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SYSTEM 2 TECHNICAL MANUAL

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Chapter 1 Introduction to system 2

The Acorn system 2 is a complete micro-computer available in kit form or fully assembled and tested. Using the popular Euro cards (100 x 160mm) an easily expanded system concept has been created and system 2 itself may be produced as an expansion of the two card system 1. The cards are housed in a 19" card frame with a backplane using DIN standard two part connectors. No peripheral devices are supplied with the basic system 2, it being left to the user to select the ASCII keyboard, CRT display, cassette tape recorder and power supplies best suited to the application. These parts are, of course, available with the system if required. The system may be furnished with professional connectors, front panels and a 19" case if desired.

At the heart of system 2 is the Cassette Operating System (C.O.S.) software and the Acorn BASIC interpereter. This resident software provides powerful high level language facilities ideally suited for all applications.

Chapters 2, 3 and 4 of this manual need to be referred to only if the system is in kit form. Chapters 9, 10 and 11 need only be referenced in case of system expansion. The Acorn BASIC is described in its separate manuals.

Chapter 2 - System 2 Parts List

Unpack the kit carefully and ensure that no components are concealed within the packing materials.

6502 C.P.U. card

PCB	Printed Circuit Card	200,000 issue 3 or later
IC1	6502 micro processor	and 40 pin socket
IC2	INS 8154 RAM/IO	"
IC3	2114 RAM	and 18 pin socket
IC4	2114 RAM	"
IC5	Not supplied	-
IC6	Not supplied	-
IC7	OS ROM	and 24 pin socket
IC8	INS 8154 RAM I/O not supplied	but 40 pin socket is
IC9	74LS20	and 14 pin socket
IC10	74LS139	and 16 pin socket
IC11	74LS04	and 14 pin socket
IC12	74LS00	and 14 pin socket
XTAL	1MHz crystal	
R1-4	4 off 4K7 resistor	
C1-2	47 or 100 nF capacitor	
C5-8	"	
C9	15 uF electrolytic capacitor	

NB C3, C4, C10, IC5, OC6, and IC13 are not fitted.
IC8 is available as an accessory.

Cassette Interface

PCB	Printed Circuit Card	200,001 issue 2 or later
IC1	CD4024B	and 14 pin socket
IC2	CD4024B	"
IC3	CD4011B	"
IC4	CD4013B	"
IC5	CD4001B	"
IC6	CD4024B	"
IC7	LM358	and 8 pin socket
R1	3K9 resistor	
R2	47K resistor	
R3	4K7 resistor	
R4	1K resistor	
R5	10K resistor	
R6	4K7 resistor	
R7	4K7 resistor	
R8	47K resistor	
R9	4K7 resistor	
R10	4K7 resistor	
R11	10K resistor	
R12	47K resistor	
R13	4K7 resistor	
R14	470K resistor	
R15	4K7 resistor	
R16	4K7 resistor	
C1	100pF capacitor	
C2	InF capacitor	
C3	10nF capacitor	
C4	1nF capacitor	
C5	15uF electrolytic capacitor	
C6	47 or 100 nF capacitor	
C7	Not fitted	
C8	22nF capacitor	
C9	47 or 100 nf capacitor	
C10	47 pr 100 nF capacitor	

Visual Display Unit Interface

PCB	Acorn Computers Ltd. pt no 200,002	
IC1	74LS139 decoder	and 16 pin socket
IC2	74LS02 NOR gate	and 14 pin socket
IC3	74LS13 Schmitt trigger	and 14 pin socket
IC4	MC6845 C.R.T. controller	and 40 pin socket
IC5, 6 & 7	74LS157 data selector	and 16 pin socket
IC8 & 9	2114-3 R.A.M.	and 18 pin socket
IC10	74LS174 hex flip-flop	and 16 pin socket
IC11	INS 8208 buffer	and 20 pin socket
IC12	74LS86 excl. OR gate	and 14 pin socket
IC13	SAA5050 character generator	and 28 pin socket
IC14	74LS00 NAND gate	and 14 pin socket
Q1	BC107 transistor	
D1	IN4148 diode	
R1	1K resistor	
R2	1K resistor	
R3	470 R preset potentiometer	
R4	10K resistor	
R5	4K7 resistor not supplied	
R6	22K resistor	
R7	4K7 resistor	
R8	10K resistor	
R9-12	4 off 10K resistors	
R13	4K7 resistor	
R14	10K resistor	
R15	470R resistor	
R16	82R resistor	
R17	18K resistor not supplied	
R18	10K resistor	
R19	10K resistor not supplied	
R20-22	3 off 10K resistors	
C1	10 or 15 uF electrolytic capacitor	
C2-7	6 off 47 nF capacitors	
C8	100 pF capacitor	
C9	150 pF capacitor	

NB For IC11 INS208 is equivalent to DP8304

Memory Board (issue 2)

PCB	Printed Circuit Card	200,003 issue 2 of later
IC3-10	2114 RAM	and 18 pin socket
IC1, 2, 11-16	18 pin sockets supplied for extension RAM	
IC17	BASIC ROM and 24 pin socket	
IC18	24 pin socket supplied for extension ROM	
IC19	74LS42 and 16 pin socket	
IC20	74LS00 and 14 pin socket	
IC21	81LS95 or 97 and 20 pin socket	
IC22	INS8208 and 20 pin socket	
IC23	81LS95 or 97 and 20 pin socket	
IC24	74L42 and 16 pin socket	
IC25	74LS00 and 14 pin socket	
R1	1K resistor	
C1-7	7 off 47 or 100 nF capacitors	
C8	15 uF electrolytic capacitor	

NB IC24 is a 74L42 from National Semiconductor only

Also supplied for system 2 is

1 off Card Frame	173-12501L
4 off 64 way plugs	17-3704L
4 off 64 way sockets	17-3705F
8 off card guides	173-12553G

1 off Back-plane PCB - 200,011
Earthwire and solder tag
16 off 2.5 mm x 10 mm screws
8 off 2.5 mm nuts

Chapter 3 - Electrical Assembly

Assembly Technique

Four Eurocards and a backplane board have to be assembled for system 2, the components for each card are packed separately in plastic bags or on conducting foam.

Before attempting to assemble each card check that all the component parts are present and that none have been damaged. It is worthwhile taking a few minutes to make sure that all the components can be identified. Sometimes components will be substituted in case of supply difficulties. For instance, 0.047 uF capacitors may replace 0.1 uF capacitors shown on the parts list. The components substituted will in no way be detrimental to the system's operation. Also some manufacturers have similar but different type numbers e.g. for the CMOS a CD4011 from R.C.A. may be replaced by an MM5611 from National Semiconductor.

For capacitors note that the value may be expressed in one of two ways:-

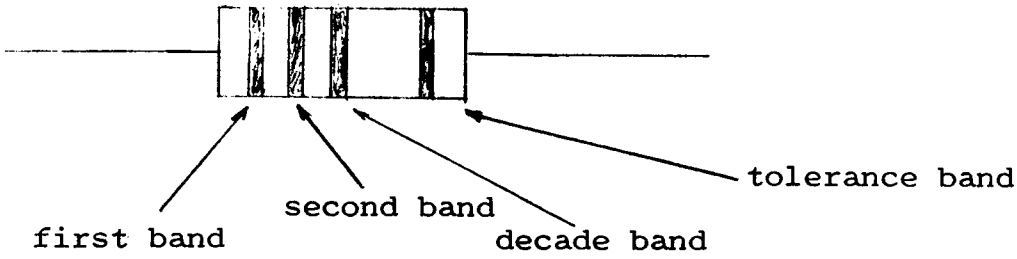
100	nF	=	0.1	uF	
10	nF	=	0.01	uF	
1	nF	=	1000	pF	
0.1	nF	=	100	pF	etc.

Capacitors supplied with the Acorn cards are usually identified by a 3 digit number, the first two digits being the first two digits of the value and the third being the number of following zeros eg.

101 = 10 and one zero ie. 100 pF
103 = 10 and three zeroes ie. 10000 pf = 10 nF
473 = 47 and three zeros i.e. 47000 pF = 47 nF = 0.047 uF.

If in doubt about the capacitor values, count the number of each of type supplied in the kit and then identify them using the parts list quantities.

The resistor colour code is shown here.

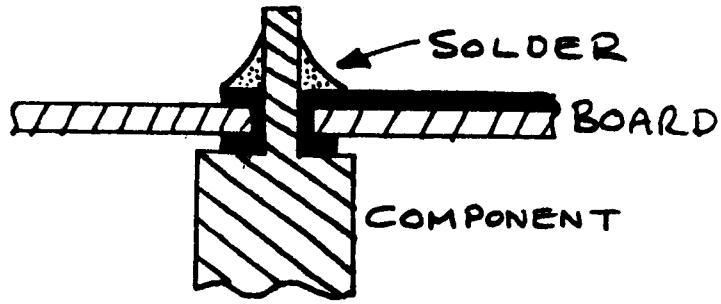


The first and second bands give the resistor value and the decade band shows the number of zeros following:-

0	Black	
1	Brown	
2	Red	
3	Orange	e.g. Yellow, Violet, Orange
4	Yellow	is Yellow, Violet = 4,7 and
5	Green	Orange = 3 zeros i.e. 000.
6	Blue	So the value is 47000 ohms,
7	Violet	i.e. 47 kilo-ohms or 47K.
8	Grey	
9	White	

The tolerance band is red for ± 2%, gold for ± 5% or silver for ± 10%.

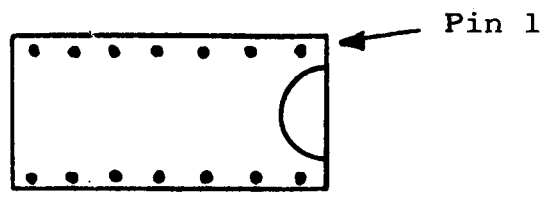
Assembling the cards will require a considerable amount of soldering and a small electric soldering iron is essential with a diameter at the end of the bit not exceeding 0.1 inches. The iron should be rated between 10 and 30 watts and fine 22 gauge flux cored solder should be used. If you have never soldered before we advise you not try to assemble the cards without assistance as Acorn Computer Ltd. cannot accept responsibility for kits which have been improperly assembled. When soldering make sure the component is well pushed on to the board as shown, use a minimum of solder and once the solder has run remove the iron.



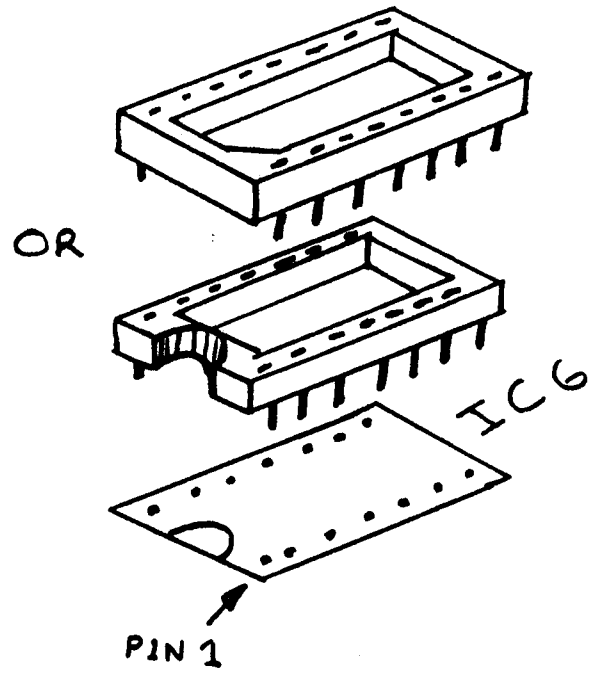
Some of the integrated circuits used in the system employ M.O.S. technology and they can be damaged by static electricity. As a general rule if there is no noticeable static charge in the area and no nylon clothes or carpets are present all will be well. An earthed soldering iron should be used when soldering on a board containing M.O.S., I.C.'s and the I.C.'s should be kept on the conducting foam on which they are supplied until required.

The Acorn Printed Circuit cards are double sided, through hole plated glass fibre and are manufactured to the highest standards. A layer of green solder resist ensures that accidental solder splashes do not stick to the tracks and a clearly marked white silk screen indicates component positions. Examine the cards for faults or damage before proceeding. It is not necessary to solder through holes which connect one side of a board to the other and do not have a component lead in them and attempting to do so can break the through hole plating and thus the connection. All soldering should only be done on the opposite side of the board to the components (i.e. side 1).

The cards are each supplied with a full set of integrated circuit sockets. The sockets must be fitted the right way round, on the circuit board viewing it from the top. Pin 1 of an I.C. is identified as shown:-



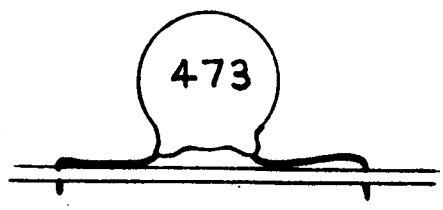
The sockets will have either a 45° chamfer for pin 1 or a semi circular cut out as shown:-



Note that on the Central Processor Unit IC1 is the opposite way round to the other sockets nearby. Fit the sockets one at a time and ensure that they are pressed fully down with no leads bent under the socket before first soldering two diagonally opposite pins at the corners. Check that the socket is the right way round and successfully fitted before soldering the rest of the pins.

There is no need to snip off the excess of the socket pins.

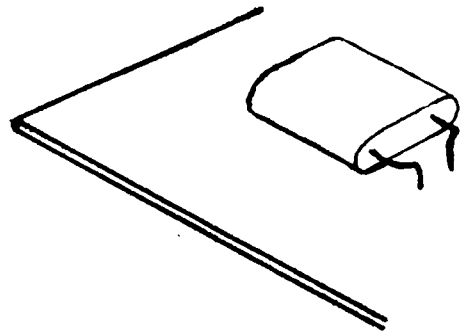
After the I.C. sockets the resistors and capacitors are fitted to the circuit cards. Identify the component from the component list and fit it to the board. Some capacitors will need to be fitted as shown.



Do not crack the capacitor body when bending the leads.

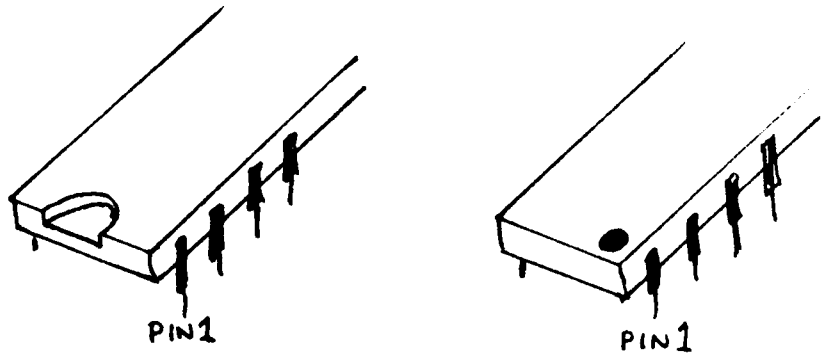
The electrolytic capacitors are polarised and the positive end marked + must be located as indicated on the circuit cards.

