

**L.J. ELECTRONICS**

'MAC' MICROPROCESSOR APPLICATION CARD

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## 'MAC' MODULE

The 'MAC' 6502 is a Microprocessor Application card designed for use with software developed on the 'EMMA' 6502. The MAC contains the same hardware as the EMMA, without the cassette interface. All the addresses of the I/O ports and the RAM are the same as the EMMA, enabling the user to develop programs on the EMMA and then transfer the completed software to a 2716 EPROM using the EPROM Programmer Module. This EPROM used in the MAC card thus provides a dedicated microprocessor system.

Following the application of a 'RESET' signal to the microprocessor, it will go to addresses FFFC and FFFD to fetch the vectored reset address. These two addresses must be programmed to hold the start address of the dedicated program. For example, if the user writes a program that begins at address F800, the reset vectors would be loaded:-

| Address | Data |
|---------|------|
| FFFC    | 00   |
| FFFD    | F8   |

This booklet does not contain programming information for the 6502 microprocessor. For these details the user is referred to the EMMA Software Manual.

## 'MAC' 6502 - PARTS LIST

### Resistors:-

8 x 4.7k $\Omega$   $\frac{1}{2}$  Watt.

### Capacitors:-

5 x 10nF Ceramic

1 x 10 $\mu$ F Electrolytic or Tantalum

### Integrated Circuits:-

1 x 6502 Microprocessor

1 x 6522 Versatile Interface Adaptor

1 x 8154 RAM, Input/Output

1 x 7420

1 x 7404

1 x 74139

1 x 7400

2 x 2114 Static RAMs

1 x 2716 EPROM

### Miscellaneous:-

3 x 40 pin I.C. Sockets

3 x 14 pin I.C. Sockets

2 x 16 pin I.C. Sockets

2 x 18 pin I.C. Sockets

1 x 24 pin I.C. Socket

1 x Push-Button Switch

1 x 1MHz Crystal

1 x 20-way 0.1" Board Pin Strip

2 x 17-way 0.1" Board Pin Strip

1 x Double-sided P.C.B.

4 x Rubber Feet.

Component IdentificationResistors

These can be recognised by standard colour code bands. The ones supplied are  $4.7k\Omega$  and have yellow, violet, red and gold bands on them.

Capacitors

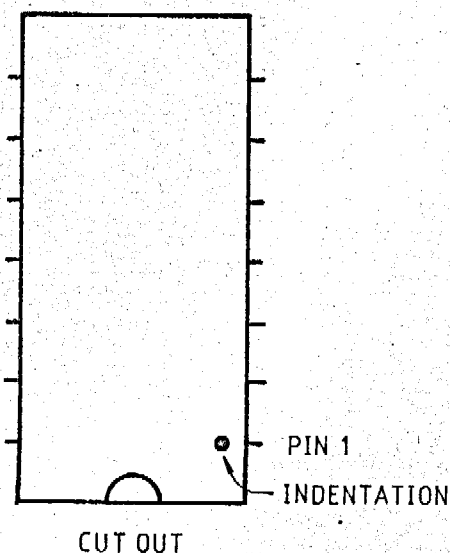
The  $10nF$  capacitors are a small ceramic plate type marked with  $10n$ .

The  $10\mu F$  capacitor is either a low leakage electrolytic or a tantalum type. They are both marked  $10\mu F$ ; the electrolytic has its negative lead marked (-) whereas the tantalum has its positive lead marked (+).

