC  53 55 42 41     FCC  'SUBA'
3036  F6D0  80              FCB  $80
3037  F6D1  03              FCB  GEN
3038  F6D2  53 55 42 42     FCC  'SUBB'
3039  F6D6  C0              FCB  $C0
3040  F6D7  03              FCB  GEN
3041  F6D8  53 55 42 44     FCC  'SUBD'
3042  F6DC  83              FCB  $83
3043  F6DD  08              FCB  LIMM
3044  F6DE  53 57 49 20     FCC  'SWI '
3045  F6E2  3F              FCB  $3F
3046  F6E3  01              FCB  INH
3047  F6E4  54 41 42 20     FCC  'TAB '
3048  F6E8  16              FCB  $16
3049  F6E9  01              FCB  INH
```

```
3050  F6EA  54 41 50 20      FCC   'TAP '
3051  F6EE  06               FCB   $06
3052  F6EF  01               FCB   INH
3053  F6F0  54 42 41 20      FCC   'TBA '
3054  F6F4  17               FCB   $17
3055  F6F5  01               FCB   INH
3056  F6F6  54 50 41 20      FCC   'TPA '
3057  F6FA  07               FCB   $07
3058  F6FB  01               FCB   INH
3059  F6FC  54 45 53 54      FCC   'TEST'
3060  F700  00               FCB   $00
3061  F701  01               FCB   INH
3062  F702  54 53 54 20      FCC   'TST '
3063  F706  6D               FCB   $6D
3064  F707  04               FCB   GRP2
3065  F708  54 53 54 41      FCC   'TSTA'
3066  F70C  4D               FCB   $4D
3067  F70D  01               FCB   INH
3068  F70E  54 53 54 42      FCC   'TSTB'
3069  F712  5D               FCB   $5D
3070  F713  01               FCB   INH
3071  F714  54 53 58 20      FCC   'TSX '
3072  F718  30               FCB   $30
3073  F719  01               FCB   INH
3074  F71A  54 53 59 20      FCC   'TSY '
3075  F71E  30               FCB   $30
3076  F71F  02               FCB   P2INH
3077  F720  54 58 53 20      FCC   'TXS '
3078  F724  35               FCB   $35
3079  F725  01               FCB   INH
3080  F726  54 59 53 20      FCC   'TYS '
3081  F72A  35               FCB   $35
3082  F72B  02               FCB   P2INH
3083  F72C  57 41 49 20      FCC   'WAI '
3084  F730  3E               FCB   $3E
3085  F731  01               FCB   INH
3086  F732  58 47 44 58      FCC   'XGDX'
3087  F736  8F               FCB   $8F
3088  F737  01               FCB   INH
3089  F738  58 47 44 59      FCC   'XGDY'
3090  F73C  8F               FCB   $8F
3091  F73D  02               FCB   P2INH
3092  F73E  42 52 53 45      FCC   'BRSE'     bit direct modes for
3093  F742  12               FCB   $12        disassembler.
3094  F743  16               FCB   BTBD
3095  F744  42 52 43 4C      FCC   'BRCL'
3096  F748  13               FCB   $13
3097  F749  16               FCB   BTBD
3098  F74A  42 53 45 54      FCC   'BSET'
3099  F74E  14               FCB   $14
```

```
3100  F74F  17                FCB   SETCLRD
3101  F750  42 43 4C 52       FCC   'BCLR'
3102  F754  15                FCB   $15
3103  F755  17                FCB   SETCLRD
3104  F756  04                FCB   EOT          End of table
3105
3106                ***********************************************
3107  0000          PG1       EQU                $0
3108  0001          PG2       EQU                $1
3109  0002          PG3       EQU                $2
3110  0003          PG4       EQU                $3
3111
3112                ***********************************************
3113                *disassem() - disassemble the opcode.
3114                ***********************************************
3115
3116  F757  DE 83   DISASSM   LDX   PC           address
3117  F759  A6 00             LDAA  0,X          opcode
3118  F75B  C6 00             LDAB  #PG1
3119  F75D  81 18             CMPA  #$18
3120  F75F  27 0A             BEQ   DISP2        jump if page2
3121  F761  81 1A             CMPA  #$1A
3122  F763  27 05             BEQ   DISP3        jump if page3
3123  F765  81 CD             CMPA  #$CD
3124  F767  26 04             BNE   DISP1        jump if not page4
3125  F769  5C        DISP4   INCB               set up page value
3126  576A  5C        DISP3   INCB
3127  F76B  5C        DISP2   INCB
3128  F76C  08                INX
3129  F76D  DF 89     DISP1   STX   DISPC        point to opcode
3130  F76F  D7 94             STAB  PNORM        save page
3131  F771  A6 00             LDAA  0,X          get current opcode
3132  F773  97 87             STAA  BASEOP
3133  F775  08                INX
3134  F776  DF 89             STX   DISPC        point to next byte
3135  F778  81 5F             CMPA  #$5F
3136  F77A  23 0F             BLS   DIS1         jump if in range
3137  F77C  81 8D             CMPA  #$8D
3138  F77E  27 0B             BEQ   DIS1         jump if bsr
3139  F780  81 8F             CMPA  #$8F
3140  F782  27 07             BEQ   DIS1         jump if xgdx
3141  F784  81 CF             CMPA  #$CF
3142  F786  27 03             BEQ   DIS1         jump if stop
3143  F788  7E F8 22          JMP   DISGRP       try next part of map
3144  F78B  D6 94     DIS1    LDAB  PNORM
3145  F78D  C1 02             CMPB  #PG3
3146  F78F  25 04             BLO   DIS2         jump if page 1 or 2
3147  F791  BD F9 E2          JSR   DISILLOP     "illegal opcode"
3148  F794  39                RTS
3149  F795  D6 87     DIS2    LDAB  BASEOP       opcode
3150  F797  5F                CLRB               class=null
```

```
3151  F798  BD F9 11        JSR   DISRCH
3152  F79B  5D              TSTB
3153  F79C  26 04           BNE   DISPEC      jump if opcode found
3154  F79E  BD F9 E2        JSR   DISILLOP    "illegal opcode"
3155  F7A1  39              RTS
3156  F7A2  96 87   DISPEC  LDAA  BASEOP
3157  F7A4  81 8D           CMPA  #$8D
3158  F7A6  26 04           BNE   DISPEC1
3159  F7A8  C6 05           LDAB  #REL
3160  F7AA  20 0A           BRA   DISPEC3     look for BSR opcode
3161  F7AC  81 8F   DISPEC1 CMPA  #$8F
3162  F7AE  27 04           BEQ   DISPEC2     jump if XGDX opcode
3163  F7B0  81 CF           CMPA  #$CF
3164  F7B2  26 05           BNE   DISINH      jump not STOP opcode
3165  F7B4  C6 01   DISPEC2 LDAB  #INH
3166  F7B6  BD F9 11 DISPEC3 JSR   DISRCH     find other entry in table
3167  F7B9  D6 88   DISINH  LDAB  CLASS
3168  F7BB  C1 01           CMPB  #INH
3169  F7BD  26 18           BNE   DISREL      jump if not inherent
3170  F7BF  D6 94           LDAB  PNORM
3171  F7C1  C1 00           CMPB  #PG1
3172  F7C3  27 0E           BEQ   DISINH1     jump if page1
3173  F7C5  96 87           LDAA  BASEOP      get opcode
3174  F7C7  C6 02           LDAB  #P2INH      class=p2inh
3175  F7C9  BD F9 11        JSR   DISRCH
3176  F7CC  5D              TSTB
3177  F7CD  26 04           BNE   DISINH1     jump if found
3178  F7CF  BD F9 E2        JSR   DISILLOP    "illegal opcode"
3179  F7D2  39              RTS
3180  F7D3  BD F9 34 DISINH1 JSR  PRNTMNE
3181  F7D6  39              RTS
3182  F7D7  D6 88   DISREL  LDAB  CLASS
3183  F7D9  C1 05           CMPB  #REL
3184  F7DB  26 10           BNE   DISBTD
3185  F7DD  7D 00 94        TST   PNORM
3186  F7E0  27 04           BEQ   DISREL1     jump if page1
3187  F7E2  BD F9 E2        JSR   DISILLOP    "illegal opcode"
3188  F7E5  39              RTS
3189  F7E6  BD F9 34 DISREL1 JSR  PRNTMNE     output mnemonic
3190  F7E9  BD F9 6D        JSR   DISRELAD    compute relative address
3191  F7EC  39              RTS
3192
3193  F7ED  D6 88   DISBTD  LDAB  CLASS
3194  F7EF  C1 17           CMPB  #SETCLRD
3195  F7F1  27 04           BEQ   DISBTD1
3196  F7F3  C1 16           CMPB  #BTBD
3197  F7F5  26 11           BNE   DISBIT      jump not direct bitop
3198  F7F7  7D 00 94 DISBTD1 TST  PNORM
3199  F7FA  27 04           BEQ   DISBTD2     jump if page 1
3200  F7FC  BD F9 E2        JSR   DISILLOP
3201  F7FF  39              RTS
```

