

SERVICING MANUAL  
FOR  
ZX SPECTRUM®

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— SAFETY MEASURES —

This instruction manual contains certain

— WARNING — and — CAUTION —

notices which MUST be followed by the user to ensure SAFE operation and to retain the equipment in a SAFE condition.

Any adjustment, maintenance and repair of the opened apparatus under voltage shall be carried out only by a skilled person who is AWARE OF THE HAZARD INVOLVED.



## HISTORY SHEET

MANUAL ISSUE	TEXT	CIRCUIT/LAYOUT DIAGRAMS	REMARKS
1			DECEMBER 1983
1			Reprinted JANUARY 1984
2			<p>MARCH 1984</p> <p>Correction of errors on pages 4.6, 4.20 and correction of Parts List errors:</p> <p>Issue 2 Board</p> <p>C31/32 100<math>\mu</math>F to 100nF  C35 10<math>\mu</math>F to 10nF  C39 10<math>\mu</math>F to 10nF  C43 100<math>\mu</math>F to 100nF</p> <p>Issue 3 Board</p> <p>C39 100<math>\mu</math>F to 10nF  C46 22<math>\mu</math>F to 1<math>\mu</math>F</p>
2			Reprinted AUGUST 1984
3			<p>APRIL 1985</p> <p>Supplement No.1 added.  This covers Issue 4A to 6A modifications.</p> <p>Supplement No.2 added.  This covers the differences between Spectrum and Spectrum+.</p>

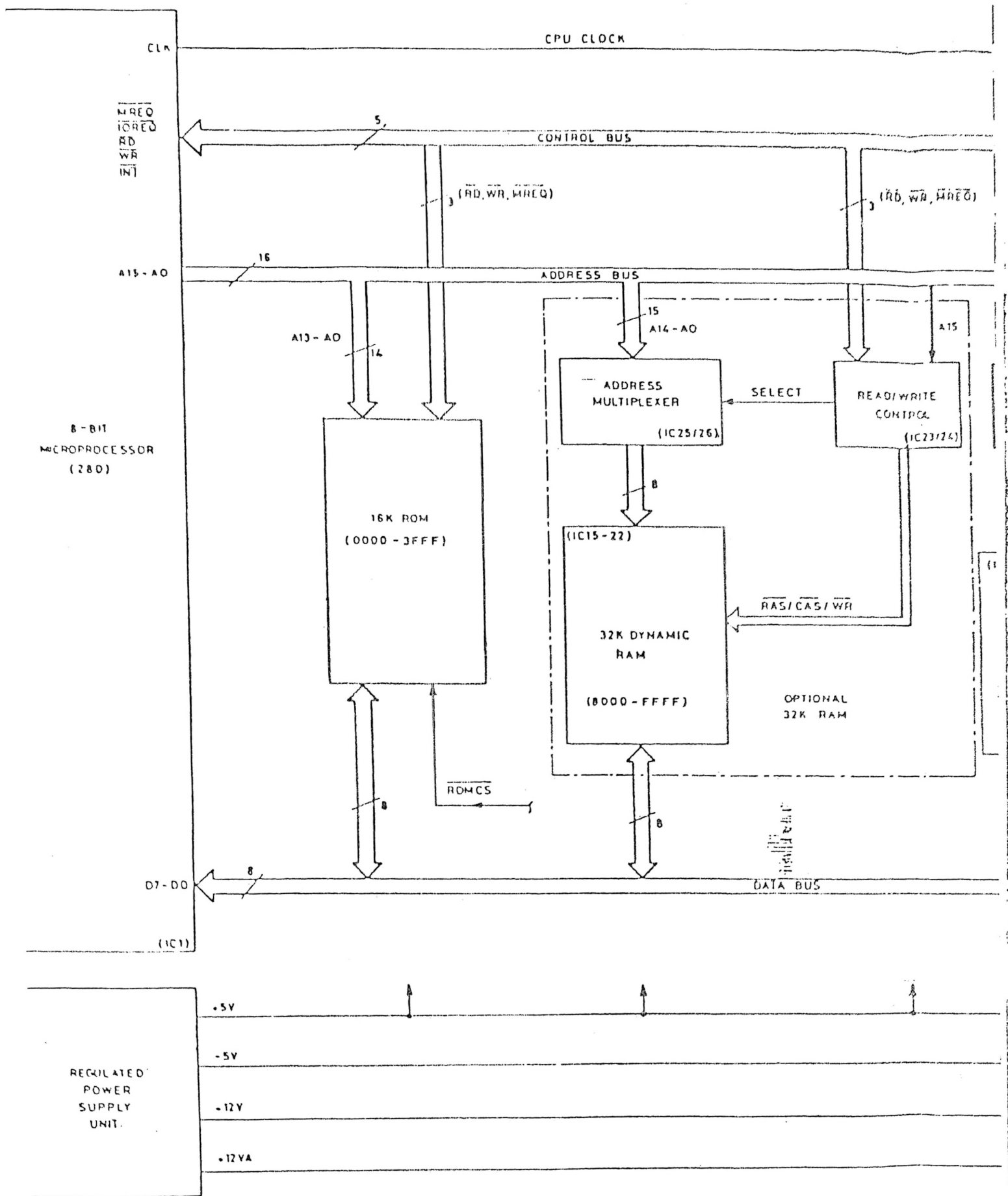
## INTRODUCTION

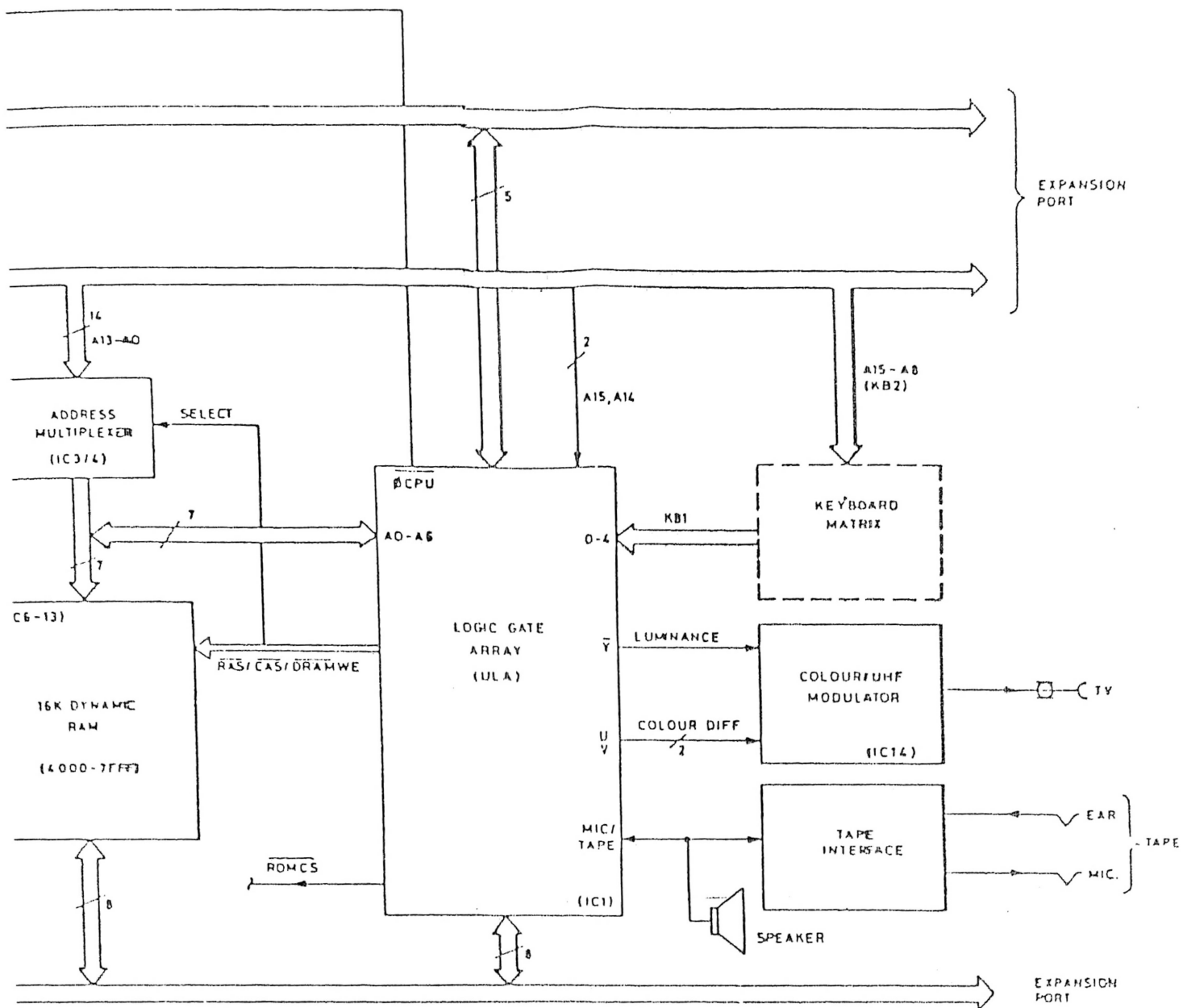
This manual is for use by authorised SINCLAIR dealers, engineers and representatives as a guide to rectifying faults on the SINCLAIR ZX SPECTRUM personal computer.

The manual refers principally to the Issue 2 and Issue 3 Spectrums but provides a background to the Issue 1 version in the section dealing with modification history.

Basic knowledge of ZX SPECTRUM operating procedures is assumed as is knowledge of current workshop practice relating to microcomputers.

**NOTE:** Essential modifications are required on some Issue 2 Spectrums. Refer to Modification History (Section 4) and implement as necessary.





ZX SPECTRUM BLOCK DIAGRAM FIG 1.1

SECTION 1  
SYSTEM DESCRIPTION

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4	Memory Organisation	1.4
	Read/Write Operations	1.4
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	ZX Spectrum, Issue 2	Fig. 1.4
	ZX Spectrum, Issue 3	Fig. 1.5

1. INTRODUCTION

1.1 A block diagram of the complete ZX SPECTRUM micro-computer is given in Figure 1.1. It is valid for all build standards, fitted with either 16k or 48k bytes of dynamic RAM memory. Although functionally identical, detailed circuit changes have been introduced to improve reliability and to assist with manufacture. The printed circuit board layout has also been modified. Details of these changes are highlighted where necessary in the following paragraphs, and in later sections referring to fault diagnosis and repair.

2. ARCHITECTURE

2.1 The architecture of the Spectrum shown in Figure 1.1 is typical of many microcomputer systems in that it comprises a single microprocessor board (in this instance a Z80A or µ780 CPU), a read only memory (ROM), an expandable RAM memory and an input/output section handling the keyboard, tape and TV display functions. The latter is recognisable as the logic gate array (ULA) and the three functional blocks shown in the right of the diagram.

2.2 The computer is built on a single printed circuit board which also includes a regulated power supply fed from an external 9V power pack. The keyboard matrix is part of the upper case assembly and is connected to the board via two ribbon cables KB1 and KB2. A description of each section follows.

### 3. Z80A CPU

- 3.1 The Z80A is an 8-bit single-IC central processing unit (CPU). It is clocked at 14.0 MHz from an external source controlled by the logic gate array (ULA) and has a standard three bus input/output arrangement. These buses are the Data Bus; Address Bus and Control Bus respectively.
- 3.2 Data Bus. D7-D10 constitutes an 8-bit bi-directional data bus with active high; tri-state input/outputs. It is used for data exchanges with the memory and with the ULA.
- 3.3 Address Bus. A15-A0 constitutes a 16-bit address bus with active high; tri-state outputs. The address bus provides the address for memory (up to 64k bytes) data exchanges and for data exchanges with the ULA. It is also used during the interrupt routine (see below) when scanning the keyboard matrix.
- 3.4 Control Bus. The control bus is a collection of individual signals which generally organise the flow of data on the address and data buses. The block diagram only shows five of these signals although others of minor importance are made available at the expansion port (see Figures 1.4 and 1.5 for details).
- 3.5 Starting with memory request ( $\overline{MREQ}$ ); this signal is active low indicating when the address bus holds a valid address for a memory read or memory write operation. Input/Output request ( $\overline{IORQ}$ ) is also active low but indicates when the lower half of the address bus holds a valid I/O address for the ULA during I/O read/write operations.
- 3.6 The read and write signals ( $\overline{RD}$  and  $\overline{WR}$ ) are active low; and one or other is active indicating that the CPU wants to read or write data to a memory location or I/O device. All the control signals discussed so far are active low; tri-state outputs.
- 3.7 The last control signal described here is the maskable interrupt ( $\overline{INT}$ ). This input is active low and is generated by the ULA once every 20 ms. Each time it is received the CPU 'calls' the 'maskable interrupt' routine during which the real-time is incremented and the keyboard is scanned.
- 3.8 CPU Clock. Returning to the CPU clock mentioned earlier in this section; the ULA is able to inhibit this input bringing the CPU to a temporary halt. This mechanism gives the ULA absolute priority; allowing it to access the standard 16k RAM without interference from the CPU (see RAM description). Switching transistor TR3 ensures that the clock amplitude is +5V rather than some arbitrary TTL level. This is essential if the CPU is to operate effectively while executing fast machine code programs of the 'space invader' type.

3.9 Dynamic Memory Refresh. The CPU incorporates built-in dynamic RAM refresh circuitry. As part of the instruction OP code fetch cycle, the CPU performs a memory request after first placing the refresh address on the lower eight bits of the address bus. At the end of the cycle the address is incremented so that over 255 fetch cycles, each row of the dynamic RAM is refreshed. This mechanism only applies to the optional 32k expansion RAM in the 48k Spectrum. An alternative refresh method is adapted for the standard 16K RAM.

#### 4. MEMORY ORGANISATION

4.1 In the standard 16k Spectrum there are 32k bytes of addressable memory equally divided between ROM and RAM.

4.2 The lower 16k bytes of memory (addresses 0000 - 3FFF) are implemented in a single ROM (IC5) which holds the monitor program. This program is a complex Z80 machine code program divided broadly into three parts one each covering the input/output routines, the BASIC interpreter and expression handling. Details of the program content, although outside the scope of this manual, are referred to as necessary.

4.3 The upper 16 bytes of memory (addresses 4000 - 7FFF) are implemented using eight 16k bit dynamic RAMs (IC6-IC13). Approximately half of this space is available to the user for writing BASIC or machine code programs. The remainder is used to hold the system variables including 6k bytes reserved for the memory mapped display area.

4.4 In the 48k Spectrum an additional 32k bytes of RAM are provided (addresses 8000 - FFFF) which are implemented using eight 32k bit dynamic RAMs (IC15-IC32). The RAM, providing extra memory space for the user, is normally fitted during manufacture but may be added retrospectively using the RAM expander kit. In addition to the RAMs, the kit includes the address multiplexer and read/write control ICs IC23-IC26. Board space and the necessary discrete components are already provided on the board.

#### 4.5 Read/Write Operations

4.5.1 The following description should be read in conjunction with the circuit diagrams given in Figures 1.4 and 1.5.

4.5.2 Read Only Memory (IC5). The CPU addresses the ROM directly during memory read cycles using the address bus A13-A0.  $\overline{MREQ}$  and  $\overline{RD}$  enable the ROM and the ROM outputs respectively. A third input (CS) derived by the ULA ( $\overline{ROMCS}$ ) selects the ROM, provided the higher order address bits A14 and A15 are both low. These are reserved for accessing the RAM memory which starts with address 4000 (i.e. address A14 set). An external ROM IC select input, supplied via the expansion port on pin 25A, selectively disables the on-board ROM by pulling the select input high. By virtue of R33 placed on the ULA side of the ROM the ULA  $\overline{ROMCS}$  output is effectively inhibited. Interface 1 uses this

mechanism allowing the CPU to read the extension ROM in the interface for microdrive and RS232 applications.

- 4.5.3 Links H and N, shown directly above IC5, allow a second source ROM to be fitted. The Hitachi (H) and NEC (N) ROMs use different pins for the enable and select inputs (i.e. pins 20 and 27). The links allow the inputs to be reversed accordingly.
- 4.5.4 Standard 16k RAM (IC6-IC13). The eight 16k RAM ICs making up the standard 16k x 8 bit RAM memory are organised as a matrix of 128 rows x 128 columns. Thus, separate 7-bit row and column addresses are required to access any one of the locations. These addresses are supplied by the CPU on address bus A13-A0 via an address multiplexer IC3/IC4. The low order address bits A6-A0 give the row address and are selected at the beginning of the memory access cycle when initially the RAS output from the ULA is high. Later, as the row address is latched, RAS goes low selecting the high order address bits A13-A7 giving the column address.
- 4.5.5 The RAS/CAS outputs from the ULA are generated in sequence in response to MREQ and A14 from the CPU. The DRAMWE output, also from the ULA is a decode of the RD/WR waveforms telling the RAM to expect either a read or a write cycle.
- 4.5.6 It is also apparent from the circuit diagram that the ULA can access RAM by generating a set of addresses independent of those generated by the CPU. The address port for the RAM is therefore dualled by the insertion of small value resistors (R17-R23) on the address multiplexer side of the RAM. This ensures that where there is likely to be conflict between the ULA and CPU, the ULA address has priority. Priority is assigned on the basis that the ULA must access the memory mapped display area in the RAM at set intervals in order to build up the video for the TV display. If the ULA is about to access the RAM and it detects either A14 or A15 (i.e. the CPU is also about to access the RAM) the ULA inhibits the CPU clock temporarily halting the CPU memory transaction until its own transaction is completed.
- 4.5.7 Resistors R1 to R8, in series with the data bus lines, perform a similar function to the address port resistors described above. They ensure that the ULA does not 'see' CPU write data while the ULA is accessing the RAM.
- 4.5.8 Refresh for the standard 16k dynamic RAM is accomplished during normal read cycles, i.e. most rows are refreshed each time the ULA accesses the memory mapped display area during picture compilation; the remaining rows are refreshed as a result of other read cycles also known to occur at regular intervals within the refresh period.



4.5.9 32k Expansion RAM (IC15-IC32). The eight 32k ICs making up the 32k x 8 bit expansion RAM are in fact 64k ICs with either row or column drop-out rendering one half of the memory non-functional. In order to accommodate the Texas Instruments RAM (Type TMS 4532) or the optional OKI RAM (Type MSM3732) a set of links are provided, visible on the circuit diagram above the address multiplexer IC25/IC26. These links not only cater for the different manufacturer (Issue 3 Spectrums only) but also allow, in both instances, one of two IC versions to be selected depending on which half of the RAM (top, bottom, left or right) is functional. The links are respectively TI and OKI (manufacturer - Issue 3 Spectrums only), -3/-4 (TI version) and -H/-L (OKI version - Issue 3 Spectrums only).

NOTE: It is essential when replacing ICs in this area that all RAMs carry the same manufacturers part number and that the links are selected accordingly.

4.5.10 The expansion RAM is organised as a matrix of 128 rows x 256 columns (TI RAMs) or 256 rows x 128 (OKI RAMs). Thus, separate 7/8 bit row and column addresses are required to access any one of these locations. These addresses are supplied by the CPU on address bus A14-A0 via an address multiplexer IC25/IC26. For example, when accessing the TI RAM the low order address bits A6 to A0 give the row address; AR is held low on the -3 version selecting the top half of the memory and high on the -4 version selecting the bottom half. The column address is given by the high order address bits A14-A7.

4.5.11 Row/column address selection and  $\overline{\text{RAS}}/\overline{\text{CAS}}$  timing for the RAM is decoded in IC23/IC24 from inputs supplied by the CPU, i.e. address line A15 selecting addresses 8000 upwards, and  $\overline{\text{MREQ}}$  heralding a memory read or write cycle. A theoretical timing diagram illustrating the RAS/CAS waveforms is given in Figure 1.2.

## 5. INPUT/OUTPUT

5.1 The input/output section of the Spectrum is centered round the ULA (IC1). The functions performed within the device include TV video compilation, keyboard scanning and tape input/output. It also derives and controls the CPU clock ( $\overline{\phi}\text{CPU}$ ) using an external 14 MHz crystal X1, and drives the loudspeaker when a 'BEEP' instruction is being executed. Each of these sections and the supporting circuits are described below.

### 5.2 TV Picture Generation

5.2.1 The video compilation section of the ULA operates in conjunction with the memory mapped picture display area in the standard 16k RAM, the colour (chrominance) modulator (IC14) and the UHF modulator. This combination produces a high resolution, 24 line x 32 character, eight colour TV display.