Integrated Circuits

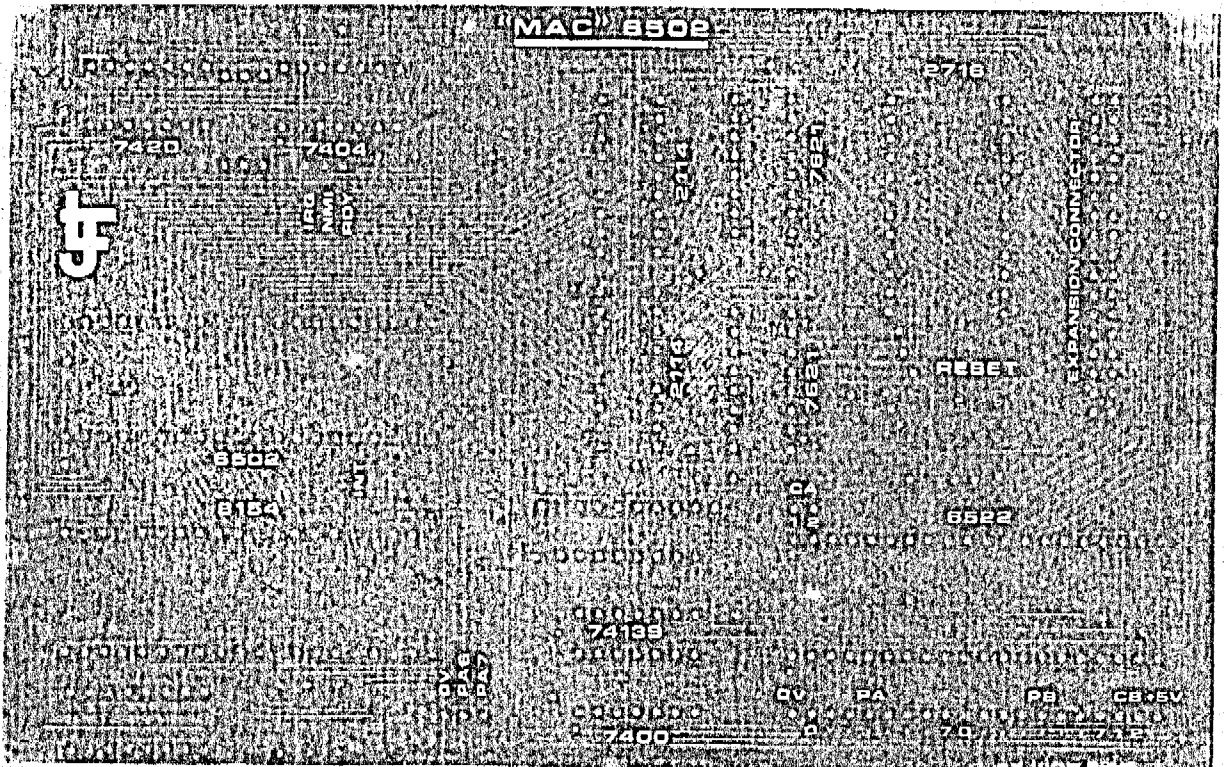
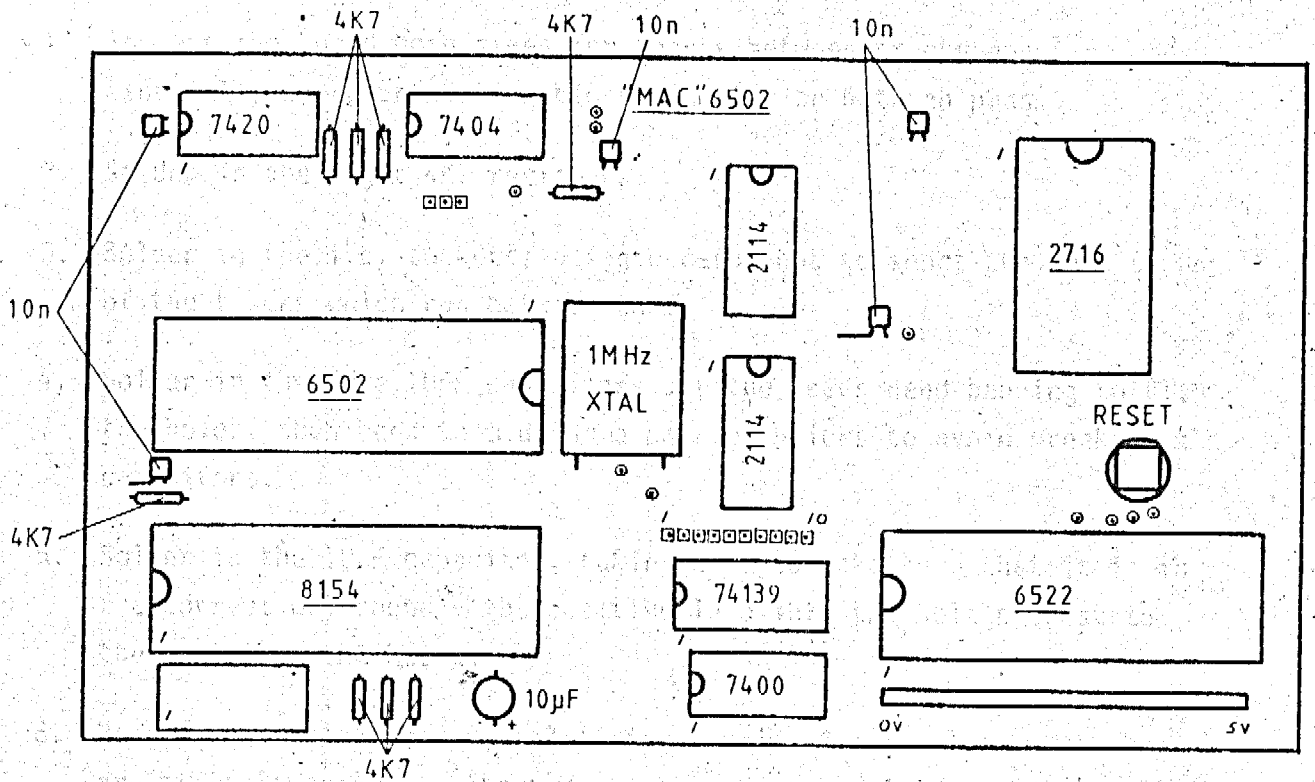
The I.C.s are identified by the numbers printed on the top. The T.T.L. I.C.s are all of the Low Power Schottky type and will contain LS in the identification number; (e.g. the I.C. to go in the socket marked 7420 will have 74LS20 printed on it).