```
3202  F800  BD F9 34  DISBTD2  JSR   PRNTMNE
3203  F803  BD F9 C2           JSR   DISDIR    operand(direct)
3204  F806  20 06              BRA   DISBIT1
3205  F808  BD F9 34  DISBIT   JSR   PRNTMNE
3206  F80B  BD F9 51           JSR   DISINDX   operand(indexed)
3207  F80E  BD E4 21  DISBIT1  JSR   OUTSPAC
3208  F811  BD F9 C2           JSR   DISDIR    mask
3209  F814  D6 88              LDAB  CLASS
3210  F816  C1 13              CMPB  #BTB
3211  F818  27 04              BEQ   DISBIT2   jump if btb
3212  F81A  C1 16              CMPB  #BTBD
3213  F81C  26 03              BNE   DISBIT3   jump if not bit branch
3214  F81E  BD F9 6D  DISBIT2  JSR   DISRELAD  relative address
3215  F821  39        DISBIT3  RTS
3216  F822  81 7F     DISGRP   CMPA  #$7F      a=opcode
3217  F824  22 30              BHI   DISNEXT   try next part of map
3218  F826  D6 94              LDAB  PNORM
3219  F828  C1 02              CMPB  #PG3
3220  F82A  25 04              BLO   DISGRP2   jump if page 1 or 2
3221  F82C  BD F9 E2           JSR   DISILLOP  "illegal opcode"
3222  F82F  39                 RTS
3223  F830  84 6F     DISGRP2  ANDA  #$6F      mask bit 4
3224  F832  5F                 CLRB            class=null
3225  F833  BD F9 11           JSR   DISRCH
3226  F836  5D                 TSTB
3227  F837  26 04              BNE   DISGRP3   jump if found
3228  F839  BD F9 E2           JSR   DISILLOP  "illegal opcode"
3229  F83C  39                 RTS
3230  F83D  BD F9 34  DISGRP3  JSR   PRNTMNE
3231  F840  96 87              LDAA  BASEOP    get opcode
3232  F842  84 F0              ANDA  #$F0
3233  F844  81 60              CMPA  #$60
3234  F846  26 07              BNE   DISGRP4   jump if not 6x
3235  F848  BD F9 51           JSR   DISINDX   operand(indexed)
3236  F84B  BD E4 21           JSR   OUTSPAC   format
3237  F84E  39                 RTS
3238  F84F  BD F9 CF  DISGRP4  JSR   DISEXT    operand(extended)
3239  F852  BD E4 21           JSR   OUTSPAC   format
3240  F855  39                 RTS
3241  F856  81 87     DISNEXT  CMPA  #$87      a=opcode
3242  F858  27 04              BEQ   DISNEX1
3243  F85A  81 C7              CMPA  #$C7
3244  F85C  26 04              BNE   DISNEX2
3245  F85E  BD F9 E2  DISNEX1  JSR   DISILLOP  "illegal opcode"
3246  F861  39                 RTS
3247  F862  84 CF     DISNEX2  ANDA  #$CF
3248  F864  5F                 CLRB            class=null
3249  F865  BD F9 11           JSR   DISRCH
3250  F868  5D                 TSTB
3251  F869  26 04              BNE   DISNEW    jump if mne found
3252  F86B  BD F9 E2           JSR   DISILLOP  "illegal opcode"
```

```
3253  F86E  39           RTS
3254  F86F  96 87  DISNEW  LDAA  BASEOP
3255  F871  84 CF         ANDA  #$CF
3256  F873  81 8D         CMPA  #$8D
3257  F875  26 04         BNE   DISNEW1   jump not jsr
3258  F877  C6 07         LDAB  #NIMM
3259  F879  20 16         BRA   DISNEW4
3260  F87B  81 8F  DISNEW1 CMPA  #$8F
3261  F87D  26 04         BNE   DISNEW2   jump not sts
3262  F87F  C6 07         LDAB  #NIMM
3263  F881  20 0E         BRA   DISNEW4
3264  F883  81 CF  DISNEW2 CMPA  #$CF
3265  F885  26 04         BNE   DISNEW3   jump not stx
3266  F887  C6 10         LDAB  #XNIMM
3267  F889  20 06         BRA   DISNEW4
3268  F88B  81 83  DISNEW3 CMPA  #$83
3269  F88D  26 0C         BNE   DISGEN    jump not subd
3270  F88F  C6 08         LDAB  #LIMM
3271  F891  BD F9 11 DISNEW4 JSR   DISRCH
3272  F894  5D           TSTB
3273  F895  26 04         BNE   DISGEN    jump if found
3274  F897  BD F9 E2      JSR   DISILLOP  "illegal opcode"
3275  F89A  39           RTS
3276  F89B  D6 88  DISGEN  LDAB  CLASS     get class
3277  F89D  C1 03         CMPB  #GEN
3278  F89F  27 08         BEQ   DISGEN1
3279  F8A1  C1 07         CMPB  #NIMM
3280  F8A3  27 04         BEQ   DISGEN1
3281  F8A5  C1 08         CMPB  #LIMM
3282  F8A7  26 31         BNE   DISXLN    jump if other class
3283  F8A9  96 87  DISGEN1 LDAA  BASEOP
3284  F8AB  84 CF         ANDA  #$CF
3285  F8AD  81 83         CMPA  #$83
3286  F8AF  26 0F         BNE   DISGEN3   jump if not #$83
3287  F8B1  D6 94         LDAB  PNORM
3288  F8B3  C1 02         CMPB  #PG3
3289  F8B5  25 09         BLO   DISGEN3   jump not pg3 or 4
3290  F8B7  C6 15         LDAB  #CPD
3291  F8B9  BD F9 11      JSR   DISRCH    look for cpd mne
3292  F8BC  C6 08         LDAB  #LIMM
3293  F8BE  D7 88         STAB  CLASS     set class to limm
3294  F8C0  D6 94  DISGEN3 LDAB  PNORM
3295  F8C2  C1 01         CMPB  #PG2
3296  F8C4  27 04         BEQ   DISGEN4   jump if page 2
3297  F8C6  C1 03         CMPB  #PG4
3298  F8C8  26 0C         BNE   #DISGEN5  jump not page 2 or 4
3299  F8CA  96 87  DISGEN4 LDAA  BASEOP
3300  F8CC  84 B0         ANDA  #$B0      mask bits 6,3-0
3301  F8CE  81 A0         CMPA  #$A0
3302  F8D0  27 04         BEQ   DISGEN5   jump if $Ax or $Ex
3303  F8D2  BD F9 E2      JSR   DISILLOP  "illegal opcode"
```

```
3304  F8D5  39              RTS
3305  F8D6  BD F9 8C DISGEN5  JSR   DISGENRL  process general class
3306  F8D9  39              RTS
3307  F8DA  D6 94    DISXLN   LDAB  PNORM
3308  F8DC  C1 01            CMPB  #PG2
3309  F8DE  27 04            BEQ   DISXLN1   jump if page2
3310  F8E0  C1 02            CMPB  #PG3
3311  F8E2  26 13            BNE   DISXLN4   jump not page3
3312  F8E4  96 87    DISXLN1  LDAA  BASEOP
3313  F8E6  84 CF            ANDA  #$CF
3314  F8E8  D6 88            LDAB  CLASS
3315  F8EA  C1 09            CMPB  #XLIMM
3316  F8EC  26 04            BNE   DISXLN2
3317  F8EE  C6 11            LDAB  #YLIMM
3318  F8F0  20 02            BRA   DISXLN3   look for ylimm
3319  F8F2  C6 12    DISXLN2  LDAB  #YNIMM   look for ynimm
3320  F8F4  BD F9 11 DISXLN3  JSR   DISRCH
3321  F8F7  D6 94    DISXLN4  LDAB  PNORM
3322  F8F9  C1 02            CMPB  #PG3
3323  F8FB  25 0C            BLO   DISXLN5   jump if page 1 or 2
3324  F8FD  96 87            LDAA  BASEOP    get opcode
3325  F8FF  84 B0            ANDA  #$B0      mask bits 6,3-0
3326  F901  81 A0            CMPA  #$A0
3327  F903  27 04            BEQ   DISXLN5   jump opcode = $Ax or $Ex
3328  F905  BD F9 E2         JSR   DISILLOP  "illegal opcode"
3329  F908  39              RTS
3330  F909  C6 08    DISXLN5  LDAB  #LIMM
3331  F90B  D7 88            STAB  CLASS
3332  F90D  BD F9 8C         JSR   DISGENRL  process general class
3333  F910  39              RTS
334
3335                 ****************************
3336                 *disrch(a=opcode,b=class)
3337                 *return b=0 if not found
3338                 *  else mneptr=points to mnemonic
3339                 *       class=class of opcode
3340                 ****************************
3341
3342  F911  CE F3 D8 DISRCH   LDX   #MNETABL  point to top of table
3343  F914  A1 04    DISRCH1  CMPA  4,X       test opcode
3344  F916  26 0F            BNE   DISRCH3   jump not this entry
3345  F918  5D              TSTB
3346  F919  27 04            BEQ   DISRCH2   jump if class=null
3347  F91B  E1 05            CMPB  5,X       test class
3348  F91D  26 08            BNE   DISRCH3   jump not this entry
3349  F91F  E6 05    DISRCH2  LDAB  5,X
3350  F921  D7 88            STAB  CLASS
3351  F923  DF 8D            STX   MNEPTR    return ptr to mnemonic
3352  F925  5C              INCB
3353  F926  39              RTS             return found
3354  F927  37       DISRCH3  PSHB           save class
```

