

# APPLE -1 OPERATION MANUAL

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## SPECIFICATIONS

|   |  |
|---|--|
| MICROPROCESSOR:   | MOS TECHNOLOGY 6502  |
| Microprocessor Clock Frequency:                         | 1.023 MHz  |
| Effective Cycle Frequency:<br>(Including Refresh Waits) | 0.960 MHz  |
| VIDEO OUTPUT:   | Composite positive video, 75 ohms,<br>level adjustable between zero and +5Vpp. |
| Line Rate:  | 15734 Hz   |
| Frame Rate:   | 60.05 Hz   |
| Format:   | 40 characters/line, 24 lines;<br>with automatic scrolling                      |
| Display Memory:   | Dynamic shift registers (1K x 7)   |
| Character Matrix:                                       | 5 x 7  |
| RAM MEMORY:   | 16-pin, 4K Dynamic, type 4096 (2104)   |
| On-board RAM Capacity:                                  | 8K bytes (4K supplied)   |
| POWER SUPPLIES:   | +5 Volts @ 3 amps, +/- 12 Volts @0.5 amps,<br>and -5 Volts @ 0.5 amps          |
| Input Power Requirements:                               | 8 to 10 Volts AC (RMS) @ 3 amps,<br>26 to 28 Volts AC (RMS) Center-Tapped, 1A. |
| Recommended Transformers:                               | Stancor # P-8380 or Triad F31-X<br>Stancor # P-8667 or Triad F40-X             |

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## INTRODUCTION

The Apple Computer is a complete micro-processor system, consisting of a Mos Technology 6502 microprocessor and support hardware, integral video display electronics, dynamic memory and refresh hardware, and fully regulated power supplies. It contains resident system monitor software, enabling the user, via the keyboard and display, to write, examine, debug, and run programs efficiently; thus being an educational tool for the learning of microprocessor programming, and an aid in the development of software.

The integral video display section and the keyboard interface renders unnecessary the need for an external teletype. The display section contains its own memory, leaving all of RAM for user programs, and the output format is 40 characters/line, 24 lines/page, with auto scrolling. Almost any ASCII encoded keyboard will interface directly with the Apple system.

The board has sockets for upto 8K bytes of the 16 pin, 4K type, RAM, and the system is fully expandable to 65K via the edge connector. The system uses dynamic memory (4K bytes sup-

plied), although static memory may also be used. All refreshing of dynamic memory, including all "off-board" expansion memory, is done automatically. The entire system timing, including the microprocessor clock and all video signals, originates in a single crystal oscillator.

Further, the printed circuit board contains a "breadboard area", in which the user can add additional "on-board" hardware (for example, extra PIA's, ACIA's, EROM's, and so on).

This manual is divided into three Sections:

- Section I GETTING THE SYSTEM RUNNING.
- Section II USING THE SYSTEM MONITOR.  
(listing included)
- Section III EXPANDING THE SYSTEM.

Please read Section I thoroughly, before attempting to "power-up" your system, and study Section III carefully before attempting to expand your system. In addition to this manual, Apple "Tech Notes" are available which contain examples of expansion hardware and techniques.

## SECTION I GETTING THE SYSTEM RUNNING

The Apple Computer is fully assembled, tested, and burned in. The only external devices necessary for operation of the system are: An ASCII encoded keyboard, a video display monitor, and AC power sources of 8 to 10 Volts (RMS) @3 amps and 28Volts (RMS) @1 amp. The following three articles describe the attachment of these devices in detail.

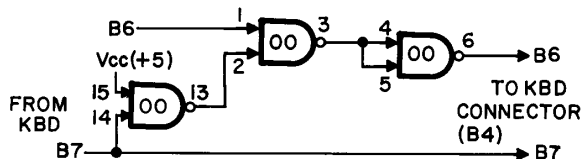
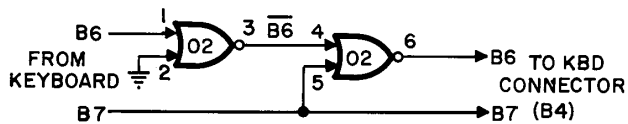
Keyboard:

Any ASCII encoded keyboard, with positive DATA outputs, interfaces directly with the Apple system via a "DIP" connector. If your keyboard has negative logic DATA outputs (rare), you can install inverters (7404) in the breadboard area. The strobe can be either positive or negative, of long or short duration. The "DIP" keyboard connector (B4) has inputs for seven DATA lines, one

STROBE line, and two normally-open pushbutton switches, used for RESET (enter monitor), and CLEAR SCREEN (see schematic diagram, sheet 3 of 3, for exact circuitry). This keyboard connector also supplies three voltages, (+5V, +12V, and -12V) of which one or more may be necessary to operate the keyboard. Pin 15 of the keyboard connector (B4) must be tied to +5V (pin 16) for normal operation.

NOTE: The system monitor accepts only upper-case alpha (A-F, R).

It is therefore convenient, though it's not essential, to have a keyboard equipped with upper-case alpha lock (usually in the electronics). Either of the following suggested circuits may be used to provide alpha lock capability, if needed, and can be built in the breadboard area.



Display:

The Apple Computer outputs a composite video signal (composite of sync and video information) which can be applied to any standard raster-scan type video display monitor. The output level is adjustable with the potentiometer located near the video output Molex connector, J2. The additional two outside pins on the Molex connector supply +5 and +12 volts, to be used in future Apple accessories. The composite video signal can also be modulated at the proper RF frequency, with an inexpensive commercially available device, and applied to the antenna terminals of a home television receiver. Since the character format is 40 characters/line, all television receivers will have the necessary bandwidth to display the entire 40 characters. Two large manufacturers of video display monitors, which connect directly with the Apple Computer, are Motorola and Ball. The mating four-pin Molex connector is provided.

AC Power Sources:

Two incoming AC power sources are required for operation: 8 to 10 VAC (RMS) at 3 amps, and 28 VAC (RMS) Center-Tapped at 1 amp. These AC supplies enter the system at the Molex connector, J1. The 8 to 10 volts AC provides the raw AC for the +5 volt supply, while the 28 VCT supplies the raw AC for the +12 and -12 volt supplies, and the -5V supply is derived from the -12V regulated output.

The board, as supplied, requires no more than 1.5 amps DC from the +5V supply, while the regulator is capable of supplying 3 amps. The remaining 1.5 amps DC from the +5V supply is available for user hardware expansion (provided suitable transformer ratings are employed).

A suitable source of the raw AC voltages required, are two commercially available transformers; Stancor P/N P-8380 or equivalent (8 to 10 volts at 3 amps), and Stancor P/N P-8667 or

equivalent (28VCT at 1 amp). Simply wire the secondaries to the mating six-pin Molex connector supplied, and wire the primaries in parallel, as shown in the schematic diagram (power supply section, Dwg.No. 00101, sheet 3 of 3).

TEST PROGRAM

After attaching the keyboard, display, and AC power sources, you can try a simple program to test if your system and the attachments are functioning together properly. While it does not test many possible areas of the microprocessor system, the test program will test for the correct attachment of the keyboard, display, and power supplies.

FIRST:

Hit the RESET button to enter the system monitor. A backslash should be displayed, and the cursor should drop to the next line.