The crystal on the C.P.U. card is fitted as shown:-



Again bend the leads away from the component body and lay the Crystal down on the board before soldering. Snip off any excess leads under the board.

The connector is fixed to a card using two 2.5 mm screws and nuts before soldering the pins. When all of the components are soldered the integrated circuits may be fitted in their sockets, pin 1 is identified by either a semicircle or a dot as shown:-



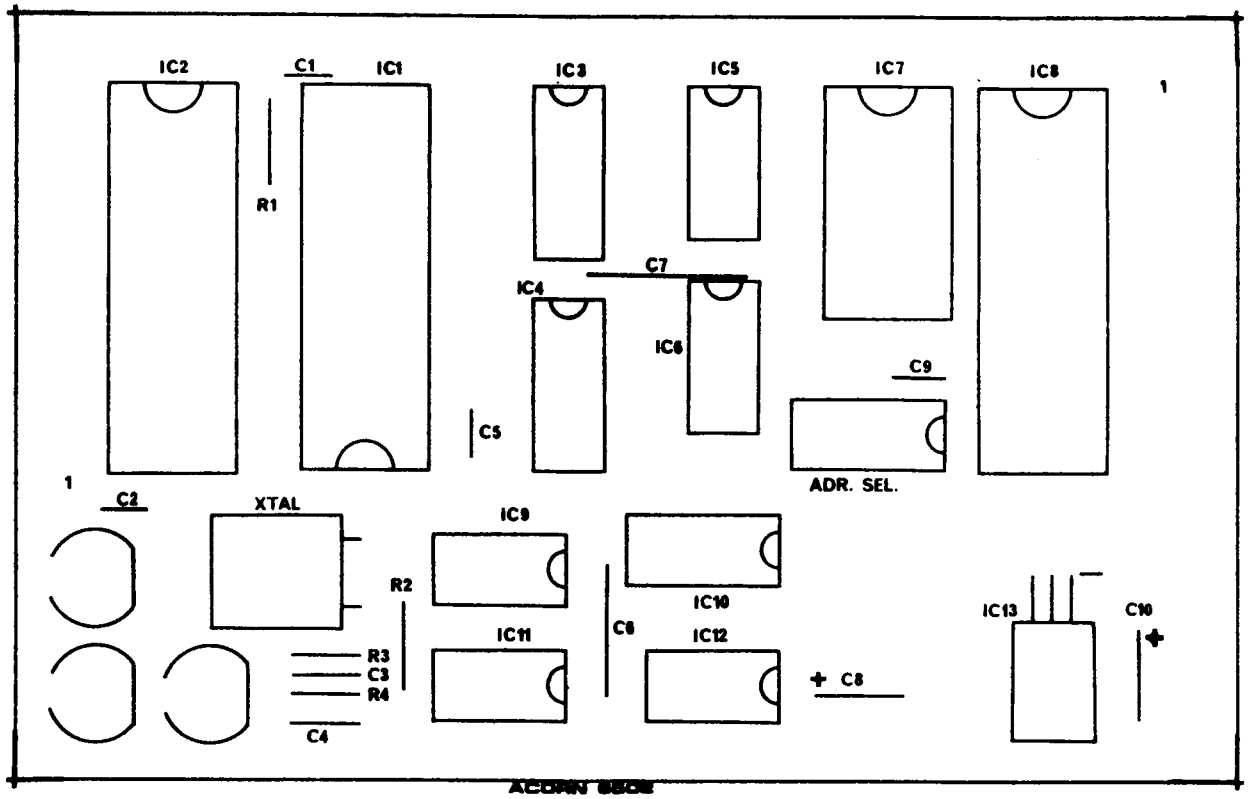
Identify the I.C. type from the components list and plug it into the appropriate socket. If the leads are splayed out press them all in together as shown until the I.C. fits easily to the socket.

Take care that no I.C. pins get bent under the I.C. when inserting and remember that I.C.1 on the C.P.U. card is the opposite way round to its neighbours.

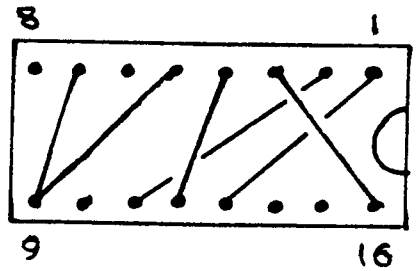
6502 C.P.U.

Printed circuit cards at issue 3 or later are supplied with complete systems. The NMI, IRQ and RST switches are not required. Also not supplied or required are I.C.'s 5 and 6 together with their 16 pin sockets and the 5 volt regulator, I.C. 13. The electrolytic decoupling capacitor is fitted at C8 and C10 must not be used. This allows the Block zero signal to be connected to the backplane by fitting a wire link to the right hand side of I.C.13 as marked on the silk screen.

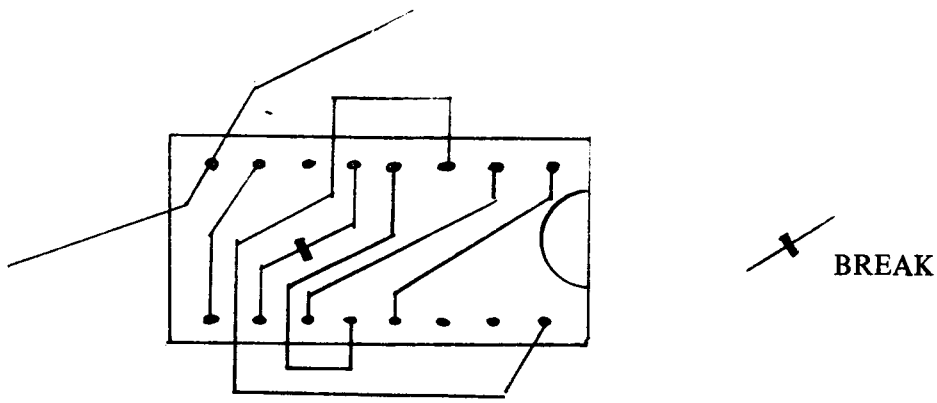
The INS 8154 RAM/IO chip is fitted at I.C. 2 and the ASCII keyboard connects to port B of it. A 20 way right angled header may be fitted for connecting the keyboard or wires can be soldered directly to the edge fingers. I.C. 8 is not used in the system but a second INS 8154 can be fitted here giving 16 I/O lines for user definition and so a socket for it is supplied.



The operating system ROM is fitted in I.C. 7 and to use it the correct address selection links are required:-



To produce this a track must be broken on side 2 of the card as shown:-



and a wire link must be fitted from pin 5 to pin 9 of the ADR SEL location. The ROM IC marked COS (Cassette Operating System) can now be fitted in I.C. 7.

In system 2 three connections from I.C. 2 to the backplane are required in order to connect to the cassette interface. On issue 3 boards these must be made with three pieces of fine insulated wire and they are as follows:-

I.C. 2 pin 16 to backplane plug pin B 19 for CASIN
I.C. 2 pin 17 to backplane plug pin B 20 for CASOUT
I.C. 2 pin 18 to backplane plug pin B 21 for NHITON

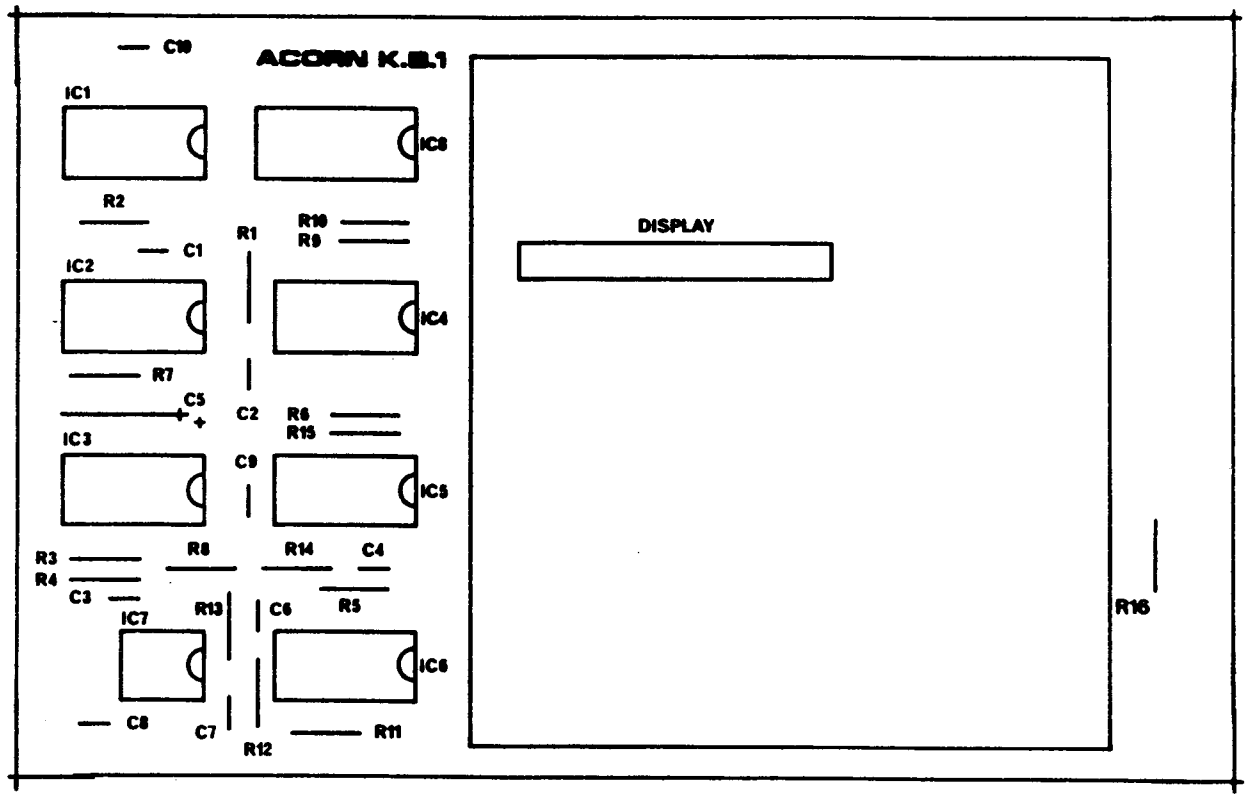
Cassette Interface

Printed Circuit Cards at issue 2 or later are supplied with complete systems. I.C. 8, the 8 digit display and the small keypad are not required for system 2.

Before fitting the 64 way plug the following pins MUST be cut off the plug as close to its body as possible. The pin numbers are marked on the body of the plug:-

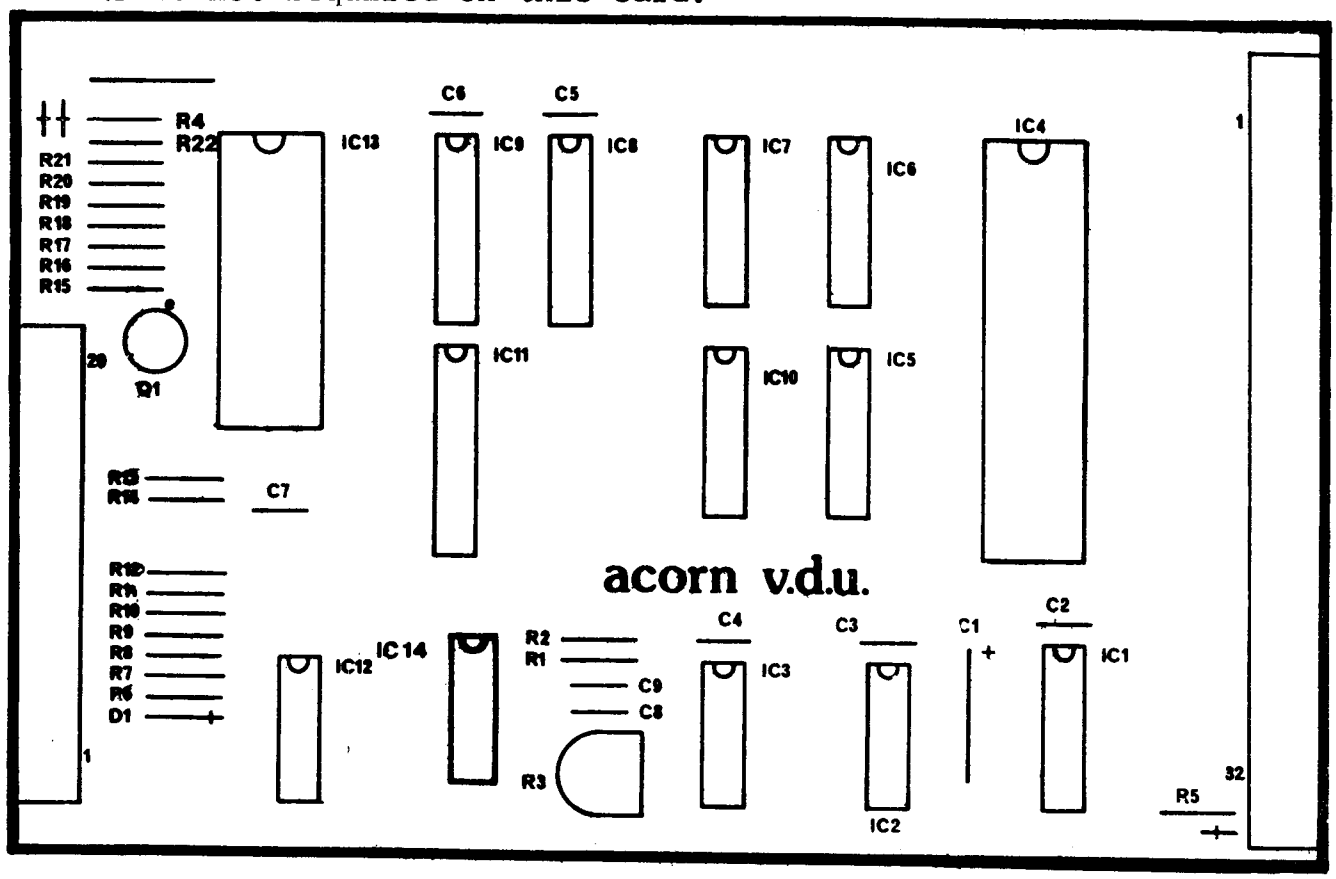
A2 - 31 inclusive
B1
B21 - 31 inclusive

A wire link is required from I.C. 6 pin 3 to pin B 14 of the connector for the Not High Tone signal.



V.D.U. Interface Card

R5 is not required on this card.