```
3355  F928  C6 06                LDAB #6
3356  F92A  3A                   ABX
3357  F92B  E6 00                LDAB  0,X
3358  F92D  C1 04                CMPB  #EOT          test end of table
3359  F92F  33                   PULB
3360  F930  26 E2                BNE  DISRCH1
3361  F932  5F                   CLRB
3362  F933  39                   RTS                 return not found
3363
3364                    ************************************
3365                    *prntmne() - output the mnemonic pointed
3366                    *at by mneptr.
3367                    ************************************
3368  F934  DE 8D       PRNTMNE   LDX   MNEPTR
3369  F936  A6 00                LDAA  0,X
3370  F938  BD E1 76             JSR   OUTPUT        output char1
3371  F93B  A6 01                LDAA  1,X
3372  F93D  BD E1 76             JSR   OUTPUT        output char2
3373  F940  A6 02                LDAA  2,X
3374  F942  BD E1 76             JSR   OUTPUT        output char3
3375  F945  A6 03                LDAA  3,X
3376  F947  BD E1 76             JSR   OUTPUT        output char4
3377  F94A  BD E4 21             JSR   OUTSPAC
3378  F94D  BD E4 21             JSR   OUTSPAC
3379  F950  39                   RTS
3380
3381                    ****************************
3382                    *disindx() - process indexed mode
3383                    ****************************
3384
3385  F951  BD F9 C2    DISINDX   JSR   DISDIR        output $byte
3386  F954  86 2C                LDAA  #','
3387  F956  BD E4 0B             JSR   OUTA          output ,
3388  F959  D6 94                LDAB  PNORM
3389  F95B  C1 01                CMPB  #PG2
3390  F95D  27 04                BEQ   DISIND1       jump if page2
3391  F95F  C1 03                CMPB  #PG4
3392  F961  26 04                BNE   DISIND2       jump if not page4
3393  F963  86 59       DISIND1  LDAA  #'Y'
3394  F965  20 02                BRA   DISIND3
3395  F967  86 58       DISIND2  LDAA  #'X'
3396  F969  BD E4 0B    DISIND3  JSR   OUTA          output x or y
3397  F96C  39                   RTS
3398
3399                    ****************************************
3400                    *disrelad() - compute and output relative address.
3401                    ****************************************
3402
3403  F96D  DE 89       DISRELAD  LDX   DISPC
3404  F96F  E6 00                LDAB  0,X           get relative offset
3405  F971  08                   INX
```

```
3406  F972  DF 89          STX   DISPC
3407  F974  5D             TSTB
3408  F975  2B 03          BMI   DISRLD1     jump if negative
3409  F977  3A             ABX
3410  F978  20 04          BRA   DISRLD2
3411  F97A  09    DISRLD1  DEX
3412  F97B  5C             INCB
3413  F97C  26 FC          BNE   DISRLD1     subtract
3414  F97E  DF 8B  DISRLD2  STX   BRADDR      save address
3415  F980  86 24          LDAA  #'$'
3416  F982  BD E1 76       JSR   OUTPUT
3417  F985  CE 00 8B       LDX   #BRADDR
3418  F988  BD E4 1B       JSR   OUT2BSP     output address
3419  F98B  39             RTS
3420
3421                *********************************************
3422                *disgenrl() - output data for the general cases which
3423                *includes immediate, direct, indexed, and extended modes.
3424                *********************************************
3425
3426  F98C  BD F9 34  DISGENRL  JSR   PRNTMNE   print mnemonic
3427  F98F  96 87             LDAA  BASEOP     get opcode
3428  F991  84 B0             ANDA  #$B0       mask bits 6,3-0
3429  F993  81 80             CMPA  #$80
3430  F995  26 17             BNE   DISGRL2    jump if not immed
3431  F997  86 23             LDAA  #'#'       do immediate
3432  F999  BD E1 76          JSR   OUTPUT
3433  F99C  BD F9 C2          JSR   DISDIR
3434  F99F  D6 88             LDAB  CLASS
3435  F9A1  C1 08             CMPB  #LIMM
3436  F9A3  27 01             BEQ   DISGRL1    jump class = limm
3437  F9A5  39                RTS
3438  F9A6  DE 89   DISGRL1   LDX   DISPC
3439  F9A8  BD E4 0F          JSR   OUT1BYT
3440  F9AB  DF 89             STX   DISPC
3441  F9AD  39                RTS
3442  F9AE  81 90   DISGRL2   CMPA  #$90
3443  F9B0  26 04             BNE   DISGRL3    jump not direct
3444  F9B2  BD F9 C2          JSR   DISDIR     do direct
3445  F9B5  39                RTS
3446  F9B6  81 A0   DISGRL3   CMPA  #$A0
3447  F9B8  26 04             BNE   DISGRL4    jump not indexed
3448  F9BA  BD F9 51          JSR   DISINDX    do extended
3449  F9BD  39                RTS
3450  F9BE  BD F9 CF  DISGRL4   JSR   DISEXT     do extended
3451  F9C1  39                RTS
3452
3453                *************************
3454                *disdir() - output "$ next byte"
3455                *************************
3456
```

```
3457  F9C2  86 24       DISDIR      LDAA  #'$'
3458  F9C4  BD E4 0B                JSR   OUTA
3459  F9C7  DE 89                   LDX   DISPC
3460  F9C9  BD E4 0F                JSR   OUT1BYT
3461  F9CC  DF 89                   STX   DISPC
3462  F9CE  39                      RTS
3463
3464                    ****************************
3465                    *disext() - output "$ next 2 bytes"
3466                    ****************************
3467
3468  F9CF              DISEXT      EQU   *
3469  F9CF  86 24                   LDAA  #'$'
3470  F9D1  BD E4 0B                JSR   OUTA
3471  F9D4  DE 89                   LDX   DISPC
3472  F9D6  BD E4 1B                JSR   OUT2BSP
3473  F9D9  DF 89                   STX   DISPC
3474  F9DB  39                      RTS
3475
3476
3477                    ****************************
3478                    *disillop() - output "illegal opcode"
3479                    ****************************
3480
3481  F9DC  49 4C 4C 4FDISMSG1      FCC   'ILLOP'
3482  F9E1  04                      FCB   EOT
3483  F9E2              DISILLOP    EQU   *
3484  F9E2  3C                      PSHX
3485  F9E3  CE F9 DC                LDX   #DISMSG1
3486  F9E6  BD E2 08                JSR   OUTSTRG
3487  F9E9  38                      PULX
3488  F9EA  39                      RTS
3489                    * redefine variable names
3490  0090              ROWCNT      EQU   PTR7+1
3491  0081              COLCNT      EQU   PTR0
3492  0082              CHARVAL     EQU   PTR0+1
3493  0093              SCANLINE    EQU   TMP3
3494                    * This routine scans the keyboard and displays the contents of
3495                    *  of CHARBUFF on a crt. The display is 5 rows of 6 characters.
3496                    *  The ASCII value of the depressed key is returned in register A.
3497                    *  If an abort key is depressed then control is passed to MAIN.
3498
3499  F9EB  37          VIDEO       PSHB                  save regs this routine uses
3500  F9EC  3C                      PSHX
3501  F9ED  18 3C                   PSHY
3502                    * output the VSYNC pulse
3503  F9EF  B6 10 08    VIDEO1      LDAA  PORTD
3504  F9F2  84 DF                   ANDA  #SSLOW
3505  F9F4  B7 10 08                STAA  PORTD
3506  F9F7  CE 00 40                LDX   #64
3507  F9FA  09          VDELAY      DEX
```

```
3508  F9FB  26 FD                  BNE   VDELAY
3509  F9FD  8A 20                  ORAA  #SSHIGH
3510  F9FF  B7 10 08               STAA  PORTD          VSYNC pulse completed
3511              * READ THE KEYBOARD
3512  FA02  18 CE 00 2C            LDY   #BLKLINES      blank line counter
3513  FA06  7D 00 00               TST   VALIDKEY       check for good key
3514  FA09  27 37                  BEQ   MAIN1          no - then go to main1
3515              *check for no key or only shift key depressed (prevent repeating key)
3516  FA0B  B6 10 29               LDAA  SPSR
3517  FA0E  4F                     CLRA
3518  FA0F  B7 10 2A               STAA  SPDR           send good data; receive trash
3519  FA12  C6 0E                  LDAB  #14
3520  FA14  5A          DELAY10    DECB
3521  FA15  26 FD                  BNE   DELAY10
3522  FA17  05                     ASLD                 kill time
3523  FA18  05                     ASLD                 kill time
3524  FA19  BD E2 63               JSR   HORPULSE       also loads shift reg.
3525  FA1C  18 09                  DEY                  decrement blank line count
3526  FA1E  B6 10 29               LDAA  SPSR
3527  FA21  B7 10 2A               STAA  SPDR           send trash; receive good data
3528  FA24  3D                     MUL                  kill time for xmit
3529  FA25  05                     ASLD
3530  FA26  05                     ASLD
3531  FA27  B6 10 29               LDAA  SPSR
3532  FA2A  B6 10 2A               LDAA  SPDR           get data
3533  FA2D  B1 FF                  CMPA  #$FF           is a key still depressed?
3534  FA2F  27 03                  BEQ   NULL2          no- take branch
3535  FA31  7E FB 69               JMP   PREVID5        output frame,try next time
3536  FA34  7F 00 00     NULL2    CLR   VALIDKEY
3537  FA37  05                     ASLD                 equalize
3538  FA38  01                     NOP                  equalize
3539  FA39  02                     IDIV                 kill time
3540  FA3A  05                     ASLD                 kill time
3541  FA3B  BD E2 63               JSR   HORPULSE
3542  FA3E  18 09                  DEY                  decrement blank line count
3543  FA40  01                     NOP                  equalize
3544  FA41  01                     NOP                  equalize
3545  FA42  4F           MAIN1     CLRA
3546  FA43  97 90                  STAA  ROWCNT
3547  FA45  97 81                  STAA  COLCNT
3548  FA47  86 FE                  LDAA  #$FE           set up (A) for first pattern
3549  FA49  F6 10 29               LDAB  SPSR
3550  FA4C  B7 10 2A               STAA  SPDR           send first patt; rec garbage
3551  FA4F  0D                     SEC
3552  FA50  49                     ROLA                 set up (A) for next pattern
3553  FA51  C6 0C                  LDAB  #12
3554  FA53  5A           DELAY20   DECB
3555  FA54  26 FD                  BNE   DELAY20
3556  FA56  01                     NOP
3557  FA57  01                     NOP
```