SECOND:

Type- 0 : A9 b 0 b AA b 20 b EF b FF b E8 b 8A b 4C b 2 b 0 (RET)  
(0 is a zero, NOT an alpha "O"; b means blank or space; and (RET) hit the "return" key on the keyboard)

THIRD:

Type- 0 . A (RET)  
(This should print out, on the display, the program you have just entered.)

FOURTH:

Type- R (RET)  
(R means run the program.)

THE PROGRAM SHOULD THEN PRINT OUT ON THE DISPLAY A CONTINUOUS STREAM OF ASCII CHARACTERS. TO STOP THE PROGRAM AND RETURN TO THE SYSTEM MONITOR, HIT THE "RESET" BUTTON. TO RUN AGAIN, TYPE : R (RET).

## SECTION II USING THE SYSTEM MONITOR

The Hex Monitor is a PROM program in locations FF00 to FFFF (hex) which uses the keyboard and display to perform the front panel functions of examining memory, and running programs. The monitor program is entered by hitting (RESET), which displays backslash-return. A backslash alone (cursor remains on same line as backslash) indicates bad page 0 RAM.

Commands are typed on a "line-at-a-time" basis with editing. Each line may consist of any number of commands (up to 128 characters). None are executed until (RETURN) is typed. The (SHIFT-0) (backarrow) backspaces and echos an underline. The (ESC) cancels a line and echos backslash-return.

One or more hexadecimal digits (0-9, A-F) are used for address and data values. Addresses use the four least significant digits of a group, and data values, the two least significant digits. The following examples illustrate the variety of acceptable commands:

1. Opening a location (examining the contents of a single address).

```
USER TYPES/ 4F (RET)
MONITOR TYPES/ 004F: 0F (contents
                of 4F)
```

2. Examining a block; from the last examined location, to a specified one.

```
USER TYPES/ .5A (RET)
MONITOR TYPES/
0050: 00 01 02 03 04 05 06 07
0058: 08 09 0A
```

Note: 4F is still considered the most recently opened location.

3. Combining examples 1 and 2 to print a block of memory in a single command.

```
USER TYPES/ 4F.5A (RET)
MONITOR TYPES/
0050: 00 01 02 03 04 05 06 07
0058: 08 09 0A
```

Note: Only the first location of the block (4F) is considered "opened".

4. Examining several individual locations at once.

```
USER TYPES/ 4F b 52 b 56 (RET)
MONITOR TYPES/ 004F: 0F
                0052: 02
                0056: 06
```

Note: 56 is considered the most recently "opened" location. The "b" is a blank or comma, and is a delimiter for separation purposes only. A string of delimiters has the same effect as a single one (bbb is as effective as b).

5. Examining several blocks of memory at once.

```
USER TYPES/ 4F.52 b 56 b 58.5A
                (RET)
MONITOR TYPES/ 004F: 0F
                0050: 00 01 02
                0056: 06
                0058: 08 09 0A
```

Note: 58 is considered the most recently "opened" location. Refer to example 2.

6. Examining successive blocks.

```
USER TYPES/ 4F.52 (RET)
MONITOR TYPES/ 004F: 0F
                0050: 00 01 02
                USER TYPES/ .55 (RET)
MONITOR TYPES/ 0053: 03 04 05
                USER TYPES/ .5A (RET)
MONITOR TYPES/ 0056: 06 07
                0058: 08 09 0A
```

7. Depositing data in a single location.

```
USER TYPES/ 30: A0 (RET)
MONITOR TYPES/ 0030: FF (prior
                contents)
```

Note: Location 30 is considered opened and now contains 30.

8. Depositing data in successive locations from that last used in a deposit command.

```
USER TYPES/ : A1 b A2 b A3 b A4
                b A5 (RET)
```

(This deposits A1 in location 31, A2 in 32, and so on.)

9. Combining examples 7 and 8 in a single command.

```
USER TYPES/ 30: A0 b A1 b A2 b
                A3 b A4 b A5 (RET)
MONITOR TYPES/
0030: FF (prior contents of location 30)
```

10. Depositing data in successive locations with separate commands.

```
USER TYPES/ 30: A0 b A1 (RET)
MONITOR TYPES/ 0030: FF
                USER TYPES/ :A2 b A3 (RET)
                USER TYPES/ :A4 b A5 (RET)
```

NOTE: Capital letters enclosed in parenthesis represent single keystrokes.

Example: (RET) means hit the "return" key.

Note: A colon in a command means "start depositing data from the most recently deposited location, or if none, then from the most recently opened one.

11. Examining a block, then depositing into it.  
USER TYPES/ 30.35 (RET)  
MONITOR TYPES/  
0030: A0 A1 A2 A3 A4 A5 A6  
USER TYPES/  
:B0 b B1 b B2 b B3 b B4 b B5 (RET)

Note: New data deposited beginning at most recently opened location (30)

12. Run a program at a specified address.  
USER TYPES/ 10F0 R (RET)  
MONITOR TYPES/ 10F0: A9 (contents)

Note: The cursor is left immediately to the right of the "A9"; it is not returned to the next line.

13. Run at the most recently examined location.  
USER TYPES/ 10F0 (RET)  
MONITOR TYPES/ 10F0: A9  
USER TYPES/ R (RET)

14. Enter a program into memory and run it in one line.  
USER TYPES/  
40: A9 b 0 b 20 b EF b FF b 38 b 69 b  
0 b 4C b 40 b 0 R (RET)  
MONITOR TYPES/ 40: FF (prior contents of 40)

MONITOR TYPES/ 40: FF (prior contents of 40)

15. An "on line" error correction.  
USER TYPES/  
40: A1 b A2 b A3A4A5A6 b A7  
(data A6 will be loaded in location 42)  
USER TYPES/ 40506070: AA  
(data AA will be loaded in location 6070)

16. Useful routines in monitor which can be accessed by user programs.  
GETLINE: location FF1F:  
monitor entry point  
(jumping to FF1F will enter monitor and echo carriage return. You can then examine memory locations with the monitor.)

ECHO: location FFEF:  
prints one byte (ASCII)  
(data from "A" (accumulator), contents of "A" not disturbed. Example:  
20 b EF b FF (JRS ECHO)).

PRBYTE: location FFDC:  
prints one byte (HEX)  
(data from "A", contents of "A" disturbed.)

PRHEX: location FFE5:  
prints one hex digit  
(data from four least significant bits of "A", contents of "A" disturbed.)

NOTE: RAM locations 0024 to 002B are used as index pointers by the monitor, and are invalid for user use, when using monitor. Also, locations 0200 to 027F are used as input buffer storage, and are also invalid for user use when using the monitor.