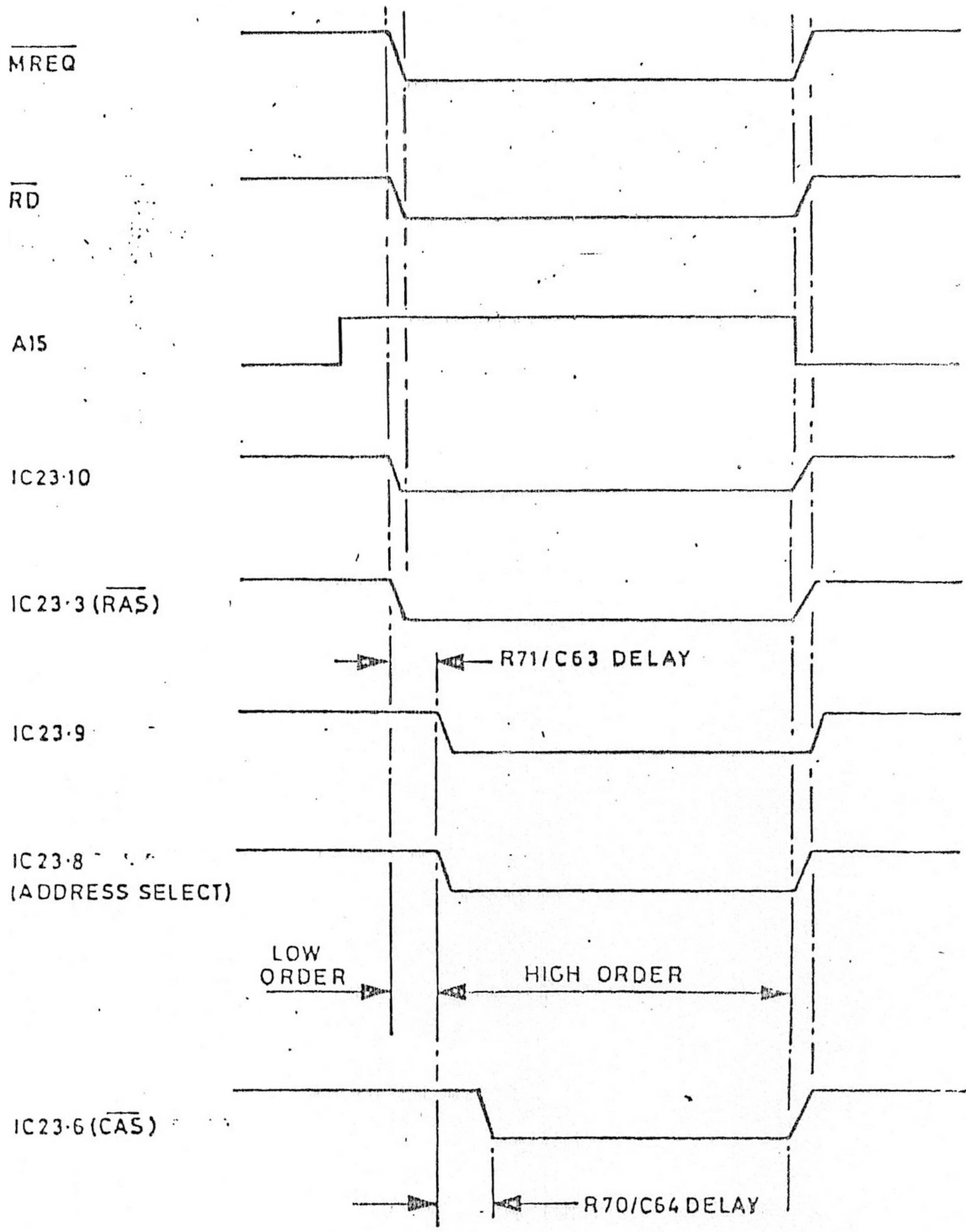
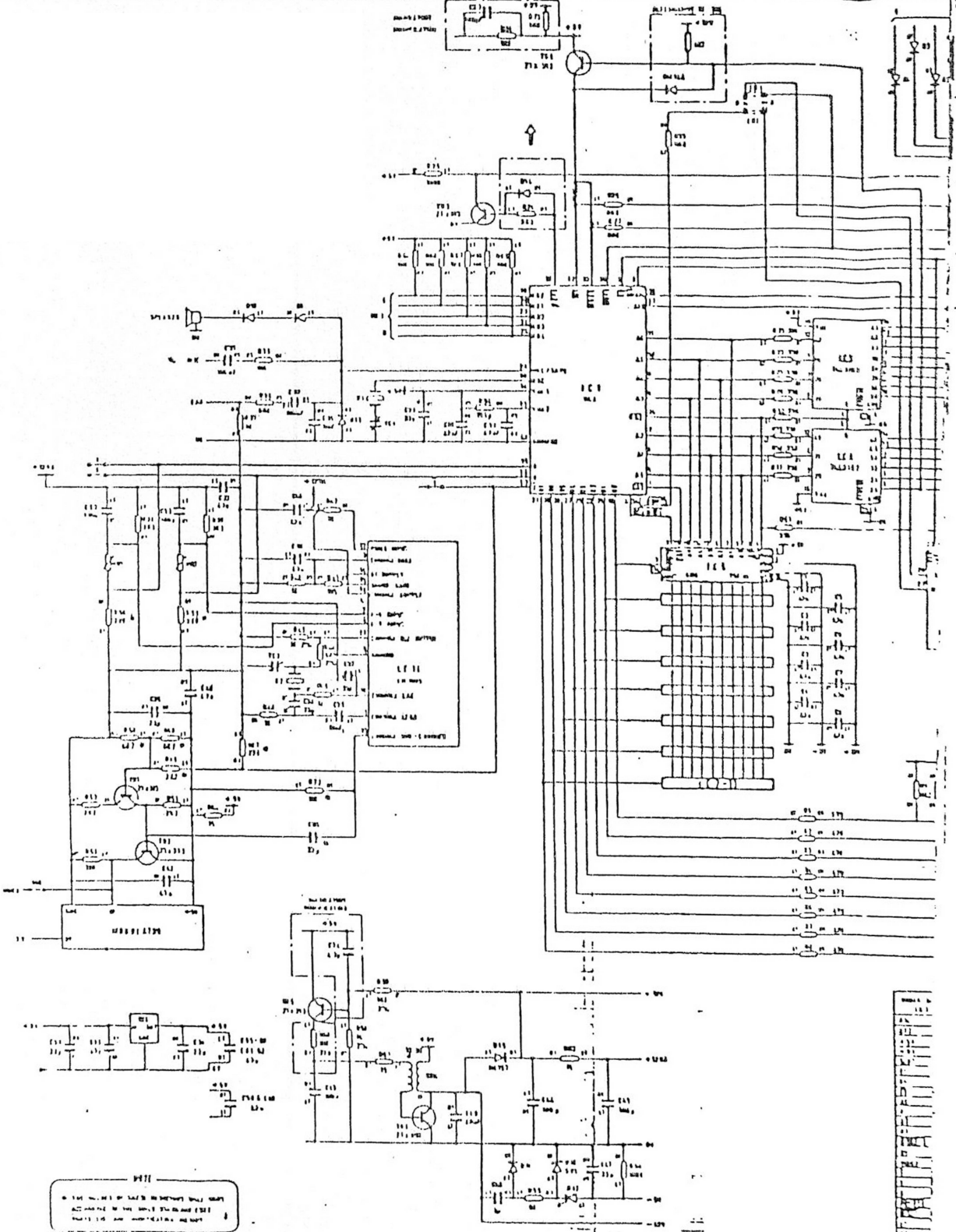
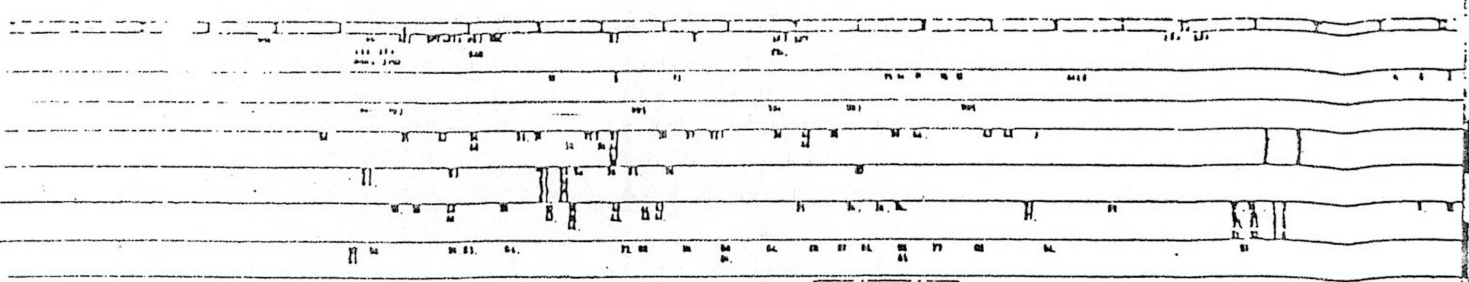


FIG 1.2 EXPANSION RAM  $\overline{RAS}/\overline{CAS}$  TIMING (READ CYCLE SHOWN)

- 5.2.2 Using the 14 MHz clock the ULA derives line and field timing compatible with the external TV receiver. Video is derived by accessing the memory mapped display area in the RAM in a set sequence at set times throughout the picture frame. The addresses are necessarily independent of the CPU and appear on the ULA address lines A6 through A0 as two separate bytes timed by the RAS/CAS row/column address select lines.
- 5.2.3 The net result is three separate video waveform outputs from the ULA on pins 15, 16 and 17. These carry the luminence signal Y, incorporating the line and field sync, and two unmodulated colour difference signals U and V making the Spectrum compatible with both colour and monochrome receivers.
- 5.2.4 From the ULA the colour difference signals are applied to the colour modulator IC14 via two level shifting networks. These match the ULA output levels with those required at the B-Y and R-Y inputs to the modulator. In the Issue 2 Spectrum the level shifting network is passive, incorporating two potentiometers VR1, VR2. These are required to set-up the chroma bias level on IC14 pin 3 such that the voltage difference measured between pin 3 and the colour difference signals on pins 2 and 3 respectively is nominally 0V d.c. In the Issue 3 Spectrum two active networks incorporating TR8 and TR9 eliminate the potentiometers, greatly improving colour stability.
- 5.2.5 The level shifted colour difference signals, input to IC14, are then encoded, by quadrature modulating two 4.43 MHz chroma sub-carriers. The sub-carriers are generated with the assistance of an external crystal X2 and a CR lead/lag network introducing a 90° phase shift between pins 1 and 18. (A further difference between the Issue 2 and 3 Spectrums lies in the bias oscillator. The early issues incorporate a trimmer TC2 allowing the chroma sub-carrier frequency to be adjusted; on the later issues the frequency is fixed). The resultant modulated colour difference signals are finally mixed producing a composite chroma sub-carrier at IC14 pin 13.
- 5.2.6 At this point the chroma signal is a.c. coupled to the base of TR2 and added to the inverted luminence signal on TR1 collector. The resultant composite video is then buffered and applied to an encapsulated UHF modulator operating on European standard channel 36.
- 5.3 Keyboard Scanning
- 5.3.1 Every 20 ms (i.e. once per maskable interrupt); the CPU systematically scans the keyboard recording which keys (if any) have been pressed. The scanning method is described below with the aid of Figure 1.3. As the figure clearly illustrates the keyboard consists of an 8 x 5 matrix; the inter-section of each row and column bridged by a normally open switch contact. The row 'outputs' and column 'inputs' are shown connected by separate ribbon cables KB1 and KB2; one to the ULA and the other to the high order address lines A15-A8. Pull-up resistors R64 through R68 ensure that when the address bus is in the high Z state; or none of the key-switches is closed, row outputs KBO to KB4 remain high.

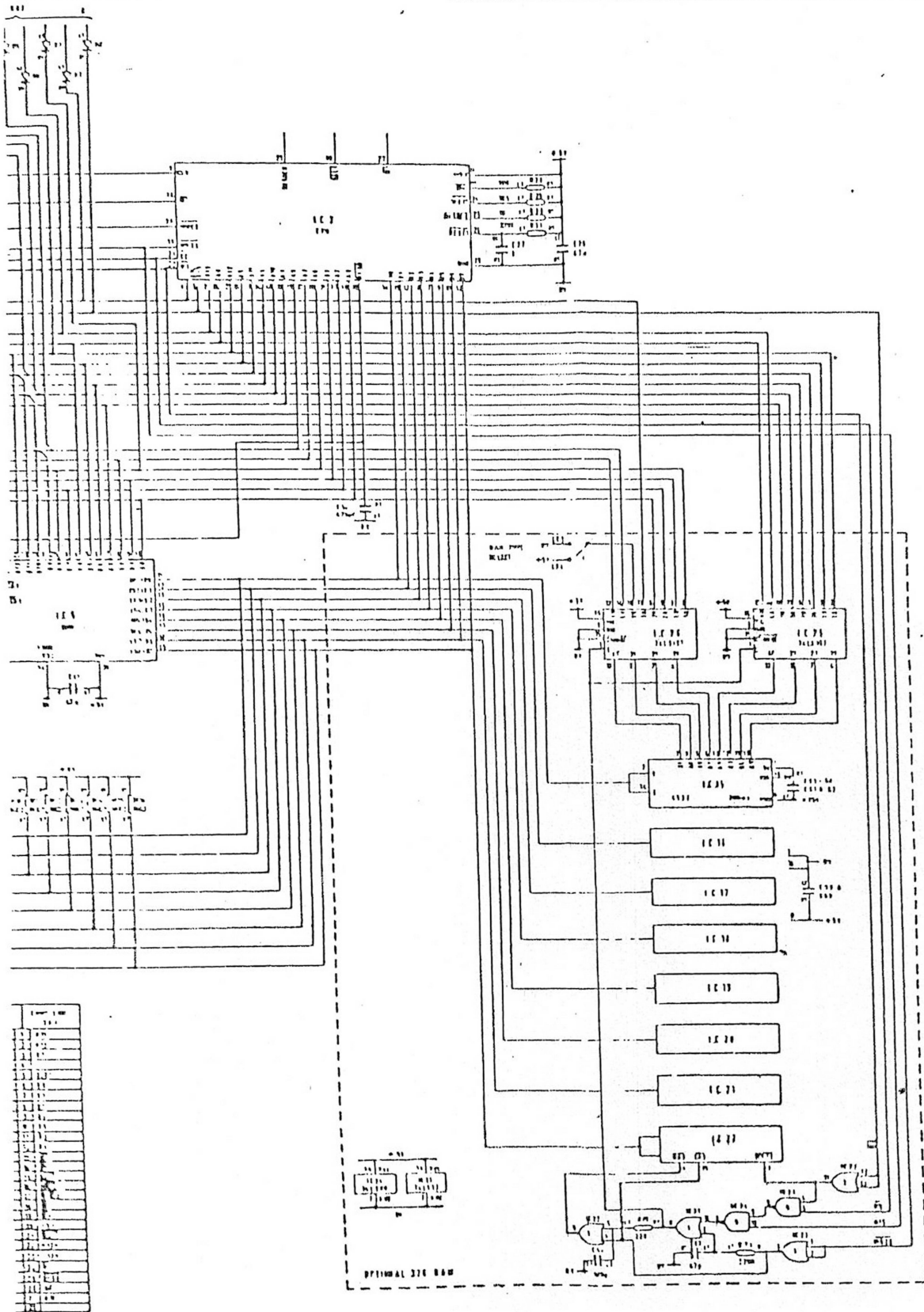
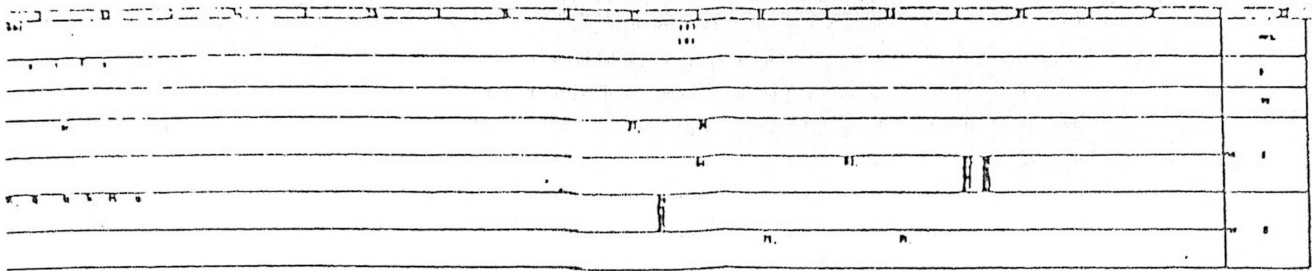
## 6. POWER SUPPLIES

- 6.1 The on-board power supply unit receives a 9V unregulated supply from the external Sinclair ZX power pack and derives the following internal supply rails:
- (a) regulated +5V for the IC logic circuits; the ULA and the UIF modulator;
  - (b) -5V and +12V for the standard 16k dynamic RAM;
  - (c) +12V for the colour modulator circuits.
- 6.2 The external power pack incorporates a mains transformer; full wave rectifier and capacitive smoothing. A thermal fuse is fitted at the transformer input.
- 6.3 The on-board power supply unit incorporates a 7805 regulator; deriving the +5V power rail; and an inverter stage TR4/TR5. The latter raises the level of the +9V unregulated supply to in excess of +12V. The resultant square wave at the junction of TR4 collector and the inverter coil is subsequently rectified and smoothed by D5/C44 producing the +12V output for the RAM. Additional smoothing, imparted by R62/C45; produces the +12V supply for the TV circuits free from noise generated by the RAM. The square wave at TR4 collector also supplies the Zener/rectifier diode combination D16/D12 generating -5V for the RAM; and is available at the expansion port for use by peripherals. The +12V; +5V and -5V are also made available.



1. ALL WIRING TO BE DONE IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE (NEC) AND THE LOCAL ELECTRICAL CODES.  
 2. ALL WIRING TO BE DONE IN ACCORDANCE WITH THE MANUFACTURER'S INSTRUCTIONS.  
 3. ALL WIRING TO BE DONE IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS.