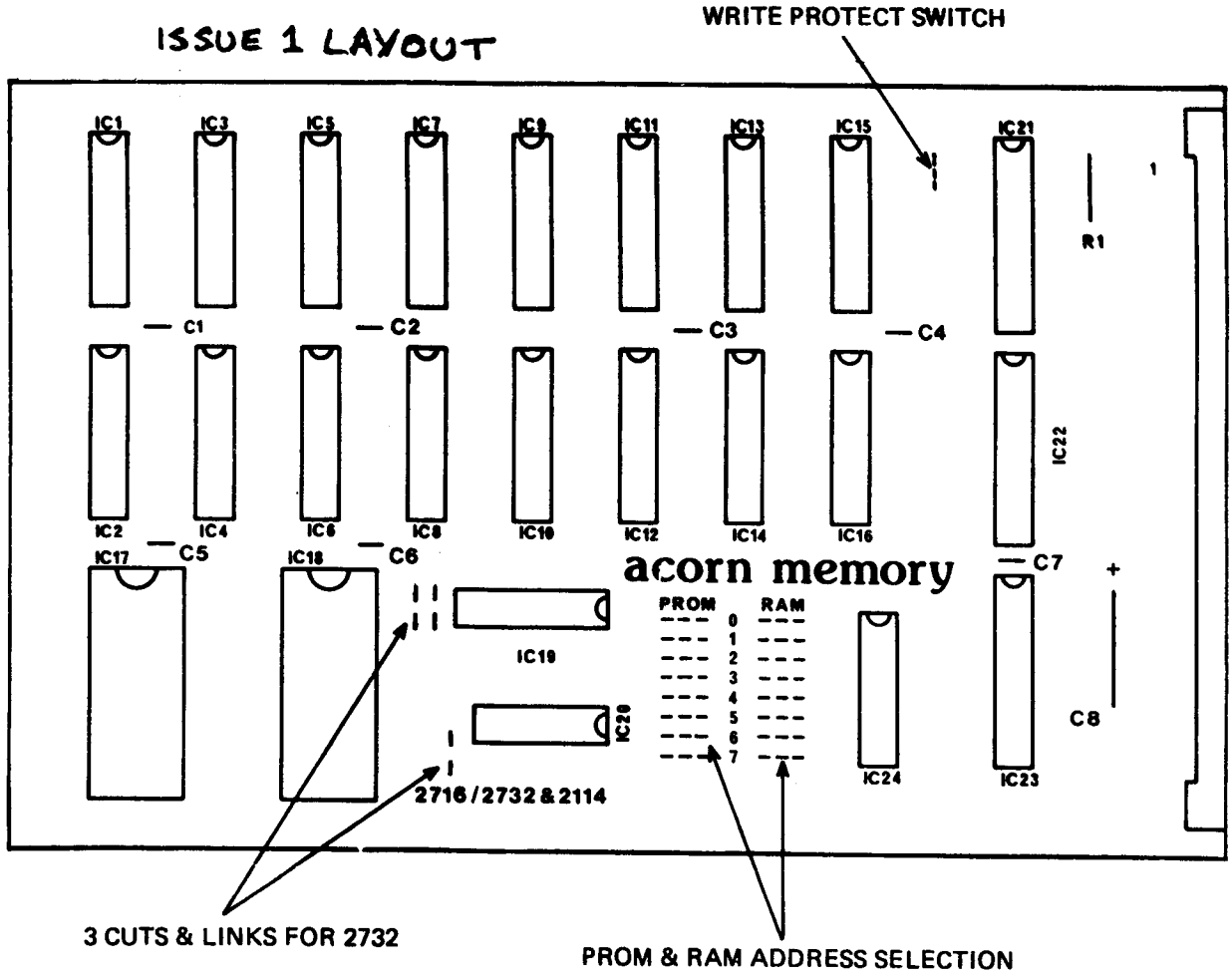


Memory Card

This card carries the 4K of user RAM in I.C.'s 3, 4, 5, 6, 7, 8, 9 and 10 and to address it a link must be fitted in position RAM 1. A further 4K of RAM (8 x 2114's) may be added at anytime and the extra sockets are supplied as standard.

If an issue 1 memory card is supplied the BASIC will be in a pair of EPROM's. The low one is fitted in I.C. 17 and the high one in I.C. 18, a link must then be fitted in position ROM 6.

Eventually all systems will be supplied with issue 2 memory cards and the BASIC in a single ROM. This ROM is fitted in I.C. 17 and again a link must be fitted in position ROM 6.

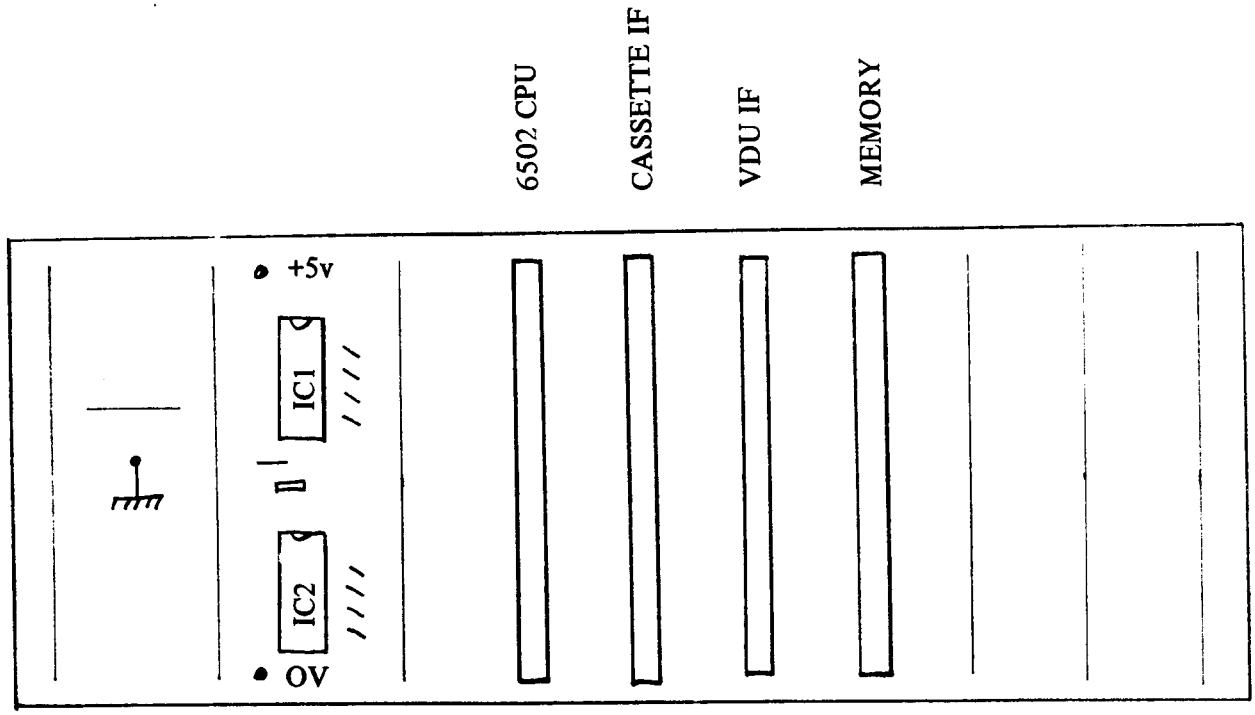


If desired a write protect switch for the RAM may be fitted by breaking the track marked between I.C.'s 15 and 21 and fitting a SPST switch across it.

Back Plane

The backplane has provision for eight 64 way Euro card sockets and two 32 way power supply sockets. Side A is connected from pin to pin right across the back plane and carries the computer data bus, address bus, control lines, clock and power. Side B is left unconnected and may be wire wrapped to configure a user defined system of additional boards, extra I/O, interrupt priorities etc.

The left hand 64 way card location has its 16 bit address bus isolated from the other cards, and so it may not be used for system 2. System 2 connectors are fitted as shown:-



IC's 1 and 2 are not required in System 2.

Ensure that the connectors have pin 1 at the top and push their pins through the backplane. With each connector pushed hard against the backplane solder pins A1 and A32, check that the connectors are all lying flat on the back plane before soldering the rest of side A. The side B pins should not be soldered at all.

Four connections are necessary to connect the 6502 C.P.U. card to the cassette interface. These may be made with soldered links but preferably are wire-wrapped. Simple hand wire-wrapping tools are available for about £5.00. The connections are:-

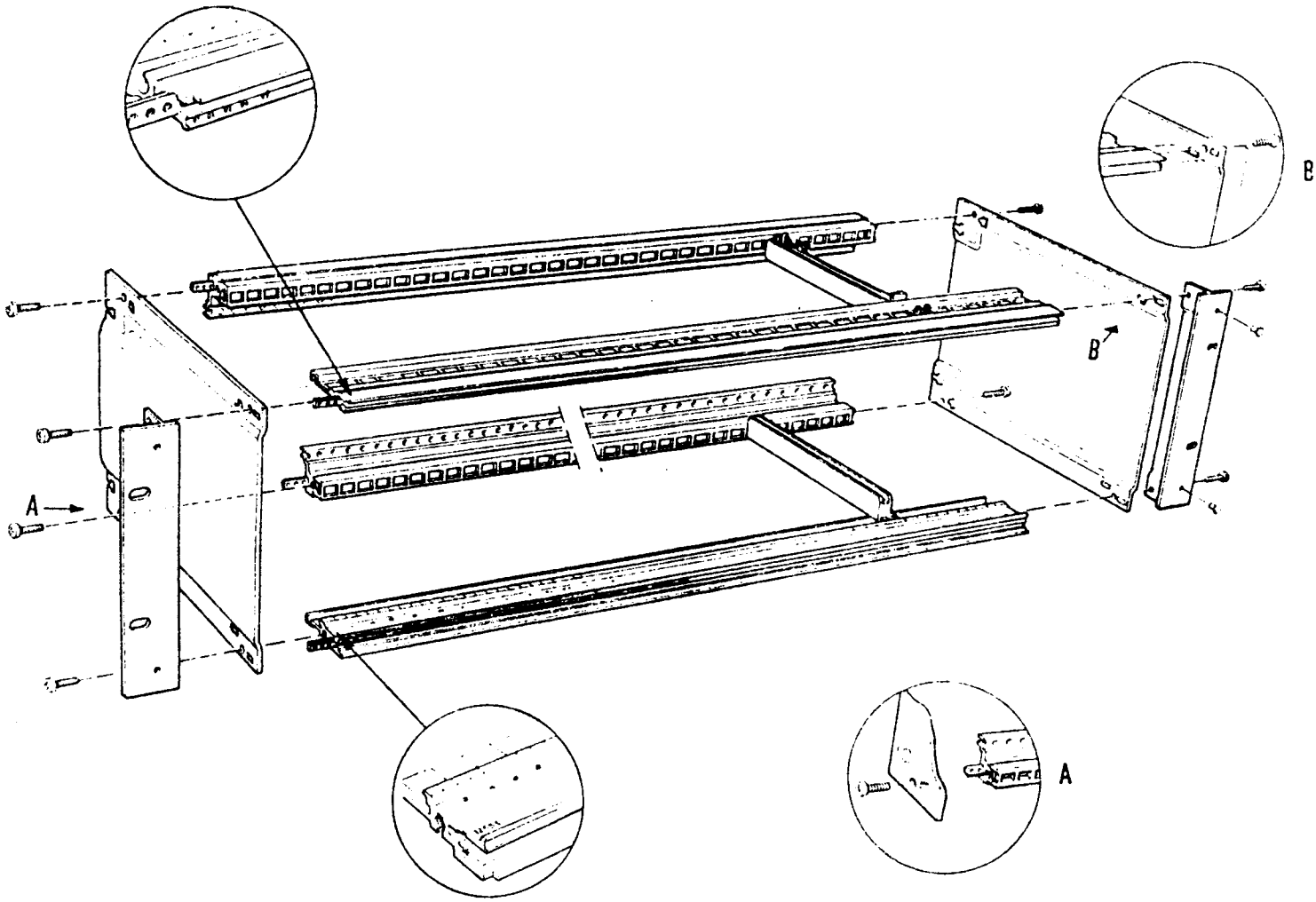
C.P.U. card pin	A29	to cassette interface pin	B11,	Ø2 clock
"	B19	"	B12,	CASIN
"	B20	"	B13,	CASOUT
"	B21	"	B14,	NHITON

Finally a wire link is soldered on the left of the back plane to connect the system Ovolts to the earthing wire. The earthing wire is soldered into the backplane and using a solder tag it is connected to the card frame metal work by the top left tie bar screw after the backplane has been mounted in the frame.

The backplane is now ready for use in system 2.

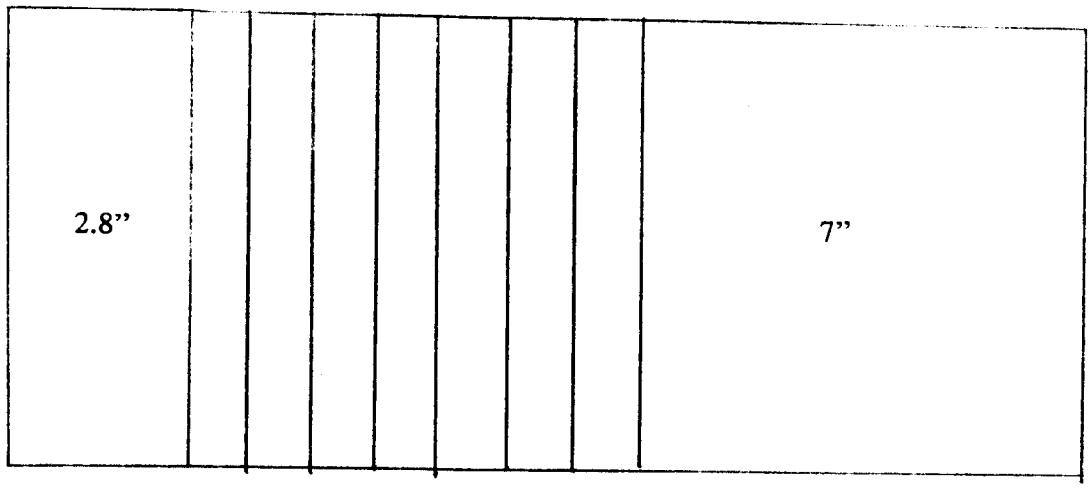
Chapter 4 - Mechanical Assembly

The Eurocard frame kit contains two end plates, two end plate front angles, two front tie bars with tapped strips, two rear connector mounting rails and eight fixing screws. Assemble the frame as shown:-



Note that viewing the frame from the front the 83rd guide position is on the right.