## 6502 HEX MONITOR LISTING

|      |          |           |               |   |
|------|----------|-----------|---------------|---|
| FF00 | D8       | RESET     | CLD           | Clear decimal arithmetic mode.            |
| FF01 | 58       |           | CLI           |   |
| FF02 | A0 7F    |           | LDY #\$7F     | Mask for DSP data direction register.     |
| FF04 | 8C 12 D0 |           | STY DSP       | Set it up.                                |
| FF07 | A9 A7    |           | LDA #\$A7     | KBD and DSP control register mask.        |
| FF09 | 8D 11 D0 |           | STA KBD CR    | Enable interrupts, set CA1, CB1, for      |
| FF0C | 8D 13 D0 |           | STA DSP CR    | positive edge sense/output mode.          |
| FF0F | C9 DF    | NOTCR     | CMP #\$DF     | "←"?                                      |
| FF11 | F0 13    |           | BEQ BACKSPACE | Yes.                                      |
| FF13 | C9 9B    |           | CMP #\$9B     | ESC?                                      |
| FF15 | F0 03    |           | BEQ ESCAPE    | Yes.                                      |
| FF17 | C8       |           | INY           | Advance text index.                       |
| FF18 | 10 0F    |           | BPL NEXTCHAR  | Auto ESC if >127.                         |
| FF1A | A9 DC    | ESCAPE    | LDA #\$DC     | "\".                                      |
| FF1C | 20 EF FF |           | JSR ECHO      | Output it.                                |
| FF1F | A9 8D    | GETLINE   | LDA #\$8D     | CR.                                       |
| FF21 | 20 EF FF |           | JSR ECHO      | Output it.                                |
| FF24 | A0 01    |           | LDY #\$01     | Initiallize text index.                   |
| FF26 | 88       | BACKSPACE | DEY           | Back up text index.                       |
| FF27 | 30 F6    |           | BMI GETLINE   | Beyond start of line, reinitialize.       |
| FF29 | AD 11 D0 | NEXTCHAR  | LDA KBD CR    | Key ready?                                |
| FF2C | 10 FB    |           | BPL NEXTCHAR  | Loop until ready.                         |
| FF2E | AD 10 D0 |           | LDA KBD       | Load character. B7 should be '1'.         |
| FF31 | 99 00 02 |           | STA IN, Y     | Add to text buffer.                       |
| FF34 | 20 EF FF |           | JSR ECHO      | Display character.                        |
| FF37 | C9 8D    |           | CMP #\$8D     | CR?                                       |
| FF39 | D0 D4    |           | BNE NOTCR     | No.                                       |
| FF3B | A0 FF    |           | LDY #\$FF     | Reset text index.                         |
| FF3D | A9 00    |           | LDA #\$00     | For XAM mode.                             |
| FF3F | AA       |           | TAX           | 0→X.                                      |
| FF40 | 0A       | SETSTOR   | ASL           | Leaves \$7B if setting STOR mode.         |
| FF41 | 85 2B    | SETMODE   | STA MODE      | \$00 = XAM, \$7B = STOR, \$AE = BLOK XAM. |
| FF43 | C8       | BLSKIP    | INY           | Advance text index.                       |
| FF44 | B9 00 02 | NEXT ITEM | LDA IN, Y     | Get character.                            |
| FF47 | C9 8D    |           | CMP #\$8D     | CR?                                       |
| FF49 | F0 D4    |           | BEQ GETLINE   | Yes, done this line.                      |
| FF4B | C9 AE    |           | CMP #\$AE     | ". "?                                     |
| FF4D | 90 F4    |           | BCC BLSKIP    | Skip delimiter.                           |
| FF4F | F0 F0    |           | BEQ SETMODE   | Set BLOCK XAM mode.                       |
| FF51 | C9 BA    |           | CMP #\$BA     | ":"?                                      |
| FF53 | F0 EB    |           | BEQ SETSTOR   | Yes, set STOR mode.                       |
| FF55 | C9 D2    |           | CMP #\$D2     | "R"?                                      |
| FF57 | F0 3B    |           | BEQ RUN       | Yes, run user program.                    |
| FF59 | 86 28    |           | STX L         | \$00→L.                                   |
| FF5B | 86 29    |           | STX H         | and H.                                    |
| FF5D | 84 2A    |           | STY YSAV      | Save Y for comparison.                    |
| FF5F | B9 00 02 | NEXTHEX   | LDA IN, Y     | Get character for hex test.               |
| FF62 | 49 B0    |           | EOR #\$B0     | Map digits to \$0-9.                      |
| FF64 | C9 0A    |           | CMP #\$0A     | Digit?                                    |
| FF66 | 90 06    |           | BCC DIG       | Yes.                                      |
| FF68 | 69 88    |           | ADC #\$88     | Map letter "A"- "F" to \$FA-FF.           |
| FF6A | C9 FA    |           | CMP #\$FA     | Hex letter?                               |
| FF6C | 90 11    |           | BCC NOTHEX    | No, character not hex.                    |
| FF6E | 0A       | DIG       | ASL           |   |
| FF6F | 0A       |           | ASL           | Hex digit to MSD of A.                    |
| FF70 | 0A       |           | ASL           |   |
| FF71 | 0A       |           | ASL           |   |
| FF72 | A2 04    |           | LDX #\$04     | Shift count.                              |
| FF74 | 0A       | HEXSHIFT  | ASL           | Hex digit left, MSB to carry.             |