```
3558  FA58  BD E2 63          JSR   HORPULSE
3559  FA5B  18 09             DEY                 decrement blank line count
3560  FA5D  CE 00 0D          LDX   #13
3561  FA60  09        DELAY30 DEX
3562  FA61  26 FD             BNE   DELAY30
3563  FA63  F6 10 29          LDAB  SPSR
3564  FA66  B7 10 2A  KEY1    STAA  SPDR          sent good patt;rec good patt
3565  FA69  D6 81             LDAB  COLCNT        kill time
3566  FA6B  BD E2 63          JSR   HORPULSE
3567  FA6E  18 09             DEY                 decrement blank line count
3568  FA70  F6 10 29          LDAB  SPSR
3569  FA73  F6 10 2A          LDAB  SPDR          get pattern
3570  FA76  C1 FF             CMPB  #$FF          check for key depression
3571  FA78  26 42             BNE   DETERM2       yes-find which one
3572  FA7A  7C 00 81          INC   COLCNT        no-increment column count
3573  FA7D  0D                SEC
3574  FA7E  49                ROLA                (A) has next pattern to send
3575  FA7F  24 09             BCC   LASTONE       all patterns have been sent
3576  FA81  C6 0A             LDAB  #10
3577  FA83  5A        DELAY40 DECB
3578  FA84  26 FD             BNE   DELAY40
3579  FA86  01                NOP                 kill time
3580  FA87  01                NOP                 kill time
3581  FA88  20 DC             BRA   KEY1          send/receive next pattern
3582  FA8A  CE 00 0A  LASTONE LDX   #10
3583  FA8D  09        DELAY50 DEX
3584  FA8E  26 FD             BNE   DELAY50
3585  FA90  D6 81             LDAB  COLCNT        kill time
3586  FA92  BD E2 63          JSR   HORPULSE
3587  FA95  18 09             DEY                 decrement blank line count
3588  FA97  F7 10 2A          STAB  SPDR          send trash; get good pattern
3589  FA9A  3D                MUL                 kill time
3590  FA9B  05                ASLD
3591  FA9C  05                ASLD
3592  FA9D  F6 10 29          LDAB  SPSR
3593  FAA0  F6 10 2A          LDAB  SPDR
3594  FAA3  C1 FF             CMPB  #$FF          key depressed?
3595  FAA5  26 03             BNE   DETERM1       yes- take branch
3596  FAA7  7E FB 67          JMP   PREVID2
3597  FAAA  D7 90     DETERM1 STAB  ROWCNT        save (B)
3598  FAAC  CE 00 08          LDX   #8
3599  FAAF  09        DELAY60 DEX
3600  FAB0  26 FD             BNE   DELAY60
3601  FAB2  05                ASLD                kill time
3602  FAB3  01                NOP
3603  FAB4  BD E2 63          JSR   HORPULSE
3604  FAB7  18 09             DEY                 decrement blank line count
3605  FAB9  3D                MUL                 kill time for equalization
3606  FABA  D6 90             LDAB  ROWCNT        get row pattern
3607  FABC  D7 90     DETERM2 STAB  ROWCNT        save it again; equalized
3608  FABE  C6 0E             LDAB  #14
```

```
3609  FAC0  5A          DELAY70   DECB              timing delay loop
3610  FAC1  26 FD                 BNE   DELAY70
3611  FAC3  01                    NOP               kill time
3612  FAC4  01                    NOP
3613  FAC5  BD E2 63              JSR   HORPULSE
3614  FAC8  18 09                 DEY
3615  FACA  4F                    CLRA
3616  FACB  D6 90                 LDAB  ROWCNT
3617  FACD  54          DETERM30  LSRB
3618  FACE  24 03                 BCC   DETERM20
3619  FAD0  4C                    INCA
3620  FAD1  20 FA                 BRA   DETERM30
3621  FAD3  97 90       DETERM20  STAA  ROWCNT
3622  FAD5  D6 90       DETERM40  LDAB  ROWCNT      kill time + equalize
3623  FAD7  4C                    INCA
3624  FAD8  81 08                 CMPA  #MAXROWS    = 8
3625  FADA  26 F9                 BNE   DETERM40
3626  FADC  05                    ASLD              kill time
3627  FADD  05                    ASLD              kill time
3628  FADE  05                    ASLD              kill time
3629  FADF  BD E2 63              JSR   HORPULSE
3630  FAE2  18 09                 DEY
3631  FAE4  3D                    MUL
3632  FAE5  3D                    MUL
3633  FAE6  3D                    MUL
3634  FAE7  96 90                 LDAA  ROWCNT
3635  FAE9  48                    ASLA              x2
3636  FAEA  48                    ASLA              x4
3637  FAEB  48                    ASLA              x8
3638  FAEC  9B 81                 ADDA  COLCNT
3639  FAEE  B1 B6 00              CMPA  SHIFTKEY    is it the shift key?
3640  FAF1  26 03                 BNE   DUM1
3641  FAF3  7E FB 6D              JMP   PREVID6     yes-go to display section
3642  FAF6  B1 B6 01    DUM1      CMPA  SHIFTLOW    if the key shiftable?
3643  FAF9  2D 3B                 BLT   LOOKUP1     no
3644  FAFB  B1 B6 02              CMPA  SHIFTHI     is the key shiftable?
3645  FAFE  2E 3A                 BGT   LOOKUP2     no
3646  FB00  F6 10 29              LDAB  SPSR        clear SPIF bit
3647  FB03  F6 B6 03              LDAB  SHFTCOLP
3648  FB06  F7 10 2A              STAB  SPDR        send shift key pattern
3649  FB09  C6 03                 LDAB  #3
3650  FB0B  5A          DELAY90   DECB              timing loop
3651  FB0C  26 FD                 BNE   DELAY90
3652  FB0E  BD E2 63              JSR   HORPULSE    send HSYNC
3653  FB11  18 09                 DEY
3654  FB13  F6 10 29              LDAB  SPSR        clear SPIF
3655  FB16  F7 10 2A              STAB  SPDR        get row pattern
3656  FB19  18 3C                 PSHY              kill time
3657  FB1B  18 38                 PULY              kill time
3658  FB1D  36                    PSHA              kill time
3659  FB1E  32                    PULA              kill time
```

```
3660  FB1F  F6 10 29          LDAB  SPSR
3661  FB22  F6 10 2A          LDAB  SPDR
3662  FB25  F4 B6 04          ANDB  SHFTROWP    is the shift key down?
3663  FB28  27 03             BEQ   DUM2         yes-take branch
3664  FB2A  01                NOP
3665  FB2B  20 05             BRA   DUM3
3666  FB2D  BB B6 05  DUM2    ADDA  SHFTRNGE     offset for shift key
3667  FB30  D6 90             LDAB  ROWCNT
3668  FB32  36        DUM3    PSHA                kill time
3669  FB33  32                PULA                kill time
3670  FB34  36                PSHA                kill time
3671  FB35  32                PULA                kill time
3672  FB36  D6 90     LOOKUP1 LDAB  ROWCNT
3673  FB38  01                NOP
3674  FB39  01                NOP
3675  FB3A  91 82     LOOKUP2 CMPA  CHARVAL       match with last decoded key?
3676  FB3C  27 05             BEQ   FOUND         yes-take branch
3677  FB3E  97 82             STAA  CHARVAL       no-save as new CHARVAL
3678  FB40  7E FB 72          JMP   PREVID3       go display frame
3679  FB43  CE B6 06  FOUND   LDX   #TABLE        keyboard table
3680  FB46  16                TAB
3681  FB47  3A                ABX                 add offset
3682  FB48  A6 00             LDAA  0,X           get ASCII code
3683  FB4A  81 FF             CMPA  #$FF          key implemented?
3684  FB4C  26 03             BNE   DUM4          yes-take branch
3685  FB4E  7E FB 75          JMP   PREVID10      no-continue display
3686  FB51  7C 00 00  DUM4    INC   VALIDKEY      indicate a valid key depressed
3687  FB54  18 38             PULY                restore registers
3688  FB56  38                PULX
3689  FB57  33                PULB
3690  FB58  81 18             CMPA  #KEYBREAK     check for abort from user
3691  FB5A  27 01             BEQ   RESET
3692  FB5C  39                RTS                 return to caller with code in A
3693  FB5D  7E E0 3E  RESET   JMP   MAIN
3694  FB60  BD E2 63  HPULSE  JSR   HORPULSE      this section equalizes the
3695  FB63  3D                MUL                 timing and outputs the
3696  FB64  3D                MUL                 remaining blank lines prior
3697  FB65  3D                MUL                 to the active display.
3698  FB66  3D                MUL
3699  FB67  01        PREVID2 NOP
3700  FB68  01                NOP
3701  FB69  01        PREVID5 NOP
3702  FB6A  05                ASLD
3703  FB6B  05                ASLD
3704  FB6C  01        PREVID4 NOP
3705  FB6D  01        PREVID6 NOP
3706  FB6E  05                ASLD
3707  FB6F  01                NOP
3708  FB70  01        PREVID7 NOP
3709  FB71  3D                MUL
3710  FB72  3D        PREVID3 MUL
```