Pin 1 on the I.C.s is identified by the cut out at one end of the package and/or a small indentation next to pin 1, e.g.:-



# MAC 6502

## P.C.B. Diagram



Assembly Instructions

1. Inspect the board both sides for shorts between tracks and i.c. pads, especially where tracks run close together or between pads.
2. Solder in the eight 4K7 resistors.
3. Solder in the i.c. sockets, being careful not to short the pads to any of the tracks which run between them.
4. Solder in the five 10nF capacitors, if the leads need bending to fit the holes, then bend them using a pair of pliers to avoid breaking the capacitors.
5. Solder in the 10 $\mu$ F capacitor, taking care to make sure that it is in the correct way round - the positive lead into the hole nearest to the bottom of the board.
6. Bend the leads of the crystal (using a pair of pliers) so that they are at right angles to the body of the crystal. Solder the crystal in so that it lays flat onto the board.
7. Solder in the RESET push-button switch with the flat side towards the top of the board (if inserted the wrong way part of the 'RESET' is covered).
8. Solder in the strips of 0.1" board pins. When soldering in the double row of pins, both rows must be inserted at the same time. The plastic piece on the pins is convex on one side and concave on the other, enabling the pins to lock together to form a double row.
9. Inspect the board for any solder shorts or dry joints. A careful inspection at this stage may save a great deal of time fault finding if the system does not work.
10. Place the integrated circuits in their sockets, making sure that they are the correct way round - see diagram and note on identification of components.

## Test Notes

### Switch On

1. Connect 0V. and +5V. to the board (0V. to the pin on the left of the 20 pin connector and the +5V. to the pin on the right of the 20 pin connector). The board will require 400mA approx.
2. Check each I.C. to make sure that it is not running hot. If any of them are hot, switch off immediately and check that they are in the correct way round and also inspect for solder shorts under the board.
3. When any obvious faults have been corrected, reconnect the power supply.

### Testing

To aid testing, the 2716 EPROM supplied with the MAC 6502 kit contains a short program which will increment the 4 I/O ports continuously. The program gives a maximum frequency of approximately 5kHz on the least significant bit of each port, halving in frequency on each bit of each port to give a frequency of approximately 18Hz on the most significant bit of the ports.

To run the program connect pin 2 (A6) on the 2716 to 0V. (pin 12) and press the RESET button - the link between pin 2 and 0V. forces the microprocessor to go to addresses FFBC and FFBD, instead of FFFC and FFFD, to pick up the RESET vectors.

If the system runs satisfactorily the link can be removed and the user can then put his own program in the EPROM and place the start address of the program at the normal RESET vector addresses of FFFC and FFFD.

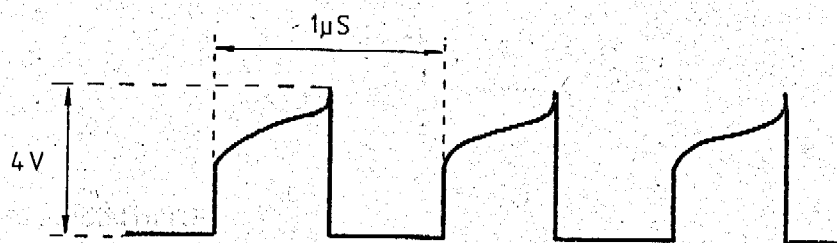
Note: If the EPROM is not erased, then locations FF80 to FFC0 cannot be used.

### Fault Finding Sequence

If the system does not work, checks to make are as follows:

- (i) Power supply voltage - should be 5V.  $\pm 0.25V$ .
- (ii) Power supply voltage present on each i.c.
- (iii)  $\phi_2$  clock on the 6502 pin 39 should be a 1MHz signal as shown overleaf.

(iii cont)



- (iv) Check that  $\phi_2$  buffered is present on pin.6 of the 7404 i.c., the waveform should be as shown below, and should be in phase with the unbuffered signal.



- (v) Check that when pressing the RESET button the following pins go to 0V. then back to 4V.(approx).