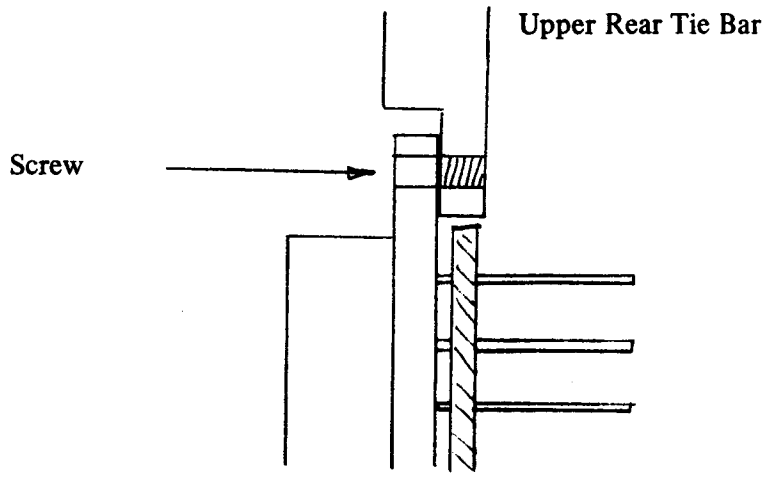
The standard allocation of the front of the cardframe is as shown:-



The 2.8" space is for a 5/12 volt power supply. Seven Eurocards spaced at 1" are allowed for with another one occupying part of the 7" space for a floppy disc controller. The left hand Eurocard location is reserved for the C.P.U. card when bus buffers are fitted to the backplane. The four card system 2 does not require buffers and so the cards are fitted as follows:-

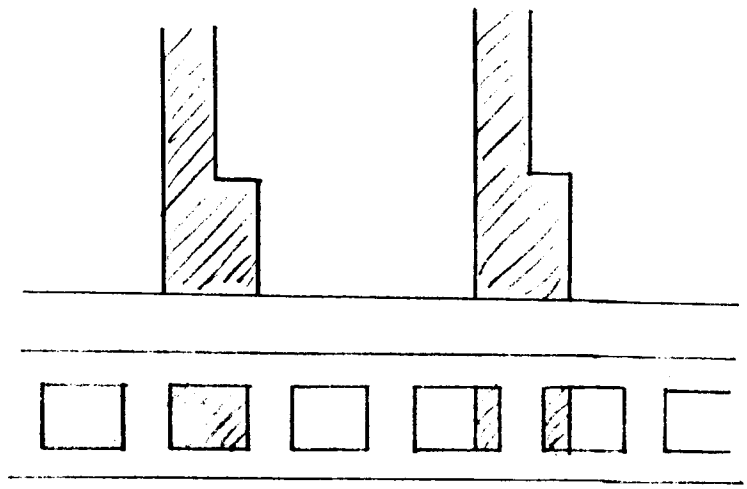
2.8" Space (power supply)
1" Space
1" C.P.U.
1" cassette interface
1" V.D.U. interface
1" memory board
1" Space
1" Space
7" Space (Floppy disc controller)

Take the backplane board with its four connectors and lay it so that the board is between the upper and lower rear tie bars with the connector mounting ears on the front of the tie bars. Pin 1 of the connectors should be at the top i.e. the bus buffer I.C. locations are to the left hand side. Using eight of the 2.5 mm screws provided fix the connectors into the tapped holes on the rear tie bars that are numbered 21, 26, 31 and 36. Check that the power bus lines on the backplane are not shorted to the tie bars.

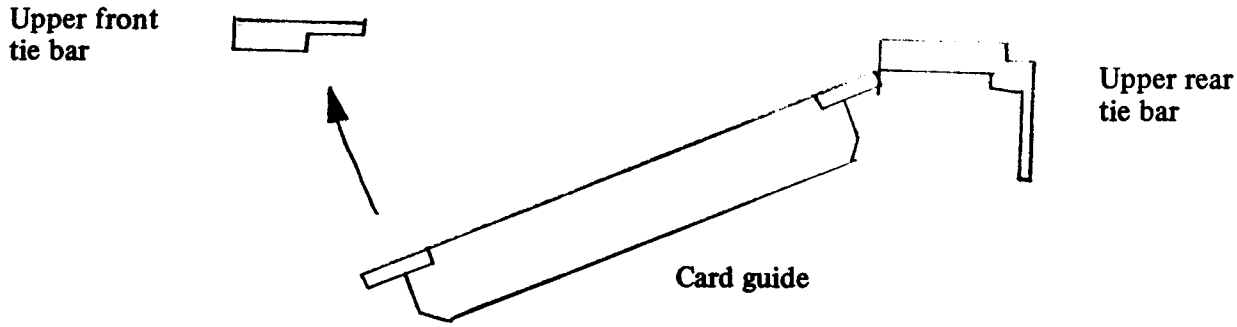


With the backplane mounted in the frame take care that the protruding connector pins are not damaged in any way.

Card and module guides may be fitted at multiples of 0.2" spacings by either clipping them into the holes, or onto the metal between the holes, of the tie bars:-



Note the guides are fitted with the flat side to the left and the stepped side to the right. To fit the guides place them in the appropriate location on the rear tie bar and then push them onto the front tie bar where they snap into position.



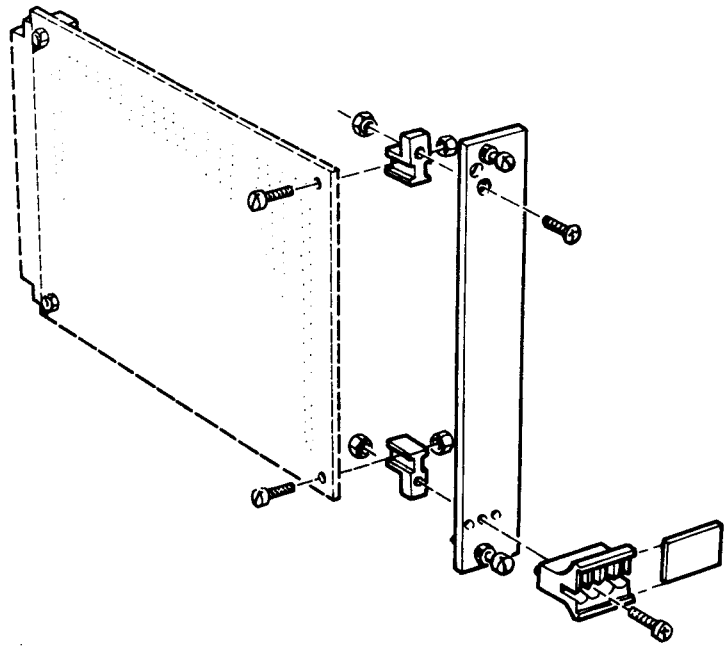
To remove the guides push them to the rear whilst unclipping them from the front tie bar. Top and bottom pairs of guides are fitted into positions 20, 25, 30 and 35.

It should now be possible to slide the four boards into the guides with their components facing to the right. The connectors should mate together but it may be necessary to loosen the screws securing the backplane connectors and move the backplane fractionally to allow the connectors to mate freely.

With a fully expanded system card guides are fitted in positions 15, 20, 25, 30, 35, 40 and 45 with the slimmer module guides in positions 2, 12, 51 and 82.

The Eurocard frame may be fitted in a 19" case giving protection for the printed circuit cards. Two front handles supplied with the case are positioned behind the card frame angles and four screws with plastic washers secure the frame and handles into the case.

One inch front panels may be fitted to the Eurocards, these are available with holes already cut for suitable front connectors for each board. The memory board only requires a blank panel. The front panel is fixed to the board using two plastic brackets also supplied as shown:-



Chapter 5 - Peripheral Devices

Power Supply

System 2 requires a 5 volt stabilised supply at a current rating of not less than 1.5 amps (2 amps with 8K of RAM). This supply may be connected with two pieces of wire to the holes provided on the backplane (see page 3-11). If the 0 volt line of the supply is not earthed a safety earth should be connected to the card frame metalwork which is in turn connected to the earth connection on the backplane. If available a 5 volt - 3 amp module may be fitted in the left of the rack using four module guides and a 32 way socket on the left of the backplane.

Keyboard

A parallel ASCII keyboard is required to be fitted on the front of C.P.U. card. A 5 volt supply for the keyboard is available and the board requires a 'low for key depressed' strobe signal. The connections may be soldered to the front of the board as follows:-

(top)	20	+ 5 volts
	19	Reset
	18	Key strobe
	17	Data bit 6
	16	Data bit 5
	15	Data bit 4
	14	Data bit 3
	13	Data bit 2
	12	Data bit 1
	11	Data bit Ø
	10	-
	9	-
	8	-
	7	-
	6	-
	5	-
	4	-
	3	-
	2	-
(bottom)	1	0 volts

The reset is provided by a simple push button connected to 0 volts. This is often available as an extra key on ASCII keyboards.

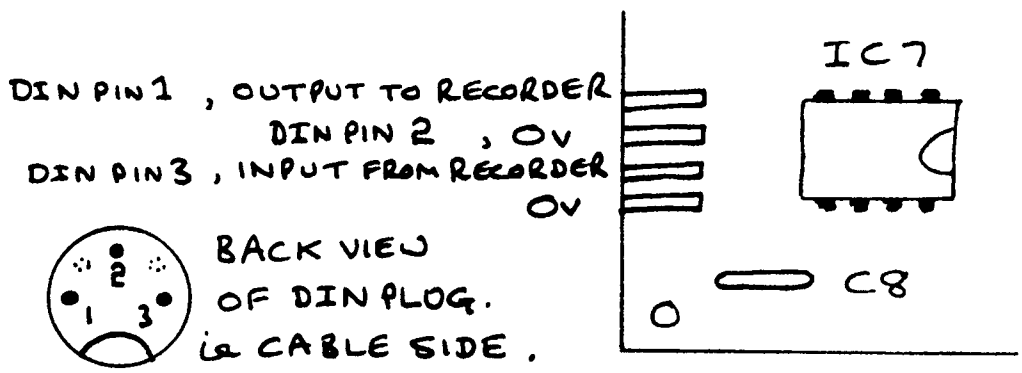
If desired a 20 way pcb header can be fitted to the C.P.U. card in which case the keyboard connections are as follows:-

20	Data bit 5		
		19	Data bit 6
18	Data bit 4		
		17	Key strobe
16	Data bit 3		
		15	Reset
14	Data bit 2		
		13	+ 5 volts
12	Data bit 1		
		11	0 volts
10	Data bit 0		
		9	-
8	-		
		7	-
6	-		
		5	-
4	-		
		3	-
2	-		
		1	-

When connecting ribbon cable sockets to the headers ensure that the pin 1 identification arrows are together.

Cassette Recorder

System 2 uses a standard Audio Cassette Recorder for program and data storage. On the cassette interface card is a Computer Users Tape Standard interface which connects to the recorder as shown:-



This recorder output consists of one of two tones, 2.4 KHz represents a logic 1 and 1.2 KHz a logic 0. Each bit i.e. o or 1 lasts for 3.3 mS giving an operating speed of 300 bits/ second.

Both recording and playback are crystal controlled giving a low error rate and except on very cheap recorders whose speed may vary, no trouble should be experienced in transferring tapes from one machine to another.

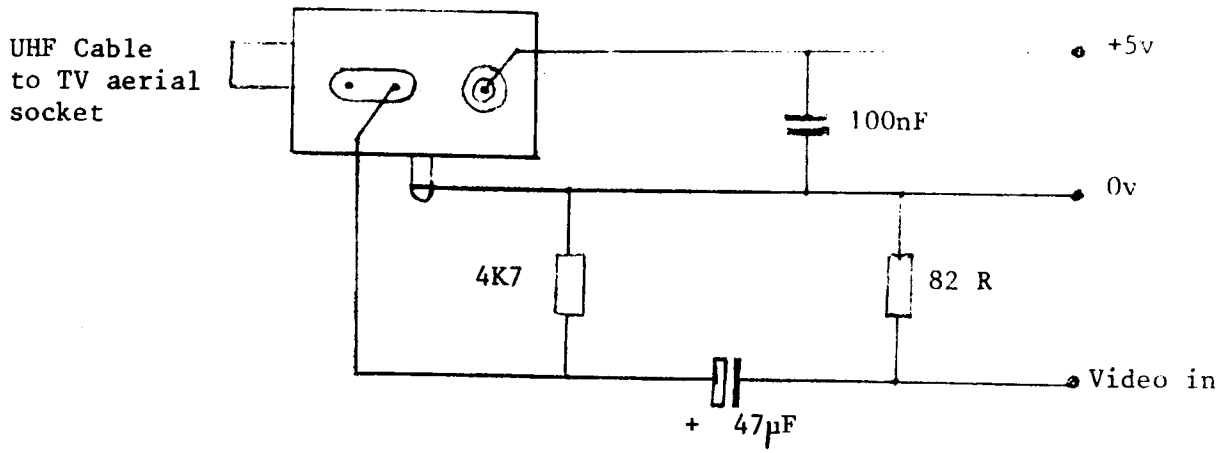
We recommend the use of a recorder with an input and output dedicated to external connection to an amplifier as opposed to the microphone and external loudspeaker connections on the cheaper recorders. These types usually have a 3 or 5 pin circular DIN connector which is wired as shown above.
The input and output recorder levels as supplied are both 300 mV r.m.s. The output may be adjusted by changing R3 and input by changing R12 on the keyboard. The output should be adjusted so that the tones play back at a comfortable audio volume without excessive distortion. The input is then adjusted for reliable operation or using an oscilloscope, to give a waveform at pin 7 of I.C. 7 which is in excess of 2 volts peak to peak but is not being clipped.

Visual Display Unit

The V.D.U. interface drives a raster scanned cathode ray tube display device e.g. a monitor or a television. The format is 40 characters on 25 lines with teletext colour graphics.

The standard output is a 1 volt/75 ohm composite video signal available on pin 15 on the front of the V.D.U. card with a 0 volt return on pin 14. A 75 ohm coaxial cable connected to this will drive a monitor directly. Also this signal may be used to drive a UHF modulator as shown below giving an interface to a standard television.

END VIEW OF MODULATOR — UM 1233 E36



A phono style plug fits the modulator and connects to the TV aerial socket via a length of 75 ohm co-axial cable. Tune the TV to channel 36.

Using the composite video output the different colours available from the VDU card will appear as different shades of grey, even on a colour monitor or television.

To obtain a colour display the Red, Green and Blue drive signals from the card together with the required sychronising signals must be fed to either a T.T.L. level input colour monitor or a colour encoder/UHF modulator system.

Note that if a BNC connector is mounted on an optional front panel for the video output the body of the connector i.e. Ov should be insulated from the panel.

After switching on and entering the COS R3 on the V.D.U. card is adjusted to give stable characters of the correct width on the screen.

Chapter 6 Cassette Operating System

This is a 2K byte program resident in ROM on the 6502 C.P.U. card. It provides support for other programs e.g. a BASIC interpreter by dealing with peripheral devices and allowing programs to be filed on cassette tapes. It is specifically written for the system 2 and it interfaces to the teletext Visual Display Unit interface, a parallel ASCII keyboard and a centronics parallel printer.

To start system 2 enter the COS by pressing the reset button (break) on the keyboard. If the system is working the COS will display on the V.D.U.:-

```
Acorn Cos
*_
```

The star is the COS prompt indicating that it is waiting for the user to type in a command. To the right of it is the flashing cursor at which the characters typed are displayed.

Commands must be typed in capital letters only and many keyboards feature a Capital Lock button so that the alphabetic keys always produce an upper case output whilst the numeric and symbolic keys continue to work in shifted or un-shifted mode as usual.