```
3711  FB73  01                        NOP
3712  FB74  01                        NOP
3713  FB75  01                  PREVID10      NOP
3714  FB76  18 09                     DEY           decrement counter
3715  FB78  26 E6                     BNE   HPULSE  do another blank line
3716  FB7A  BD E2 63                  JSR   HORPULSE
3717                  * initialize some variables
3718  FB7D  86 03                     LDAA  #SLINES
3719  FB7F  B7 00 2C                  STAA  >SLCNT   force extend for timing
3720  FB82  CE 00 27                  LDX   #DISPBUFF+2
3721  FB85  DF 23                     STX   DISPTR
3722                  * toggle FIELD flag
3723  FB87  7D 00 2B                  TST   FIELD    this section toggles the
3724  FB8A  27 05                     BEQ   TOGGLE1  FIELD variable
3725  FB8C  7F 00 2B                  CLR   FIELD
3726  FB8F  20 04                     BRA   TOGGLE2
3727  FB91  7C 00 2B  TOGGLE1         INC   FIELD
3728  FB94  05                        ASLD           equalize time
3729  FB95  18 CE 00 04TOGGLE2        LDY   #CHARBUFF-1
3730  FB99  D6 2B                     LDAB  FIELD
3731  FB9B  18 3A                     ABY
3732  FB9D  18 DF 03                  STY   READBUFF
3733  FBA0  CC 01 FF                  LDD   #$01FF
3734  FBA3  97 93                     STAA  SCANLINE
3735  FBA5  D7 25                     STAB  DISPBUFF  set up first half of DISPBUF
3736  FBA7  D7 26                     STAB  DISPBUFF+1
3737  FBA9  D7 27                     STAB  DISPBUFF+2
3738  FBAB  3D                        MUL            kill time
3739  FBAC  3D                        MUL            "  "
3740  FBAD  3D                        MUL            "  "
3741  FBAE  3D                        MUL            "  "
3742                  * DISPLAY DATA IN CHARACTER BUFFER
3743  FBAF  B6 10 08  LINE1           LDAA  PORTD    output HSYNC, update
3744  FBB2  84 DF                     ANDA  #SSLOW   index register Y, and ensure
3745  FBB4  B7 10 08                  STAA  PORTD    SPIF bit is cleared
3746  FBB7  F6 10 29                  LDAB  SPSR
3747  FBBA  18 08                     INY
3748  FBBC  8A 20                     ORAA  #SSHIGH
3749  FBBE  B7 10 08                  STAA  PORTD
3750  FBC1  96 2B                     LDAA  FIELD    check FIELD for timing
3751  FBC3  27 06                     BEQ   EVEN1
3752  FBC5  E6 00                     LDAB  0,X      get pattern
3753  FBC7  DE 23                     LDX   DISPTR   get pointer
3754  FBC9  E7 00                     STAB  0,X      put pattern at pointer address
3755  FBCB  18 E6 00  EVEN1           LDAB  0,Y      get ASCII code from buffer
3756  FBCE  08                        INX            update DISPTR
3757  FBCF  DF 23                     STX   DISPTR
3758  FBD1  96 25                     LDAA  DISPBUFF send first pattern
3759  FBD3  B7 10 2A                  STAA  SPDR
3760  FBD6  4F                        CLRA
3761  FBD7  58                        ASLB           multiply ASCII code by 8
```

```
3762  FBD8 05                ASLD
3763  FBD9  05               ASLD
3764  FBDA  8F               XGDX                save 8*ASCII in X
3765  FBDB  96 26            LDAA  DISPBUFF+1    send second pattern
3766  FBDD  F6 10 29         LDAB  SPSR
3767  FBE0  B7 10 2A         STAA  SPDR
3768  FBE3  8F               XGDX                put 8*ASCII in D
3769  FBE4  DB 93            ADDB  SCANLINE      add SCANLINE
3770  FBE6  C3 FC 5D         ADDD  #FONTABLE-$100  point at pattern
3771  FBE9  8F               XGDX                put pointer in X
3772  FBEA  96 27            LDAA  DISPBUFF+2    send third pattern
3773  FBEC  F6 10 29         LDAB  SPSR
3774  FBEF  B7 10 2A         STAA  SPDR
3775  FBF2  7A 00 2C         DEC   SLCNT         decrement SLCNT
3776  FBF5  27 0E            BEQ   OUT1          done?
3777  FBF7  18 08            INY                 increment CHARBUFF ptr
3778  FBF9  96 2B            LDAA  FIELD         test FIELD
3779  FBFB  26 06            BNE   EVEN2
3780  FBFD  E6 00            LDAB  0,X           get pattern
3781  FBFF  DE 23            LDX   DISPTR        get pointer
3782  FC01  E7 00            STAB  0,X           put pattern at pointer address
3783  FC03  20 AA     EVEN2  BRA   LINE1         do next line
3784  FC05  96 2B     OUT1   LDAA  FIELD
3785  FC07  26 06            BNE   EVEN3
3786  FC09  E6 00            LDAB  0,X           get pattern
3787  FC0B  DE 23            LDX   DISPTR        get pointer
3788  FC0D  E7 00            STAB  0,X           put pattern at pointer address
3789  FC0F  05        EVEN3  ASLD                kill time
3790  FC10  01               NOP                 kill time
3791  FC11  01               NOP                 kill time
3792  FC12  B6 10 08         LDAA  PORTD         output HSYNC pulse and
3793  FC15  84 DF            ANDA  #SSLOW        update variables
3794  FC17  B7 10 08         STAA  PORTD
3795  FC1A  F6 10 29         LDAB  SPSR
3796  FC1D  C6 03            LDAB  #SLINES
3797  FC1F  01               NOP
3798  FC20  8A 20            ORAA  #SSHIGH
3799  FC22  B7 10 08         STAA  PORTD
3800  FC25  D7 2C            STAB  SLCNT
3801  FC27  18 DE 03         LDY   READBUFF      point Y at start of char line
3802  FC2A  96 2B            LDAA  FIELD
3803  FC2C  27 06            BEQ   TEST1
3804  FC2E  E6 00            LDAB  0,X           get pattern
3805  FC30  DE 23            LDX   DISPTR        get pointer
3806  FC32  E7 00            STAB  0,X           put pattern at pointer address
3807  FC34  01        TEST1  NOP                 kill time
3808  FC35  01               NOP                 kill time
3809  FC36  96 25            LDAA  DISPBUFF      send first pattern
3810  FC38  B7 10 2A         STAA  SPDR
3811  FC3B  7C 00 93         INC   SCANLINE      increment SCANLINE count
3812  FC3E  CE 00 24         LDX   #DISPBUFF-1
```