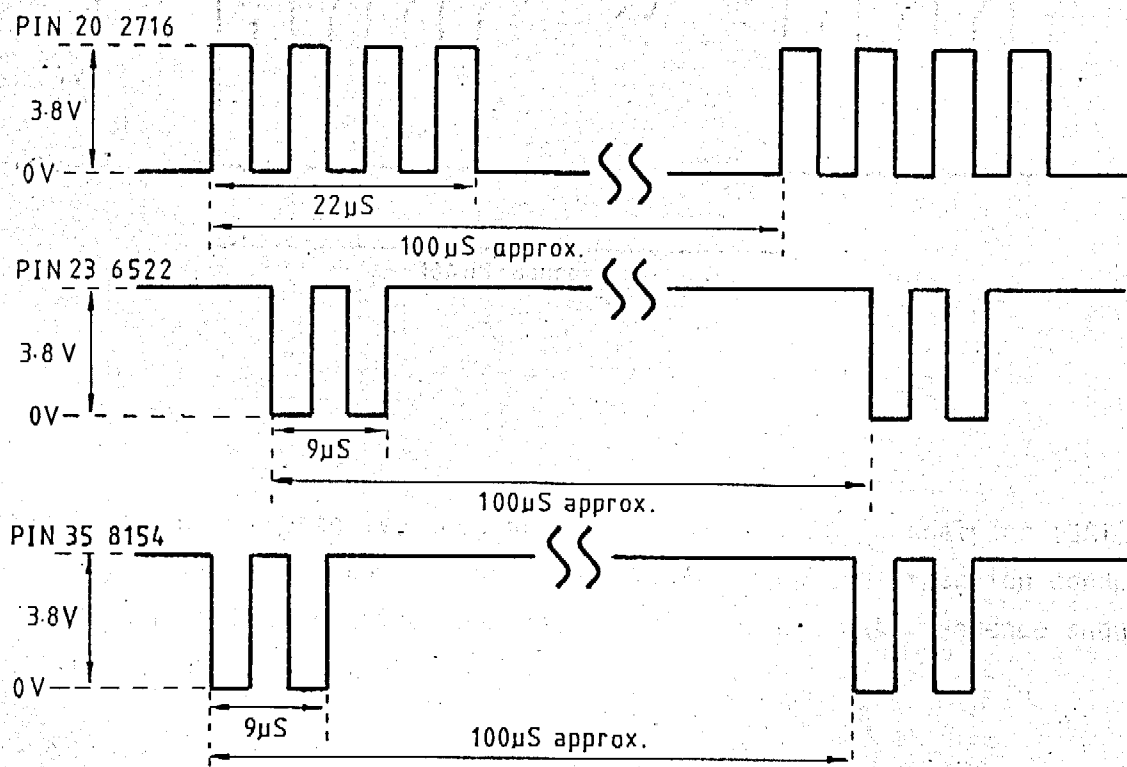
\*NRST on Pin 36 of 8154

RST on Pin 40 of 6502

RST on Pin 34 of 6522

- (vi) All the address and data lines, except  $A_{11}$  and  $A_6$  should be changing.  
 $A_{11}$  should be approximately 3V. and  $A_6$  at 0V.

- (vii) Chip select signals on 2716, 8154 and 6522 should be as shown below



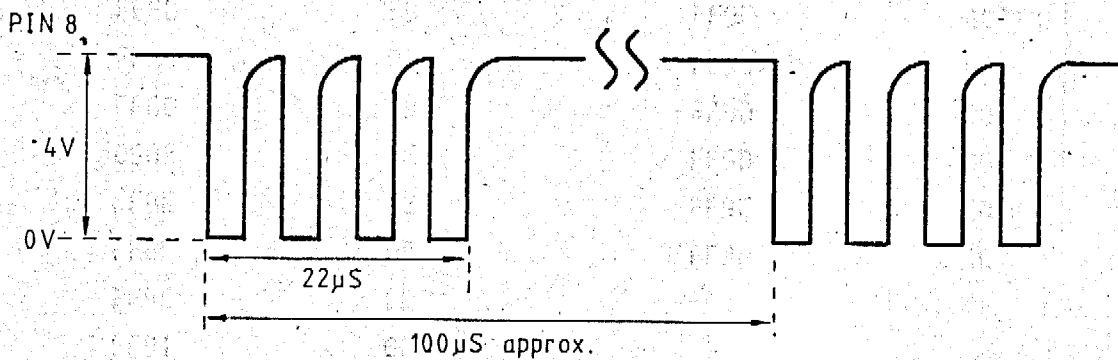
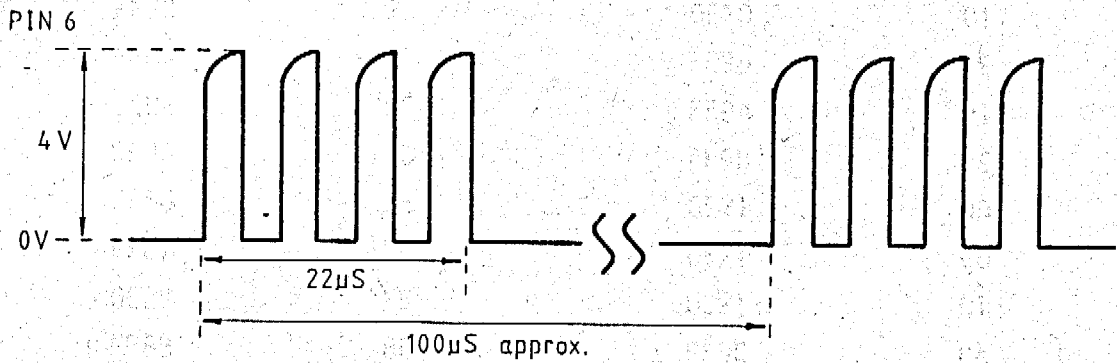
If these are not correct, there may be a fault in the address decoding.