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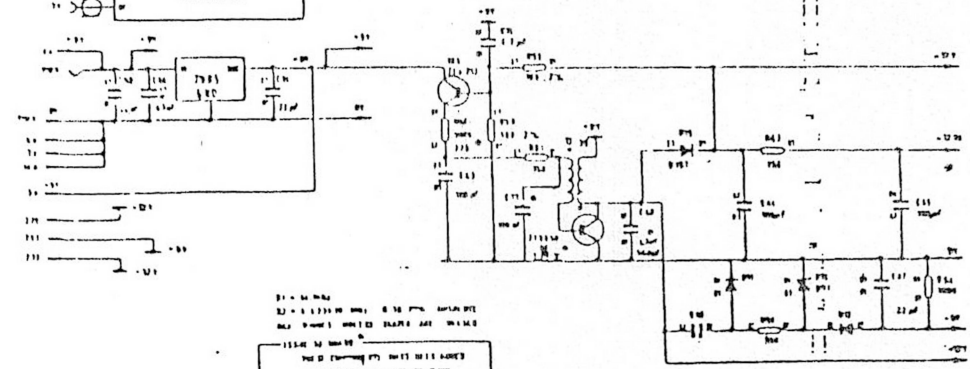
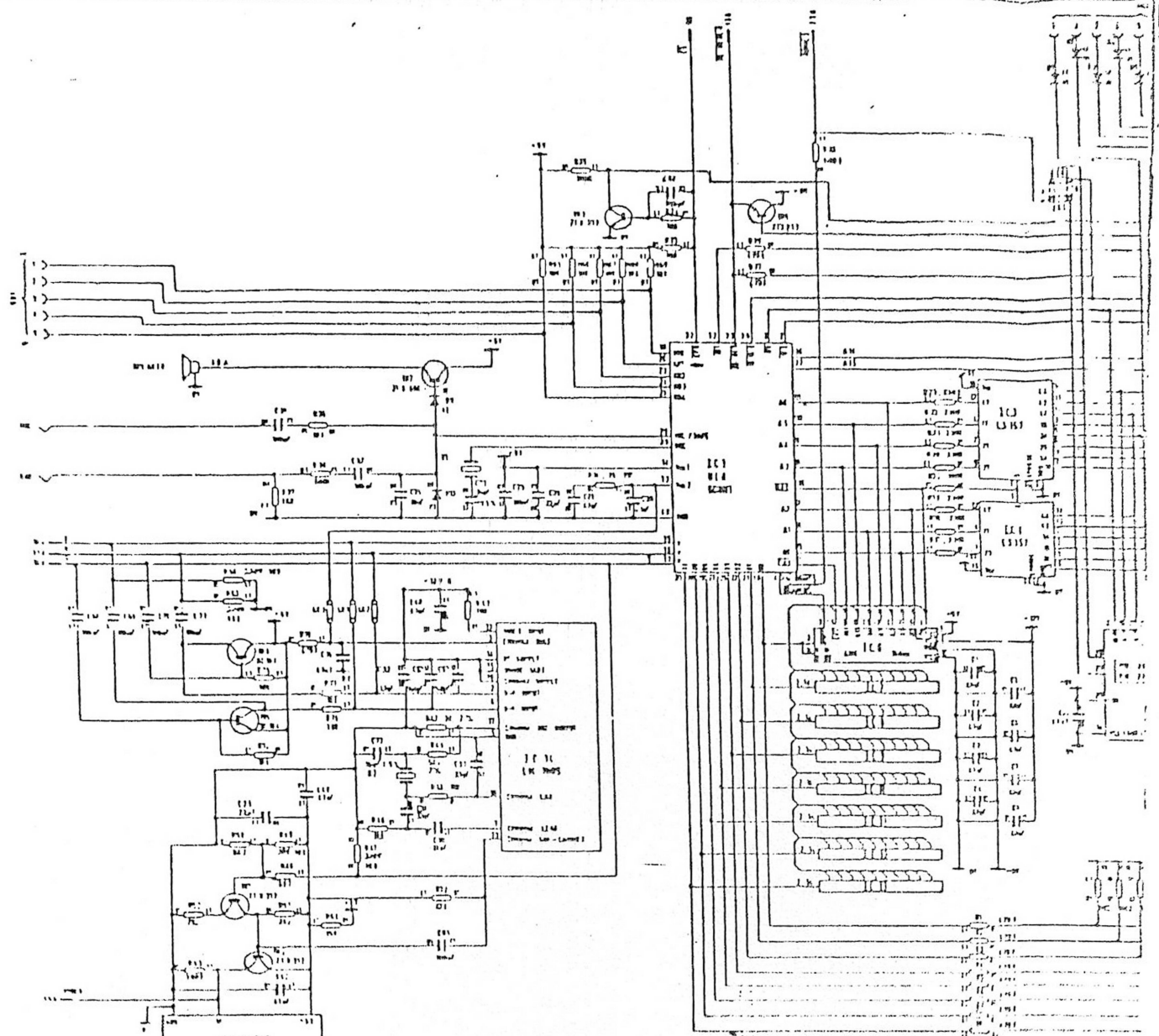
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5	74181	TI
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8	74181	TI
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25	74181	TI
26	74181	TI
27	74181	TI
28	74181	TI

IC No.	Part No.	Manufacturer
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23	74181	TI
24	74181	TI
25	74181	TI
26	74181	TI
27	74181	TI
28	74181	TI

ZX SPECTRUM (ISSUE 2) FIG. 14  
CIRCUIT DIAGRAM ESK 12740



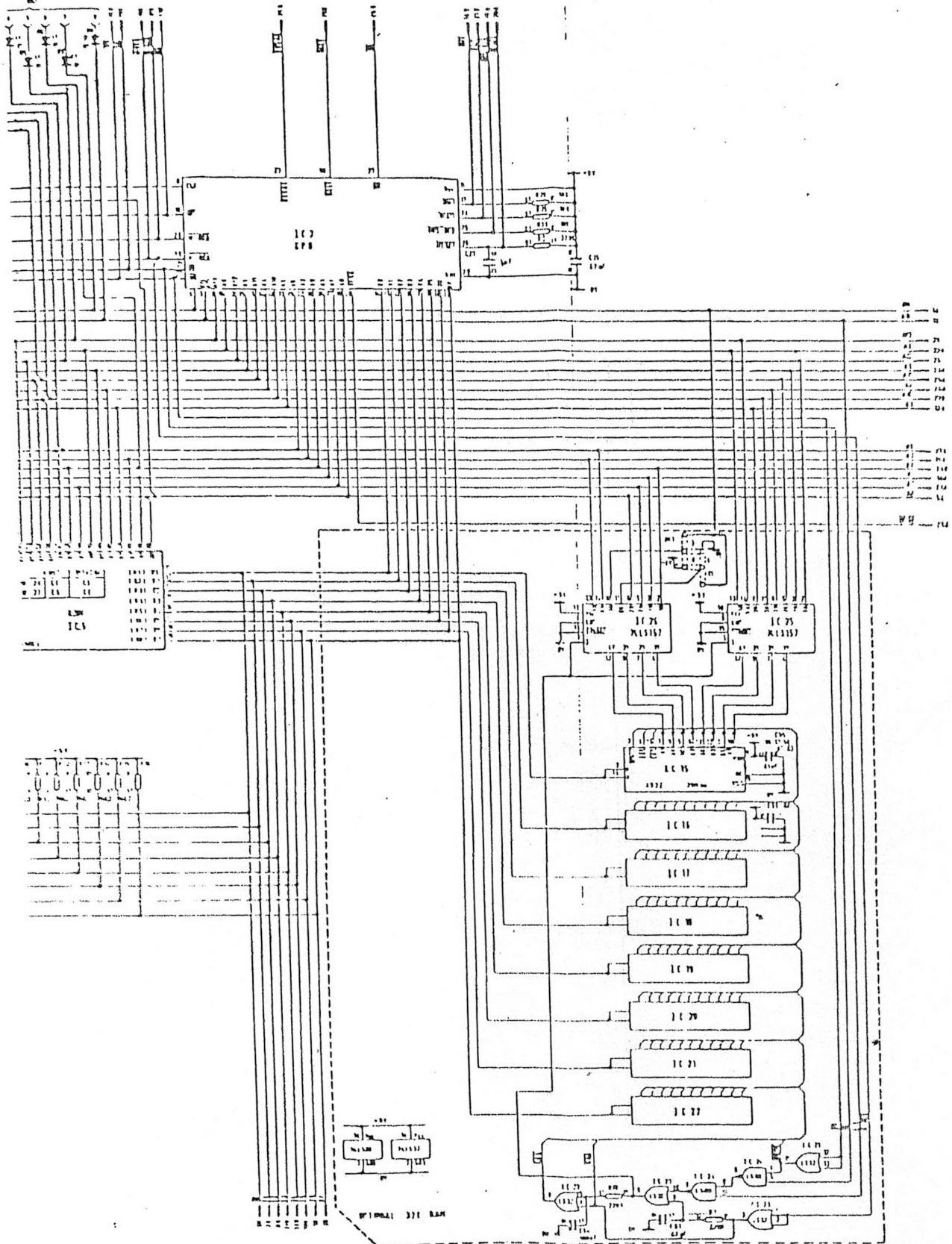
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1. Check all connections for tightness.  
 2. Verify all component values against the schematic.  
 3. Ensure proper polarity for all polarized components.  
 4. Test the circuit with a multimeter before applying power.  
 5. If the circuit does not function as intended, refer to the troubleshooting guide.

Wire No.	Color	Destination
1	Red	Terminal 1
2	Blue	Terminal 2
3	Green	Terminal 3
4	Black	Terminal 4
5	White	Terminal 5
6	Yellow	Terminal 6
7	Purple	Terminal 7
8	Brown	Terminal 8
9	Pink	Terminal 9
10	Grey	Terminal 10
11	Orange	Terminal 11
12	Light Blue	Terminal 12
13	Light Green	Terminal 13
14	Light Purple	Terminal 14
15	Light Brown	Terminal 15
16	Light Pink	Terminal 16
17	Light Grey	Terminal 17
18	Light Orange	Terminal 18
19	Light Yellow	Terminal 19
20	Light Blue	Terminal 20

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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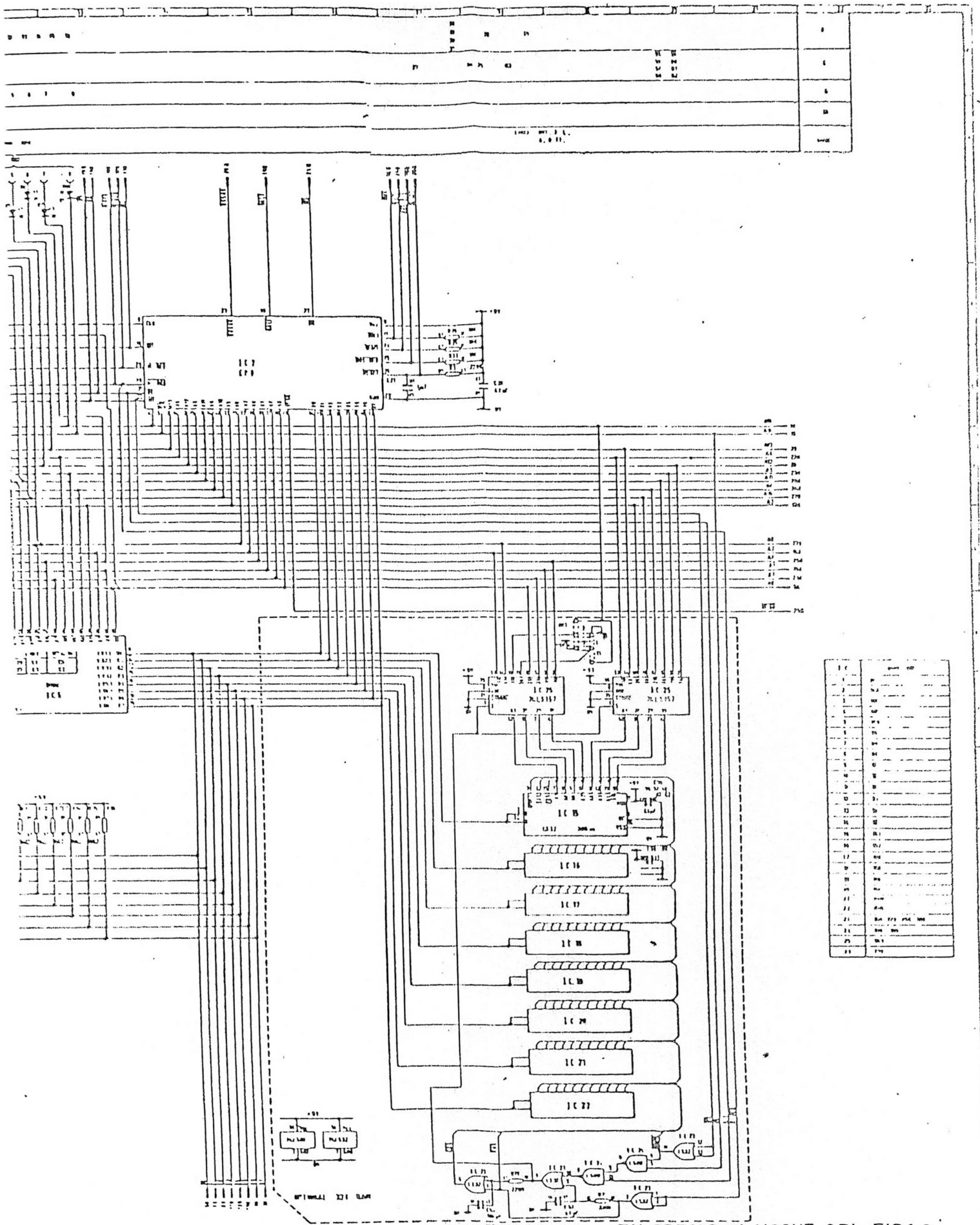


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ZX SPECTRUM (ISSUE 3) FIG. 1.5  
 CIRCUIT DIAGRAM ESK12750  
 ISSUE A



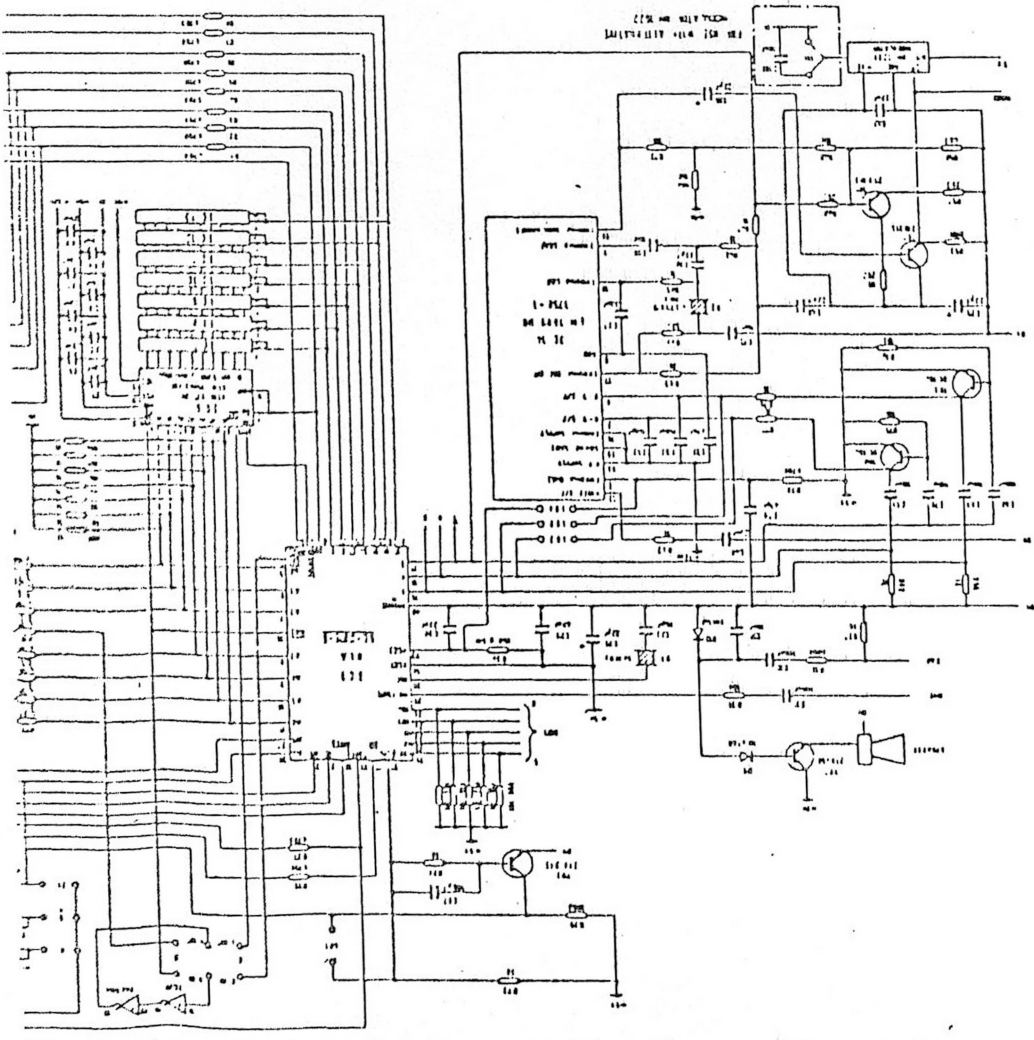
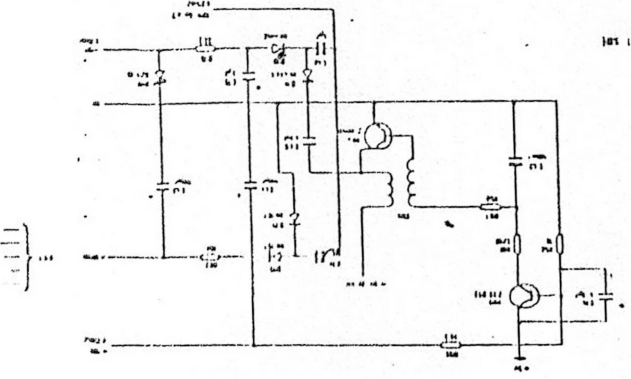




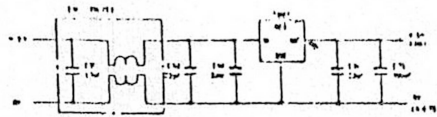
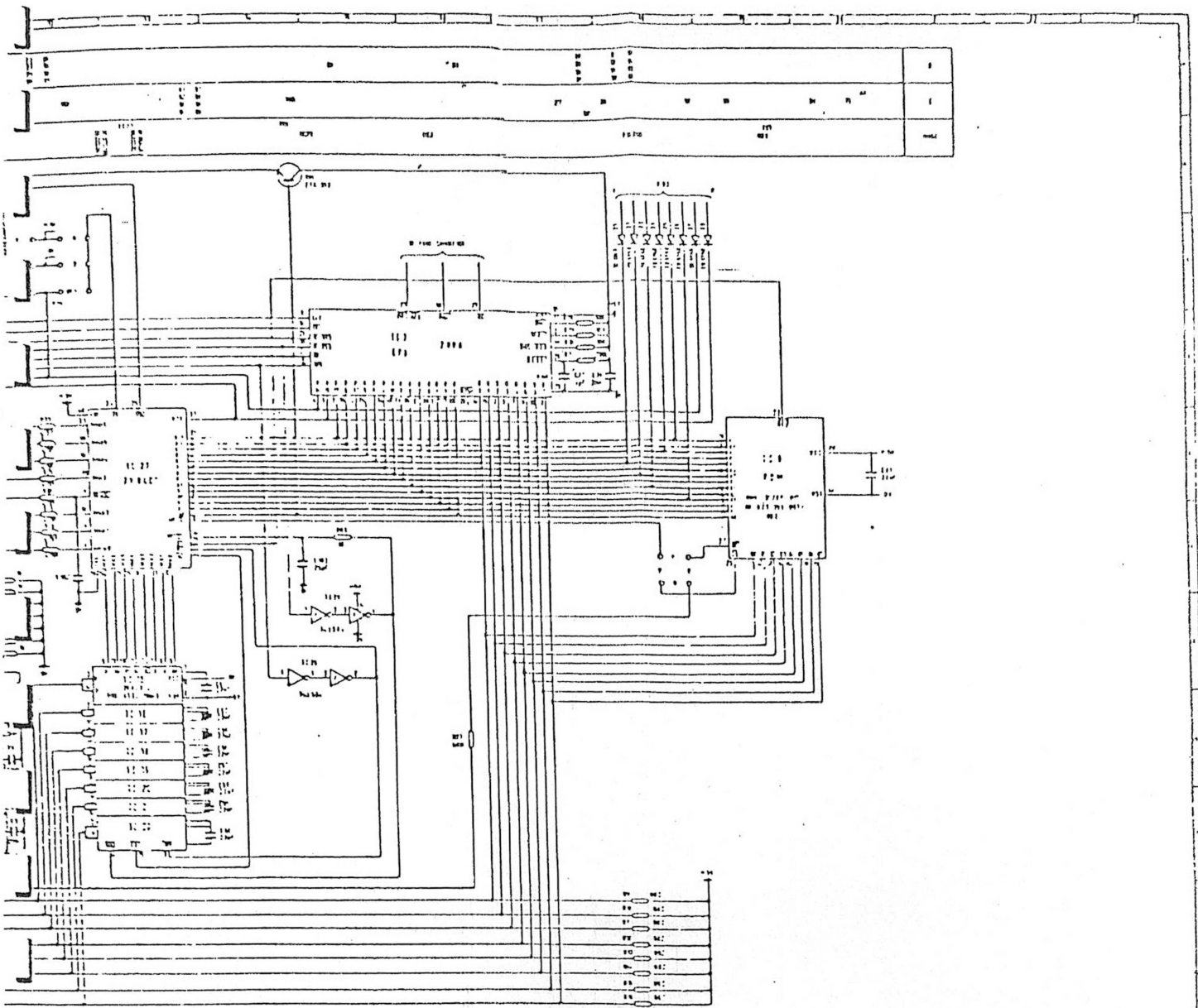
IC	Part No.	Value
1	74LS125	5V
2	74LS125	5V
3	74LS125	5V
4	74LS125	5V
5	74LS125	5V
6	74LS125	5V
7	74LS125	5V
8	74LS125	5V
9	74LS125	5V
10	74LS125	5V
11	74LS125	5V
12	74LS125	5V
13	74LS125	5V
14	74LS125	5V
15	74LS125	5V
16	74LS125	5V
17	74LS125	5V
18	74LS125	5V
19	74LS125	5V
20	74LS125	5V
21	74LS125	5V
22	74LS125	5V
23	74LS125	5V
24	74LS125	5V
25	74LS125	5V
26	74LS125	5V
27	74LS125	5V
28	74LS125	5V
29	74LS125	5V
30	74LS125	5V
31	74LS125	5V
32	74LS125	5V
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34	74LS125	5V
35	74LS125	5V
36	74LS125	5V
37	74LS125	5V
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40	74LS125	5V
41	74LS125	5V
42	74LS125	5V
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94	74LS125	5V
95	74LS125	5V
96	74LS125	5V
97	74LS125	5V
98	74LS125	5V
99	74LS125	5V
100	74LS125	5V

ZX SPECTRUM (ISSUE 3B) FIG.1.6  
 CIRCUIT DIAGRAM ESK12750  
 ISSUE D 1

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Component	Value	Notes
R1	100K	
R2	100K	
R3	100K	
R4	100K	
R5	100K	
R6	100K	
R7	100K	
R8	100K	
R9	100K	
R10	100K	
R11	100K	
R12	100K	
R13	100K	
R14	100K	
R15	100K	
R16	100K	
R17	100K	
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R90	100K	
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R93	100K	
R94	100K	
R95	100K	
R96	100K	
R97	100K	
R98	100K	
R99	100K	
R100	100K	



ZX SPECTRUM (ISSUE 5) CIRCUIT DIAGRAM FIGURE 4

SECTION 2  
DISASSEMBLY/ASSEMBLY

Sub-Section	LIST OF CONTENTS	Page No.
1	Disassembly	2.1
2	Assembly	2.1

1. DISASSEMBLY

1.1 Unplug all input/output leads and turn the computer upside-down to reveal five self-tapping screws. Remove the screws. Hold the two halves of the case together and return the computer to the keys uppermost position. The top half of the case can now be separated from the bottom half, although it remains connected to it by two flexible keyboard ribbon connectors. Care should be taken not to damage the ribbon connectors. As an aid to reassembly, the lie of the connectors within the case should be noted.