```
3813  FC41  DF 23          STX   DISPTR          update DISPTR
3814  FC43  96 26          LDAA  DISPBUFF+1      send second pattern
3815  FC45  F6 10 29       LDAB  SPSR
3816  FC48  B7 10 2A       STAA  SPDR
3817  FC4B  3D             MUL                   kill time
3818  FC4C  05             ASLD                  kill time
3819  FC4D  96 27          LDAA  DISPBUFF+2      send third pattern
3820  FC4F  F6 10 29       LDAB  SPSR
3821  FC52  B7 10 2A       STAA  SPDR
3822  FC55  3D             MUL                   kill time
3823  FC56  05             ASLD                  kill time
3824  FC57  05             ASLD                  kill time
3825  FC58  96 2B          LDAA  FIELD
3826  FC5A  26 02          BNE   LINE2
3827  FC5C  3D             MUL                   kill time
3828  FC5D  01             NOP                   kill time
3829  FC5E  B6 10 08  LINE2 LDAA  PORTD           this section is exactly
3830  FC61  84 DF          ANDA  #SSLOW          the same as the previous
3831  FC63  B7 10 08       STAA  PORTD           section except the second
3832  FC66  F6 10 29       LDAB  SPSR            half of the display buffer
3833  FC69  18 08          INY                   is displayed and first half
3834  FC6B  8A 20          ORAA  #SSHIGH         is filled with new patterns
3835  FC6D  B7 10 08       STAA  PORTD
3836  FC70  96 2B          LDAA  FIELD
3837  FC72  27 06          BEQ   EVEN11
3838  FC74  E6 00          LDAB  0,X
3839  FC76  DE 23          LDX   DISPTR
3840  FC78  E7 00          STAB  0,X
3841  FC7A  18 E6 00  EVEN11 LDAB 0,Y
3842  FC7D  08             INX
3843  FC7E  DF 23          STX   DISPTR
3844  FC80  96 28          LDAA  DISPBUFF+3
3845  FC82  B7 10 2A       STAA  SPDR
3846  FC85  4F             CLRA
3847  FC86  58             ASLB
3848  FC87  05             ASLD
3849  FC88  05             ASLD
3850  FC89  8F             XGDX
3851  FC8A  96 29          LDAA  DISPBUFF+4
3852  FC8C  F6 10 29       LDAB  SPSR
3853  FC8F  B7 10 2A       STAA  SPDR
3854  FC92  8F             XGDX
3855  FC93  DB 93          ADDB  SCANLINE
3856  FC95  C3 FC 5D       ADDD  #FONTABLE-$100
3857  FC98  8F             XGDX
3858  FC99  96 2A          LDAA  DISPBUFF+5
3859  FC9B  F6 10 29       LDAB  SPSR
3860  FC9E  B7 10 2A       STAA  SPDR
3861  FCA1  7A 00 2C       DEC   SLCNT
3862  FCA4  27 0E          BEQ   OUT2
3863  FCA6  18 08          INY
```

```
3864  FCA8  96 2B          LDAA  FIELD
3865  FCAA  26 06          BNE   EVEN12
3866  FCAC  E6 00          LDAB  0,X
3867  FCAE  DE 23          LDX   DISPTR
3868  FCB0  E7 00          STAB  0,X
3869  FCB2  20 AA  EVEN12   BRA   LINE2
3870  FCB4  96 2B  OUT2     LDAA  FIELD
3871  FCB6  26 06          BNE   TEST2
3872  FCB8  E6 00          LDAB  0,X
3873  FCBA  DE 23          LDX   DISPTR
3874  FCBC  E7 00          STAB  0,X
3875  FCBE  C6 03  TEST2    LDAB  #SLINES
3876  FCC0  D7 2C          STAB  SLCNT
3877  FCC2  01             NOP
3878  FCC3  B6 10 08       LDAA  PORTD
3879  FCC6  84 DF          ANDA  #SSLOW
3880  FCC8  B7 10 08       STAA  PORTD
3881  FCCB  F6 10 29       LDAB  SPSR
3882  FCCE  18 08          INY
3883  FCD0  8A 20          ORAA  #SSHIGH
3884  FCD2  B7 10 08       STAA  PORTD
3885  FCD5  96 2B          LDAA  FIELD
3886  FCD7  27 06          BEQ   EVEN13
3887  FCD9  E6 00          LDAB  0,X
3888  FCDB  DE 23          LDX   DISPTR
3889  FCDD  E7 00          STAB  0,X
3890  FCDF  CE 00 27 EVEN13 LDX  #DISPBUFF+2
3891  FCE2  DF 23          STX   DISPTR
3892  FCE4  D6 93          LDAB  SCANLINE
3893  FCE6  5C             INCB
3894  FCE7  96 28          LDAA  DISPBUFF+3
3895  FCE9  B7 10 2A       STAA  SPDR
3896  FCEC  D7 93          STAB  SCANLINE
3897  FCEE  3D             MUL
3898  FCEF  96 29          LDAA  DISPBUFF+4
3899  FCF1  F6 10 29       LDAB  SPSR
3900  FCF4  B7 10 2A       STAA  SPDR
3901  FCF7  96 93          LDAA  SCANLINE     check to see if the character
3902  FCF9  81 09          CMPA  #9           row is complete
3903  FCFB  26 1E          BNE   NEXTSCLN
3904  FCFD  86 01          LDAA  #1
3905  FCFF  97 93          STAA  SCANLINE
3906  FD01  96 2A          LDAA  DISPBUFF+5
3907  FD03  F6 10 29       LDAB  SPSR
3908  FD06  B7 10 2A       STAA  SPDR
3909  FD09  18 8C 00 22    CPY   #CHARBUFF+BUFFLEN-1  check to see if
3910  FD0D  2C 22          BGE   DONE         the entire CHARBUFF has
3911  FD0F  18 DF 03       STY   READBUFF     been displayed
3912  FD12  96 2B          LDAA  FIELD
3913  FD14  26 02          BNE   TEST20
```

```
3914  FD16  3D                    MUL
3915  FD17  01                    NOP
3916  FD18  7E FB AF  TEST20      JMP   LINE1
3917  FD1B  18 DE 03  NEXTSCLN    LDY   READBUFF
3918  FD1E  96 2A                 LDAA  DISPBUFF+5
3919  FD20  F6 10 29              LDAB  SPSR
3920  FD23  B7 10 2A              STAA  SPDR
3921  FD26  3D                    MUL
3922  FD27  05                    ASLD
3923  FD28  96 2B                 LDAA  FIELD
3924  FD2A  26 02                 BNE   TEST80
3925  FD2C  3D                    MUL
3926  FD2D  01                    NOP
3927  FD2E  7E FB AF  TEST80      JMP   LINE1
3928  FD31  18 CE 00 2EDONE       LDY   #TOTBLKS-BLKLINES  output the
3929  FD35  01                    NOP                      remaining blank lines
3930  FD36  01                    NOP                      to complete the display
3931  FD37  96 2B                 LDAA  FIELD
3932  FD39  26 02                 BNE   EVEN41
3933  FD3B  3D                    MUL
3934  FD3C  01                    NOP
3935  FD3D  B6 10 08  EVEN41      LDAA  PORTD
3936  FD40  84 DF                 ANDA  #SSLOW
3937  FD42  B7 10 08              STAA  PORTD
3938  FD45  05                    ASLD
3939  FD46  05                    ASLD
3940  FD47  01                    NOP
3941  FD48  8A 20                 ORAA  #SSHIGH
3942  FD4A  B7 10 08              STAA  PORTD
3943  FD4D  C6 13                 LDAB  #19
3944  FD4F  5A        DELAY200    DECB
3945  FD50  26 FD                 BNE   DELAY200
3946  FD52  05                    ASLD
3947  FD53  18 09                 DEY
3948  FD55  26 E6                 BNE   EVEN41
3949  FD57  02                    IDIV
3950  FD58  01                    NOP
3951  FD59  05                    ASLD
3952  FD5A  7E F9 EF              JMP   VIDEO1
3953
3954                      **********************
3955                      * Font Table
3956                      * contain the patterns necessary
3957                      * for display of characters
3958                      *  5 X 7 format
3959                      **********************
3960  FD5D  FF FF     FONTABLE    FDB   $FFFF      ASCII space character
3961  FD5F  FF FF                 FDB   $FFFF
3962  FD61  FF FF                 FDB   $FFFF
3963  FD63  FF FF                 FDB   $FFFF
3964  FD65  FF CF                 FDB   $FFCF      ASCII '!'
```

```
3965  FD67  CF CF     FDB   $CFCF
3966  FD69  CF FF     FDB   $CFFF
3967  FD6B  CF CF     FDB   $CFCF
3968  FD6D  FF D7     FDB   $FFD7     ASCII ""
3969  FD6F  D7 FF     FDB   $D7FF
3970  FD71  FF FF     FDB   $FFFF
3971  FD73  FF FF     FDB   $FFFF
3972  FD75  FF FF     FDB   $FFFF     ASCII '#'
3973  FD77  D7 93     FDB   $D793
3974  FD79  FF 93     FDB   $FF93
3975  FD7B  D7 FF     FDB   $D7FF
3976  FD7D  FF C7     FDB   $FFC7     ASCII '$'
3977  FD7F  AB AF     FDB   $ABAF
3978  FD81  C7 EB     FDB   $C7EB
3979  FD83  AB C7     FDB   $ABC7
3980  FD85  FF 9F     FDB   $FF9F     ASCII '%'
3981  FD87  9B F7     FDB   $9BF7
3982  FD89  EF DF     FDB   $EFDF
3983  FD8B  B3 F3     FDB   $B3F3
3984  FD8D  FF DF     FDB   $FFDF     ASCII '&'
3985  FD8F  AF AF     FDB   $AFAF
3986  FD91  DF AB     FDB   $DFAB
3987  FD93  B7 CB     FDB   $B7CB
3988  FD95  FF F7     FDB   $FFF7     ASCII '
3989  FD97  EF DF     FDB   $EFDF
3990  FD99  FF FF     FDB   $FFFF
3991  FD9B  FF FF     FDB   $FFFF
3992  FD9D  FF FB     FDB   $FFFB     ASCII '('
3993  FD9F  F7 EF     FDB   $F7EF
3994  FDA1  EF EF     FDB   $EFEF
3995  FDA3  F7 FB     FDB   $F7FB
3996  FDA5  FF BF     FDB   $FFBF     ASCII ')'
3997  FDA7  DF EF     FDB   $DFEF
3998  FDA9  EF EF     FDB   $EFEF
3999  FDAB  DF BF     FDB   $DFBF
4000  FDAD  FF FF     FDB   $FFFF     ASCII '*'
4001  FDAF  EF C7     FDB   $EFC7
4002  FDB1  83 C7     FDB   $83C7
4003  FDB3  EF FF     FDB   $EFFF
4004  FDB5  FF FF     FDB   $FFFF     ASCII '+'
4005  FDB7  EF EF     FDB   $EFEF
4006  FDB9  83 EF     FDB   $83EF
4007  FDBB  EF FF     FDB   $EFFF
4008  FDBD  FF FF     FDB   $FFFF     ASCII ','
4009  FDBF  FF FF     FDB   $FFFF
4010  FDC1  CF CF     FDB   $CFCF
4011  FDC3  EF DF     FDB   $EFDF
4012  FDC5  FF FF     FDB   $FFFF     ASCII '-'
4013  FDC7  FF FF     FDB   $FFFF
4014  FDC9  83 FF     FDB   $83FF
4015  FDCB  FF FF     FDB   $FFFF
```