On typing a character the V.D.U. will display that character and advance the cursor along one position to the right. Another character may then be entered. Should a character be typed in error it may be corrected by pressing the delete (back space or rub out) key in which case the character to the left of the cursor is erased and the cursor moved back to that position. If desired the whole line may be thrown away by entering control X ie. pressing the control key and X together. A new cursor is displayed and a new line of text can then be entered. After typing a word or some words separated by spaces the displayed text may be entered to the COS by typing return.

If the text is not a command recognised by the COS it will respond with

Com?

*_

The user may then type in more text. If the COS recognises the command but it is not presented in the correct way i.e. its syntax is wrong the display will show

Syn?

*_

The COS recognises the following commands any of which may be abbreviated by entering enough of the characters to distinguish it from any other command followed by a full stop.
Spaces are used to separate the arguments, unless otherwise stated leading zeroes are not required.
The commands are listed giving the command, its full name and its shortest possible abbreviation:-

BASIC

This command causes execution of the Acorn BASIC interpreter if it is present. Refer to the BASIC manual for explanation of how to use it. If BASIC is not present either in ROM or RAM then the system crashes and must be re-set.

LOAD Load from Tape L.

The syntax of this command is as follows:-

LOAD "FILNAME" XXXX

The name of the file to be loaded is inside double quotes and may be up to sixteen characters long. Files are normally loaded to where they were originally saved from. The optional four digit hexadecimal address allows relocation to a new section of memory starting at the address specified. On pressing RETURN the COS will respond with

Play drive Ø

The user should now start the cassette recorder in play mode at the desired position on the tape and press the space bar on the keyboard to indicate to the COS that this has been done. The COS will display the names of any files that are on the tape between the starting position and the file that it is searching for. When the file to be loaded is found it is loaded and the COS will then display the * prompt indicating that the loading process is complete and that the recorder may now be stopped and that new commands may now be entered.

Files are stored as a number of 256 byte blocks each of which is identified on the tape. If the file to be loaded is part way past the tape heads this is detected at the start of the next block. Loading ceases and the COS displays

Rewind drive Ø

The user should then stop the tape, rewind it and then press the space bar to which the COS will respond with

Play drive Ø

The loading process should then be repeated.

One error message may be produced

sum

This indicates that the checksum has failed at the end of a block i.e. a byte or some bytes have not loaded correctly. The * prompt is displayed and the user may rewind the tape and try to re-load if desired.

The loading operation may be aborted by pressing the space key. When the COS reaches the end of the block it is loading, loading ceases and the * prompt appears.

Another syntax may be used for load

LOAD XXXX

Files without names are assumed to be Acorn system 1 files which have a different storing format on the tape. Tapes originally created on a system 1 are unnamed and the COS will load the first one to appear after starting the tape and pressing the space bar. Note that system 1 files are not subdivided onto blocks and no error checking is used. The file is loaded into the memory it was originally saved from unless it is relocated to a new position whose start is specified in the command.

RUN Load and Run R.

The syntax of this command is as follows:-

RUN "FILNAME" XXXX

The command functions exactly as for LOAD but on completion of the load program, execution is transferred to the third address specified when the file was saved. If the file was saved with only two address execution is transferred to the first address. i.e. to the start of the file when it was saved. No indication that the load is finished and that the recorder may now be stopped is given so this should be built into the start of the program to be run if required. The optional address following RUN is used to relocate the start of the file in memory if desired.

Again system 1 tapes may be run by omitting the file name

RUN XXXX

Execution is started at the first address of the file when it was saved. The file is optionally relocated.

GO Go G.

The syntax of this command is as follows:-

GO XXXX

When entered program execution is transferred to the address specified which is obligatory.

SAVE — Save on Tape — S.

The syntax of this command is as follows:-

SAVE "FILNAME" XXXX YYYY ZZZZ

The name that the file is to be saved under is inside double quotes and may be up to sixteen characters long. This must be followed by two hexadecimal addresses, the start address and the end address plus one of the section of memory to be saved. The optional third address specifies where execution is passed to after loading the file back using the RUN command. On pressing return the COS will respond with

Record drive Ø

The user should now start the cassette recorder in record mode at the desired position on the tape and press the space bar on the keyboard to indicate to the COS that this has been done. After the COS has finished outputting to the tape it will respond with the * command and the recorder may then be stopped. The escape does not allow the save sequence to be aborted.

Tapes may be created in the system 1 format by omitting the filename, the third address has no significance in this case

SAVE XXXX YYYY

DRIVE — Drive select — D.

The syntax of this command is

DRIVE N

where N is Ø, 1, 2 or 3. This command is included to maintain compatibility with more advanced operating systems and has no effect in the COS except to change the number printed on the screen which is initially set to Ø.

MON — Messages on — MO.

When entered this command allows messages from the COS to appear in the output stream to the V.D.U. and printer. This is the usual condition after reset. Possible messages are:-

Rewind drive N
Play drive N
Record drive N
FILNAME

NOMON — Messages off — N.

This command turns off the messages enabling the V.D.U. contents to be preserved and stopping unwanted printouts.

CAT — Catalogue — I.

This command allows the display of information about the files on a cassette tape. When entered it will respond with

Play drive ø

and after starting the recorder in play mode and pressing the space bar the following display format is produced

FILNAME AAAA ZZZZ BBBB CC

This is produced everytime the COS encounters the start of a block. AAAA is the start address of the block. ZZZZ is the execution address of the file as used by RUN. BBBB is the block number, blocks are numbered in a file starting at zero. CC is the number of valid bytes in the block, minus one. All these are, of course, in hexadecimal. When a system 1 file is encountered the display is

XXXX YYYY

Here XXXX is the start address and YYYY the end address plus one of the file as used in SAVE.

To stop the flow of information press the *space bar* and stop the recorder.

FLOAD — Finish loading — F.

The syntax of this command is

FLOAD "FILNAME" XXXX

The normal LOAD demands that files are loaded from the start of the first block and will request that the tape is re-wound if started in the middle of the file. FLOAD allows loading to commence from the start of any block in the file. The optional hexadecimal address XXXX specifies the memory address to which the start of the first block is loaded if relocation is required.

This is useful after a checksum error has been encountered. The tape may be stopped and re-wound to anypoint prior to the block which produced the error. FLOAD is then used to allow loading to continue and the block identifiers will ensure that blocks are loaded in the correct place. However if the file was being relocated the block identifiers do not specify the correct memory address for that block. In this case CAT can be used to find out which block is next on the tape. Knowing how many 256 byte blocks have been loaded the optional start address for the next block can be calculated and entered in the FLOAD command.

USE — Use qualifier — U.

The syntax of this command is

USEQ

This command is included to maintain compatibility with other operating systems and has no effect at all in the COS. Note that the syntax demands that there is no space between USE and the specified qualifier which may be any ASCII character.

MEM Memory examine-edit M.

The syntax of this command is

MEM XXXX

On pressing return the display will show the address followed by its contents in hexadecimal. If the specified address is in RAM new hexadecimal data may be entered or the return key may be used to obtain a * prompt. Also after MEM either U or V may be entered which increment or decrement the address being examined. In this way machine code programs such as the cassette test may be entered and then executed using the GO command.

Chapter 7 COS Control Characters

Screen Editor

Five keys on the ASCII keyboard allow cursor movement and editing anywhere on the V.D.U. screen. These are

Control A	-	cursor left
Control S	-	cursor right
Control W	-	cursor up
Control Z	-	cursor down
Control Q	-	read character

Pressing the control key and the A, S, W or Z keys move the cursor around the screen but do not send any new characters down the input channel.

Once the cursor is positioned over the desired character, this character may be sent down the input channel using control Q, the cursor is then moved one space to the right automatically.

For example, suppose it is required to edit a BASIC line:-

```
LIST
10  REM EXAMPLE
20  FOR I = 0 TO 50
30  PRINT "ORANGES AND LEMONS"
40  NEXT I
50  END
 > -
```

After listing the program the screen is as above with the cursor at the bottom following the BASIC prompt.

First move the cursor to the start of the line to be edited using control A, S, W and Z :-

```
LIST
10  REM EXAMPLE
20  FOR I = 0 TO 60
30  PRINT "ORANGES AND LEMONS"
```

```
40  NEXT I
50  END
```

Now use control Q to re-enter the line number and first part of line 30 :-

```
LIST
10
20
30  PRINT "ORANGES AND LEMONS"
40
50
```

Next the new output required is typed:-

```
LIST
10
20
30  PRINT "APPLE OR PLUM "MONS"
40
50
```

And as no more of the old line is required the return key is now pressed and the program may be listed again.

Printer and Screen Control

The following ASCII control characters affect the V.D.U. screen when they are output. They are listed together with their keyboard key and decimal value. The operating system also provides for a printer which may be connected using an extra interface card. Control characters for this printer stream are also listed:-

STX (ctrl B, 2) Start Printer

This starts the printer output stream but is not sent out to the printer. It also sets alphanumerics green on the V.D.U.

ETX (ctrl C, 3) End Printer

This ends printer output stream. It also sets alphanumerics yellow on the V.D.U.

ACK (ctrl F, 6) Start Screen

This starts the output stream to the V.D.U. screen, which is the normal condition initially set by the COS.

BD (ctrl H, 8) Cursor Back

This moves the cursor back one character position

HT (ctrl I, 9) Cursor Forward

This moves the cursor forward one character position

LF (ctrl J, 10) Line Feed

This moves the cursor down one line.

VT (ctrl K, 11) Vertical Tab

This moves the cursor up one line.

FF (ctrl L, 12) Form Feed

This clears the screen and moves the cursor to the top left hand corner.

CR (ctrl M, 13) Carriage Return

This moves the cursor to the start of the current line.

NAK (ctrl U, 21) End Screen

This ends the output stream to the V.D.U.

RS (ctrl , 30) Home Cursor

This moves the cursor to the top left hand corner of the screen.

DEL (DEL, 127) Delete

This backspaces the cursor and deletes the character at that position.

Printers connected to the system printer port will often respond to other control characters in the output stream so refer to the relevant printer manual. Note that some of these other control characters may produce a response on the V.D.U. if its output stream is enabled.

Because some printers will initiate the printing of a line in response to either a carriage return or a line feed character in the output stream the operating system prevents the character specified by location 254 in zero page from reaching the printer. This character is initialised on reset to be a line feed but it may be changed by altering the contents of location 254. Thus it is possible to stop any one character from being printed but note that if neither line feed nor carriage return are specified some printers will do a double line feed after printing.

Chapter 8 Visual Display Unit

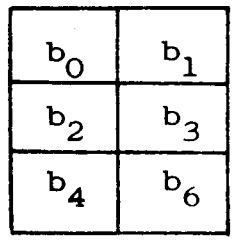
The teletext standard V.D.U. in the system produces coloured alphanumerics and graphics as well as some other features in response to some control codes. These codes are listed in decimal as follows:-

129	Red alphanumerics	145	Red Graphics
130	Green "	146	Green "
131	Yellow "	147	Yellow "
132	Blue "	148	Blue "
133	Magenta "	149	Magenta "
134	Cyan "	150	Cyan "
135	White "	151	White "
136	Flash	152	Conceal display
137	Steady	153	Contiguous Graphics
138	End Box	154	Separated Graphics
139	Start Box		
140	Normal Height	156	Black background
141	Double Height	157	New background
		158	Hold graphics
		159	Release graphics

These characters affect the characters displayed to the right of them on a line, and provide the following options:-

ALPHA (COLOUR) causes following characters on the line to be in the colour specified.

GRAPHICS (COLOUR) In Graphics mode each character space displayed is divided into 6 cells. Each cell is illuminated, in the specified colour, if a corresponding binary bit in the code stored at that location is set. The bit assignments are:-



bit 7 set.

Bit 5 in the byte is always set for a graphics character, if bit 5 is clear then the upper case, alphabet and characters ←, ½, →, ↑, #, @ are available in the same colour.

FLASH — causes the following characters on the line to flash.

STEADY — terminates the flash option on a line

END BOX & START BOX — Are options for using the circuit to superimpose text onto a normal TV picture.

DOUBLE HEIGHT — Must appear on two consecutive lines followed by the same characters in which case the characters fill the two lines specified.

NORMAL HEIGHT — Clears the double height option on a line.

CONCEAL DISPLAY — Switches off the characters on a line. These can only be revealed by applying a signal to the character generator chip (or deleting the CONCEAL character).

CONTIGUOUS GRAPHICS — In this mode the graphics cells in a character are joined up.

SEPARATED GRAPHICS — In this mode the graphics cells are separated by one character bit width.

NEW BACKGROUND — Sets the background to the colour of the last colour specifying character.

BLACK BACKGROUND	Resets the back ground colour to black.
HOLD GRAPHICS	Causes the last graphics character to be displayed when a control character is entered.
RELEASE GRAPHICS	Causes a space (Background colour) to be displayed when a control character is entered.

The character generator assumes an initial setting at the start of each line of:-

ALPHA WHITE, STEADY, END BOX, NORMAL HEIGHT.
CONTIGUOUS GRAPHICS, BLACK BACKGROUND, RELEASE GRAPHICS.

The characters produced by the V.D.U. and their decimal codes are tabulated here:-

32	space	64	@	96	—
33	!	65	A	97	a
34	"	66	B	98	b
35	£	67	C	99	c
36	$	68	D	100	d
37	%	69	E	101	e
38	&	70	F	102	f
39	'	71	G	103	g
40	(	72	H	104	h
41	)	73	I	105	i
42	*	74	J	106	j
43	+	75	K	107	k
44	,	76	L	108	l
45	-	77	M	109	m
46	.	78	N	110	n
47	/	79	O	111	o
48	0	80	P	112	p
44	1	81	Q	113	q
50	2	82	R	114	r
51	3	83	S	115	s
52	4	84	T	116	t
53	5	85	U	117	u
54	6	86	V	118	v
55	7	87	W	119	w
56	8	88	X	120	x
57	9	89	Y	121	y
58	:	90	Z	122	z
59	;	91	←	123	¼
60	<	92	½	124	ll
61	=	93	→	125	¾
62	>	94	↑	126	÷
63	?	95	≠		

CHAPTER 9. O.S. SOFTWARE SPECIFICATION

The COS contains several routines which can be called to interface between user programs and the system hardware.

The routines are defined in such a way that they will be compatible with future Acorn operating systems and higher level software, and are defined as follows:-

OSCLI This subroutine interprets a string of characters held at ØIØØ terminated by a carriage return, as an operating system command. Detected errors are met with a brk. All processor registers are used, the decimal mode flag will be set to binary on exit.

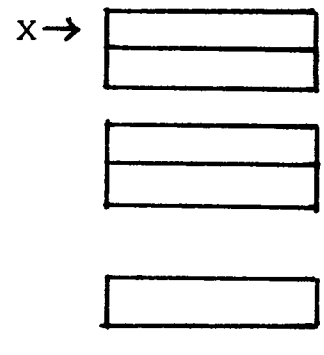
OSWRCH This subroutine sends the byte in A down the output channel. This channel is usually treated as ASCII data and special action may be taken on ASCII control characters. In the COS the recognised control characters are the cursor movement and printer control characters detailed in chapter seven. No processor registers are destroyed.