1.2 To remove the board from the lower half of the case, remove one self-tapping screw (adjacent to IC22 socket) and lift out the board. It may be advantageous to make up two short pluggable extensions for the keyboard connectors in order to improve accessibility to the board.

1.3 To change either the keyboard membrane or the rubber keyboard mat it is first necessary to remove the escutcheon plate (template). This is attached to the case by double-sided adhesive tape around the edges. The template is removed by inserting a screwdriver at one end and levering it away from the case. It is not normally possible to remove the template without damage.

2. ASSEMBLY

2.1 Assembly is carried out using the reverse procedure to that of disassembly. Do not overtighten self-tapping fixing screws.

2.2 When replacing a keyboard component, note that the membrane keys into projections on the case. Place the keypad over the membrane and ensure that it is positioned and seated properly. Faulty installation can result in depressed keys being trapped under the template during subsequent key operations. To install the template, place double-sided adhesive tape around all four edges; locate it in position on the case and apply firm pressure around the edges (12 mm tape on sides and bottom, 6 mm at top).

- 2.3 When aligning the top half of the case with the bottom half ensure that the two keyboard ribbon cables are not trapped between projecting components within the case. In their correct positions there is sufficient room for the cables to take up a comfortably curved position inside the case. If a cable is trapped and bent double, an open circuit will sooner or later result.



## SECTION 3

### SETTING UP AND SYSTEM TEST

Sub-Section	LIST OF CONTENTS	Page No.
1	General Alignment	3.1
	Introduction	3.1
	Voltage Check	3.1
	Colour Adjustment	3.1
	Sub-Carrier Oscillator	3.2
	14MHz Oscillator	3.2
2	System Test	3.3

#### 1. GENERAL ALIGNMENT

1.1 Introduction. The Issue 3 Spectrum modification removes the need for adjustment of the colour tuning using potentiometers and trimmers. Therefore, the setting-up procedure for this board is confined to checking that the internally generated power supply voltages and two oscillator frequencies are correct. Adjustment instructions apply strictly to the Issue 2 Spectrum boards only but are generally relevant to the Issue 1 Spectrum as well.

To carry out the setting up procedure it is first necessary to remove the ZX SPECTRUM from the case (Section 2, Assembly/Disassembly). For convenience the keyboard may also be disconnected.

1.2 Voltage Check. Check that the internally generated power voltages are as follows:

Circuit Reference	Nominal Value	Tolerance
IC6 pin 9	+ 5V	± 0.25V
IC6 pin 1	- 5V	- 5.5V to -4V
IC6 pin 8	+12V	± 1.2V
LT side of C52	+12VA	± 1.2V

1.3 Colour Adjustment. Potentiometers VR1 and VR2 are used to effectively null the voltages between pins 4 and 2 (for VR1) and pins 2 and 3 (for VR2) on IC14 (LM1889). To allow for thermal drift, the potentiometers are set for non-zero voltages; furthermore these voltage off-sets are set to satisfactory but non-optimum levels in production, and optimum values may be used to advantage in servicing. The relevant figures are given in the following table - voltages are given relative to pin 3 of LM1889.

Pot.	IC14 Pin No.	Factory Setting (mV)	Optimum Voltage	(mV) Tolerance	Overall Range (mV)
VR1	4	130 ± 20	+50	-5	+45 to +150
VR2	2	75 ± 20	-50	-50 +5	-45 to -100

- 1.4 Sub-Carrier Oscillator. The chrominance sub-carrier oscillator frequency should be 4.433619 MHz ± 50 Hz. This frequency may be checked/adjusted by using one of two methods, listed in (a) or (b) below.

Apply power to the power socket using a bench power supply set at 9V. Current consumption will be approximately 500 mA to 700 mA for the 16k Spectrum and 700 mA to 900 mA for the 48k Spectrum.

- (a) Feed the Spectrum modulator output via a co-axial cable into a standard colour TV receiver. Measure the frequency of the locked TV chroma sub-carrier.
- (b) Connect pin 17 of IC14 (LM1889) via a 4.7 pF capacitor and a lead to the frequency meter. It is recommended that this is done using a jig made up from an IC test clip. Pin 18 of this clip must be removed to minimise stray capacitance. Connect a 10k ohm resistor between the input terminals of the frequency meter. Measure the frequency and adjust trimmer TC2 if the measured frequency is outside tolerance.

- 1.5 14 MHz Oscillator. This frequency is not readily set by working to a specified frequency and tolerance. On Issue 2 boards trimmer TC1 should be adjusted to minimise the effects of beat frequencies which cause waves of distortion to flow across the screen. These are particularly apparent with certain colour combinations; e.g. red INK or green PAPER, and the phenomenon is sometimes referred to as 'dot crawl'. It is stressed that adjustment of this frequency is not straight-forward; as deviations due to temperature change are easily visible; tuning should be adjusted to minimise rather than remove this effect. Proceed as follows:

- (a) Set up the Spectrum to display green PAPER with red INK.
- (b) Type-in three or four lines of characters and monitor the screen.
- (c) Adjust trimmer TC1 to minimise the effects of distortion.



## 2. SYSTEM TEST

- 2.1 The system test for the Spectrum may be undertaken using the ZXTP taped program (see 1.1 Test Equipment in Section 4) loaded conventionally; this requires that the keyboard is connected. The test should be carried out with the Spectrum connected to its own power supply.
- 2.2 The test program exercises all of the Spectrum circuitry with the exception of the SAVE function. To test this function a small; possibly one line program should be typed in, SAVED and then VERIFIED as described in the instruction manual.

SECTION 4  
FAULT DIAGNOSIS AND REPAIR

Sub-Section	LIST OF CONTENTS	Page No.
1	Introduction	4.2
	Test Equipment	4.2
	Modification History	4.3
	Modifications - Issue 1 Board	4.4
	Modifications - Issue 2 Board	4.5
	32k Extension Memory - (16k-48k)	4.5
	Hitachi vs NEC ROM	4.6
2	Fault Diagnosis	4.6
	Techniques	4.6
	Power Supply Unit	4.7
	Initialisation	4.7
	Memory Check	4.8
	Keyboard Structure	4.10
	Fault-Finding Guide	4.11
3	Repair	4.19
4	16k to 48k Upgrade	4.19
	Integrated Circuits/Link Settings	4.19
	Issue 2 Board	4.20
	Issue 3 Board	4.20

## 1. INTRODUCTION

### 1.1 Test Equipment

Section 4 is intended as a guide to fault diagnosis and repair of the ZX SPECTRUM. It is assumed that users have a reasonable knowledge of electronic servicing, theory and standard fault-finding techniques and have access to the test equipment and tools required to carry out the task. The table below contains a list of the minimum recommended test equipment and materials.

EQUIPMENT	SPECIFICATION/MANUFACTURER
Oscilloscope with Oscilloscope probe (x10)	Rise Time: 0.02 $\mu$ s/cm
Variable power supply unit	0 to 30V d.c.
Mono cassette recorder	With RECORD and PLAYBACK facilities
Mains extension lead	'Safebloc' type
Multimeter	General purpose
Colour Television	Open Market
ZX Printer	Sinclair
ZXTP test tape	
Blank tape	Open Market
Double-sided adhesive tape	12mm and 6mm wide; Tesafix 959 (B.D.F. TESA) or 3M equivalent

Engineers who are already familiar with the Sinclair ZX81 will find some similarities in the ZX SPECTRUM. The Spectrum, however, is a more sophisticated device with colour and sound circuitry.

The ZX SPECTRUM is supplied with either 16k or 48k of on-board RAM. The 16k version is wired so that it can be expanded to 48k by the addition of a number of appropriate plug-in ICs. For details of the memory upgrade, see sub-section 4 of this section.

See Section 5, Figures 5.1 and 5.2 for the layouts of the Issue 2 and Issue 3 boards respectively.

## 1.2. Modification History

Two major modifications have been implemented on the Spectrum boards:

(a) A modified layout of board (i.e. Issue 1, Issue 2 and Issue 3)

Issue 1. This layout allowed for the 16k RAM to be mounted direct on the board, with the 32k extension consisting of a subsidiary board mounting onto special DIL connectors. Approximately 26,000 units were manufactured.

Issue 2. This layout allows for all 48k of RAM to be mounted direct on the board; sockets, ready for a memory update, are fitted on 16k versions. A small number of Issue 2 units were manufactured using disc capacitors for 47  $\mu$ F and 100  $\mu$ F values, but subsequently axials were introduced.

Issue 3. This layout incorporates advanced circuitry for the colour tuning, removing the need for potentiometers and trimmers and the associated adjustment. It also allows for OKI ICs to be used in the 32k extension memory. The heatsink is also redesigned and is relocated at the back of the case.

(b) The Ferranti ULA, type 5C102, plus spider addition replaced by ULA type 5C112.

5C102. This ULA has a timing fault which was cured by connecting a 74LS00 IC mounted on a miniature board and spider. This ULA was fitted to approximately 40,000 units.

5C112. This improved ULA has no spider modification, but has either a diode or resistor or transistor connected to it. The details are:

Diode/resistor mod : 4k7 resistor from +12V to pin 30 on IC2 and diode (1N 4148) from pin 30 of IC2 to pin 33 of IC1.

Transistor mod : TR6 (ZTX313) connected as follows:

Base to IC2, pin 30.

Emitter to IC1, pin 33.

Collector to IC2, pin 11.

6C001 This ULA alters the timing of the colour burst signal, and improves the performance of the Spectrum with certain television sets (e.g. Hitachi, Grundig). It also causes the screen picture to be shifted by one character width to the left.

NOTE: The values of certain components vary depending on which board and which ULA is used as follows:

Board Issue No ULA Type	2 5C112	2 6C001	3 6C001
Component			
R47	220 $\Omega$	1 k	1 k
R49	8 k2	10 k	10 k
R56	220 $\Omega$	470 $\Omega$	1 k
R63	220 $\Omega$	470 $\Omega$	1 k

### 1.3 Modifications - Issue 1 Board

A number of modifications were introduced, and these should be checked for and, if necessary, introduced retrospectively:

- (a) 100 pF capacitor between RAS and ground - necessary only when using ULA 5C102.
- (b) 470 pF capacitor between IC2, pin 28 and ground - required only when IC2 and RAM ICs are all of NEC manufacture.
- (c) 1 k resistor between RAS and 23V and 1 k resistor between CAS and 12V; only when RAM ICs are of National manufacture. R57 (330 $\Omega$ ) must be removed, and the 470 pF capacitor is not required.
- (d) 47 k resistor between pin 13 of LM1889 and ground - required only if the difference between white and yellow colours is inadequate.
- (e) If disc capacitors are used for C41 and C49 (47 nF) they must be replaced by axial components.
- (f) Capacitor C46 (1  $\mu$ F electrolytic) should be replaced by a high temperature component.
- (g) This modification is required for efficient operation of certain machine code software and should be implemented on all units. It has been implemented in manufacture for all ULAs 5C112-2 and later.

D14 replaced by C67 (100 pF)  
R24 changed from 3k3 to 1k  
R27 changed from 680  $\Omega$  to 470  $\Omega$   
R73 (1k) added between IC1/32 and +5V

- (h) A significant cause of problems has been found to be failure of the internal power supply transistor TR4. The circuit may be improved by changing the value of R60 from 100  $\Omega$  to 270  $\Omega$  and connecting a 4.7  $\mu$ F electrolytic (preferably radial type) with positive end to TR5 emitter (positive end of C34) and negative end to TR5 base (to R58).

#### 1.4 Modifications - Issue 2 Board

A number of modifications have also been introduced for the Issue 2 board. These should be checked and, if necessary, introduced retrospectively.

- (a) These components should be changed if colour quality needs upgrading:

R48 changed from 4k7 to 2k2  
R49 changed from 18 k to 8k2  
R50 changed from 8k2 to 4k7  
R72 changed from 47 k (or 18 k) to 10 k  
C65 changed from 100  $\mu$ F to 22  $\mu$ F

- (b) Early Issue 2 boards were manufactured using a considerable number of 47  $\mu$ F and 100  $\mu$ F disc capacitors. C41 (47 nF) and C43 (100 nF) should be replaced with axial components to prevent undue risk of short circuits.

- (c) To prevent lifting of the keyboard template, a thin strip (6 mm wide) of double-sided tape was introduced to the top edge of the template. (Previously, only the other 3 edges had tape). This modification should be introduced whenever template lifting is found to be a problem.

- (d) See Items 1.3(g) and (h) above.

#### 1.5 Modifications - Issue 3B Board

Although functionally similar to the Issue 3 board, the layout differs. The DC converter design has been improved, providing greater power supply reliability. Component changes are as follows (see Fig 1.5 for details):

C77 (100nF) added  
C49 changed from 47nF to 560pF  
R60 changed from 270 $\Omega$  to 68 $\Omega$   
TR4 can be either ZTX650 or T1PP31.

#### 1.6 32k Extension Memory - (16k to 48k)

Board Issue 1: The extension memory is supplied as a plug-in module which is inserted into sockets near the edge connector. The ICs used are either TI 4532-3 or TI 4532-4, and all ICs in a unit must be of the same type (i.e. all must be -3 or all must be -4).

Board Issue 2: The extra memory is obtained by plugging in 4 logic ICs and 8 memory ICs (see Sub-Section 4). The ICs used are either TI 4532-3 or TI 4532-4, and all ICs must again be of the same type. It should be noted that the RAM select signal is 0V for the -3 IC and +5V for the -4. A link on the board provides the required select level.

Board Issue 3: This allows OKI ICs to be used in place of TI 4532. Again, all ICs must be of the same designation. Appropriate links (2) must be fitted in the grid located on the board between the edge-connector and the 'mic' jack socket. Again the extra memory is obtained by plugging in 4 logic ICs and eight memory ICs.

## 1.7 Hitachi vs NEC ROM

During manufacture, wiring links are selected and inserted in the board according to whether a Hitachi or NEC ROM is used. These links are marked 'H' and 'N' as appropriate and are located as follows:

Board Issue 1 - between the ROM and the heatsink

Board Issue 2 - beneath the raised portion of the heatsink

Board Issue 3 - adjacent to the loudspeaker

Clearly, if the ROM is changed for one of a different make, then these links must be changed as well.

## 2: FAULT DIAGNOSIS

### 2.1 Techniques

In a closed loop system such as a computer, because of the interdependence of numerous component parts, fault diagnosis is not necessarily straight-forward. In addition, because of the high speed cyclic operation, interpretation of any waveforms on control, data and address lines as being valid depends to a large extent on practical experience of the system. There are however, certain checks with valid waveforms and levels that can be carried out before substituting any integrated circuits. Experience has shown that the best method of initially checking waveforms and levels can be to compare with the same point in a known serviceable board. The following pages provide a basic fault-finding procedure and furnish a list of possible faults along with suggested ways of curing them.

With a densely populated board such as the ZX SPECTRUM, a careful physical examination of the board can sometimes indicate an obvious fault. Burst-out discrete components or an overheated track show up immediately, as do the attentions of an enthusiastic amateur. Bearing in mind the latter, short circuits caused by hairline solder 'splatter' can be of several ohms resistance and can cause some very misleading fault symptoms.

Provided first principles are adhered to and a common-sense approach is adopted, it will be found after a short space of time that fixing a faulty Spectrum is very much a routine operation.

## 2.2 Power Supply Unit

The unregulated external power supply unit is a source of some problems. The design is such that, at minimum input voltage (215V a.c.) and 1.4A output, the voltage trough should not be less than 7.0V; at maximum input voltage (265V a.c.) and 600mA output, the voltage peak should be less than 13V.

## 2.3 Initialisation

At switch-on the computer should automatically 'initialise' and produce a clear screen with the statement

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displayed in the lower left section of the screen. This indicates that most of the system is working. If the Spectrum does not initialise, carry out the following basic checks.

Basic Checks. It is difficult to be specific in a fault-finding guide because of the large variety of fault conditions which can occur, but the following procedure, starting with a table of checks set out in order of priority, will however isolate the major fault area.

FUNCTION	CIRCUIT REF.	WAVEFORM/VOLTAGE
Voltage regulator input	+ve side of C50	+9V d.c. $\pm$ 2.0V. At less than +7V the regulator may not operate correctly.
Voltage regulator output	+ve side of C34	+5V d.c. $\pm$ 0.25V - no discernable ripple.
On-board power supply outputs: +5V d.c. -5V d.c. +12V d.c. +12VA(to IC14 only)	IC6 pin 9 IC6 pin 1 IV6 pin 8 LT end of C52	+5V d.c. $\pm$ 0.25V - no discernable ripple. -5V d.c. +12V d.c. +12V d.c.
Clock pulses	IC1 pin 32 IR3 base and collector IC2 pin 6	14MHz squarewave at +5V amplitude.
Address and data lines (following through to relevant ICs)	RT side of R17-R23 RT side of R1-R8	Waveform of amplitude 3.5V



If these tests prove satisfactory check IC1 pin 14, IC2 pin 11 and IC5 pin 28 for +5V. Also check for ground at IC1 pin 40, IC2 pin 29 and IC5 pin 14. If all is still satisfactory at this point and IC1 is the plug-in type, replace IC1. If replacement of IC1 does not cure the fault, check the address and data lines of IC1, IC2 and IC5 for active data.

It is possible that one of the Z80A or RAM control lines has become faulty therefore, comparing with a known serviceable board if possible, check the waveforms at the following points at origin and destination:

(a) IC2:	Pin 16 - $\overline{\text{INT}}$	Pin 17 - $\overline{\text{NMI}}$
	Pin 20 - $\overline{\text{IOREQ}}$	Pin 24 - $\overline{\text{WAIT}}$
	Pin 19 - $\overline{\text{MREQ}}$	Pin 25 - $\overline{\text{BUS/REQ}}$
	Pin 21 - $\overline{\text{RD}}$	Pin 26 - $\overline{\text{RESET}}$
	Pin 22 - $\overline{\text{WR}}$	
(b) IC22:	Pin 4 - $\overline{\text{RAS}}$	Pin 3 - $\overline{\text{WRITE}}$
	Pin 15 - $\overline{\text{CAS}}$	

If no fault has been found and the computer still has not initialised, the fault could lie in the RAM. If the computer is a 48k machine the 32k of expansion RAM can be isolated. An easy way of doing this, assuming that the ICs are not fitted into sockets, is to remove the +5V from IC25. This is probably best done by very carefully cutting the track to IC25 pin 16. If this operation clears the fault condition, the expansion RAM will have to be further isolated. In either instance the point has been reached where it is necessary to start replacing ICs.