(vii cont)

To check address decoding:-

Refer to diagram of address decoding and observe the waveform on pin 6 and pin 8 of the 74139, they should be:-



(viii) To do a comprehensive test of the MAC system, Logic Analyser (SA1) may be connected to the bus lines available on the expansion connector. With the EPROM routine running, the address and data sequence should be as listed overleaf.

# Logic Analyser connections:

Clock to  $\emptyset_2$ . Clock Edge  $\downarrow$ . Qualifier word disabled. Trigger qualifier to RESET.

| <u>Address</u> | <u>Data</u> | <u>Address</u> | <u>Data</u> |                       |
|----------------|-------------|----------------|-------------|-----------------------|
| FFBC           | 80          | FF96           | EE          |                       |
| FFBD           | FF          | FF97           | 20          |                       |
| FF80           | A9          | FF98           | 0E          |                       |
| FF81           | FF          | 0E20           | 00          |                       |
| FF82           | 8D          | 0E20           | 00          |                       |
| FF83           | 22          | 0E20           | 01          |                       |
| FF84           | 0E          | FF99           | EE          |                       |
| 0E22           | FF          | FF9A           | 21          |                       |
| FF85           | 8D          | FF9B           | 0E          |                       |
| FF86           | 23          | 0E21           | 00          |                       |
| FF87           | 0E          | 0E21           | 00          |                       |
| 0E23           | FF          | 0E21           | 01          |                       |
| FF88           | 8D          | FF9C           | CA          | Time<br>Waste<br>Loop |
| FF89           | 03          | FF9D           | D0          |                       |
| FF8A           | 09          | FF9D           | D0          |                       |
| 0903           | FF          | FF9E           | FD          |                       |
| FF8B           | 8D          | FF9F           | 4C          |                       |
| FF8C           | 02          | FF9C           | CA          |                       |
| FF8D           | 09          | FF9D           | D0          |                       |
| 0902           | FF          | FF9D           | D0          |                       |
| FF8E           | A2          | FF9E           | FD          |                       |
| FF8F           | 0E          | FF9F           | 4C          |                       |
| FF90           | EE          |                |             |                       |
| FF91           | 00          |                |             |                       |
| FF92           | 09          |                |             |                       |
| 0900           | 00          |                |             |                       |
| 0900           | 00          |                |             |                       |
| 0900           | 01          |                |             |                       |
| FF93           | EE          |                |             |                       |
| FF94           | 01          |                |             |                       |
| FF95           | 09          |                |             |                       |
| 0901           | 00          |                |             |                       |
| 0901           | 00          |                |             |                       |
| 0901           | 01          |                |             |                       |