6502 HEX MONITOR LISTING (continued)

|      |          |            |                |   |
|------|----------|------------|----------------|---|
| FF75 | 26 28    |            | ROL L          | Rotate into LSD.                            |
| FF77 | 26 29    |            | ROL H          | Rotate into MSD's.                          |
| FF79 | CA       |            | DEX            | Done 4 shifts?                              |
| FF7A | D0 F8    |            | BNE HEXSHIFT   | No, loop.                                   |
| FF7C | C8       |            | INY            | Advance text index.                         |
| FF7D | D0 E0    |            | BNE NEXTHEX    | Always taken. Check next character for hex. |
| FF7F | C4 2A    | NOTHEX     | CPY YSAV       | Check if L, H empty (no hex digits).        |
| FF81 | F0 97    |            | BEQ ESCAPE     | Yes, generate ESC sequence.                 |
| FF83 | 24 2B    |            | BIT MODE       | Test MODE byte.                             |
| FF85 | 50 10    |            | BVC NOTSTOR    | B6 = 0 for STOR, 1 for XAM and BLOCK XAM    |
| FF87 | A5 28    |            | LDA L          | LSD's of hex data.                          |
| FF89 | 81 26    |            | STA (STL, X)   | Store at current 'store index'.             |
| FF8B | E6 26    |            | INC STL        | Increment store index.                      |
| FF8D | D0 B5    |            | BNE NEXTITEM   | Get next item. (no carry).                  |
| FF8F | E6 27    |            | INC STH        | Add carry to 'store index' high order.      |
| FF91 | 4C 44 FF | TONEXTITEM | JMP NEXTITEM   | Get next command item.                      |
| FF94 | 6C 24 00 | RUN        | JMP (XAML)     | Run at current XAM index.                   |
| FF97 | 30 2B    | NOTSTOR    | BMI XAMNEXT    | B7 = 0 for XAM, 1 for BLOCK XAM.            |
| FF99 | A2 02    |            | LDX #02        | Byte count.                                 |
| FF9B | B5 27    | SETADR     | LDA L-1, X     | Copy hex data to                            |
| FF9D | 95 25    |            | STA STL-1, X   | 'store index'.                              |
| FF9F | 95 23    |            | STA XAML-1, X  | And to 'XAM index'.                         |
| FFA1 | CA       |            | DEX            | Next of 2 bytes.                            |
| FFA2 | D0 F7    |            | BNE SETADR     | Loop unless X = 0.                          |
| FFA4 | D0 14    | NXTPRNT    | BNE PRDATA     | NE means no address to print.               |
| FFA6 | A9 8D    |            | LDA #8D        | CR.   |
| FFA8 | 20 EF FF |            | JSR ECHO       | Output it.                                  |
| FFAB | A5 25    |            | LDA XAMH       | 'Examine index' high-order byte.            |
| FFAD | 20 DC FF |            | JSR PRBYTE     | Output it in hex format.                    |
| FFB0 | A5 24    |            | LDA XAML       | Low-order 'examine index' byte.             |
| FFB2 | 20 DC FF |            | JSR PRBYTE     | Output it in hex format.                    |
| FFB5 | A9 BA    |            | LDA #BA        | ":":  |
| FFB7 | 20 EF FF |            | JSR ECHO       | Output it.                                  |
| FFBA | A9 A0    | PRDATA     | LDA #A0        | Blank.                                      |
| FFBC | 20 EF FF |            | JSR ECHO       | Output it.                                  |
| FFBF | A1 24    |            | LDA (XAML, X)  | Get data byte at 'examine index'.           |
| FFC1 | 20 DC FF |            | JSR PRBYTE     | Output it in hex format.                    |
| FFC4 | 86 2B    | XAMNEXT    | STX MODE       | 0 -> MODE (XAM mode).                       |
| FFC7 | A5 24    |            | LDA XAML       |   |
| FFC8 | C5 28    |            | CMP L          | Compare 'examine index' to hex data.        |
| FFCA | A5 25    |            | LDA XAMH       |   |
| FFCC | E5 29    |            | SBC H          |   |
| FFCE | B0 C1    |            | BCS TONEXTITEM | Not less, so no more data to output.        |
| FFD0 | E6 24    |            | INC XAML       |   |
| FFD2 | D0 02    |            | BNE MOD8CHK    | Increment 'examine index'.                  |
| FFD4 | E6 25    |            | INC XAMH       |   |
| FFD6 | A5 24    | MOD8CHK    | LDA XAML       | Check low-order 'examine index' byte        |
| FFD8 | 29 07    |            | AND #07        | For MOD 8 = 0                               |
| FFDA | 10 C8    |            | BPL NXTPRNT    | Always taken.                               |
| FFDC | 48       | PRBYTE     | PHA            | Save A for LSD.                             |
| FFDD | 4A       |            | LSR            |   |
| FFDE | 4A       |            | LSR            |   |
| FFDF | 4A       |            | LSR            | MSD to LSD position.                        |
| FFE0 | 4A       |            | LSR            |   |
| FFE1 | 20 E5 FF |            | JSR PRHEX      | Output hex digit.                           |
| FFE4 | 68       |            | PLA            | Restore A.                                  |
| FFE5 | 29 0F    | PRHEX      | AND #0F        | Mask LSD for hex print.                     |
| FFE7 | 09 B0    |            | ORA #B0        | Add "0".                                    |
| FFE9 | C9 BA    |            | CMP #BA        | Digit?                                      |



6502 HEX MONITOR LISTING (continued)

|                     |          |                            |
|---------------------|----------|----------------------------|
| FFEB 90 02          | BCC ECHO | Yes, output it.            |
| FFED 69 06          | ADC #06  | Add offset for letter.     |
| FFEF 2C 12 D0 ECHO  | BIT DSP  | DA bit (B7) cleared yet?   |
| FFF2 30 FB          | BMI ECHO | No, wait for display.      |
| FFF4 8D 12 D0       | STA DSP  | Output character. Sets DA. |
| FFF7 60             | RTS      | Return.                    |
| FFF8 00 00 (unused) |          |                            |
| FFFA 00 0F (NMI)    |          |                            |
| FFFC 00 FF (RESET)  |          |                            |
| FFFE 00 00 (IRQ)    |          |                            |

HARDWARE NOTES

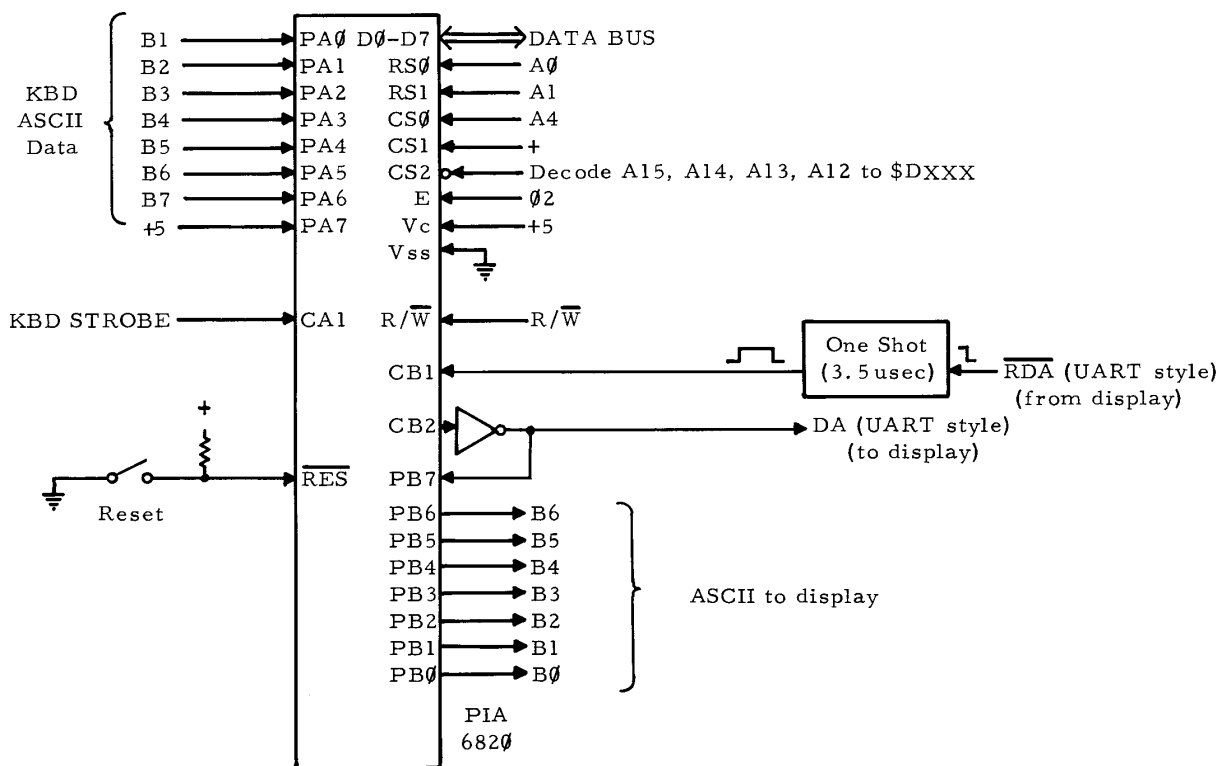
Page 0 Variables

|      |    |
|------|----|
| XAML | 24 |
| XAMH | 25 |
| STL  | 26 |
| STH  | 27 |
| L    | 28 |
| H    | 29 |
| YSAV | 2A |
| MODE | 2B |

Other Variables

|        |         |       |
|--------|---------|-------|
| IN     | 200-27F | } PIA |
| KBD    | D010    |       |
| KBD CR | D011    |       |
| DSP    | D012    |       |
| DSP CR | D013    |       |

KBD/DSP Interface



**SECTION III**  
**HOW TO EXPAND THE APPLE SYSTEM**

The Apple system can be expanded to include more memory and IO devices, via a 44-pin edge connector. The system is fully expandable to 65K, with the entire data and address busses, clocks, control signals (i. e. IRQ, NMI, DMA, RDY, etc.), and power sources available at the connector. All address lines are TTL buffered, and data lines can drive ten equivalent capacitive loads (one TTL load and 130pf) without external buffers. All clock signals are TTL. The Apple system runs at approximately 1 MHz (see spec sheet) and is fully compatible with 6800/6500 style timing.