Where the fault persists after isolating the 32k expansion RAM it would be necessary to start changing individual ICs in the order of IC13 to IC6 (RAM), IC1 (ULA), IC2 (Z80A). After each change of IC the unit must be powered up to check for correct initialisation.

A method of fault-finding that can be used on both the 16k and 48k versions is to make up a 'test IC' device. This may be done by using an IC test clip, to which is attached a serviceable IC (of the relevant type e.g. 4116 or 4532), to bridge across each suspect IC in turn. This method is not guaranteed to work but can often save a lot of time unnecessarily changing suspect ICs.

## 2.4 Memory Check

Where a Spectrum has initialised correctly but a RAM memory fault is suspected, it is possible to find the faulty address and relate it to a faulty IC by carrying out the following procedure:

Key in the instruction:

```
PRINT PEEK 23732 + PEEK 23733 * 256
```

The value printed should be:

- (a) for a 48k unit - 65535
- (b) for a 16k unit - 32767

The value printed in each instance is the last valid memory location, and in a serviceable unit would be as set out above. Therefore, if a different value, n, is printed the faulty location will be n + 1. If the value returned is less than 32767 the fault lies in the original 16k of RAM. The following example illustrates the method of relating a faulty location to a faulty IC.

Example. If a 48k Spectrum is giving a memory of 25.25k key in the following instruction:

```
PRINT PEEK 23732 + PEEK 23733 * 256
```

Assume the answer displayed is 43200, therefore the faulty location is 43201 (stops at last valid location). Key-in:

```
POKE 43201,85 : PRINT PEEK 43201 (= answer A)
```

If answer A is 85, key-in:

```
POKE 43201,170 : PRINT PEEK 43201 (= answer B)
```

If answer B is anything other than 170 look up in the following table which IC to change (e.g. if answer B is 234 change IC21). Similarly, if answer A is other than 85 refer to the table to find the faulty IC.

Data 85 IC6-IC13	Data 170 IC15-IC22	Size of Error	Error Bit	Faulty RAM location if:	
				< 32767	> 32767
84	171	1	0	IC6	IC15
87	168	2	1	IC7	IC16
81	174	4	2	IC8	IC17
93	162	8	3	IC9	IC18
69	186	16	4	IC10	IC19
117	138	32	5	IC11	IC20
21	234	64	6	IC12	IC21
213	42	128	7	IC13	IC22

If there is more than one faulty RAM location the first fault identified will have to be repaired before it is possible to proceed.

## 2.5 Keyboard Structure

The keyboard is connected horizontally in eight blocks of five keys and vertically in five blocks of eight keys. Figure 4.1 shows the configuration. It follows that if any block of five keys fail the fault is with KB2 circuitry or the 8-way membrane, and that if any block of eight keys fail the fault is with KB1 circuitry or the 5-way membrane. Possible keyboard faults are listed in paragraph 2.6.

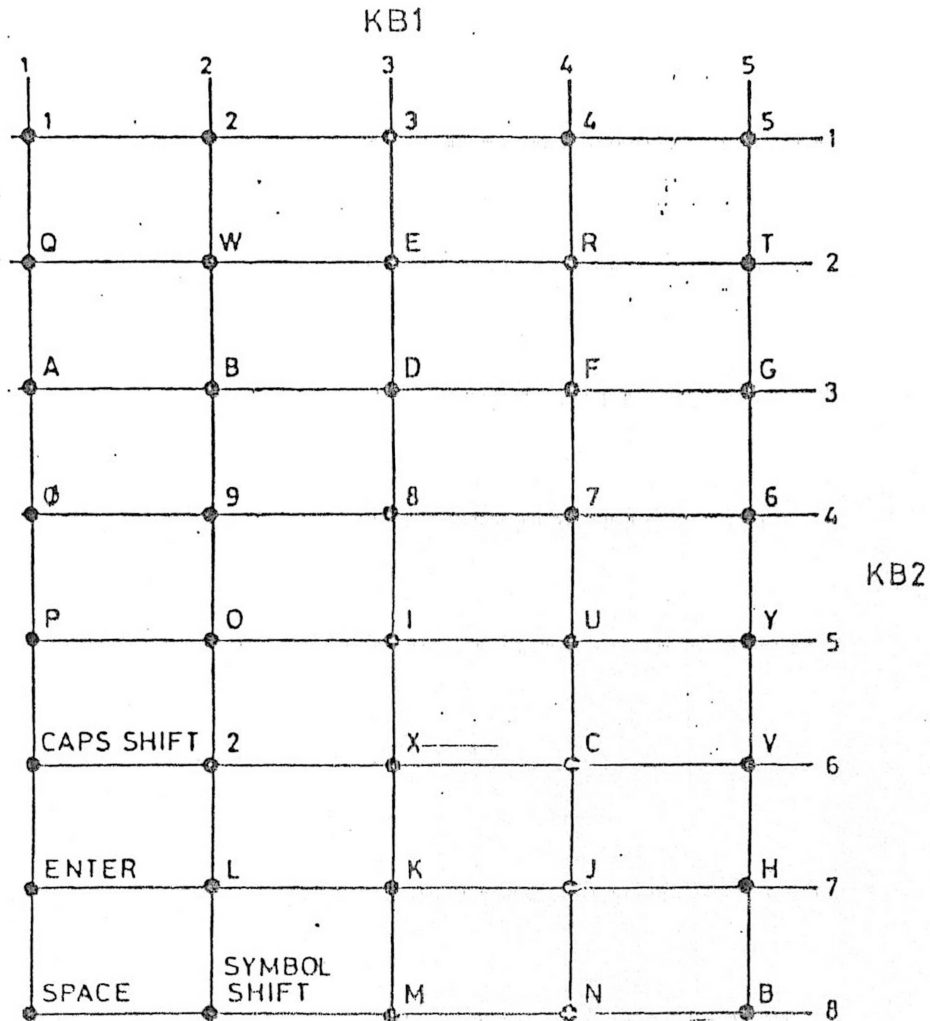
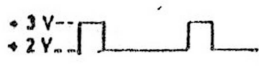
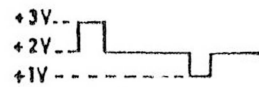
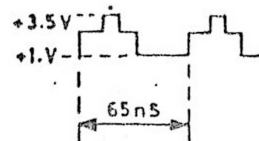


FIGURE 4.1 KEYBOARD FORMAT

## 2.6 Fault-Finding Guide

As with any complex digital equipment the possible fault permutations are vast, thus the following table is not intended to be an exhaustive list of the faults that might occur on the Spectrum. It is intended as a guide only to possible courses of action to follow when faults show up in particular areas of the circuit. These areas are listed in the table with sub-headings; in no particular order of priority. It is envisaged that the ZXTP test tape has been loaded, or an attempt has been made to load the tape, in order to check for a faulty condition.

AREA	SYMPTOM	ACTION
TV screen dead; smoke appears on switch-on.	<p>TR4 base-collector shorted.</p> <p>Short persists with TR4 removed.</p> <p>TR4 blows again.</p>	<p>Remove TR4</p> <ol style="list-style-type: none"> <li>1. Check TR5 and C44.</li> <li>2. Visually check track.</li> <li>3. Check TR4.</li> </ol> <ol style="list-style-type: none"> <li>1. Change TR4 and TR5 (even though TR5 checks out).</li> <li>2. Check that TR5 circuit components are to latest specification.</li> </ol>
Not initialising.	No '(C)1982 Sinclair Research Ltd' statement.	Follow fault-finding procedure, paragraph 2.2 above.
<p>No video.</p> <p>NOTE: Table 4.1 sets out typical signals found on IC14 pins 1-18. IC14 pins 1-18.</p>	<p>No video.</p> <p>No video after ULA changed.</p> <p>No +5V input.</p>	<ol style="list-style-type: none"> <li>1. Change IC1.</li> <li>2. Check TR1 and TR2.</li> </ol> <ol style="list-style-type: none"> <li>1. Visually check IC1 and socket.</li> <li>3. Check for shorting between C65 and R53.</li> <li>4. Carry out fault-finding procedure, para 2.2 above.</li> </ol> <ol style="list-style-type: none"> <li>1. Check voltage drop across R64.</li> <li>2. Check +5V regulator O/P and +9V regulator I/P.</li> <li>3. Check PWR socket not shorted.</li> <li>4. Check power unit.</li> </ol>

AREA	SYMPTOM	ACTION
No video. (contd)	No VIDEO INPUT at IC14 pin 12.	<ol style="list-style-type: none"> <li>1. Check waveform at IC14 pin 13. If correct check TR1 and TR2.</li> <li>2. Check waveforms at IC1 pins 15, 16 and 17:           <div style="margin-left: 20px;"> <p>PIN 15</p>  <p>PIN 16</p>  <p>PIN 17</p>  </div> <p>If correct check VR1, VR2 (Issue 1 and Issue 2 boards).</p> </li> <li>3. Change IC1.</li> <li>4. If +5V and VIDEO INPUT correct change modulator.</li> </ol>
Corrupt Paper, after ULA change.	No 3 MHz at IC2 pin 6.	<ol style="list-style-type: none"> <li>1. Check IC1 socket.</li> <li>2. Check PWR socket is not intermittent.</li> <li>3. Check IC1 pin 14 for +5V with no discernible ripple.</li> <li>1. Low amplitude - check R25.</li> <li>2. Check TR3.</li> <li>3. Check IC1 pin 32 for 3 MHz.</li> <li>4. Check IC1 pin 39 for 14 MHz.</li> <li>5. Check crystal X1.</li> <li>6. Check IC1 pin 13 for +3V.</li> </ol>

- - AREA - -	SYMPTOM	ACTION
Video Incorrect.	<p>Dark Screen.</p> <p>Dim 'Sinclair' logo.</p>	<p>1. Check tuning.</p> <p>2. Change modulator.</p> <p>1. Check +12V.</p> <p>2. Check C65 for high impedance.</p> <p>3. Check R52.</p> <p>4. Check +5V on IC14 pin 3.</p>
	<p>Wavy lines across screen.</p> <p>Self resetting.</p> <p>Random dynamic squares.</p> <p>Paper area too low.</p> <p>Diagonal lines in the border area.</p> <p>Distorted video.</p>	<p>1. Press down on each electrolytic capacitor to see if lines disappear. If so change that capacitor.</p> <p>2. Check crystal X2.</p> <p>3. Check/change TR1 and/or TR2.</p> <p>4. Check/change IC14.</p> <p>Check TR6.</p> <p>Change C54.</p> <p>Change IC1.</p> <p>Change R47.</p> <p>1. Check for +3V at IC1 pin 13.</p> <p>2. Change C30.</p>
Colour tuning faults (Issue 1 and Issue 2 boards)	<p>VR1 or VR2 fails to adjust IC14 pin 13 waveform.</p>	<p>Visually check IC14 circuits.</p> <p>1. Monitor IC14 pin 2 trimming VR2</p> <p>2. Monitor IC14 pin 4 trimming VR1.</p> <p>3. Change IC14.</p>

AREA	SYMPTOM	ACTION
<p>Colour tuning faults. (cont'd)</p>	<p>VR1 or VR2 d.c. shifts IC14 pin 13 waveform.</p> <p>Alternate dark lines on screen.</p> <p>No colour after trimming TC2:</p> <p>IC14 pin 17 not oscillating</p> <p>IC14 pin 17 oscillating but fails to tune.</p> <p>IC14 pin 17 output correct but still no colour (boards at all Issue Nos).</p>	<p>Change IC14.</p> <p>Change IC14.</p> <ol style="list-style-type: none"> <li>1. Check crystal X2.</li> <li>2. Change IC14.</li> <li>3. Change X2.</li> </ol> <ol style="list-style-type: none"> <li>1. Check for broken track.</li> <li>2. Change TC2.</li> <li>3. Change IC14.</li> </ol> <ol style="list-style-type: none"> <li>1. With 'Sinclair' logo on screen IC14 pin 2 and IC14 pin 4 should be as follows:</li> </ol> <div data-bbox="987 1062 1325 1332" style="text-align: center;"> <p>PIN 2</p> <p>PIN 4</p> <p>65 nS</p> </div> <ol style="list-style-type: none"> <li>2. If IC14 pins 2 and 4 are correct, change modulator.</li> </ol>
<p>Colour faults (Issue 1 - Issue 3 boards.</p>	<p>Pin screen.</p> <p>Blue haze around 'Sinclair' logo.</p> <p>Screen too yellow.</p>	<p>Change crystal X2.</p> <p>If untunable (Issue 1 and Issue 2 boards) change IC14.</p> <p>Change IC14.</p>



AREA	SYMPTOM	ACTION
Colour faults (cont'd)	Intermittent colour.  Red, Blue or Green 'Sinclair' logo.  Washed-out colours.	1. Change TC2 (Issue 1 and Issue 2 boards). 2. Change IC14.  Change IC1.  Check TR2.
Keyboard faults.	KBI fault.  KB2 fault.  Dead keyboard.  Wrong keyboard response.  Keyboard response too fast.	1. Check for short on 2 or more of the 5 tracks. 2. Change membrane.  1. Check for short on 2 or more of the 8 tracks. 2. Change membrane.  Change IC1.  Change IC1.  Change IC1.
Regulator coil.	Coil excessively noise.	Change coil.
Speaker.  NOTE: Figure 4.2 shows typical waveforms in the speaker circuit	No speaker output.	1. Check load input waveforms. 2. Check TR7. 3. Check D9. 4. Change speaker.
Test program.	'Tape Loading Error' output.  Paper area edges distort.	Reload program.  Change IC1.

AREA	SYMPTOM	ACTION
<p>Test Program. (cont'd)</p>	<p>Paper area corrupts during tests.</p> <p>Border colours are striped.</p> <p>Failure messages.</p> <p>'Test Passed' message not flashing.</p> <p>Reduced memory size.</p>	<p>1. Change IC1.</p> <p>2. Carry out fault-finding procedure(paragraph 2.2).</p> <p>Change IC14.</p> <p>Carry out fault-finding procedure (paragraph 2.2).</p> <p>Change IC1.</p> <p>1. Perform memory test.</p> <p>2. Change IC1.</p>
<p>Program Loading.</p>	<p>Keyboard does not allow loading.</p> <p>Program fails to load.</p> <p>'Program appears.</p>	<p>See keyboard faults.</p> <p>1. Check jack sockets are fully inserted.</p> <p>2. If loading stripes in border are unusually wide, check D13.</p> <p>3. Check/change IC1.</p> <p>Check/Change IC2.</p>

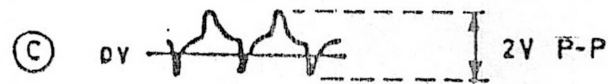
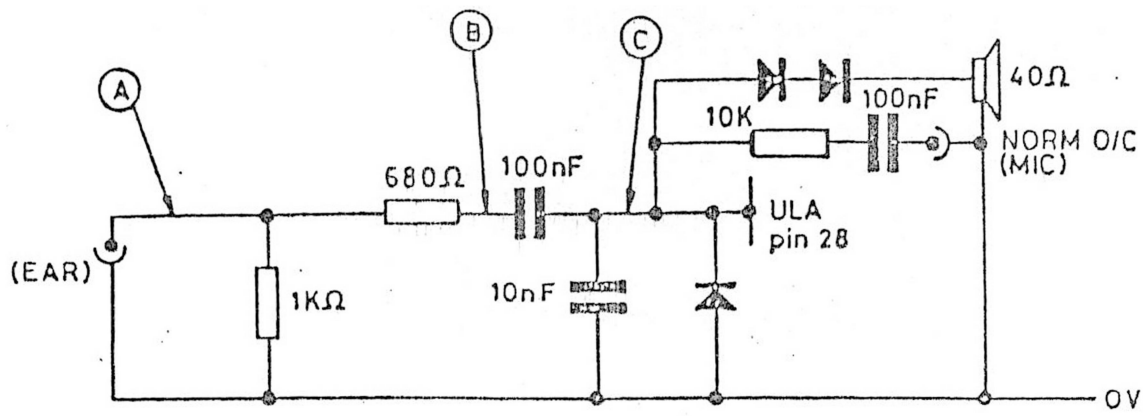
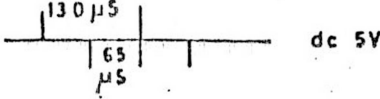
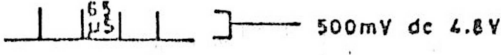
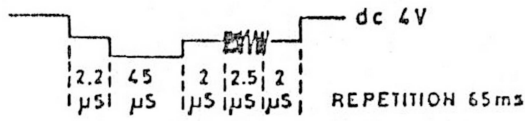


FIGURE 4.2 SPEAKER LOAD INPUT WAVEFORMS

TABLE 4.1. IC14 (LM1889) PIN SIGNALS

Pin No.	Signal
1	(CHROMA LEAD) SINEWAVE 500mV, 0.2 $\mu$ s, d.c. 9.5V
2	(R - Y INPUT)  dc 5V
3	(CHROMA BIAS) d.c. 4.8V
4	(B - Y INPUT)  500mV dc 4.8V
5	0V (GROUND)
12	(VIDEO INPUT) d.c. 12V unreg.
13	(CHROMA SUBCARRIER)  dc 4V REPETITION 65ms
14	(R.F SUPPLY)
15	(SOUND TANK) 'LINKED' 12V d.c.
16	(CHROMA SUPPLY)
17	(CHROMA OSCILLATOR OUTPUT) SQUAREWAVE 0.2 $\mu$ s 4V P-P. D.C. 0.8V
18	(CHROMA LAG) SINEWAVE 500mV P-P 2 $\mu$ s d.c. 9.5V
6,7,8 9,10, 11	Not Connected
<p>NOTES:</p> <p>(1) Rails and signals taken on switch-on, computer displaying 'Sinclair' logo.</p> <p>(2) No keys pressed</p> <p>(3) All d.c. levels positive wrt 0V</p>	

### 3. REPAIR

3.1 Renewal of components should be carried out using recognised desoldering/heatsinking techniques to prevent damage to the component or to the printed circuit board. Other points to be noted are:

- (a) When replacing a keyboard matrix; take care that the ribbon connectors are fully inserted into the board connectors; and are not kinked during insertion.
- (b) Make sure there is a good contact made between the voltage regulator body and the associated heatsink in order to ensure adequate heat conduction. The heatsink hole in certain Issue 3 boards allows excessive play which could cause fouling of the edge connector. Take care in re-assembly that the heatsink is fitted away from the edge connector.
- (c) When the regulator is being replaced it is recommended that a suitable proprietary thermal grease is applied to the rear surface of the component body.
- (d) The modulator should be replaced as a complete unit.
- (e) When replacing plug-in ICs it is advisable to use the correct removal and insertion tools. Avoid contaminating the connection pins by handling.
- (f) When handling ICs take normal anti-static precautions. It is recommended that only a suitably earthed, low power soldering iron be used.
- (g) After any component has been renewed the circuit board should be examined carefully, to ensure that there are no solder 'splatters' which may cause short circuits between tracks or connector pins.

### 4. 16k TO 48k UPGRADE

#### 4.1 Integrated Circuits/Link Settings

For both the Issue 2 and the Issue 3 boards the memory upgrade is accomplished by plugging four logic ICs and eight memory ICs into existing board sockets. Depending on the types of memory IC used; appropriate circuit links must be fitted on the board. Figure 4.3 shows the layout of the area of the board containing the empty sockets. The Issue 3 board is shown which also gives positions (top left of diagram) of the links.

#### 4.2 Issue 2 Board

The ICs used on this board are as follows:

IC	TYPE
IC15 - IC22	TI 4532-3 or TI 4532-4 200ns (or 250ns)
IC23	74LS32
IC24	74LS00
IC25, IC26	74LS157 (NOT National Semiconductors)

- NOTES:
- (1) All external RAM ICs must be of the same type (i.e. all -3 or -4 variants).
  - (2) LINK 3 on the board (IC26, pin 10) should be fitted if IC15-IC22 are type 4532-3.
  - (3) LINK 4 should be fitted if IC15-IC22 are type 4532-4.