OSCRLF This subroutine generated a line feed and then a carriage return using OSWRCH. A will contain ØD, N will be Ø, Z will be Ø all other registers will be as before.

OSECHO This subroutine fetches a byte from OSRDCH and then writes it out using OSWRCH. If a carriage return occurs in OSRDCH both a line feed and a carriage return are sent to as OSWRCH. A will contain the byte, N, Z and C are unknown, all other registers are unchanged.

OSRDCH This subroutine fetches a byte from the input channel into A. The state of N, Z and C is unknown, all other registers are unchanged.

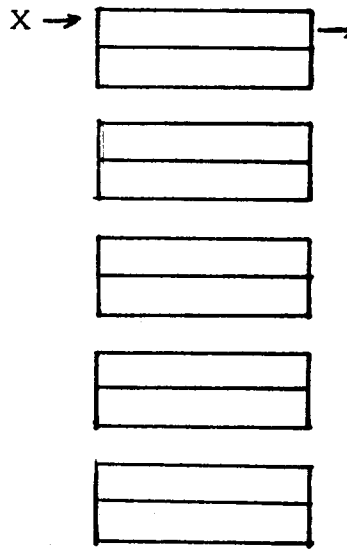
OSLOAD This subroutine loads all of a file into a specified area of memory. On entry X must point to the following data in zero page:



The data is copied by the operating system and is not harmed. All processor registers are used but the status is saved. A break will occur if the file cannot be found.

In interrupt or dma driven systems a wait until completion should be performed if the carry flag was set on entry.

OSSAVE This subroutine saves all of an area of memory to a specified file. On entry X must point to the following data in zero page.



The data is copied by the operating system and is not harmed. All processor registers are used but the status is saved.

In interrupt or dma driven operating systems a wait until completion should be performed if the carry flag was set on entry. A break should occur if no storage space large enough can be found.

OSBPUT This subroutine outputs the byte in the accumulator to a sequential write file, X and Y are saved, N, Z and C are unknown. In the COS interrupts are disabled during BPUT but the interrupt status is restored on exit. In other systems the files sequential byte pointer will be incremented after the byte has been saved.

OSBGET This subroutine returns the next byte from a sequential read file in A. X and Y are retained N, Z and C are unknown. In the COS interrupts are disabled during BGET but the interrupt status is restored on exit. In other systems the files sequential byte pointer will be incremented after the byte has been read.

On reset a set of vectors are moved into RAM in block zero which point to these routines. These vectors are in RAM so that they may be changed by a user's program to point to other routines ie. serial interface etc. The vectors are as follows:-

0200	NMIVEC	NMI routine entry
0202	BRKVEC	BRK routine entry
0204	IRQVEC	IRQ routine entry
0206	COMVEC	operating system command line interpreter
0208	WRCVEC	write character to output subroutine
020A	RDCVEC	read character to input subroutine
020C	LODVEC	load program subroutine
020F	SAVVEC	save program subroutine
0210	RDRVEC	ERROR
0212	STRVEC	ERROR
0214	BGTVEC	get byte from tape
0216	BPTVEC	put byte to tape
0218	FNDVEC	ERROR
021A	SHTVEC	ERROR

The vectors which point to error are there to allow for software expansion to sequential file handling. A call to error causes the COS to output

Com?

a break is then executed.

CALLS

As there is no jump to subroutine indirect to use these vectors the COS has the following calls in it.

```
FFCB    OSSHUT      JMP (SHTVEC)     unused
FFCE    OSFIND      JMP (FNDVEC)     unused
FFDI    OSBPUT      JMP (BPTVEC)
FFD4    OSBGET      JMP (BGTVEC)
FFD7    OSSTAR      JMP (STRVEC)     unused
FFDA    OSRDAR      JMP (RDRVEC)     unused
FFDD    OSSAVE      JMP (SAVVEC)
FFE0    OSLOAD      JMP (LODVEC)
FFE3    OSRDCH      JMP (RDCVEC)
FFE6    OSECHO      JSR  OSRDCH
FFE9    OSASCI    CMPIM #$OD
FFEB                BNE  OSWRCH
FFED    OSCRLF      LDA #$OA
FFEF                JSR  OSWRCH
FFF2                LDA #$OD
FFF4    OSWRCH      JMP (WRCVEC)
FFF7    OSCLI       JMP (COMVEC)
```

INTERRUPTS

The following action is taken on interupts

```
NMI     PHA
        JMP  (NMIVEC)

IRQ/BRK
        STA     $FF
        PLA
        PHA
        AND  # $10          which interrupt was it
        BNE     BRK
        LDA     $FF
        PHA
        JMP     (IRQVEC)    it was an IRQ
   BRK  LDA     $FF
        PLP
        PHP
        JMP     (BRKVEC)    it was a BRK
```

RESET

On reset the operating system is executed starting with the transfer of the vectors into page two.

The COS uses locations $C\emptyset$ upwards in zero page for scratch pad memory and these locations should not be altered by user programs.

Note that the basic interpreter uses locations $64 and below and care must be taken not to alter these locations if the interpreter is being used.

TAPE TEST ROUTINE

The listing given is of a short program to test that the cassette interface is working correctly, the program also illustrates the use of the defined software interface.

The program should be entered into memory starting at $\emptyset 2\emptyset\emptyset$ using the MEM function of COS with the cassette recorder connected and set-up to record, the program should be executed from the start at $\emptyset 2\emptyset\emptyset$ using the CO command. The program will save stars as data on the tape using the OSBPUT routine and should be left to run for about a minute then the escape key should be pressed.

The second half of the program may then be used to check that this data has been stored correctly and can be read back. The tape should be wound back and set to play the data back which has just been recorded and the program should be executed from location $\emptyset 217$.

The program will fetch bytes from the tape and display them on the screen as ASCII characters using OSBGET and OSWRCH. It should be possible by adjusting the volume and tone controls to get stars on the screen starting in the top left hand corner. When 256 characters have been loaded the screen will clear and loading will start again. Only when two complete blocks of stars have been loaded without error can the interface be expected to run reliably in normal operation. If the end of the test data is reached on the tape, the tape should be rewound and replayed. At the end of the test the escape key may be used to return to the COS.

For those with access to an oscilloscope the following program may be used:

```
0200  A9 55  LOOP  LDAIM $55
0202  20 DI FF     JSR OSBPUT
0205  4C 0002      JMP LOOP
```

If this program is then executed from location Ø2ØØ a square wave should be present on the cassette interface board at IC4 pin 9. This is the data being output by the program.

If tape recorder input and output pins are then linked on the interface board, the modulated and demodulated signal should then appear at pin 2 of IC 4. If this does not work recheck the construction of the tape interface board.

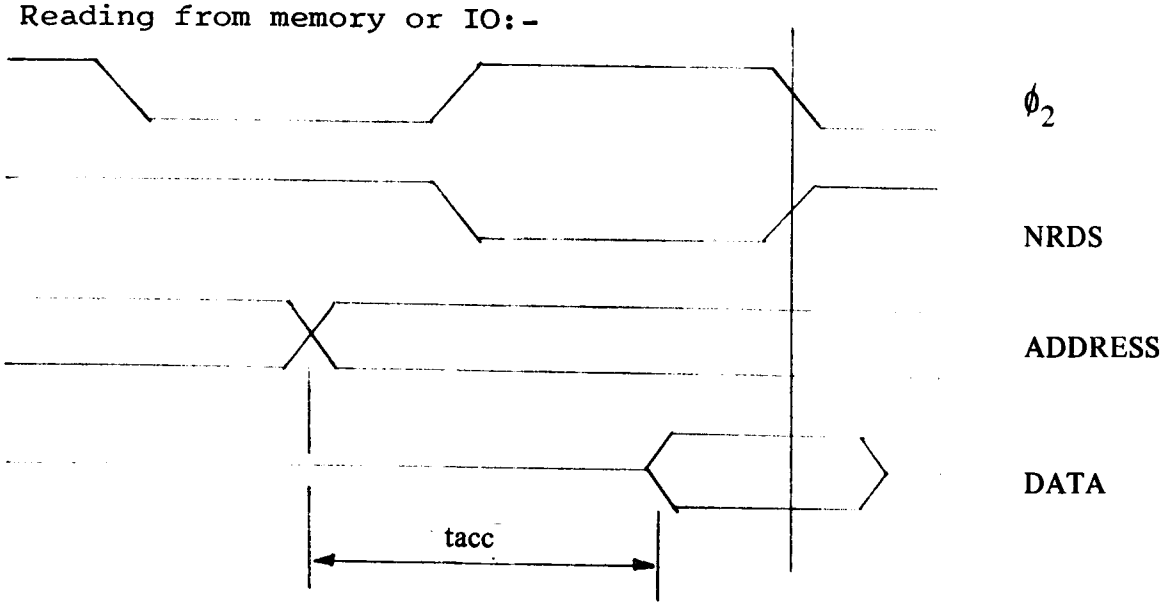
```
save ID

ID 00

TEST       ACORN 6502 Assembler   Page 01


0010: 2E00             TEST   ORG    $2E00
0020: 2E00             ESC    *      $1B       Define escape key
0030: 2E00             KB     *      $0E21
0040: 2E00             OSBGET *      $FFD4
0050: 2E00             OSBPUT *      $FFD1
0060: 2E00             OSWRCH *      $FFF4
0070: 2E00             OSASCI *      $FFE9
0080: 2E00 A9 2A               LDAIM  '*       Send a load of stars
0090: 2E02 20 D1 FF            JSR    OSBPUT
0100: 2E05 A0 06               LDYIM  $06       A high tone wait between bytes
0110: 2E07 A2 00               LDXIM  $00
0120: 2E09 CA          DLY     DEX
0130: 2E0A D0 FD               BNE    DLY
0140: 2E0C 88                  DEY
0150: 2E0D D0 FA               BNE    DLY
0160: 2E0F AD 21 0E            LDA    KB       Do we stop yet?
0170: 2E12 C9 1B               CMPIM  ESC
0180: 2E14 D0 EA               BNE    TEST     no so round again
0190: 2E16 60          RTS     RTS             yes so return
0200: 2E17 A0 00       INPUT   LDYIM  $00      Get 256 bytes back
0210: 2E19 A9 0C               LDAIM  $0C       Send a form feed
0220: 2E1B 20 F4 FF            JSR    OSWRCH
0230: 2E1E 20 D4 FF    LOOP    JSR    OSBGET   Get a byte
0240: 2E21 20 F4 FF            JSR    OSWRCH   and display it
0250: 2E24 AD 21 0E            LDA    KB
0260: 2E27 C9 1B               CMPIM  ESC       Do we want to stop?
0270: 2E29 F0 EB               BEQ    RTS       yes so return
0280: 2E2B C8                  INY
0290: 2E2C D0 F0               BNE    LOOP     Next byte of 256
0300: 2E2E F0 E7               BEQ    INPUT    and round again
ID
```

Chapter 10 - Circuit Descriptions

6502 C.P.U.

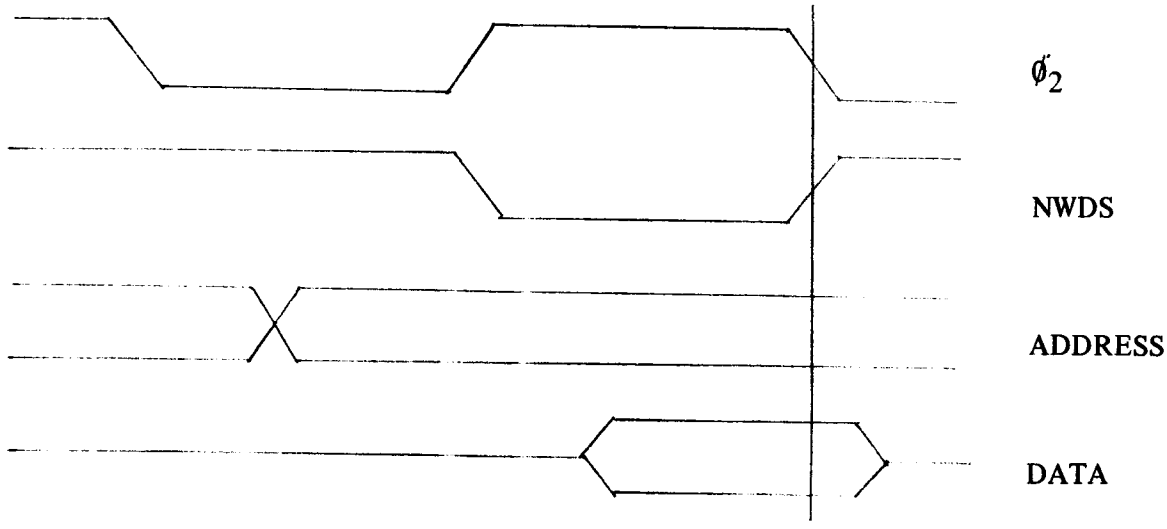
The 6502 micro-processor contains an on chip clock oscillator which runs at 1 MHz as defined by the crystal. This is buffered to provide the ϕ_2 clock (E in 6800 terminology) which is fed to the back plane. The 6502 also produces a Read/Not Write signal which combined with ϕ_2 produces a Not Read strobe and a Not Write strobe. The setting up of the 16 bit address and the reading or writing of data is synchronised by these signals.

Reading from memory or IO:-



t_{acc} is the access time of the device being read which must not exceed 575nS

Writing to memory or IO:-



The 6502 provides the data byte to be written at the end of ϕ_2.