Three power sources are available at the edge connector: +5 volts regulated, and raw DC (approximately +/- 14V) for the +12V, -12V, and -5V supplies. If +12V, -12V, or -5V supplies are required, EXTERNAL REGULATORS MUST BE USED. An excess of 1.5 amps from the "on-board" regulated +5V supply is available for expansion (assuming suitable transformer ratings are employed). Exercise great care in the handling of the raw DC, as no short-circuit protection is provided.

**REFRESH:**

Four out of every 65 clock cycles is dedicated to memory refresh. At the start of a refresh cycle (150 ns after leading edge of  $\phi 1$ ),  $\overline{RF}$  goes low, and remains low for one clock cycle.  $\phi 2$  is inhibited during a refresh cycle, and the processor is held in  $\phi 1$  (it's inactive state). Dynamic memories, which must clock during refresh cycles, should derive their clock from  $\phi 0$ , which is equivalent to  $\phi 2$ , except that it continues during a refresh cycle. Devices, such as PIA's, will not be affected by a refresh cycle, since they react to  $\phi 2$  only. Refer to Apple "Tech Notes" for a variety of interfacing examples.

**DMA:**

The Apple system has full DMA capability. For DMA, the DMA control line tri-states the address buss, thus allowing external devices to control the buss. Consult MOS TECHNOLOGY 6502 Hardware Manual for details. (For DMA use, the solder jumper on the board, marked "DMA", must be broken.)

For the 6502 microprocessor, the RDY line is used to halt the processor for single stepping, or slow ROM applications. Refer to Apple "Tech Notes" for examples.

**SOFTWARE CONSIDERATIONS:**

The sequences listed below are the routines used to read the keyboard or output to the display.

**Read Key from KBD:**

```
LDA KBD CR (D011)
BPL
LDA KBD DATA (D010)
```

**Output to Display:**

```
BIT DSP (D012)
BPL
STA DSP (D012)
```

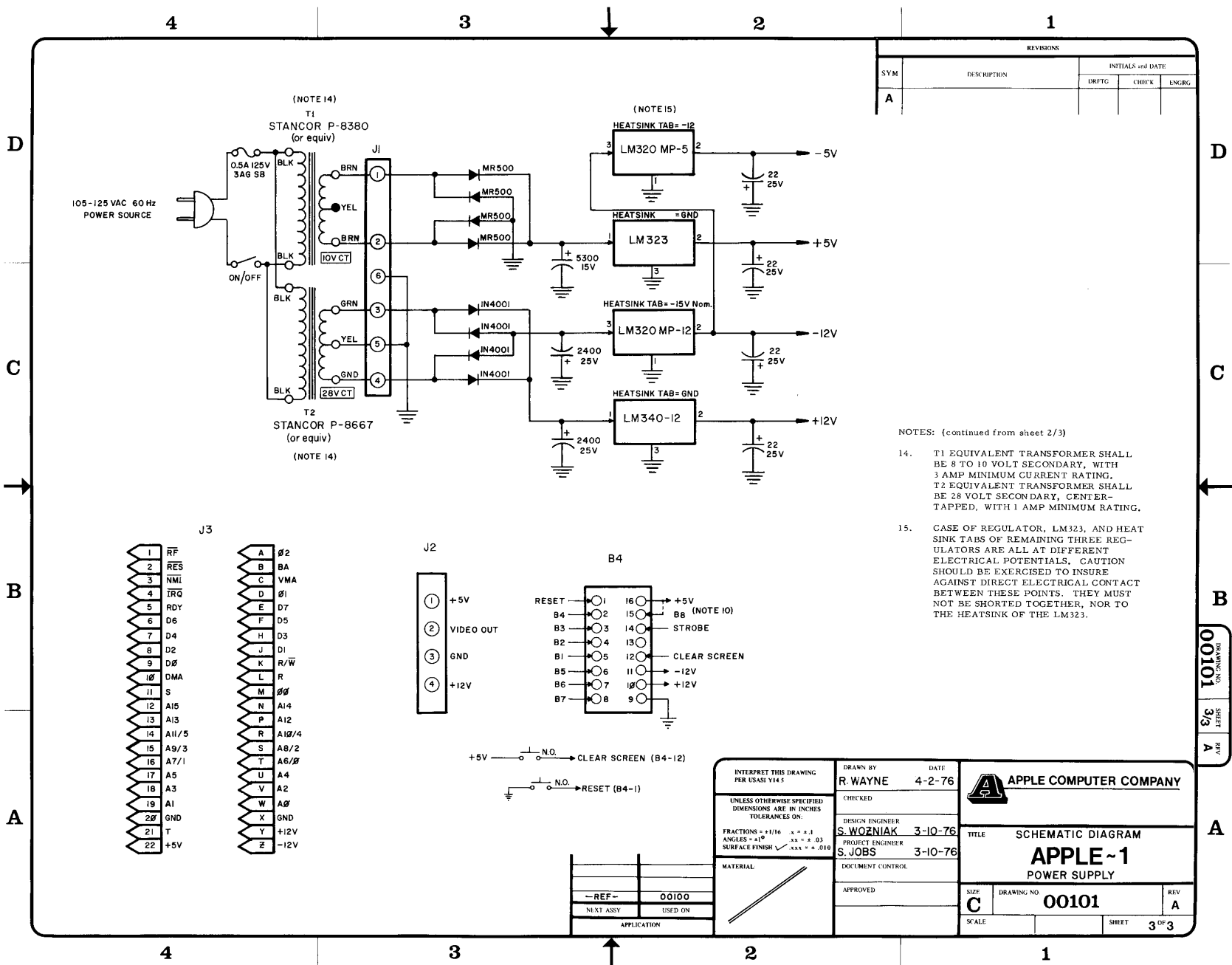
**PIA Internal Registers:**

KBD Data D010  
High order bit equals 1.

KBD Control Reg. D011  
High order bit indicates "key ready".  
Reading key clears flag. Rising edge of KBD sets flag.