```
4016  FDCD  FF FF     FDB   $FFFF     ASCII ':'
4017  FDCF  FF FF     FDB   $FFFF
4018  FDD1  FF FF     FDB   $FFFF
4019  FDD3  CF CF     FDB   $CFCF
4020  FDD5  FF FF     FDB   $FFFF     ASCII '/'
4021  FDD7  FB F7     FDB   $FBF7
4022  FDD9  EF DF     FDB   $EFDF
4023  FDDB  BF FF     FDB   $BFFF
4024  FDDD  FF E7     FDB   $FFE7     ASCII '0'
4025  FDDF  DB DB     FDB   $DBDB
4026  FDE1  DB DB     FDB   $DBDB
4027  FDE3  DB E7     FDB   $DBE7
4028  FDE5  FF EF     FDB   $FFEF     ASCII '1'
4029  FDE7  CF EF     FDB   $CFEF
4030  FDE9  EF EF     FDB   $EFEF
4031  FDEB  EF C7     FDB   $EFC7
4032  FDED  FF C7     FDB   $FFC7     ASCII '2'
4033  FDEF  BB FB     FDB   $BBFB
4034  FDF1  C7 FB     FDB   $C7BF
4035  FDF3  BF 83     FDB   $BF83
4036  FDF5  FF C7     FDB   $FFC7     ASCII '3'
4037  FDF7  BB FB     FDB   $BBFB
4038  FDF9  C7 FB     FDB   $C7FB
4039  FDFB  BB C7     FDB   $BBC7
4040  FDFD  FF F7     FDB   $FFF7     ASCII '4'
4041  FDFF  E7 D7     FDB   $E7D7
4042  FE01  B7 83     FDB   $B783
4043  FE03  F7 F7     FDB   $F7F7
4044  FE05  FF 83     FDB   $FF83     ASCII '5'
4045  FE07  BF 87     FDB   $BF87
4046  FE09  FB FB     FDB   $FBFB
4047  FE0B  BB C7     FDB   $BBC7
4048  FE0D  FF E7     FDB   $FFE7     ASCII '6'
4049  FE0F  DF BF     FDB   $DFBF
4050  FE11  87 BB     FDB   $87BB
4051  FE13  BB C7     FDB   $BBC7
4052  FE15  FF 83     FDB   $FF83     ASCII '7'
4053  FE17  FB F7     FDB   $FBF7
4054  FE19  EF DB     FDB   $EFDF
4055  FE1B  DF DF     FDB   $DFDF
4056  FE1D  FF C7     FDB   $FFC7     ASCII '8'
4057  FE1F  BB BB     FDB   $BBBB
4058  FE21  C7 BB     FDB   $C7BB
4059  FE23  BB C7     FDB   $BBC7
4060  FE25  FF C7     FDB   $FFC7     ASCII '9'
4061  FE27  BB BB     FDB   $BBBB
4062  FE29  C3 FB     FDB   $C3FB
4063  FE2B  F7 CF     FDB   $F7CF
4064  FE2D  FF FF     FDB   $FFFF     ASCII ':'
4065  FE2F  CF CF     FDB   $CFCF
4066  FE31  FF CF     FDB   $FFCF
```

```
4067  FE33  CF FF     FDB   $CFFF
4068  FE35  FF CF     FDB   $FFCF      ASCII ';'
4069  FE37  CF FF     FDB   $CFFF
4070  FE39  CF CF     FDB   $CFCF
4071  FE3B  EF DF     FDB   $EFDF
4072  FE3D  FF FB     FDB   $FFFB      ASCII '<'
4073  FE3F  F7 EF     FDB   $F7EF
4074  FE41  DF EF     FDB   $DFEF
4075  FE43  F7 FB     FDB   $F7FB
4076  FE45  FF FF     FDB   $FFFF      ASCII '='
4077  FE47  FF 83     FDB   $FF83
4078  FE49  FF 83     FDB   $FF83
4079  FE4B  FF FF     FDB   $FFFF
4080  FE4D  FF BF     FDB   $FFBF      ASCII '>'
4081  FE4F  DF EF     FDB   $DFEF
4082  FE51  F7 EF     FDB   $F7EF
4083  FE53  DF BF     FDB   $DFBF
4084  FE55  FF C7     FDB   $FFC7      ASCII '?'
4085  FE57  BB F7     FDB   $BBF7
4086  FE59  EF EF     FDB   $EFEF
4087  FE5B  FF EF     FDB   $FFEF
4088  FE5D  FF C7     FDB   $FFC7      ASCII '@'
4089  FE5F  BB A3     FDB   $BBA3
4090  FE61  AB A3     FDB   $ABA3
4091  FE63  BF 83     FDB   $BF83
4092  FE65  FF C7     FDB   $FFC7      ASCII 'A'
4093  FE67  BB BB     FDB   $BBBB
4094  FE69  83 BB     FDB   $83BB
4095  FE6B  BB BB     FDB   $BBBB
4096  FE6D  FF 87     FDB   $FF87      ASCII 'B'
4097  FE6F  DB DB     FDB   $DBDB
4098  FE71  C7 DB     FDB   $C7DB
4099  FE73  DB 87     FDB   $DB87
4100  FE75  FF C7     FDB   $FFC7      ASCII 'C'
4101  FE77  BB BF     FDB   $BBBF
4102  FE79  BF BF     FDB   $BFBF
4103  FE7B  BB C7     FDB   $BBC7
4104  FE7D  FF 87     FDB   $FF87      ASCII 'D'
4105  FE7F  DB DB     FDB   $DBDB
4106  FE81  DB DB     FDB   $DBDB
4107  FE83  DB 87     FDB   $DB87
4108  FE85  FF 83     FDB   $FF83      ASCII 'E'
4109  FE87  BF BF     FDB   $BFBF
4110  FE89  87 BF     FDB   $87BF
4111  FE8B  BF 83     FDB   $BF83
4112  FE8D  FF 83     FDB   $FF83      ASCII 'F'
4113  FE8F  BF BF     FDB   $BFBF
4114  FE91  87 BF     FDB   $87BF
4115  FE93  BF BF     FDB   $BFBF
4116  FE95  FF C3     FDB   $FFC3      ASCII 'G'
4117  FE97  BF BF     FDB   $BFBF
```

```
4118  FE99  A3 BB     FDB  $A3BB
4119  FE9B  BB C7     FDB  $BBC7
4120  FE9D  FF BB     FDB  $FFBB      ASCII 'H'
4121  FE9F  BB BB     FDB  $BBBB
4122  FEA1  83 BB     FDB  $83BB
4123  FEA3  BB BB     FDB  $BBBB
4124  FEA5  FF C7     FDB  $FFC7      ASCII 'I'
4125  FEA7  EF EF     FDB  $EFEF
4126  FEA9  EF EF     FDB  $EFEF
4127  FEAB  EF C7     FDB  $EFC7
4128  FEAD  FF FB     FDB  $FFFB      ASCII 'J'
4129  FEAF  FB FB     FDB  $FBFB
4130  FEB1  FB FB     FDB  $FBFB
4131  FEB3  BB C7     FDB  $BBC7
4132  FEB5  FF BB     FDB  $FFBB      ASCII 'K'
4133  FEB7  B7 AF     FDB  $B7AF
4134  FEB9  9F AF     FDB  $9FAF
4135  FEBB  B7 BB     FDB  $B7BB
4136  FEBD  FF BF     FDB  $FFBF      ASCII 'L'
4137  FEBF  BF BF     FDB  $BFBF
4138  FEC1  BF BF     FDB  $BFBF
4139  FEC3  BF 83     FDB  $BF83
4140  FEC5  FF BB     FDB  $FFBB      ASCII 'M'
4141  FEC7  93 AB     FDB  $93AB
4142  FEC9  AB BB     FDB  $ABBB
4143  FECB  BB BB     FDB  $BBBB
4144  FECD  FF BB     FDB  $FFBB      ASCII 'N'
4145  FECF  9B AB     FDB  $9BAB
4146  FED1  B3 BB     FDB  $B3BB
4147  FED3  BB BB     FDB  $BBBB
4148  FED5  FF 83     FDB  $FF83      ASCII 'O'
4149  FED7  BB BB     FDB  $BBBB
4150  FED9  BB BB     FDB  $BBBB
4151  FEDB  BB 83     FDB  $BB83
4152  FEDD  FF 87     FDB  $FF87      ASCII 'P'
4153  FEDF  BB BB     FDB  $BBBB
4154  FEE1  87 BF     FDB  $87BF
4155  FEE3  BF BF     FDB  $BFBF
4156  FEE5  FF C7     FDB  $FFC7      ASCII 'Q'
4157  FEE7  BB BB     FDB  $BBBB
4158  FEE9  BB AB     FDB  $BBAB
4159  FEEB  B7 CB     FDB  $B7CB
4160  FEED  FF 87     FDB  $FF87      ASCII 'R'
4161  FEEF  BB BB     FDB  $BBBB
4162  FFF1  87 AF     FDB  $87AF
4163  FFF3  B7 BB     FDB  $B7BB
4164  FFF5  FF C7     FDB  $FFC7      ASCII 'S'
4165  FFF7  BB DF     FDB  $BBDF
4166  FFF9  EF F7     FDB  $EFF7
4167  FFFB  BB C7     FDB  $BBC7
4168  FFFD  FF 83     FDB  $FF83      ASCII 'T'
```