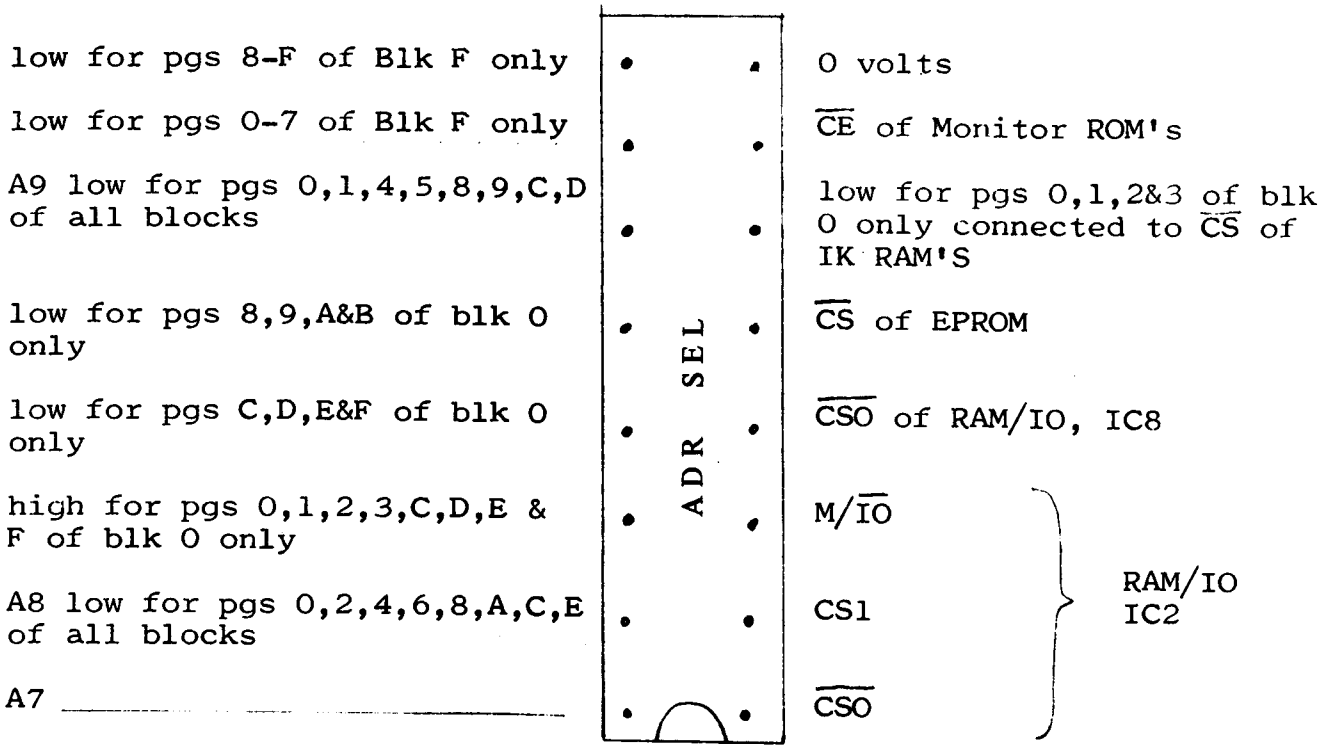
A versatile address decoding system in four TTL devices may be specified and devices on the card that may be addressed are:-

1K byte of static RAM in 2114's
512 bytes of bipolar ROM in 74S571's
1, 2 or 4K bytes of ROM in 2758, 2516 or 2532
32 lines of IO and 256 bytes of RAM in two INS8154's

The terminology employed is that the 65,536 addresses capable of being specified by AO thro' A15 are denoted by a four digit hexadecimal number in the range 0000 to FFFF. The most significant Hex digit, i.e. A12 thro' A15, specifies one of 16 BLOCKS of addresses, i.e. Block 0 thro F, and these are further subdivided into pages. There are a total of 256 pages, each of 256 bytes specified by A8 thro' A15, i.e. pages 00 thro' FF.

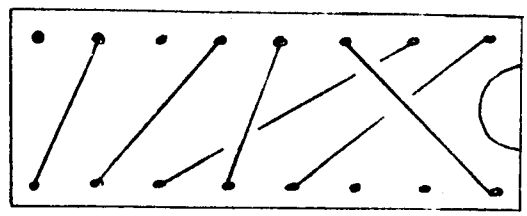
Basically the 6502 Micro Processor requires that page FF is Read Only Memory and in particular address FFFC is used after a reset. Also it requires that page 01 is used for the stack starting at address 01 FF and extending downwards. It is usual to also make page 00 Random Access Memory as this is particularly easy to access for Scratch Pad use.

A 16 pin location called ADR SEL configures the Address Map. Decoded address signals feed to this and these are connected to the Chip Select lines of the IC's on the card. Using the recommended addressing schemes block 0 and F are used for IC's on the circuit board and blocks 1 through E are left completely free for circuits external to the C.P.U. card.



CS1 of IC8 is always on A8 i.e. high for pgs 1,3,5,7,9,B,D & F
M/$\overline{IO}$ of IC is always on A7.

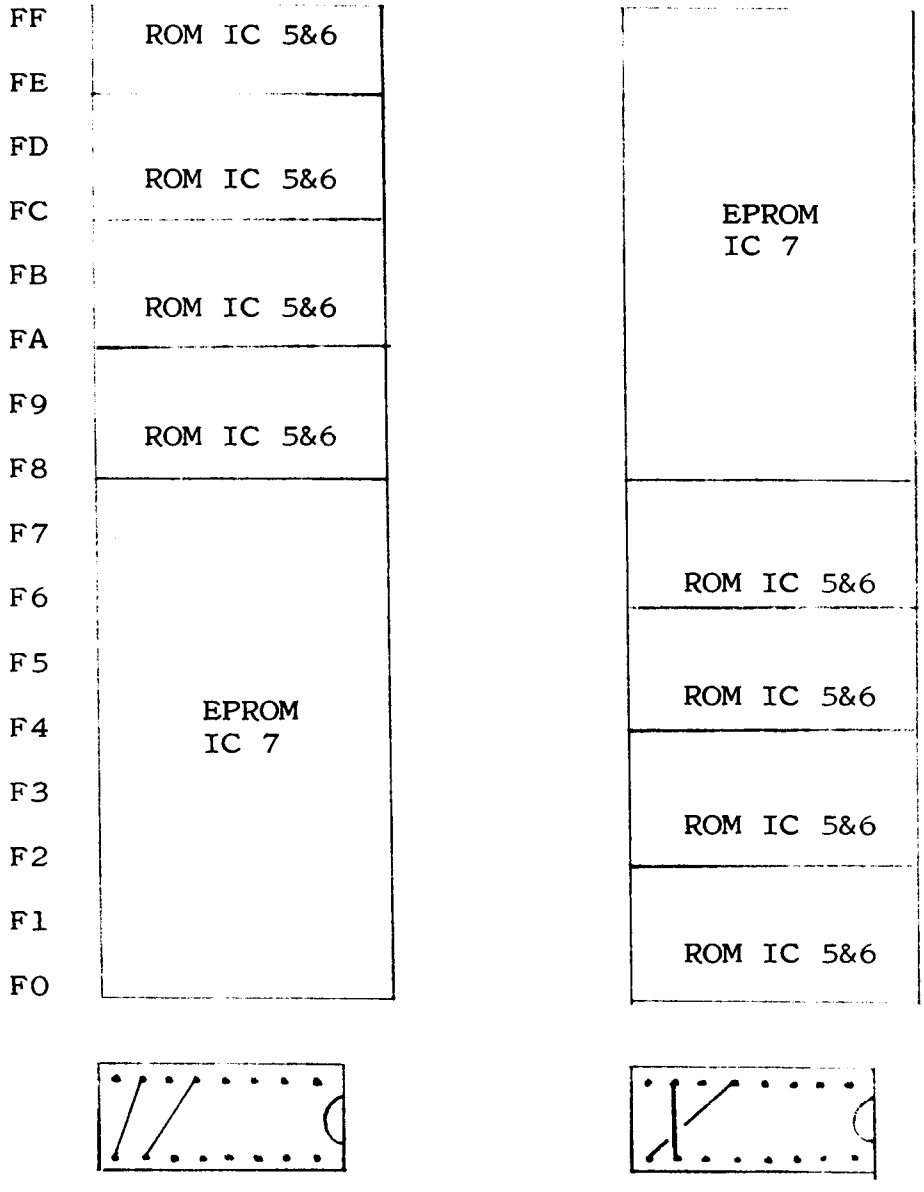
6502 C.P.U. cards from issue 2 onwards have tracks connecting the ADR SEL on side 2 of the card to provide the system 1 address selection scheme —



ADR SEL

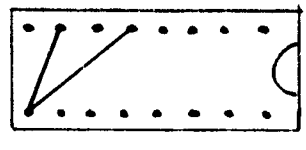
Earlier cards require wire links to be fitted as appropriate before they will work. The address selection may be changed if desired by breaking these tracks and fitting new wire links.

Block F is decoded into two halves of 8 pages each. i.e. 2048 bytes each. Two schemes are possible giving page FF in either the pair of 74S571's or the EPROM:-

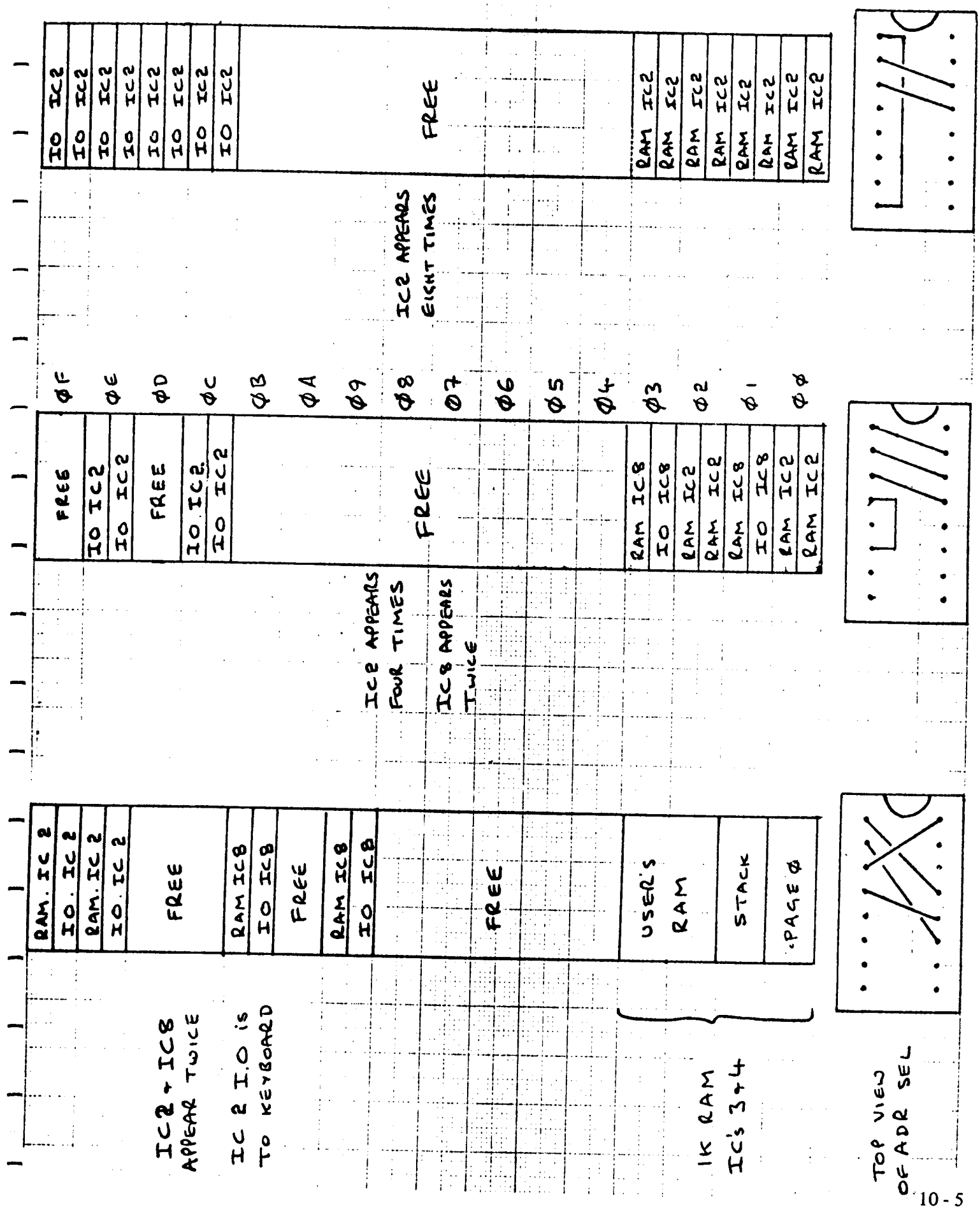


Note that the 512 byte ROM's appear four times. A 2048 byte EPROM is fully decoded but if desired a 1024 byte EPROM may be used in which case it will appear twice.

System 2 requires that the EPROM appears at the top and as the 74S571's are not present they may be left at the top as well i.e.

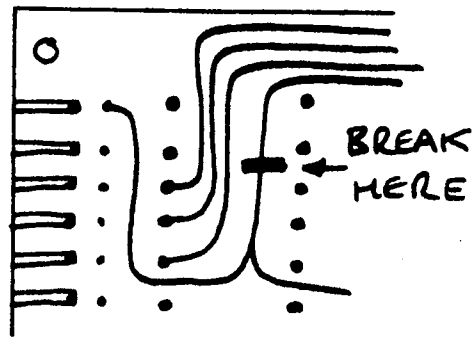


Block O is decoded so that pages 00 and 01 may be Random Access Memory contained in IC's 3 & 4, IC's 2 and 8 or IC 2 alone. When using IC2 alone care must be taken that the stack is not overwritten by the Scratch Pad.



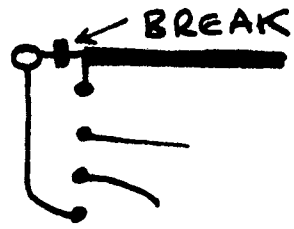
Read Only Memories with pin out systems similar to the 2708, 2758 and 2716 EPROM's may be used for firmware storage. As supplied the card is ready for a 2716 PROM to go in the lower 2 K bytes of block F, changing the address select links as on page 10-4 will place it in the upper 2 K bytes including the Reset Address.

To use the 2758 it is only necessary to groundpin 19. This is done by breaking a track on side 1 of the card as shown



A wire link is then soldered to the card from pin 19 to pin 12 of the ROM socket or Ov is connected to pin 1 of side B on the backplane.

To use the 2708 which requires +12v (Vdd) and -5v (Vbb) the track above is broken and also pin 21 is disconnected from +5v by breaking a track on side 1 as shown:-

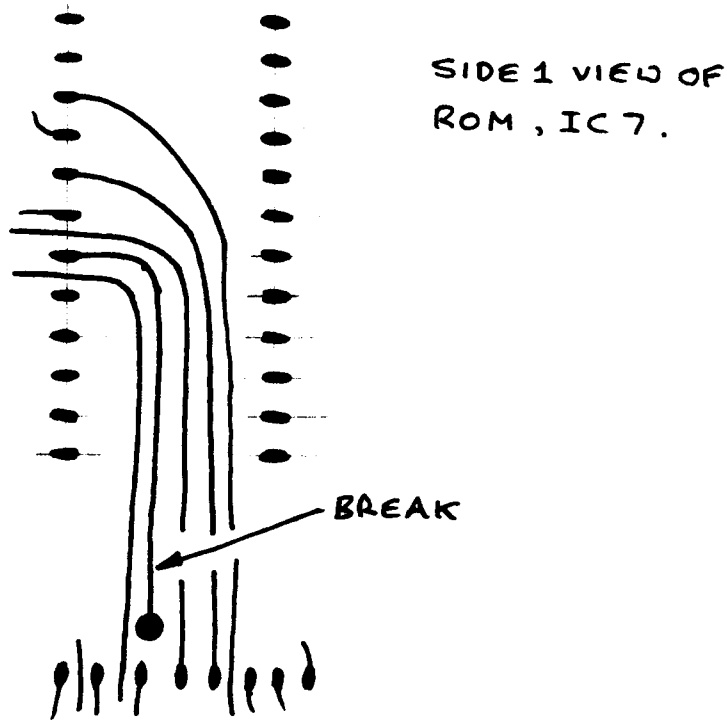


The two extra supplies are then fed in on pins 1 and 2 of side B on the backplane.