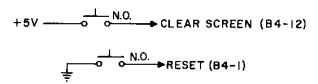
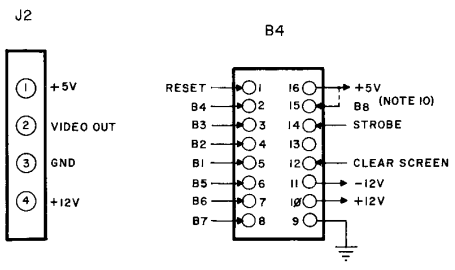
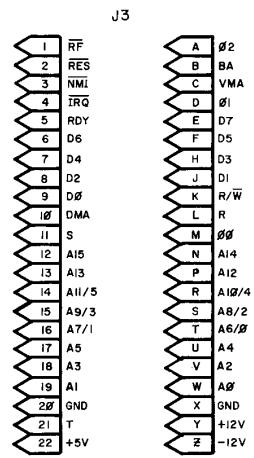
DSP DATA D012  
Lower seven bits are data output,  
high order bit is "display ready"  
input (1 equals ready, 0 equals busy)

DSP Control Reg. D013



| REVISIONS |             |                   |       |       |
|-----------|-------------|-------------------|-------|-------|
| SYM       | DESCRIPTION | INITIALS and DATE |       |       |
|           |             | DRAFT             | CHECK | ENGR. |
| A         |             |                   |       |       |

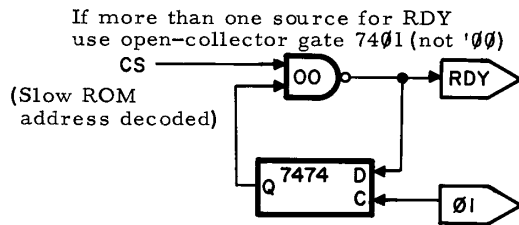
- NOTES: (continued from sheet 2/3)
- T1 EQUIVALENT TRANSFORMER SHALL BE 8 TO 10 VOLT SECONDARY, WITH 3 AMP MINIMUM CURRENT RATING.
  - T2 EQUIVALENT TRANSFORMER SHALL BE 28 VOLT SECONDARY, CENTER-TAPPED, WITH 1 AMP MINIMUM RATING.
  - CASE OF REGULATOR, LM323, AND HEAT SINK TABS OF REMAINING THREE REGULATORS ARE ALL AT DIFFERENT ELECTRICAL POTENTIALS. CAUTION SHOULD BE EXERCISED TO INSURE AGAINST DIRECT ELECTRICAL CONTACT BETWEEN THESE POINTS. THEY MUST NOT BE SHORTED TOGETHER, NOR TO THE HEATSINK OF THE LM323.



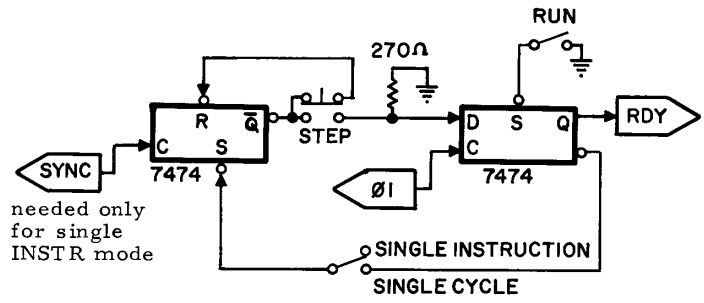
|  |                              |                                   |                               |
|--|------------------------------|-----------------------------------|-------------------------------|
| INTERPRET THIS DRAWING PER USAS1 V14.5<br>UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON:<br>FRACTIONS = +1/16 x . . . 1<br>ANGLES = ±1° x . . . 0.5<br>SURFACE FINISH = .010 x . . . 0.010 | DRAWN BY<br><b>R. WAYNE</b>  | DATE<br><b>4-2-76</b>             | <b>APPLE COMPUTER COMPANY</b> |
|  | CHECKED<br><b>S. WOZNIAK</b> | DESIGN ENGINEER<br><b>3-10-76</b> |                               |
| MATERIAL<br>   | DOCUMENT CONTROL<br>APPROVED | DRAWING NO<br><b>00101</b>        | REV<br><b>A</b>               |
| APPLICATION<br>~ REF ~<br>NEXT ASSY<br>USED ON   | SCALE<br><b>C</b>            | SHEET<br><b>3 OF 3</b>            |                               |

DRAWING NO 00101 SHEET 3/3 REV A

A



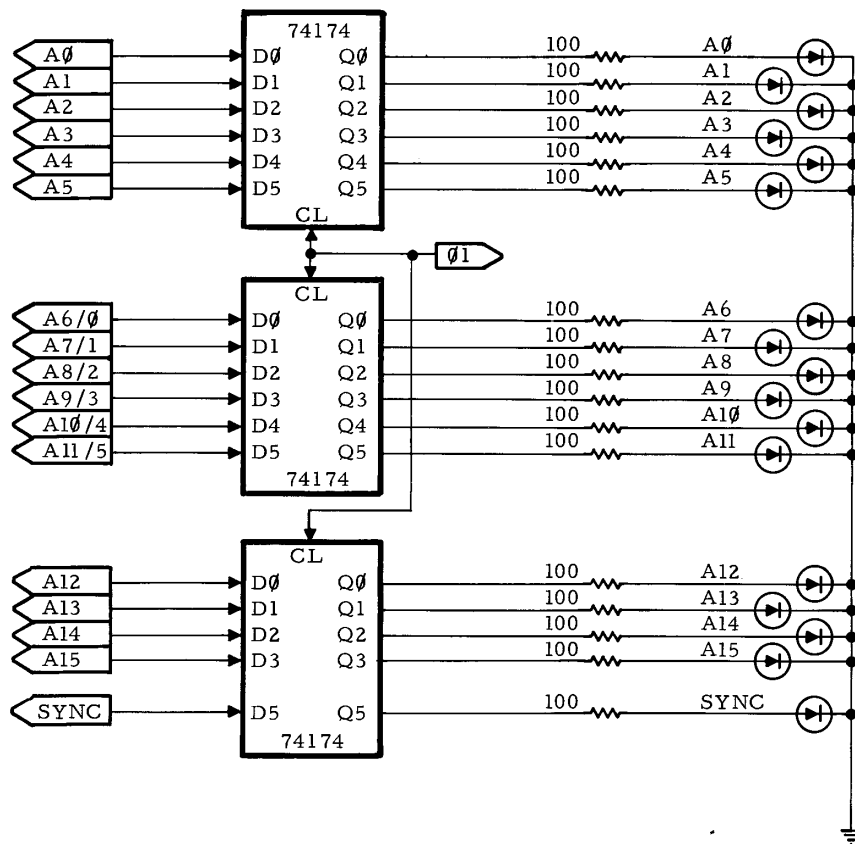
SLOW ROM



(NOTE: Features not needed may be omitted)