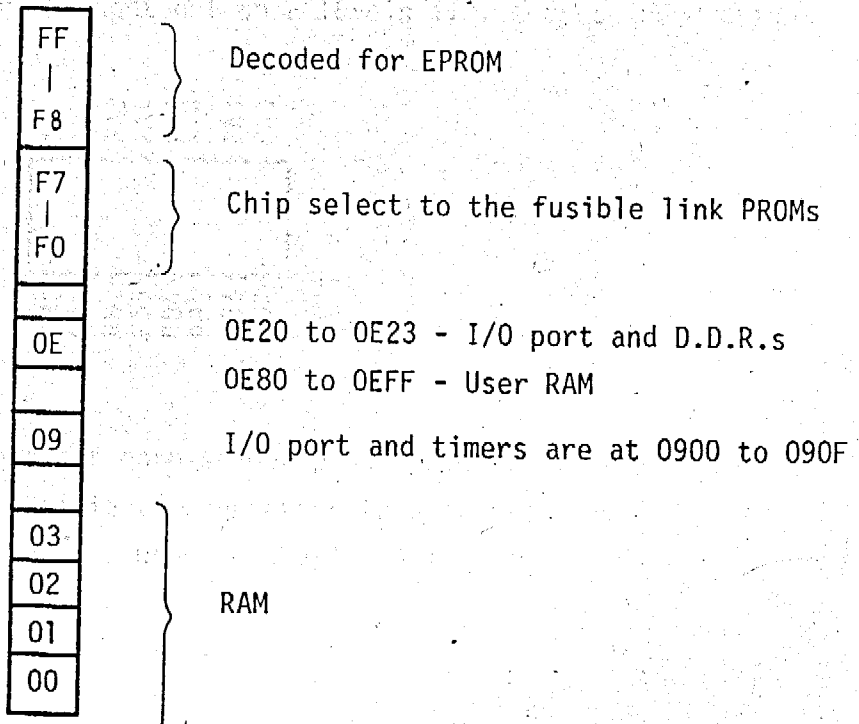
## MAC 6502

### System Information

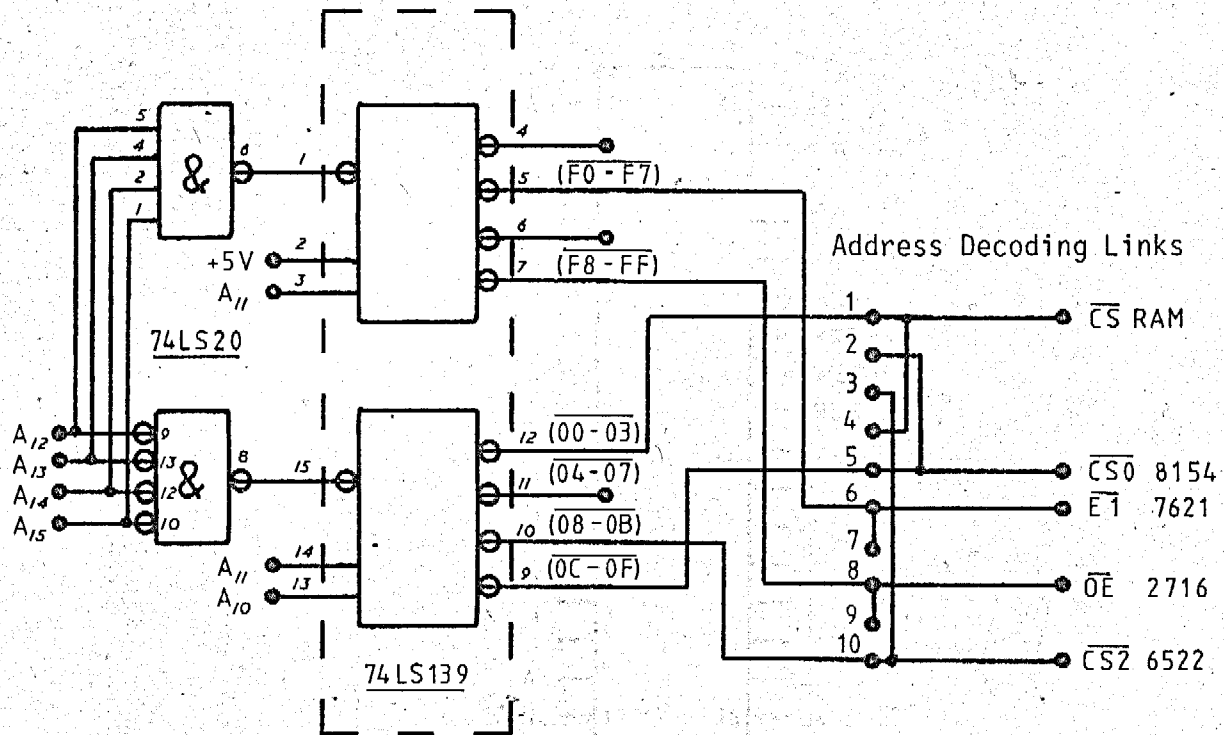
#### Listing of Program in EPROM

|      |          |          |
|------|----------|----------|
| FF80 | A9,FF    | LDA#FF   |
| 82   | 8D,22,0E | STA 0E22 |
| 85   | 8D,23,0E | STA 0E23 |
| 88   | 8D,03,09 | STA 0903 |
| 8B   | 8D,02,09 | STA 0902 |
| 8E   | A2,0E    | LDX#0E   |
| 90   | EE,00,09 | INC 0900 |
| 93   | EE,01,09 | INC 0901 |
| 96   | EE,20,0E | INC 0E20 |
| 99   | EE,21,0E | INC 0E21 |
| 9D   | CA       | DEX      |
| 9E   | D0,FD    | BNE FD   |
| A0   | 4C,8E,FF | JMP FF8E |

#### Memory Map Pages

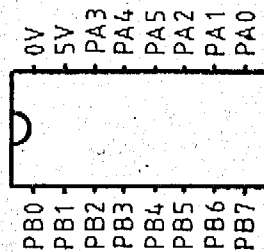


## Address Decoding and Connections

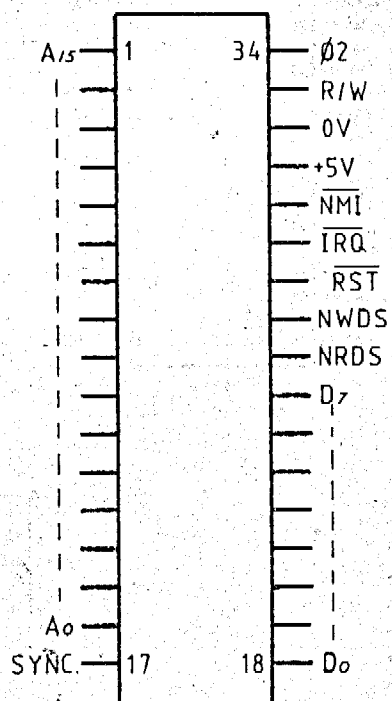


## Connections for 8154 I/O Ports

The 8154 I/O ports are brought out to a 16-pin i.c. socket, connections are as follows:

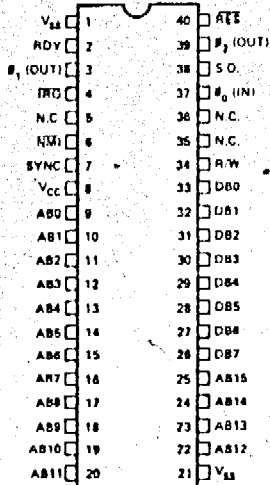


PA<sub>6</sub> and PA<sub>7</sub> are brought out onto solder pads spaced to take a 0.1" connector, this will facilitate connection to a cassette interface (in a manner similar to that used on the 'EMMA') if required.