#### 4.3 Issue 3 Board

The ICs used on this board are as follows:

IC	TYPE
IC15 - IC22	TI 4532-3, TI 4532-4 or OKI MSM3732 200 ns (or 250ns)
IC23	74LS32
IC24	74LS00
IC25, IC26	74LS157 (NOT National Semiconductors)

- NOTES:
- (1) All extension RAM ICs must be of the same type.
  - (2) Two links must be fitted on the board (grid located between edge connector and m/c jack socket) depending on memory manufacturer and type (high or low enable). See Figure 4.4 for link positions vs manufacturer and IC type.

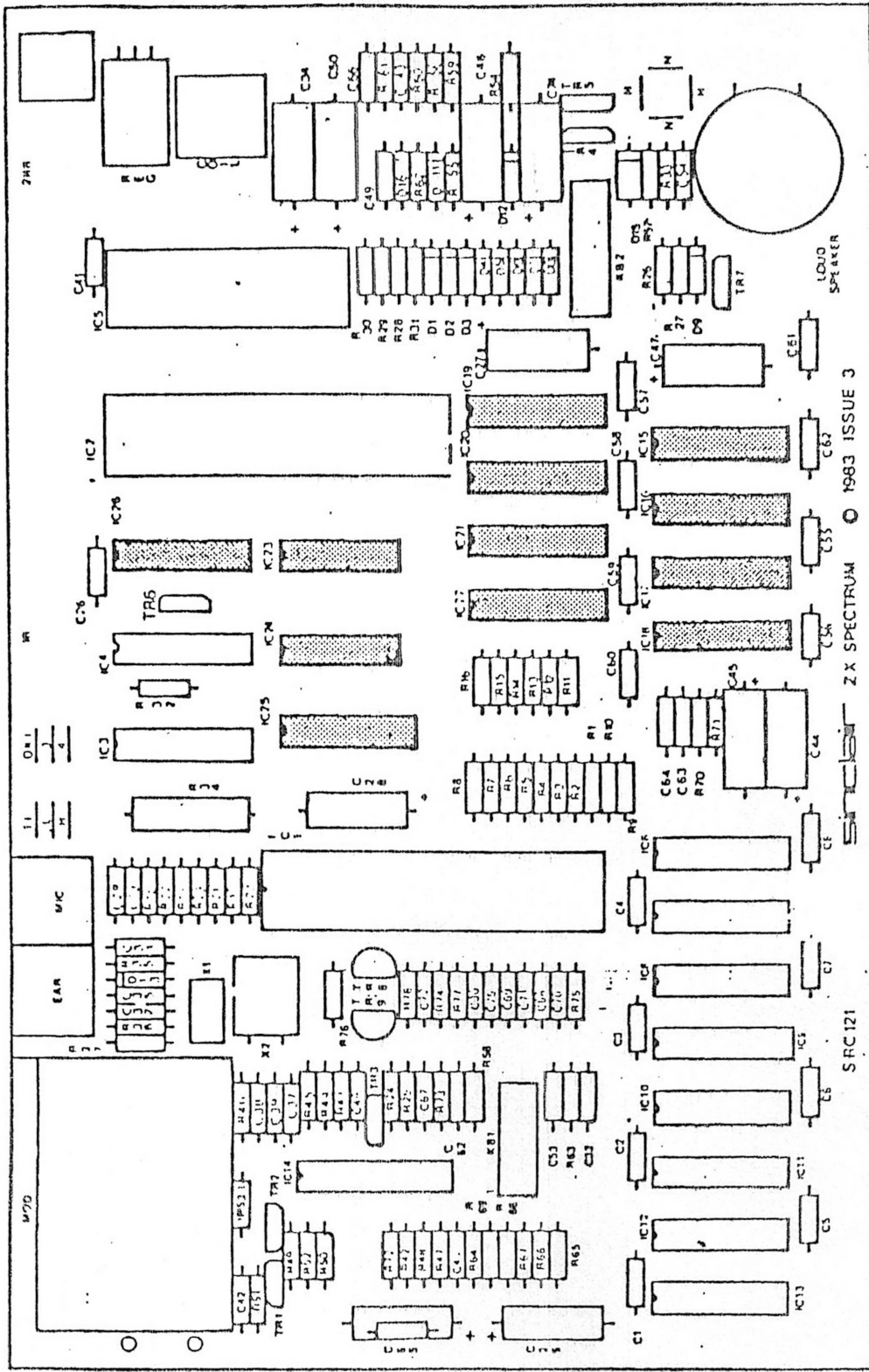
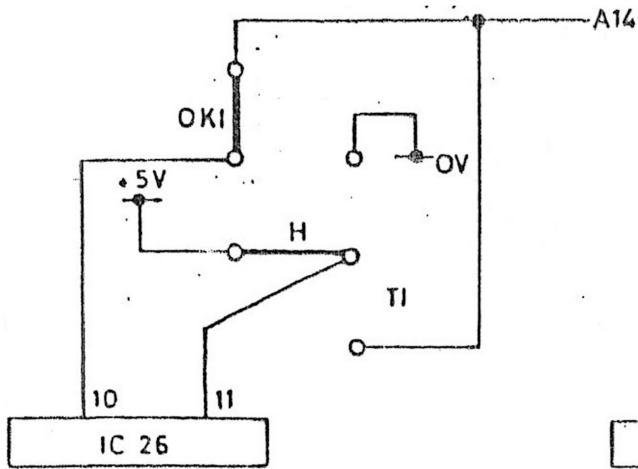


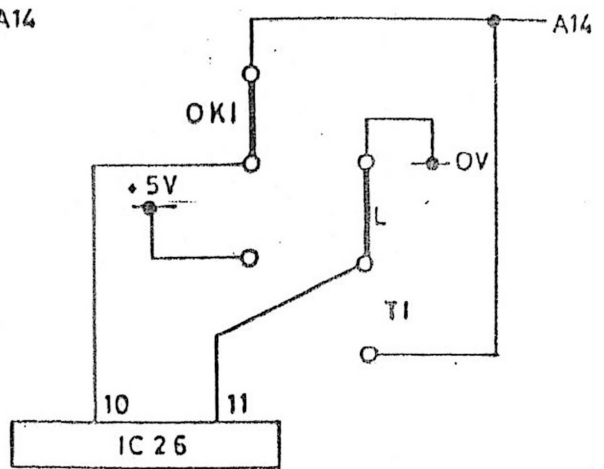
FIGURE 4.3 EXPANSION MEMORY IC LOCATIONS

Denotes IC location.

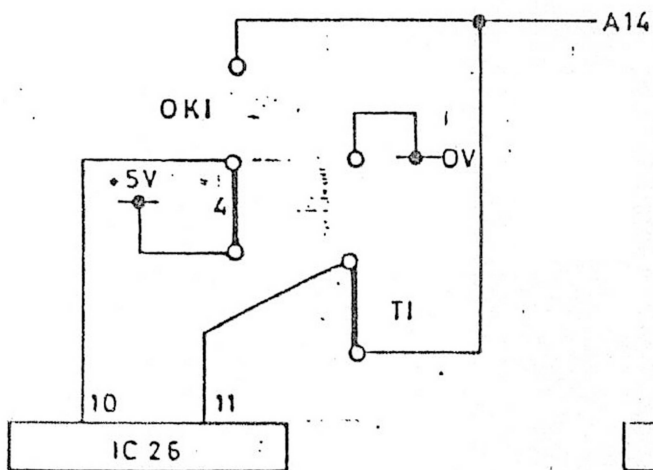




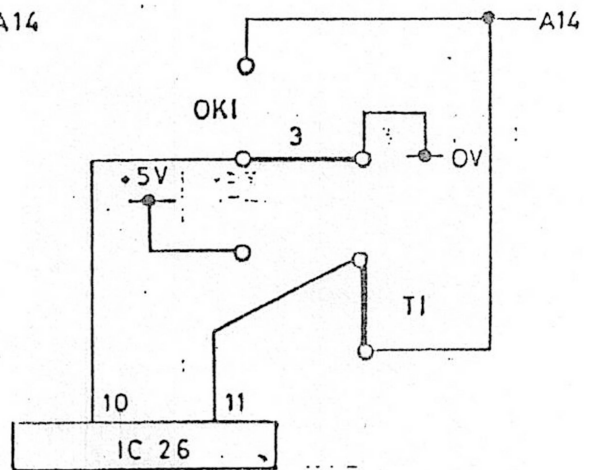
OKI HIGH ENABLE



OKI LOW ENABLE



TI 4532-4



TI 4532-3

FIGURE 4.4. ISSUE 3 LINKS vs. IC MANUFACTURER AND TYPE. ....

SUPPLEMENT NO. 1  
Issue 4A to 6A Modifications

DECEMBER 1984

# SPECTRUM SERVICE SUPPLEMENT NO.1

Sub-Section	LIST OF CONTENTS	Page No.
1	Introduction	S.1
2	DC-DC Converter Modification	S.1
3	Issue 3B Board	S.2
4	Issue 4 Board	S.2
5	Issue 4A Board	S.2
6	Issue 4B Board	S.2
7	Issue 5 Board	S.3
8	Issue 6 Board	S.3
9	Issue 6A Board	S.3
10	Fault Finding - Servicing Addenda	S.3
11	Warranty Seal	S.3
12	Parts Lists	S.4

## 1. INTRODUCTION

- 1.1 In line with Sinclair's policy of continual product improvement a number of changes to the Spectrum Printed Circuit Board have been implemented. Since the Service Manual was published the printed circuit board has been upgraded through Issues 4A, 4B, 5 and is currently at Issue 6A. This supplement details the modifications, board by board and also provides additional servicing information and spare parts lists.
- 1.2 A substantial change has been introduced in the area of the dc-dc converter and the method of implementing this modification is detailed under its own heading. It is recommended that this modification is embodied in units on which either TR4 or the 16K DRAM has blown. Some Issue 3B and 4A units, and all later issues have this modification embodied.

## 2. DC-DC CONVERTER MODIFICATION

- 2.1 The following new materials are required:

### Diodes

- D17 - BR157
- D18 - 1N 4148
- D19 - 5V1 Zener

### Capacitors

- C78 - 1 $\mu$ F 25V WKG Electrolytic
- C79 - 1 $\mu$ F 16V WKG Electrolytic

### Resistors

- R60 - 220 $\Omega$  5%, 1/4 W
- R79 - 2K2 5%, 1/4 W

2.2 Remove the following components from the printed circuit board:

D12 - IN 4148 Diode  
D16 - 5V1 Zener  
C47 - 22 $\mu$ F Electrolytic  
R54 - 100K  
R55 - 56 $\Omega$   
R60 - 270 $\Omega$

2.3 Embody the modification as follows:

- (a) Break the connection between D15 and C49.
- (b) Connect C78 between C49 and D15 (positive end of C78 to C49).
- (c) Connect D17 between ground (positive end of D17) and the new connection of C78 to D15.
- (d) Substitute components as follows:

Remove:	Substitute:
D12	R79
D16	C79 (positive to ground)
C47	Open circuit
R54	D19 (positive to ground)
R55	D18 (positive to C46)
R60	R60, 220 $\Omega$

2.4 Circuit Operation. The modification is confined to adding/changing protection components in the rectification circuit to improve reliability. Circuit function does not change.

3. ISSUE 3B BOARD - (Already covered in existing manual).

4. ISSUE 4 BOARD - None issued.

5. ISSUE 4A BOARD

5.1 This differs from the issue 3B as follows:

- (a) R32 deleted.
- (b) Two spare gates from IC24 have been used to improve ULA timing. It is important that ULA 6C001-7 or later issues (the issue number is designated by the number after the hyphen) are used in this circuit. The gates are fitted in series with the RASL output from the ULA and the input to the display RAM multiplexers.
- (c) Provision is made for fitting interference suppression coils and a modulator channel switch, as required on VHF units.

6. ISSUE 4B BOARD

- 6.1 The Issue 4B board is the same as that for the Issue 4A with the addition of the dc-dc converter modification. The board layout was changed at this stage as shown in Figure 4. Due to lack of board space, C61 (22 $\mu$ F decoupler) was omitted. It is reinstated on subsequent board issues. The circuit diagram is shown in Figure 2.

7. ISSUE 5 BOARD

- 7.1 1000 of these boards were supplied. They are restricted to the UK market only. A single ULA, IC27, (Mullard ZX 84/01) replaces the six 74LS chips. Figure 5 shows the circuit diagram. An inverter chip IC28 has been added and is used in the decoding of the RAS/CAS function. Circuit functions do not change. Some discrete components were added/changed as reference to the parts list show. The board layout is shown in Figure 6.

8. ISSUE 6 BOARD - None issued.

9. ISSUE 6A BOARD

- 9.1 This board is similar to Issue 5 but can be fitted with either a Ferranti or a Saga main ULA. Figure 7 shows the circuit diagram and Figure 8 the board layout.

10. FAULT FINDING - SERVICING ADDENDA

- 10.1 The following are additions to Section 4 of the servicing manual:
- (a) Picture quality and possible RAM failures. Test at elevated temperature to show up faults.
  - (b) Interface 1 fault. Inspect the edge connector to check for damaged pins. Check the M1 signal from the CPU; this signal is only used with Interface 1 and so a failure is not evident when the Spectrum is used on its own.
  - (c) SAVE/LOAD failure. Inspect the jack sockets for deformation of contact springs.

11. WARRANTY SEAL

- 11.1 From August 1984 a new warranty seal label is fitted. The label is applied over the central screw hole at the rear of the base and has a four digit code. Breaking of this seal invalidates the warranty.

## 12. PARTS LISTS

- 12.1 As alternatives to ZTX 213 in TR5 position, transistors BC213, BX214 or FRB925 may be used.
- 12.2 As alternatives to ZTX 313 in TR1, TR2, TR3 and TR6 positions, transistors MPD 2369 or MPS 2713 (both in TO-92 packages) can be used.
- 12.3 Table 1 details new issue parts lists. Some components on this table are not always fitted. Each is identified by reference to the note number in the NB column. The notes are explained below.

### Notes:

- 1. With Issue 5 boards, if R80-R86 are seen to be fitted, the value of R17-R23 is 470R. If R80-R86 are fitted, the values of R17-R23 are 330R.
- 2. With Issue 6 boards, this is not necessary with the SAGA version of IC1.
- 3. With Issue 6 boards, this is not necessary with the FERRANTI version of IC1.
- 4. With Issue 6 boards, this is only required on VHF models.
- 5. With Issue 6 boards, this is only required on the 48K model.
- 6. With all issues of Spectrum, if TR3 is type KSC839, resistor R24 should be 15K0.
- 7. With all Issue Spectrums, if TR4 is to be replaced by type KTC2236A-Y, the pin connections differ to all other replacement types (Pin 1 is emitter, Pin 2 is collector and Pin 3 is base, i.e. the base and collectors are reversed).

TABLE 1 PARTS LISTS

Circuit Ref.	Issue 4A	Issue 4B	Issue 5	Issue 6A	Rating ± Tol%	Type	NB
CAPACITORS							
(Unless otherwise stated all capacitors are axial types)							
C1-C8	22 nF	22 nF	22 nF	2 nF	25V,10%	Ceramic	
C9-C24	NOT USED	NOT USED	NOT USED	NOT USED			
C25	22 μF	22 μF	22 μF	22 μF	10V,-10%+80%	Elect.	
C26	22 nF	22 nF	22 nF	22 nF	25V,10%	Ceramic	
C27	1 μF	1 μF	1 μF	1 μF	50V,10%	Ceramic	
C28	22 μF	22 μF	22 μF	22 μF	10V,-10%+80%	Elect.	
C29	47 nF	47 nF	44 nF	22 nF	25V,10%	Ceramic	
C30	22 nF	22 nF	22 nF	22 nF	25V,10%	Ceramic	2
C31	100nF	100nF	100μF	100nF	25V,10%	Ceramic	
C32	100nF	100nF	100nF	100nF	25V,10%	Ceramic	2
	-	-	-	220nF	25V,10%	Ceramic	3
C33	22 nF	22 nF	22 nF	47 nF	25V,10%	Ceramic	
C34	22 μF	22 μF	22 μF	22 μF	10V,-10%+80%	Elect.	
C35	10 nF	10 nF	10 nF	10 nF	25V,10%	Ceramic	2
	-	-	-	100nF	25V,10%	Ceramic	3
C36	NOT USED	NOT USED	NOT USED	NOT USED			
C37/C38	33 pF	33 pF	33 pF	33 pF	25V,10%	Ceramic	
C39	10 nF	10 nF	10 nF	10 nF	25V,10%	Ceramic	
C40/C42	22 nF	22 nF	22 nF	22 nF	25V,10%	Ceramic	
C43	100nF	100nF	100nF	100nF	25V,10%	Ceramic	
C44/C45	100μF	100μF	NOT USED	100μF	16V,-10%+80%	Ceramic	
C46	1 μF	1 μF	1 μF	1 μF	50V,-10%+80%	Elect.	
C47	22 nF	22 nF	NOT USED	NOT USED	10V,-10%+80%	Elect.	
C48	22 nF	22 nF	22 nF	22 nF	25V,10%	Ceramic	
C49	560pF	560pF	560pF	560pF	25V,10%	Ceramic	
C50	22 μF	22 μF	22 μF	22 μF	10V,-10%+80%	Elect.	
C51	NOT USED	NOT USED	NOT USED	NOT USED			
C52/C53	150 pF	150pF	150pF	150pF	25V,10%	Ceramic	2
C54	NOT USED	NOT USED	NOT USED	NOT USED			
C55-C60	22 nF	22 nF	22 nF	22 nF	25V,10%	Ceramic	
C61	22 nF	NOT USED	22 nF	22 nF	25V,10%	Ceramic	
C62	22 nF	22 nF	22 nF	22 nF	25V,10%	Ceramic	
C63	47 pF	47 pF	NOT USED	NOT USED	25V,10%	Ceramic	
C64	180pF	180pF	NOT USED	NOT USED	25V,10%	Ceramic	
C65	22 μF	22 μF	22 μF	22 μF	20V,-10%+80%	Elect.	
C66	22 nF	22 nF	22 nF	22 nF	25V,10%	Ceramic	
C67	100pF	100pF	100pF	100pF	25V,10%	Ceramic	2
C68-C71	100nF	100nF	100nF	100nF	25V,10%	Ceramic	2
C72/C73	16 pF	16 pF	16 pF	16 pF	25V,5%	Ceramic	
C74	4.7μF	4.7μF	4.7μF	4.7μF	5V min.	Elect.	
C75	100nF	100nF	100nF	100nF	25V,10%	Ceramic	
C76	47 nF	47 nF	47 nF	22 nF	25V,10%	Ceramic	2
C77	100nF	100nF	NOT USED	NOT USED	25V,10%	Ceramic	



CAPACITORS (contd)

Circuit Ref.	Issue 4A	Issue 4B	Issue 5	Issue 6A	Rating ± Tol%	Type	NB
C78	NOT USED	NOT USED	22 µF	NOT USED	25V,10%	Elect.	
C79	NOT USED	1 µF	1 µF	1 µF	16V,10%	Elect.	
C80	NOT USED	22 µF	NOT USED	22 µF	25V,10%	Elect.	
C100	NOT USED	NOT USED	NOT USED	10 nF	25V,10%	Ceramic	4
C101	NOT USED	NOT USED	NOT USED	22 nF	25V,10%	Ceramic	4
C102	NOT USED	NOT USED	NOT USED	NOT USED			
C103	NOT USED	NOT USED	NOT USED	NOT USED			
C104	NOT USED	NOT USED	100nF	100nF	25V,10%	Ceramic	
C105	NOT USED	NOT USED	180pF	180pF	25V,10%	Ceramic	

COIL

Circuit Ref.	Issue 4A	Issue 4B	Issue 5	Issue 6A	Manufacturer
Coil L1-L2	Spectrum TFR, 2 windings on toroidal former				N. Devon

RESISTORS (1/4W, 5% unless otherwise stated)