SINGLE STEP FOR 6502

ADDRESS DISPLAY





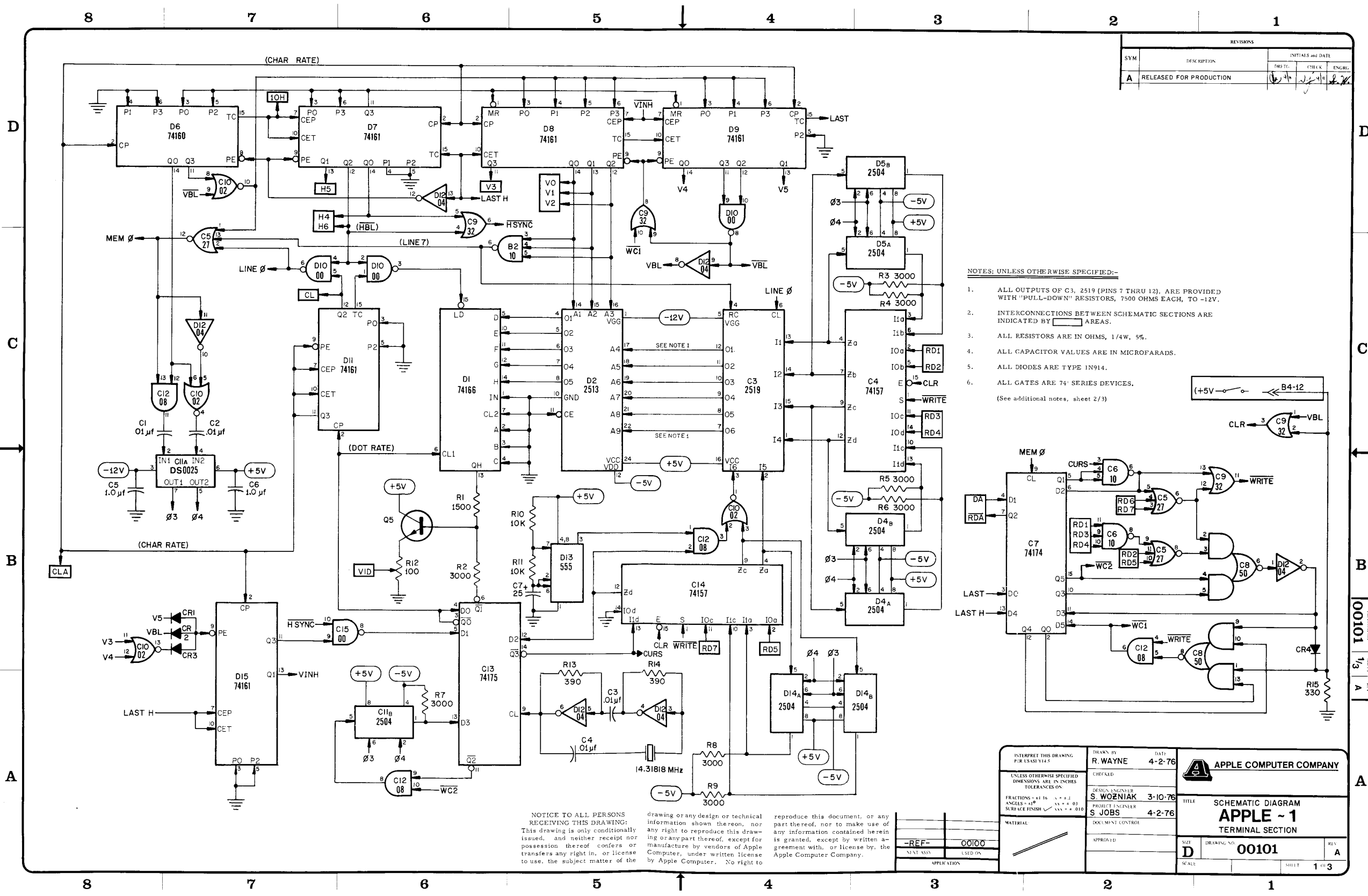
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The Apple Computer Company hereby warrants each of its products, and all components therein contained, to be free from defects in materials and/or workmanship for a period of thirty (30) days from date of purchase. In the event of the occurrence of malfunction, or other indication of failure attributable directly to faulty workmanship and/or material, then, upon return of the product to the Apple Computer Company, at 770 Welch Road, Palo Alto, California, 94304 (postage prepaid), the Apple Computer Company will, at its option, repair or replace said products or components thereof, to whatever extent Apple Computer Company shall deem necessary, to restore said product to proper operating condition. All such repairs or replacements shall be rendered by the Apple Computer Company, without charge to the customer.

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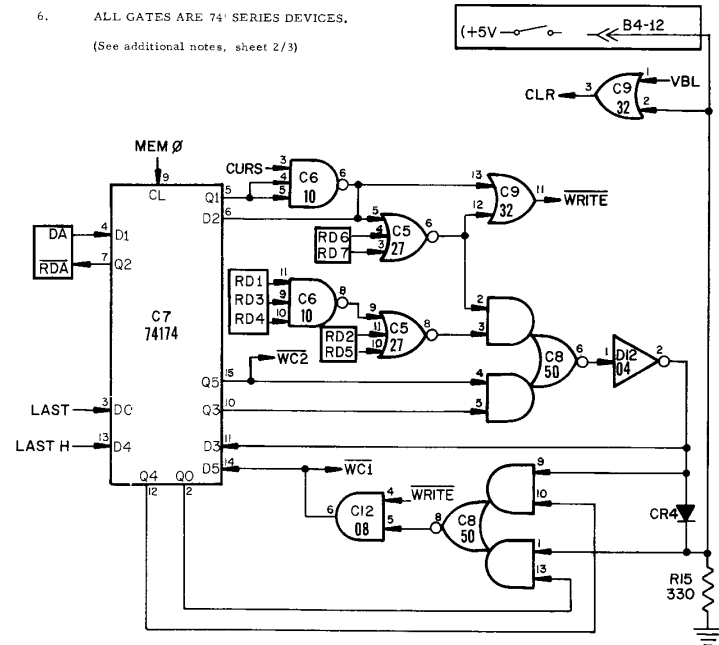
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| REVISIONS |                         |            |        |
|-----------|-------------------------|------------|--------|
| SYM       | DESCRIPTION             | INITIALS   | DATE   |
| A         | RELEASED FOR PRODUCTION | (initials) | (date) |