```
4169  FFFF  EF EF                FDB   $EFEF
4170  FF01  EF EF                FDB   $EFEF
4171  FF03  EF EF                FDB   $EFEF
4172  FF05  FF BB                FDB   $FFBB       ASCII 'U'
4173  FF07  BB BB                FDB   $BBBB
4174  FF09  BB BB                FDB   $BBBB
4175  FF0B  BB C7                FDB   $BBC7
4176  FF0D  FF BB                FDB   $FFBB       ASCII 'V'
4177  FF0F  BB BB                FDB   $BBBB
4178  FF11  D7 D7                FDB   $D7D7
4179  FF13  EF EF                FDB   $EFEF
4180  FF15  FF BB                FDB   $FFBB       ASCII 'W'
4181  FF17  BB BB                FDB   $BBBB
4182  FF19  AB AB                FDB   $ABAB
4183  FF1B  AB D7                FDB   $ABD7
4184  FF1D  FF BB                FDB   $FFBB       ASCII 'X'
4185  FF1F  BB D7                FDB   $BBD7
4186  FF21  EF D7                FDB   $EFD7
4187  FF23  BB BB                FDB   $BBBB
4188  FF25  FF BB                FDB   $FFBB       ASCII 'Y'
4189  FF27  BB D7                FDB   $BBD7
4190  FF29  EF EF                FDB   $EFEF
4191  FF2B  EF EF                FDB   $EFEF
4192  FF2D  FF 83                FDB   $FF83       ASCII 'Z'
4193  FF2F  FB F7                FDB   $FBF7
4194  FF31  EF DF                FDB   $EFDF
4195  FF33  BF 83                FDB   $BF83
4196  FF35  FF                   FCB   $FF         end of table
4197
4198                  **********************
4199                  * VECTOR TABLE- determine if user
4200                  *  has a specified service routine
4201                  *  for a particular interrupt.
4202
4203  FF36  86 01     VECT1      LDAA  #1
4204  FF38  20 42                BRA   VECTCHK
4205  FF3A  82 02     VECT2      LDAA  #2
4206  FF3C  20 3E                BRA   VECTCHK
4207  FF3E  86 03     VECT3      LDAA  #3
4208  FF40  20 3A                BRA   VECTCHK
4209  FF42  86 04     VECT4      LDAA  #4
4210  FF44  20 36                BRA   VECTCHK
4211  FF46  86 05     VECT5      LDAA  #5
4212  FF48  20 32                BRA   VECTCHK
4213  FF4A  86 06     VECT6      LDAA  #6
4214  FF4C  20 2E                BRA   VECTCHK
4215  FF4E  86 07     VECT7      LDAA  #7
4216  FF50  20 2A                BRA   VECTCHK
4217  FF52  86 07     VECT8      LDAA  #8
4218  FF54  20 26                BRA   VECTCHK
4219  FF56  86 09     VECT9      LDAA  #9
```

```
4220  FF58  20 22                BRA   VECTCHK
4221  FF5A  86 0A    VECT10      LDAA  #10
4222  FF5C  20 1E                BRA   VECTCHK
4223  FF5E  86 0B    VECT11      LDAA  #11
4224  FF60  20 1A                BRA   VECTCHK
4225  FF62  86 0C    VECT12      LDAA  #12
4226  FF64  20 16                BRA   VECTCHK
4227  FF66  86 0D    VECT13      LDAA  #13
4228  FF68  20 12                BRA   VECTCHK
4229  FF6A  86 0E    VECT14      LDAA  #14
4230  FF6C  20 0E                BRA   VECTCHK
4231  FF6E  86 0F    VECT15      LDAA  #15
4232  FF70  20 0A                BRA   VECTCHK
4233  FF72  86 10    VECT16      LDAA  #16
4234  FF74  20 06                BRA   VECTCHK
4235  FF76  86 11    VECT17      LDAA  #17
4236  FF78  20 02                BRA   VECTCHK
4237  FF7A  86 12    VECT18      LDAA  #18
4238  FF7C  91 95    VECTCHK     CMPA  VECTR1      user routine for VECTR1?
4239  FF7E  26 04                BNE   VECTCHK1
4240  FF80  DE 96                LDX   VJMP1       get address of routine
4241  FF82  6E 00                JMP   0,X         go there
4242  FF84  91 98    VECTCHK1    CMPA  VECTR2      check VECTR2
4243  FF86  26 04                BNE   VECTCHK2
4244  FF88  DE 99                LDX   VJMP2
4245  FF8A  6E 00                JMP   0,X
4246  FF8C  3B       VECTCHK2    RTI               no service routine-return
4247
4248  FFD6                       ORG   $FFD6
4249                  *** Vectors ***
4250  FFD6  FF 36    VSCI        FDB   VECT1
4251  FFD8  FF 3A    VSPI        FDB   VECT2
4252  FFDA  FF 3E    VPAIE       FDB   VECT3
4253  FFDC  FF 42    VPAO        FDB   VECT4
4254  FFDE  FF 46    VTOF        FDB   VECT5
4255  FFE0  00 9B    VTOC5       FDB   VOC5        dedicated oc5 vector
4256  FFE2  FF 4A    VTOC4       FDB   VECT6
4257  FFE4  FF 4E    VTOC3       FDB   VECT7
4258  FFE6  FF 52    VTOC2       FDB   VECT8
4259  FFE8  FF 56    VTOC1       FDB   VECT9
4260  FFEA  FF 5A    VTIC3       FDB   VECT10
4261  FFEC  FF 5E    VTIC2       FDB   VECT11
4262  FFEE  FF 62    VTIC1       FDB   VECT12
4263  FFF0  FF 66    VRTI        FDB   VECT13
4264  FFF2  FF 6A    VIRQ        FDB   VECT14
4265  FFF4  FF 6E    VXIRQ       FDB   VECT15
4266  FFF6  00 9E    VSWI        FDB   VSWIIN      dedicated SWI vector
4267  FFF8  FF 72    VILLOP      FDB   VECT16
4268  FFFA  FF 76    VCOP        FDB   VECT17
4269  FFFC  FF 7A    VCLM        FDB   VECT18
4270  FFFE  E0 00    VRST        FDB   PGMSTRT
```

```
4271
4272                    ********************************
4273                    * KEYBOARD LOOKUP TABLE        *
4274                    ********************************
4275  B600                          ORG   $B600
4276  B600  37         SHIFTKEY     FCB   55            shiftkey matrix position
4277  B601  21         SHIFTLOW     FCB   33            first shiftable key
4278  B602  2F         SHIFTHI      FCB   47            last shiftable key
4279  B603  7F         SHFTCOLP     FCB   $7F           column pattern for shift key
4280  B604  40         SHFTROWP     FCB   $40           row pattern for shift key
4281  B605  18         SHFTRNGE     FCB   18            offset to shifted characters
4282  B606  40 41 42 43 TABLE        FCC '@ABCDEFGHIJKLMNOPQRSTUVWXYZ'
4283  B621  5E                      FCB   $5E
4284  B622  0D                      FCB   CRETURN
4285  B623  08                      FCB   BACKSPCE
4286  B624  20                      FCB   SPACE
4287  B625  20                      FCB   SPACE
4288  B626  30 31 32 33             FCC   "0123456789:;,-./"
4289  B636  0D                      FCB   CRETURN
4290  B637  FF                      FCB   $FF
4291  B638  18                      FCB   CTLX
4292  B639  21 22 23 24             FCC   /!"#$%&'()*+<=>?/
4293  B648              ENDKEYS     EQU   *
```

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Vita

Kevin Eugene Williams was born in Canton, Illinois, on July 4, 1957, the son of Joyce Elenor Williams and Eddie Franklin Williams. In May 1979, he graduated from Kansas State University, Manhattan, Kansas, with a Bachelor of Science degreee in Electrical Engineering. Upon graduation, he was commissioned as a Second Lieutenant in the United States Air Force. In January of 1981, he completed Undergraduate Pilot Training. He was assigned to RAF Lakenheath, United Kingdom, to fly the F-111F fighter-bomber until July, 1985. In August 1985, he entered The Graduate School of The University of Texas.

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