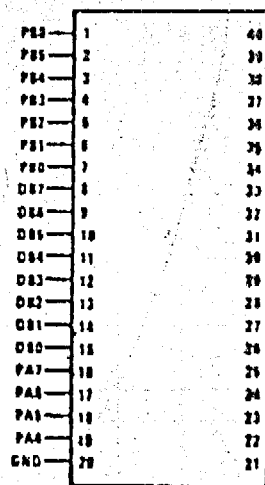


Expansion Connector Lay-out

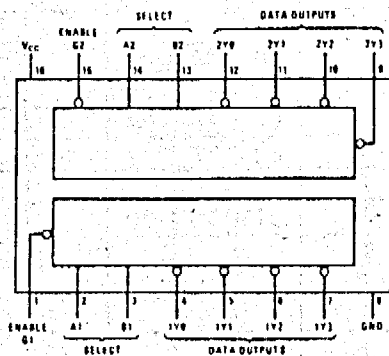
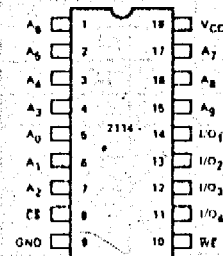
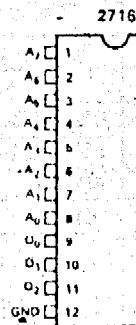
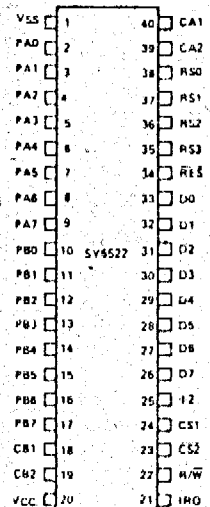
# Pin Connections



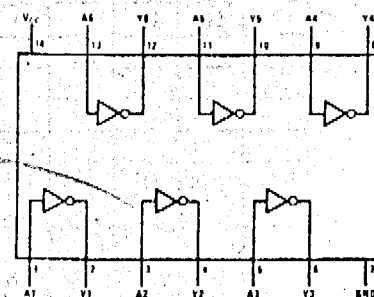
6502



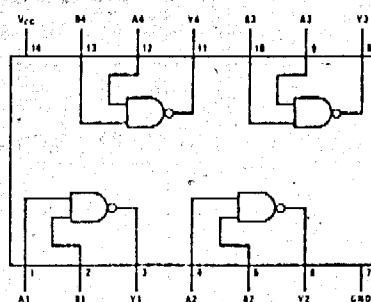
8154



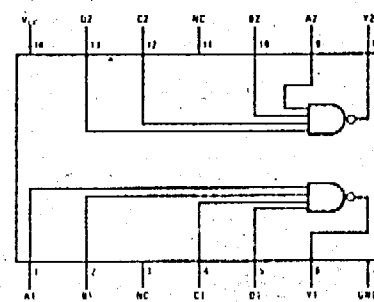
54LS139/74LS139(J, N, W); 74S139(N)



5404/7404(J, N); 54H04/74H04(J, N);  
54L04/74L04(J, N); 54LS04/74LS04(J, N, W);  
74S04(N)



5430/7400(J, N); 54H00/74H00(J, N);  
54L00/74L00(J, N); 54LS00/74LS00(J, N, W);  
74S00(N)



5420/7420(J, N); 54H20/74H20(J, N);  
54L20/74L20(J, N); 54LS20/74LS20(J, N, W);  
74S20(N)