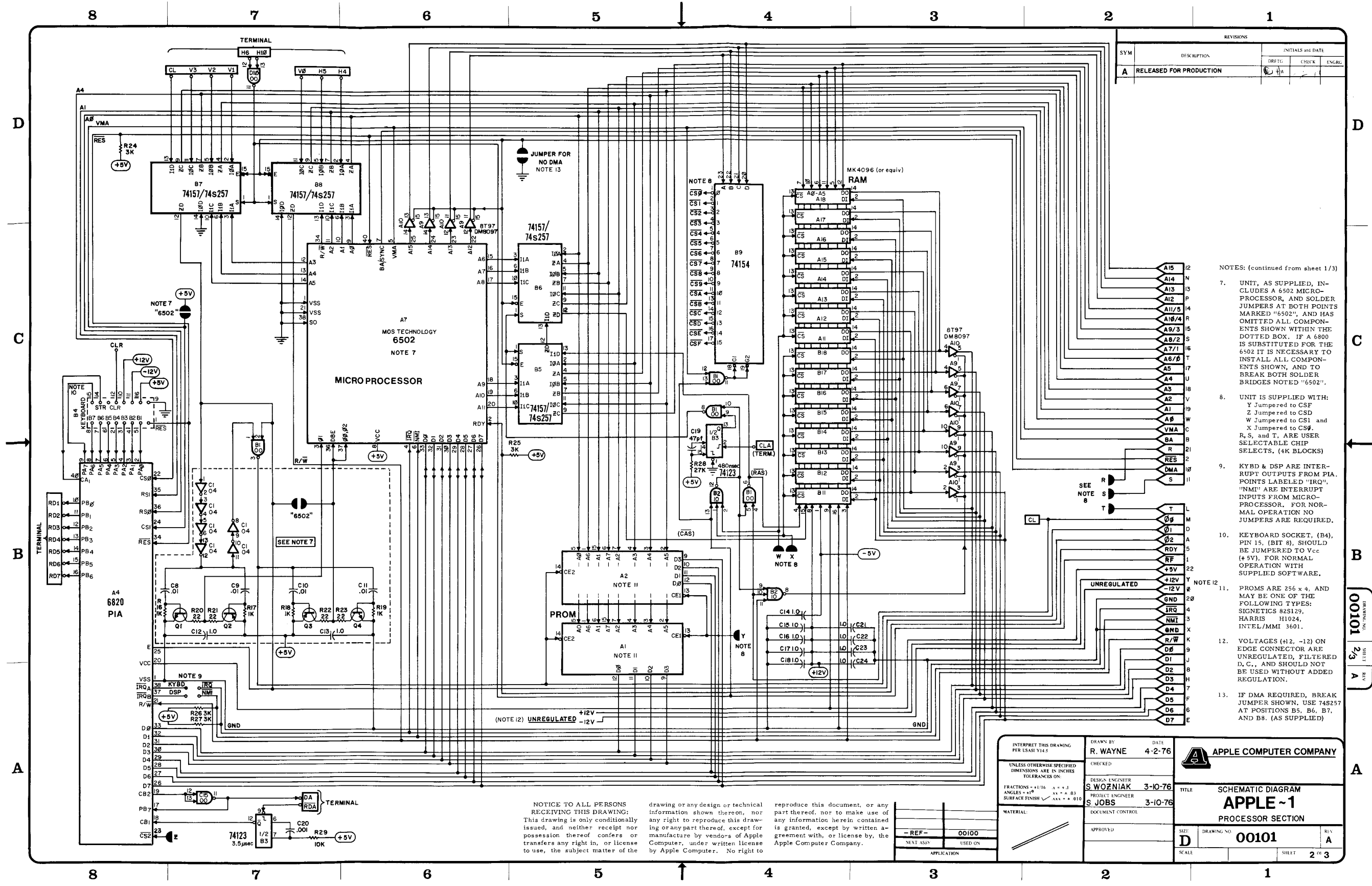
NOTES: UNLESS OTHERWISE SPECIFIED:-

- ALL OUTPUTS OF C3, 2519 (PINS 7 THRU 12), ARE PROVIDED WITH "PULL-DOWN" RESISTORS, 7500 OHMS EACH, TO -12V.
- INTERCONNECTIONS BETWEEN SCHEMATIC SECTIONS ARE INDICATED BY [ ] AREAS.
- ALL RESISTORS ARE IN OHMS, 1/4W, 5%.
- ALL CAPACITOR VALUES ARE IN MICROFARADS.
- ALL DIODES ARE TYPE IN914.
- ALL GATES ARE 74' SERIES DEVICES.  
(See additional notes, sheet 2/3)



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|   |                            |                 |                        |
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| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON:<br>FRACTIONS ±.10<br>DECIMALS ±.01<br>ANGLES ±.1°<br>SURFACE FINISH UNLESS OTHERWISE SPECIFIED | CHECKED<br>S. WOZNIAK      | DATE<br>3-10-76 |                        |
|   | DESIGN ENGINEER<br>S. JOBS | DATE<br>4-2-76  |                        |
| MATERIAL  |                            |                 | DOCUMENT CONTROL       |
| APPROVED  |                            |                 |                        |
| TITLE<br>SCHEMATIC DIAGRAM<br>APPLE - 1<br>TERMINAL SECTION   |                            |                 | REV<br>A               |
| DRAWING NO.<br>00101  |                            |                 | SCALE                  |
| SHEET<br>1 OF 3   |                            |                 |                        |



| REVISIONS |                         |      | INITIALS AND DATE |       |       |
|-----------|-------------------------|------|-------------------|-------|-------|
| SYM       | DESCRIPTION             | DATE | DRFTG             | CHECK | ENGRG |
| A         | RELEASED FOR PRODUCTION |      |                   |       |       |

- NOTES: (continued from sheet 1/3)
- UNIT, AS SUPPLIED, INCLUDES A 6502 MICRO-PROCESSOR, AND SOLDERS JUMPERS AT BOTH POINTS MARKED "6502", AND HAS OMITTED ALL COMPONENTS SHOWN WITHIN THE DOTTED BOX. IF A 6800 IS SUBSTITUTED FOR THE 6502 IT IS NECESSARY TO INSTALL ALL COMPONENTS SHOWN, AND TO BREAK BOTH SOLDER BRIDGES NOTED "6502".
  - UNIT IS SUPPLIED WITH:  
Y Jumpered to CSF  
Z Jumpered to CSD  
W Jumpered to CS1 and X Jumpered to CS9.  
R, S, and T, ARE USER SELECTABLE CHIP SELECTS. (4K BLOCKS)
  - KYBD & DSP ARE INTERRUPT OUTPUTS FROM PIA. POINTS LABELED "IRQ", "NMI" ARE INTERRUPT INPUTS FROM MICRO-PROCESSOR. FOR NORMAL OPERATION NO JUMPERS ARE REQUIRED.
  - KEYBOARD SOCKET, (B4), PIN 15, (BIT 8), SHOULD BE JUMPERED TO Vcc (+5V), FOR NORMAL OPERATION WITH SUPPLIED SOFTWARE.
  - PROMS ARE 256 x 4, AND MAY BE ONE OF THE FOLLOWING TYPES:  
SIGNETICS 825129,  
HARRIS H1024,  
INTEL/MMI 3601.
  - VOLTAGES (+12, -12) ON EDGE CONNECTOR ARE UNREGULATED, FILTERED D, C, AND SHOULD NOT BE USED WITHOUT ADDED REGULATION.
  - IF DMA REQUIRED, BREAK JUMPER SHOWN, USE 74S257 AT POSITIONS B5, B6, B7, AND B8. (AS SUPPLIED)

|  |                               |                |  |
|--|-------------------------------|----------------|--|
| INTERPRET THIS DRAWING PER ISSA 2145                               | DRAWN BY<br>R. WAYNE          | DATE<br>4-2-76 | <br>APPLE COMPUTER COMPANY   |
| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: | CHECKED                       |                |  |
| FRACTIONS = 1/16 x = +.3   | DESIGN ENGINEER<br>S. WOZNIAK | 3-10-76        | TITLE<br><b>SCHEMATIC DIAGRAM</b><br><b>APPLE-1</b><br>PROCESSOR SECTION |
| ANGLES = 45° x x = +.03  | PRODUCT ENGINEER<br>S. JOBS   | 3-10-76        |  |
| SURFACE FINISH ✓ xxx = .010  | APPROVED                      |                | SIZE<br><b>D</b>   |
| MATERIAL:  | DOCUMENT CONTROL              |                | DRAWING NO.<br><b>00101</b>  |
| - REF - 00100  |                               |                | REV<br><b>A</b>  |
| NEXT ASSY USED ON  |                               |                | SHEET<br><b>2</b> OF <b>3</b>  |

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