When a 1K byte PROM of the 2708/2758 type is used it will appear twice in the selected 2K bytes of block F.

If desired a 4K byte ROM of the 2732 type may be used in which case the track to pin 19 (A10) is left unbroken but the track to pin 21 is broken as above and pin 21 is linked to A11 on pin 13 of IC10.

The 2532 style of ROM has different pin assignments. The track to pin 19 (A 10) is left unbroken and also pin 21 is left at +5v. Pin 18 is broken from the Ov rail as shown:-



All is linked to pin 18 from pin 13 of IC 10.

For both 2532 and 2732 ROMs neither of the block F address select links are used but instead a link is made from pin 20 of the ROM to IC9 pin 6 which is low for the whole of the 4K block F.

The track to pin 5 of ADR SEL must therefore be broken as shown on page 3 - 7.

There is provision on the 6502 C.P.U. card for a 5 volt regulator. but this can only power the single card or system 1. Also three switches can be fitted to give Reset, Non maskable Interrupt and Interrupt request.

Cassette Interface

This card carries the circuitry to provide a scanned keyboard and multiplexed 8 digit/7 segment display. A 7445 operates as a 3 line to 8 line decoder and scans the keyboard in three groups of eight. The three key sense lines may then be read. Also the 7445 scans the display digit cathodes and the appropriate seven segment code for each digit may be applied to the display.

Also on the board is a Computer Users Tape Standard interface. IC1 is a counter which is clocked at 1MHz until 26 μS have elasped, the counter is then reset and R1/C1 ensure that the reset pulse is long enough to reset all the counter outputs before the next clock edge. The 26 μS pulses are then divided by IC2 to provide C.U.T.S. frequencies of 2.403 KHz and 1.202 KHz. The data to be outputted is fed via C2/R2 to IC2 and thus IC2 is reset every time the data goes low. Also the data selects the high or low C.U.T.S. frequency in synchronism with the 26 μS reset pulses. In this way the data is locked to the 1.2 or 2.4 KHz signal giving whole output cycles. R3, R4 and C3 provide output level adjustment and a high frequency output filter.

Incoming data is amplified by the first part of IC7 and then the second part of the device acts as a Schmitt trigger giving a clean logic signal. IC6 is clocked such that Q7 would normally run at 868 Hz. This frequency is used so that with the counter, IC6, being set on every negative transition of the data Q7, achieving a high level means that the data is at 1.2 KHz but if the data is at 2.4 KHz Q7 stays low. The result of Q7 is clocked out to provide the output data.

Visual Display Unit

The Acorn Display Unit Controller Card connects to the Standard Acorn Computer Bus and contains a memory mapped character storage R.A.M. which is transparently written to or read from by the C.P.U.

An MC 6845 programmable controller I.C. provides all the synchronisation signals to drive a 625 line 50 fields per second V.D.U. together with read addresses for the character R.A.M. Characters are then fed to an SAA5050 character generator IC which produces the necessary dot patterns to create the characters to refresh the V.D.U.

The SAA5050 produces Teletext standard characters and has Red, Green and Blue drive outputs giving coloured characters or graphics.

The R.G.B. and sync outputs may be used to drive a colour encoder and modulator for a U.H.F. Television; also provided is a 1 volt/75 ohm composite sync and video output which can directly drive a Monochrome Monitor on which the different colours will appear as different scales of grey.

To use this card in the Acorn system a low for block zero signal must be present on pin 31A of the Acorn Bus. This is provided by connecting pin 8 of IC9 to pin 31A of the connector on the 6502 C.P.U. card.

A 1 volt at 75 ohm video monitor may be driven directly from connections 14 and 15 on the front of the card. Alternatively a UHF modulator may be driven which connects to the aerial input of a domestic television.

IC3 on the VDU card forms a 6MHz dot clock which is adjusted using the preset resistor R3 to give characters of the right width on a steady picture after MC6845 has been initialised by the operating system.

The 1024 byte character memory appears in block zero of the Acorn address map filling pages 04, 05, 06 and 07. Two registers, which set up the 6845, are at addresses 0800 and 0801 and these repeat throughout page 08. The register at 0800 is a 5 bit

write only register used to determine which of the data is accessed at 0801. The data registers, their addresses and their functions are tabulated here.

Register Address	Function	Program Unit	Type	No of Bits Used
00	Horizontal total	char	Write only	8
01	Horizontal displayed	"	" "	8
02	H Sync Position	"	" "	8
03	H Sync Width	"	" "	4
04	Vertical total	char row	" "	7
05	V total adjust	scan line	" "	5
06	Vertical displayed	char row	" "	7
07	V sync position	char row	" "	7
08	Interlace mode	-	" "	2
09	Max Scan line address	scan line	" "	5
OA	Cursor start	scan line	" "	5 + 2
OB	Cursor end	scan line	" "	5
OC	Start address H	-	" "	6
OD	Start address L	-	" "	8
OE	Cursor H	-	Read/Write	6
OF	Cursor L	-	Read/Write	8
10	Light pen H	-	Read only	6
11	Light pen L	-	Read only	8

Using the operating system all these registers are initialised for 625 line, 50 fields per second, interlaced operation with 25 rows each of 40 characters. Early versions of the MC6845 without interlace mode are automatically catered for by the operating system.

Hardware scrolling is used in the system which, with transparent access, gives a clean display and uses only a very small proportion of C.P.U.'s time. The character memory may be read from or written to at any time like any other piece of R.A.M.

The light pen input to the board may be used after breaking the link to Ov and fitting a 4K7 resistor for R5. When the light pen input goes high the contents of the character refresh address counter are strobed into registers 10 and 11 i.e. high byte and low byte. Thus the screen co-ordinates of the pen position may be determined by the user.

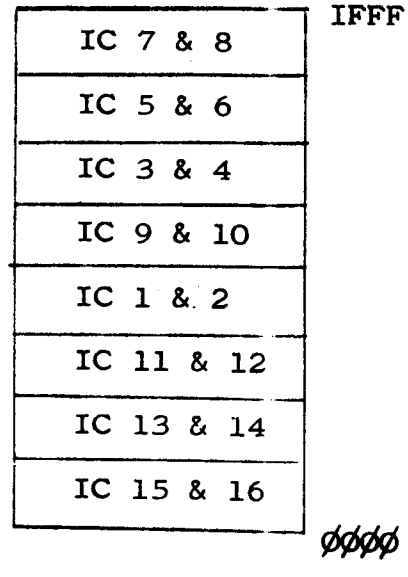
Memory Card (issue 2)

The Acorn Extension Memory card provides 8K bytes of user R A M space and has sockets for two R.O.M.'s which may be 2516 or 2532 providing 4K bytes or 8K bytes of firm ware. The card connects to the Acorn Computer bus via a 32 way Euro-connector and bus buffers ensuring a low loading on the bus.

A write protect switch may be fitted by breaking a track and fitting a single pole, single throw switch across the break, wiring to the two holes provided.

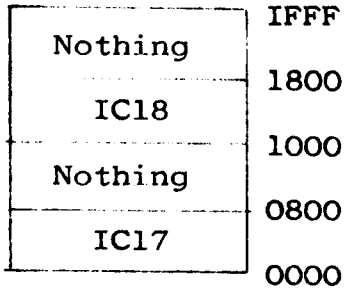
The RAM and ROM may each be set to appear in any 2 out of 16 blocks in the address map by fitting wire links. If the board is to be used either without any ROM or without any RAM then both the RAM and ROM address links should be fitted in the same positions ensuring that one input to IC 20 pins 9 or 10 is not left open circuit.

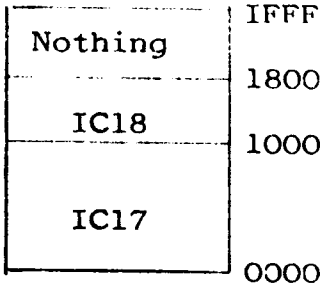
The RAM map for one board is shown:-

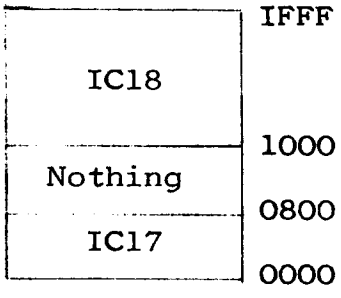


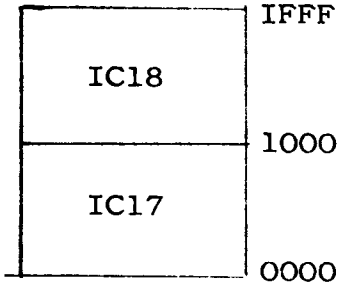
This may be positioned to start at ØØØØ, 2ØØØ, 4ØØØ etc by linking in position Ø, 1, 2 etc on the board

Five ROM maps are possible using 2K (2516), 4K (2532) devices or a mixture of both:-

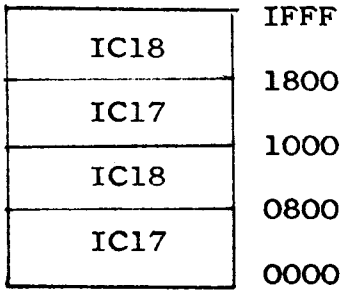








The above maps are with the board as supplied. To obtain contiguous ROM using 2K devices two tracks are cut and two links fitted as shown on the board layout giving the map shown:-



Again the start address may be set to 0000, 0200, 0400 etc. by linking in position 0, 1, 2 etc. on the card.

Chapter 11 System Expansion

A variety of further Eurocards and modules may be fitted in the rack ultimately achieving a system 3 with floppy disc storage.

Backplane Buffers

One other card eg. a further 8 K memory or a Versatile Interface Board may be driven by an un-buffered 6502 CPU card after which bus buffers must be fitted. I.C.'s 1 and 2 on the backplane are two 74LS244's which buffer the signals AØ-A15. They are fitted to the backplane together with nine wire links and a 47 or 100 nF decoupling capacitor as shown on page 3-11 . Using bus buffers the 6502 CPU card must be fitted in the leftmost card location using an extra 64 way socket. Usually the cassette interface is moved one location to the left as well and so the wire links specified on page 3-12 will need to be re-made. One of the sockets already fitted further to the right then becomes free for an extra Eurocard.

System Printer

Using a Versatile Interface Board a system printer may be installed. The VIB carries a standard Centronics interface which will drive a parallel ASCII printer. The 6522 integrated circuit for the printer is at address ØCØØ (hexadecimal) which is recognised by the operating system software details of which are in chapter 7. With the printer a hard copy of the VDU display may be obtained giving program output, listings etc.

Serial and Parallel Input Output

The 6502 CPU card may have an extra INS 8154 RAM/IO device fitted to it giving 16 individually programmable input or output lines. These appear on pins B3 to B18 of the backplane and will drive one standard TTL load. The hexadecimal register addresses for this device are

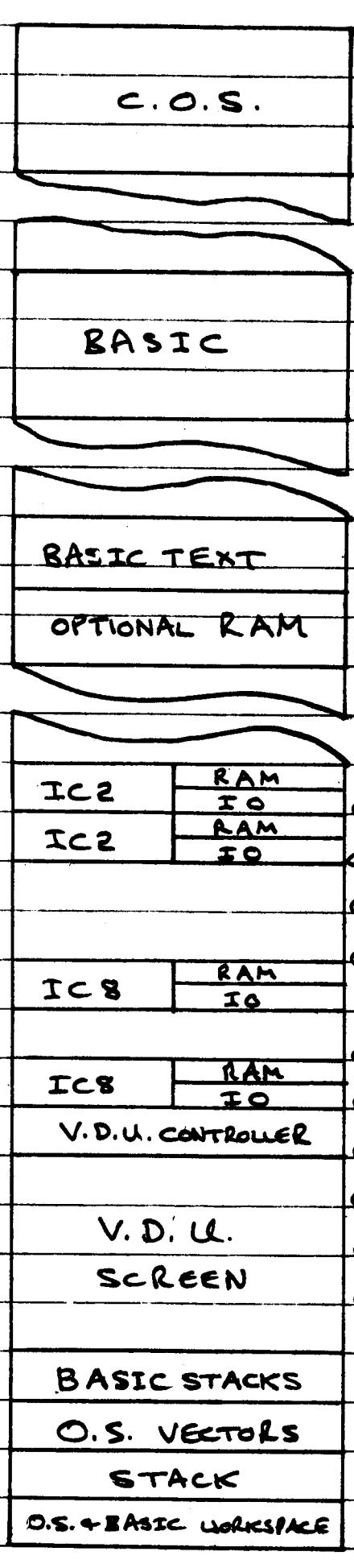
0923	Data Direction Port B
0922	Data Direction Port A
0921	Input/Output data Port B
0920	Input/Output data Port A

The data directions are cleared to zeros (ie. all inputs at reset) and the bits must be set to make the corresponding pin functions as an output. Using the MEM command in the COS these registers.may be accessed directly. The INS 8154 also operates in other modes described fully on its complete data sheet. The start address for the device is 0900 (hex).

Using a Versatile Interface Board further parallel inputs or outputs may be obtained and also on this board is a serial interface with RS232C or 20 mA drives and receivers. There is no software in the COS for accessing the serial I/O directly

MEMORY EXPANSION

As supplied System 2 is mapped as shown:-



Text pointers are usually initialised to hex 3000.

The RAM in IC's 2 & 8 is free to the user. The parallel keyboard data from IC2 may be read at hex OE21.

Pages OA, OC and OD are reserved for other Acorn circuit cards.

The Cassette Operating system occupies pages F8 to FF. BASIC is always in pages CO to CF whether in RAM or resident in ROM with its normal text space starting at 3000 (link 1 on a memory board). The BASIC text space may be extended by the addition of further 4K blocks of RAM at 4000 and 5000 (link 2 on a memory board), 6000 and 7000 (link 3) etc.

The memory board supplied with system 2 may have a 4K block of RAM added to it which will start at 2000. With this addition 8K of RAM is available for the user but note that to use it for BASIC text space the text pointer must be changed (LET ?18 = # 20).

If available a BASIC extension ROM may be fitted at block D ie. pages DO to DF. This will go on the same issue 2 memory board that carries the BASIC with ROM link 6 fitted.

Block 1 ie. pages 10 to 1F is usually used for external interfaces eg. additional versatile interface boards, analogue to digital converters etc.

Block O is reserved for system hardware and operating system workspace. Note that I.C.'s 2 and 8 on the 6502 CPU are not fully decoded and appear twice.

System 2 may be used with BASIC loaded from a cassette tape. BASIC does not re-locate and so to do this with only one memory board 8K of RAM must be fitted at blocks C and D (ie. RAM link 6). The BASIC text space must then be changed to start at DO and is only 4K.