Circuit Ref.	Issue 4A	Issue 4B	Issue 5	Issue 6A	Rating ± Tol%	NB
R1-R8	470R	470R	470R	470R		
R9-R16	8K2	8K2	8K2	8K2		
R17-R23	330R	330R	470R	470R		1
R24	1K0	1K0	1K0	1K0		6
R25	180R	180R	180R	180R		
R26/R27	470R	470R	470R	470R		
R28	10K0	10K0	10K0	10K0		
R29	10K0	10K0	10K0	10K0		
R30	10K0	10K0	10K0	10K0		
R31	220K0	220K0	220K0	220K0		
R32	NOT USED	NOT USED	NOT USED	NOT USED		
R33	680R	680R	680R	680R		2
	-	-	-	560R		3
R34	15R	15R	-	15R	0.5 or 1W	2
R35	10K0	10K0	10K0	10K0		
R36	680R	680R	680R	680R		
R37	1K0	1K0	1K0	1K0		
R38-R41	NOT USED	NOT USED	NOT USED	NOT USED		

RESISTORS (contd) (1/4W, 5% unless otherwise stated)

Circuit Ref.	Issue 4A	Issue 4B	Issue 5	Issue 6A	Rating ± Tol%	NB
R42	1K0	1K0	1K0	1K0		
R43	3K0	3K0	3K0	3K0	2%	
R44	5K1	5K1	5K1	5K1	2%	
R45/R46	1K0	1K0	1K0	1K0		
R47	1K0	1K0	1K0	1K0		
R48	2K2	2K2	2K2	2K2		2
	-	-	-	0		3
R49	10K0	10K0	10K0	10K0		2
R50	4K7	4K7	4K7	4K7		2
R51	2K2	2K2	2K2	2K2		2
	-	-	-	1K2		3
R52	2K2	2K2	2K2	2K2		
R53	390R	390R	390R	390R		
R54-R55	NOT USED	NOT USED	NOT USED	NOT USED		
R56	1K0	1K0	1K0	1K0		2
R57	NOT USED	NOT USED	NOT USED	NOT USED		
R58	1K0	1K0	1K0	1K0	2%	
R59	1K8	1K8	1K8	1K8	2%	
R60	220R	220R	220R	220R		
R61/R62	15R	15R	15R	15R		
R63	1K0	1K0	1K0	1K0		2
R64	15R	15R	15R	15R		
R65-R67	10K0	10K0	10K0	10K0		2
R68	10K0	10K0	10K0	6K8		2
R69	10K0	10K0	10K0	10K0		2
R70/R71	220R	220R	NOT USED	NOT USED		
R72	10K0	10K0	10K0	10K0		
R73	1K0	1K0	1K0	1K0		2
R74/R75	10K0	10K0	10K0	10K0		2
R76/R77	1K0	1K0	1K0	1K0		2
R78	470R	470R	470R	470R		
R79	NOT USED	NOT USED	2K2	2K2		
R80-R86	NOT USED	NOT USED	1K0	1K0		1
R87	NOT USED	NOT USED	LINK	0		
R88	NOT USED	NOT USED	1K0	1K0		
R89	NOT USED	NOT USED	8K2	8K2		
R90	NOT USED	NOT USED	NOT USED	2K7		

CONNECTORS

Reference	Description	Manufacturer/Part Number
EAR	3.5 mm jack socket	Tuda
MIC	3.5 mm jack socket	Tuda
PWR	2.1 mm co-axial socket	Hoseiden
KB1	5-way ribbon connector	Molex 5229-05CPB/Flexlock
KB2	8-way ribbon connector	Molex 5229-08CPB/Flexlock

CRYSTALS

Circuit Reference	Issue 4A	Issue 4B Issue 5 Issue 6A
X1 X2	14.000000 MHz 4.43361875 MHz	same all issues

DIODES

Circuit Reference	Issue 4A	Issue 4B	Issue 5	Issue 6A	Type
D1-D9	1N4148	1N4148	1N4148	1N4148	Signal
D10	NOT USED	NOT USED	NOT USED	NOT USED	Signal
D11/D13	1N4148	1N4148	1N4148	1N4148	
D12	NOT USED	NOT USED	NOT USED	NOT USED	Rectifier
D14	NOT USED	NOT USED	NOT USED	NOT USED	
D15	BA157	BA157	BA157	BA157	Zener
D16	5V1	NOT USED	NOT USED	NOT USED	
D17	-	BA157	BA157	BA157	Rectifier
D18	-	1N4148	1N4148	1N4148	Signal
D19	-	5V1	BZY88C	BZY88C	Zener

INTEGRATED CIRCUITS

Circuit Reference	Issue 4A, Issue 4B	Issue 5	Issue 6A	Manufacture/Type
IC1(ULA)	6C001-7 (6C011) 6C001E-7	6C001E-7	Z80A	Ferranti (HTSC) or SAGA (Iss.6)
IC2(CPU)	Z80A/μ780	NOT USED	-	NEC/ZILOG
IC3/IC4	74LS157N (MUX)			NOT National
IC5(ROM)	SPECTRUM			NEC/Hitachi
IC6-IC13	4116/416-3/MN5290-2		4116	150 ns
IC14	LM1889		LM1889	National
IC15-IC22	T14532/MSM3732 (48k only)		4532	Texas/OKI (See Note 5)
IC23	74LS32N/74AL532 (48k only)	NOT USED		NOT National
IC24	74LS00N/74AL500 (48k only)	NOT USED		
IC25, IC26	74LS157N/74157 (48k only)	NOT USED		Mullard
IC27	NOT USED	ZX84/01	ZX84/01	
IC28	NOT USED	74LS04	74LS04	Texas

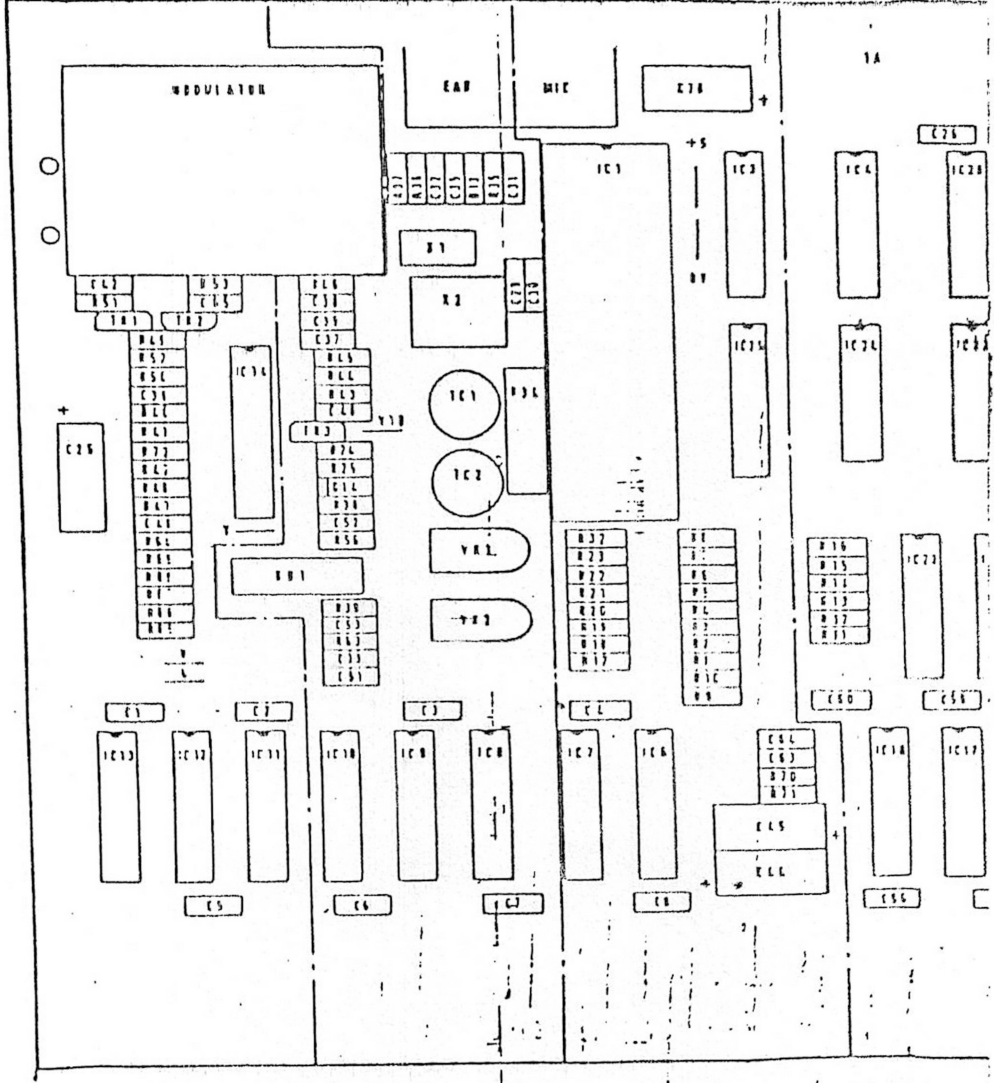
TRANSISTORS

Circuit Reference	Issue 4A, 4B, 5, 6A	NB
TR1-TR2	ZTX313/MPS2369/MPS2713/KSC945-Y	2 and 6
TR3	ZTX313/MPS2369/MPS2713/KSC839-0	
TR4	ZTX650/T1PP31/KTC2236A-Y	7
TR5	ZTX213/BC213/BX214/FRB925	
TR6	ZTX313/MPS2369/MPS2713	
TR7	ZTX450	
TR8/TR9	BC184/BC549B	2

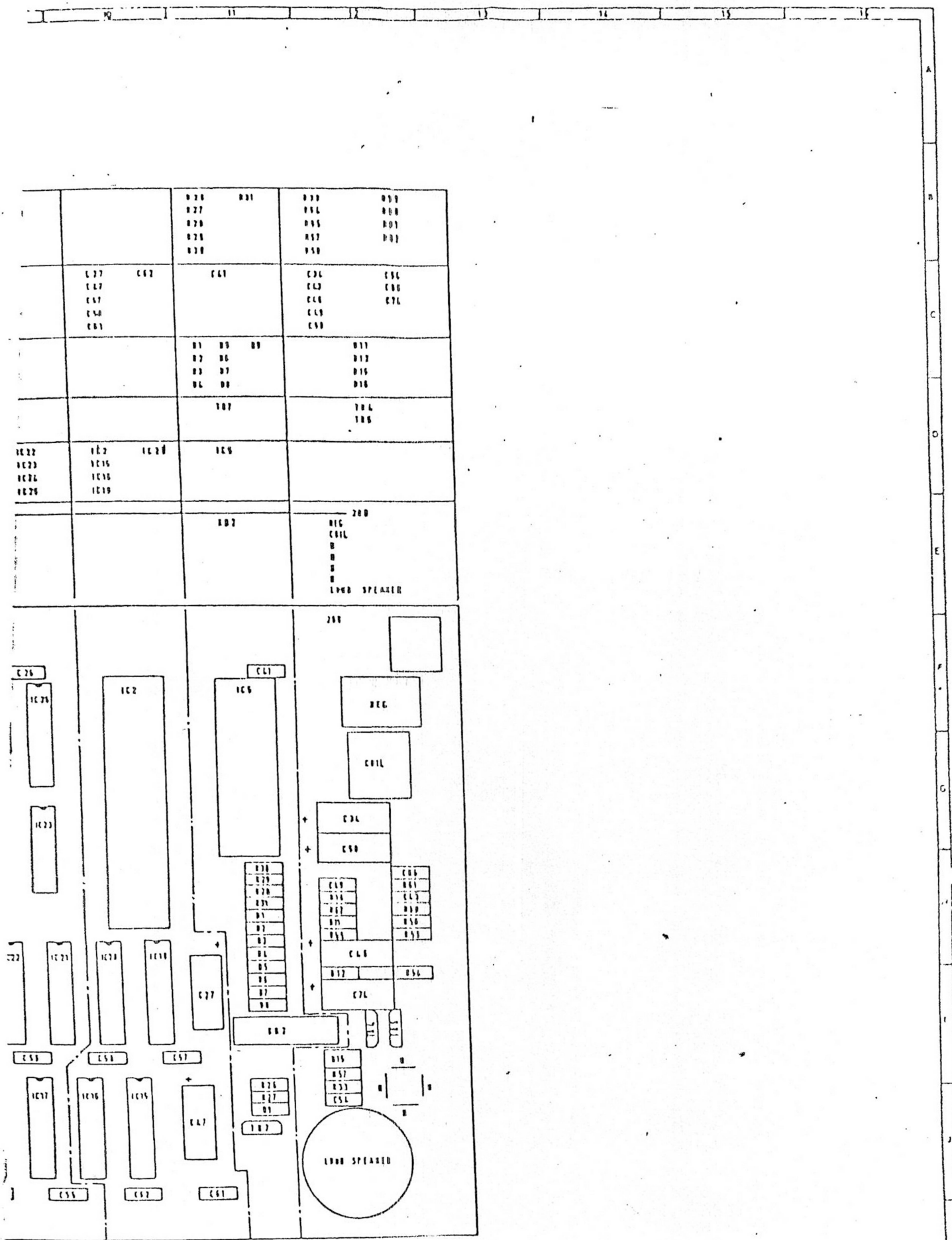
MISCELLANEOUS

Reference	Description	Manufacturer/ Part Number
REG	5V regulator	7805
MOD	UHF modulator with E36 vision carrier (UK only)	Astec UM1233 (UM16--- for VHF versions)
Loudspeaker	40 ohm T.V. type	G.English (Merry)
Modulator Screen Insulator	-	Stafford Rubber SRC090
Heatsink	Special (Issue 2 or 3)	
Regulator Fixings (1) (2) (3)	Screw, ch hd. 4BA x 15/16 in. Washer, shk prf, 4BA. Nut, hex. 4BA.	
DIL SKT	16-way (10-off) for 48k expansion RAM (16k model only)	
DIL SKT	14-way (2-off) for 48k expansion RAM (16k model only)	
DIL SKT	28-way for IC1 (ULA)	

IC	11. 12. 13. 14.	8. 9. 10.	1. 2. 3. 4. 5. 6. 7.	17. 18. 19. 20.
B	40. 49. 56. 59. 41. 50. 58. 72. 42. 51. 54. 66. 47. 52. 57. 68. 48. 53. 60.	24. 27. 45. VR1 25. 28. 46. VR2 26. 29. 55. 35. 43. 53. 36. 44.	1. 6. 17. 22. 2. 7. 18. 23. 3. 8. 19. 24. 4. 9. 20. 25. 5. 10. 21. 26.	11. 16. 12. 17. 13. 18. 14. 19. 15.
C	1. 48. 2. 47. 5. 55. 25. 26.	3. 31. 36. 53. 6. 32. 38. 51. 7. 33. 40. 52. 28. 35. 51. 30. 37 52	6. 53. 8. 54. 28. 44. 45.	24. 55. 56. 58. 59.
D		13. 14		
EA	1. 2.	3.		
MIXC.	MODULATOR	X1, X2. E01 EAR CODE.	MIC. CODE.	

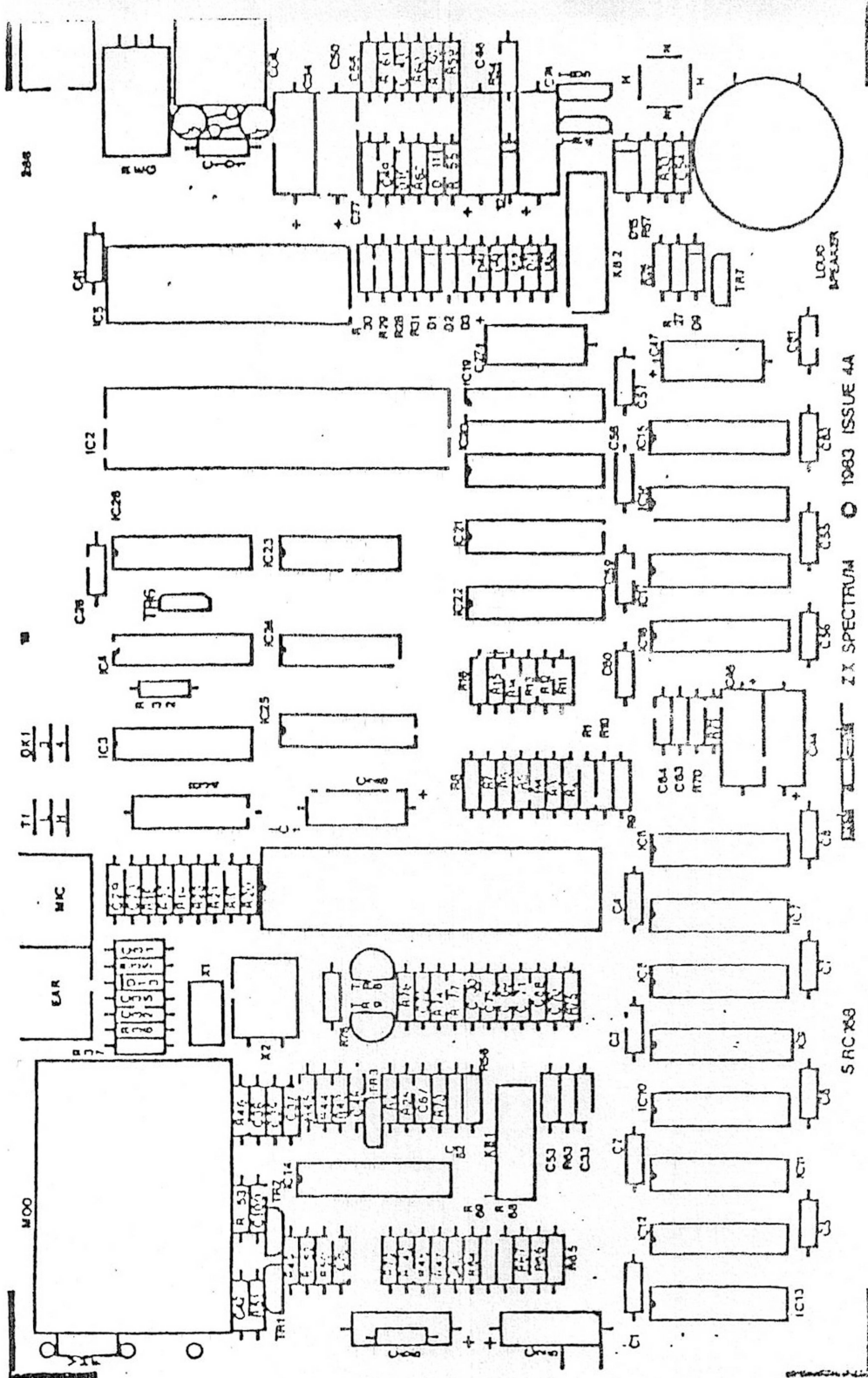


5a



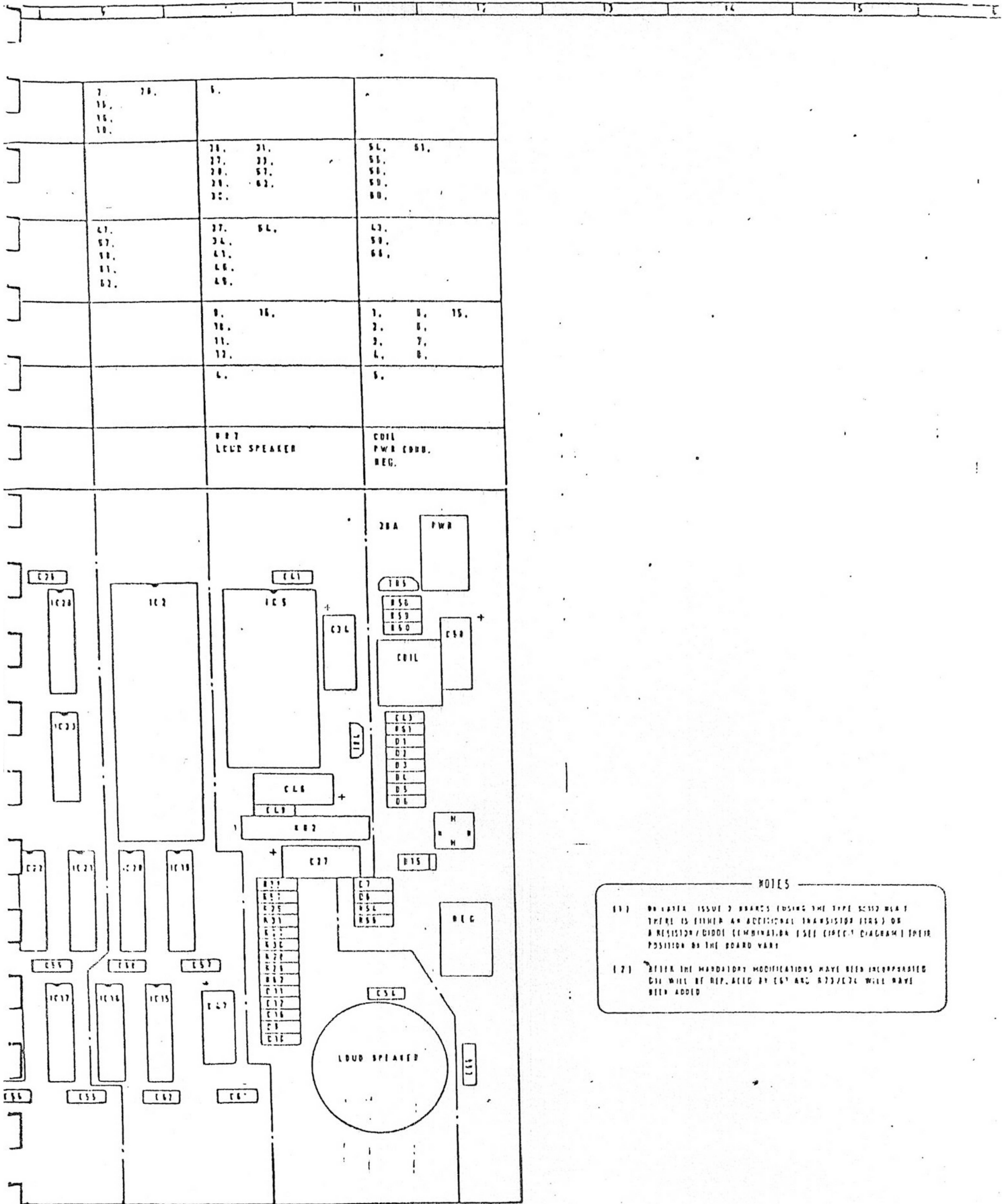
PRINTED CIRCUIT BOARD (ISSUE 3) FIG. 5.2  
 COMPONENT LAYOUT. DSK12756