|     | ACCUMULATOR | IMMEDIATE | ZERO PAGE | ZERO PAGE, X | ZERO PAGE Y | ABSOLUTE | ABSOLUTE, X | ABSOLUTE, Y | IMPLIED | RELATIVE | (INDIRECT, X) | (INDIRECT), Y | ABSOLUTE INDIRECT |
|-----|-------------|-----------|-----------|--------------|-------------|----------|-------------|-------------|---------|----------|---------------|---------------|-------------------|
| ADC |             | 69        | 65        | 75           |             | 6D       | 7D          | 79          |         |          | 61            | 71            |                   |
| AND |             | 29        | 25        | 35           |             | 2D       | 3D          | 39          |         |          | 21            | 31            |                   |
| ASL | 0A          |           | 06        | 16           |             | 0E       | 1E          |             |         |          |               |               |                   |
| BCC |             |           |           |              |             |          |             |             |         | 90       |               |               |                   |
| BCS |             |           |           |              |             |          |             |             |         | B0       |               |               |                   |
| BEQ |             |           |           |              |             |          |             |             |         | F0       |               |               |                   |
| BIT |             |           | 2C        |              |             |          |             |             |         |          |               |               |                   |
| BMI |             |           |           |              |             |          |             |             |         | 30       |               |               |                   |
| BNE |             |           |           |              |             |          |             |             |         | D0       |               |               |                   |
| BPL |             |           |           |              |             |          |             |             |         | 10       |               |               |                   |
| BRK |             |           |           |              |             |          |             |             | 00      |          |               |               |                   |
| BVC |             |           |           |              |             |          |             |             |         | 50       |               |               |                   |
| BVS |             |           |           |              |             |          |             |             |         | 70       |               |               |                   |
| CLC |             |           |           |              |             |          |             |             | 18      |          |               |               |                   |
| CLD |             |           |           |              |             |          |             |             | D8      |          |               |               |                   |
| CLI |             |           |           |              |             |          |             |             | 58      |          |               |               |                   |
| CLV |             |           |           |              |             |          |             |             | B8      |          |               |               |                   |
| CMP |             | C9        | C5        | D5           |             | CD       | DD          | D9          |         |          | C1            | D1            |                   |
| CPX |             | E0        | E4        |              |             | EC       |             |             |         |          |               |               |                   |
| CPY |             | C0        | C4        |              |             | CC       |             |             |         |          |               |               |                   |
| DEC |             |           | C6        | D6           |             | CE       | DE          |             |         |          |               |               |                   |
| DEX |             |           |           |              |             |          |             |             | CA      |          |               |               |                   |
| DEY |             |           |           |              |             |          |             |             | 88      |          |               |               |                   |
| EOR |             | 49        | 45        | 55           |             | 4D       | 5D          | 59          |         |          | 41            | 51            |                   |
| INC |             |           | E6        | F6           |             | EE       | FE          |             |         |          |               |               |                   |
| INX |             |           |           |              |             |          |             |             | E8      |          |               |               |                   |
| INY |             |           |           |              |             |          |             |             | C8      |          |               |               |                   |
| JMP |             |           |           |              |             | 4C       |             |             |         |          |               |               | 6C                |
| JSR |             |           |           |              |             | 20       |             |             |         |          |               |               |                   |
| LDA |             | A9        | A5        | B5           |             | AD       | BD          | B9          |         |          | A1            | B1            |                   |
| LDX |             | A2        | A6        |              | B6          | AE       |             | BE          |         |          |               |               |                   |
| LDY |             | A0        | A4        | B4           |             | AC       | BC          |             |         |          |               |               |                   |
| LSR | 4A          |           | 46        | 56           |             | 4E       | 5E          |             |         |          |               |               |                   |
| NOP |             |           |           |              |             |          |             |             | EA      |          |               |               |                   |
| ORA |             | 09        | 05        | 15           |             | 0D       | 1D          | 19          |         |          | 01            | 11            |                   |
| PHA |             |           |           |              |             |          |             |             | 48      |          |               |               |                   |
| PHP |             |           |           |              |             |          |             |             | 08      |          |               |               |                   |
| PLA |             |           |           |              |             |          |             |             | 68      |          |               |               |                   |
| PLP |             |           |           |              |             |          |             |             | 28      |          |               |               |                   |
| ROL | 2A          |           | 26        | 36           |             | 2E       | 3E          |             |         |          |               |               |                   |
| ROR | 6A          |           | 66        | 76           |             | 6E       | 7E          |             |         |          |               |               |                   |
| RTI |             |           |           |              |             |          |             |             | 40      |          |               |               |                   |
| RTS |             |           |           |              |             |          |             |             | 60      |          |               |               |                   |
| SBC |             | E9        | E5        | F5           |             | ED       | FD          | F9          |         |          | E1            | F1            |                   |
| SEC |             |           |           |              |             |          |             |             | 38      |          |               |               |                   |
| SED |             |           |           |              |             |          |             |             | F8      |          |               |               |                   |
| SEI |             |           |           |              |             |          |             |             | 78      |          |               |               |                   |
| STA |             |           | 85        | 95           |             | 8D       | 9D          | 99          |         |          | 81            | 91            |                   |
| STX |             |           | 86        |              | 96          | 8E       |             |             |         |          |               |               |                   |
| STY |             |           | 84        | 94           |             | 8C       |             |             |         |          |               |               |                   |
| TAX |             |           |           |              |             |          |             |             | AA      |          |               |               |                   |
| TAY |             |           |           |              |             |          |             |             | A8      |          |               |               |                   |
| TYA |             |           |           |              |             |          |             |             | 98      |          |               |               |                   |
| TSX |             |           |           |              |             |          |             |             | BA      |          |               |               |                   |
| TXA |             |           |           |              |             |          |             |             | 8A      |          |               |               |                   |
| TXS |             |           |           |              |             |          |             |             | 9A      |          |               |               |                   |

SUMMARY OF INSTRUCTION CODES AND ADDRESSING MODES