PRINTED CIRCUIT BOARD (ISSUE 4A) COMPONENT LAYOUT FIGURE 2



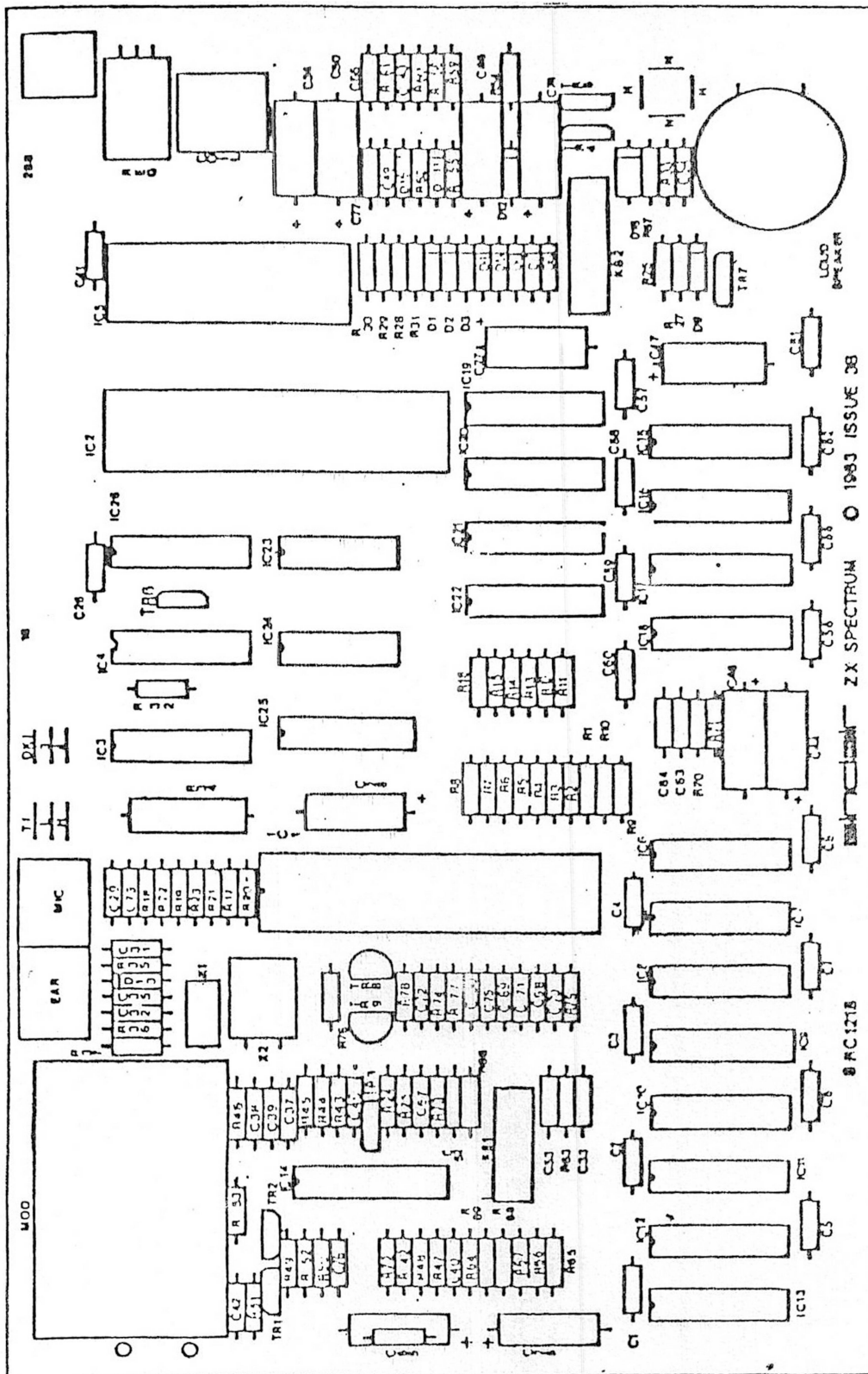


NOTES

(1) ON LATER ISSUE 3 BRACS (USING THE TYPE SC512 WEA 1 THERE IS EITHER AN ADDITIONAL TRANSISTOR (TR5) OR A RESISTOR/DIODE (EMMINATED) (SEE SPEC' DIAGRAM) THEIR POSITION ON THE BOARD VARY

(2) AFTER THE MANDATORY MODIFICATIONS HAVE BEEN INCORPORATED C11 WILL BE REP. BY C67 AND R12/12L WILL HAVE BEEN ADDED

PRINTED CIRCUIT BOARD (ISSUE 2) FIG. COMPONENT LAYOUT CSK10



PRINTED CIRCUIT BOARD (ISSUE 3B) FIG 5.3  
 COMPONENT LAYOUT





SUPPLEMENT NO. 2  
ZX Spectrum +  
FEBRUARY 1985

Sub-Section	LIST OF CONTENTS	Page No.
1	Introduction	S2.1
2	Conversion Procedure - Spectrum to Spectrum+	S2.1
3	Assembly of the Keyboard for the Spectrum+	S2.2
4	Keyboard Operation	S2.3

## 1. INTRODUCTION

- 1.1 The ZX Spectrum+ is basically the same as the 48k ZX Spectrum with a different keyboard and case, and a reset button. The board circuitry is similar apart from the reset button and the fitment of an extra resistor.
- 1.2 The layout of the keyboard is different, which because of its complexity now needs a five-layer membrane. The spring action of the keys is provided by a bubble mat.

## 2. CONVERSION PROCEDURE - SPECTRUM TO SPECTRUM+

- (a) Remove board from the early version case.
- (b) Change heatsink (on Issue 1 and Issue 2 boards only), retaining the triangular insulator, if originally fitted.
- (c) Connect the reset switch across C27 on the top side of the board.
- (d) Test keyboard, especially STOP.
- (e) If STOP does not work, connect a 22 k $\Omega$  resistor across R68. (On the Issue 1 board, connect a 22 k $\Omega$  resistor between pins 1 and 5 of RP1, on the reverse side of the board).
- (f) Fit four rubber feet to the underside of the case.
- (g) Fit board to case bottom.
- (h) Press the reset switch into the recess in the side wall (ensure that the leads are not trapped).
- (j) Fit foam pads: one to the top of the modulator; and on Issue 3 (and higher issue boards), two on the top of the heatsink. These are to protect the membrane tails from chafing.
- (k) Drop folding legs into slots. Sit the springs on top of the legs.

- (m) Connect the keyboard flextails.
- (n) Fit the top cover, taking care not to crease the tails.
- (p) Test.
- (q) Fit warranty seal, if applicable.

For details, see ZX Spectrum+ upgrade instructions, which accompany the upgrade kits.

### 3. ASSEMBLY OF THE KEYBOARD FOR THE SPECTRUM+

- 3.1 The flextails running from the keyboard to the clamps should lie in an S shape, to prevent tension in the membrane. This is achieved by ensuring that the end of the tracks on the middle layer protrude by 1 mm past the clamps. This is easily seen on the wider tail, but not so clear on the narrow one. Visible markers are provided on future membranes.
- 3.2 When clamping the flextails, ensure that an extra packing piece is included under the tails at the clamp position. (These are fitted to current production models). These should be approximately 0.75 mm thick, and as wide as the tail. Paxolin is a suitable material. This section does not apply to any Spectrum+ which has S as the first digit in the serial number.
- 3.3 When assembling the keyboard, it is advisable to tighten the screws in the following order:
  - Centre line of 3 screws first
  - Screws adjacent to tail clamps last.

The screws should be tightened to the minimum to give a firm fit, (e.g. a quarter-turn back from full tightness).
- 3.4 Ensure that on each membrane tail the 2 tail surfaces are stuck together, to avoid short circuits on the board. This is best achieved by using a piece of double-sided tape, or a pair of tabs round the edges, near the connector end. This is current practice in production.
- 3.5 Both metal and plastic reaction plates are possible. The metal plate has to be accompanied by a plastic insulator. The plastic reaction plate is simpler and cheaper. The metal plate needs 6.5 mm fixing screws and the plastic plate needs 8 mm.
- 3.6 It is advisable to check the operation of all the keys on a new assembled keyboard.

#### 4. KEYBOARD OPERATION

- 4.1 The Spectrum+ keyboard is in effect two switching membranes in parallel, a 'top' membrane and a 'lower' membrane, as shown in Figures 1 and 2.
- 4.2 The top membrane is similar to that for the Spectrum 48k, except that pressing any one of the following keys also makes contact between row 1 and column 6 on the top membrane in addition to their dedicated row/column positions:

TRUE VIDEO	EXTEND MODE	CURSOR →
INV VIDEO	EDIT	CURSOR ←
BREAK	CAPS LOCK	CURSOR ↑
DELETE		CURSOR ↓
GRAPH		

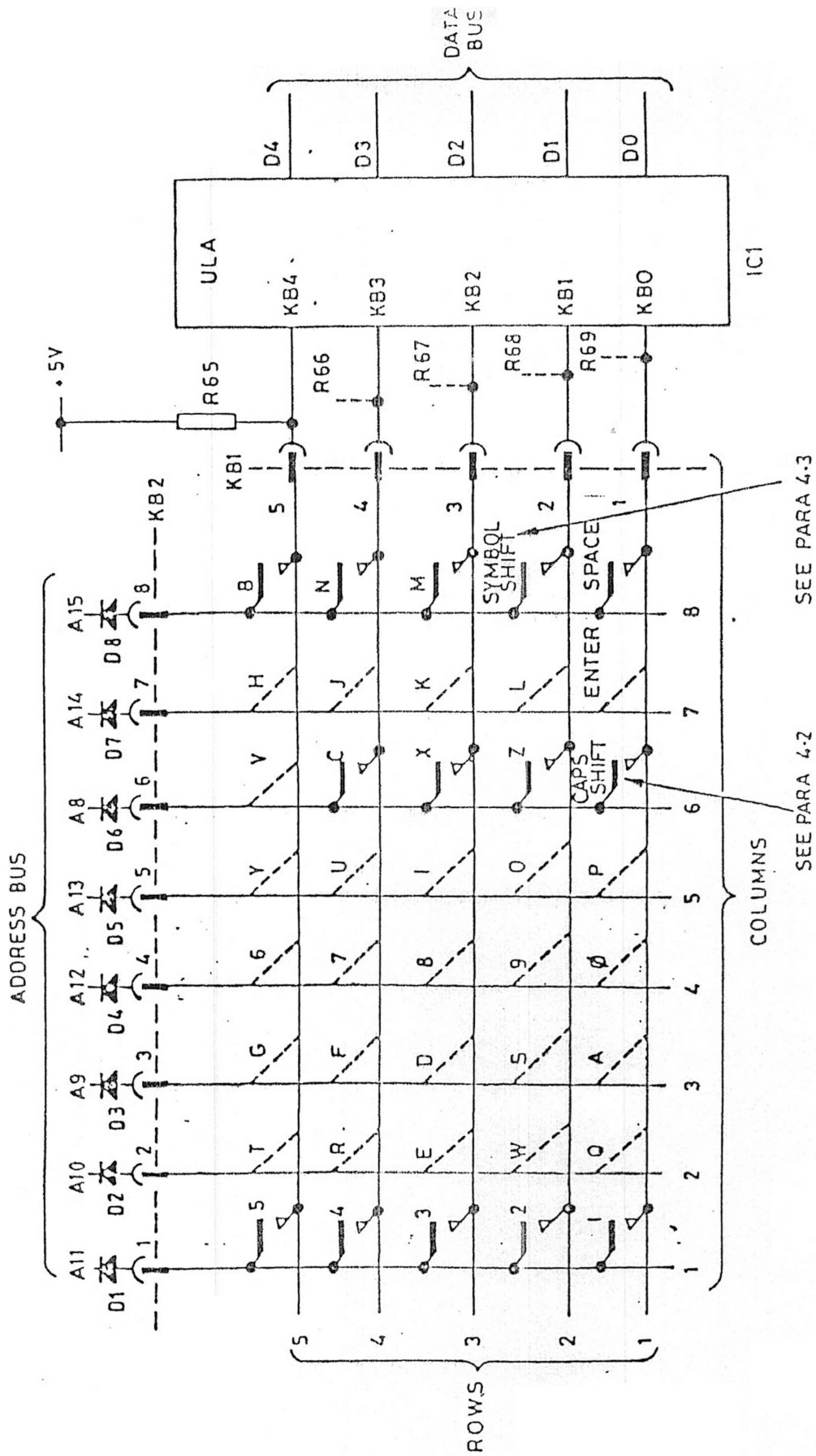
For example, pressing TRUE VIDEO connects row 1/column 6 on the top membrane as well as row 3/column 1 on the lower membrane.

- 4.3 Also pressing any one of the following keys also makes contact between row 2 and column 8 on the top membrane in addition to their dedicated row/column positions.

- . (full stop)
- ; (semi-colon)
- " (inverted commas)
- , (comma)

For example, pressing the full stop key connects row 2/column 8 on the top membrane as well as row 3/column 8 on the lower membrane.

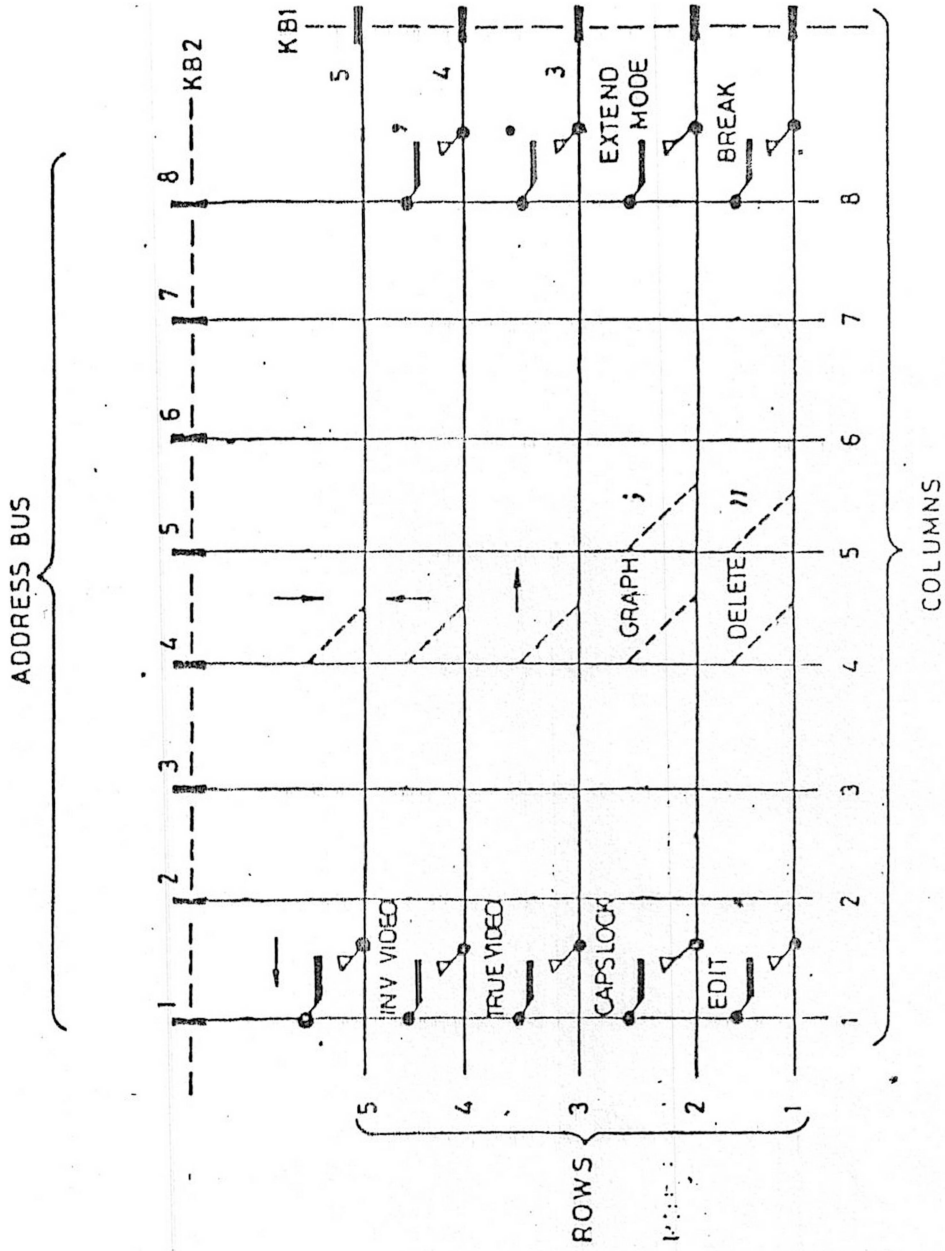




SEE PARA 4.2

SEE PARA 4.3

FIG 1 SPECTRUM+ KEYBOARD : TOP MEMBRANE



NOTE: FOR OPERATION OF THESE KEYS SEE SUB-SECTION 4

FIG 2 SPECTRUM+ KEYBOARD : LOWER MEMBRANE

SECTION 5  
PARTS LIST

Sub-Section	LIST OF CONTENTS	Page No.
1	Introduction	5.1
2	Notes to Table 5.2	5.1

1. INTRODUCTION

1.1 Parts lists for the ZX SPECTRUM are provided in table form; one for the case assembly (Table 5.1) and another for the board assembly (Table 5.2). The latter covers the Issue 2 and 3 Spectrums and is related to the board layout diagrams given in Figure 5.1 and 5.2. Table 5.2 also lists the alternative components which the service engineer will occasionally find on production versions of the Issue 2 board or may introduce retrospectively in order to improve performance. These components are listed in the column headed 'ISSUE 2 MODS' with references to notes against them. These notes are explained below.

2. NOTES TO TABLE 5.2 .

- (1) The alternative values given for R47, R49, R56 and R63 are used if the ULA fitted is Type 6C001.
- (2) The alternative values for R48, R50, R72 and C65 are introduced to improve the colour quality.
- (3) C74 is essential on all Issue 2 boards and should be fitted retrospectively. At the same time R60 must be replaced with the larger value.
- (4) The introduction of alternative components for R24 and R27 is essential. At the same time C67 replaces D14 and R73 is added.
- (5) Issue 2 boards fitted with the Type 5C112 ULA have either a transistor (1R6) or diode/resistor modification (see Issue 2 circuit diagram for details).
- (6) On Issue 3 boards only crystal X2 must have a close tolerance specification (i.e. 10 ppm absolute, 10 ppm 20°C to 60°C, 5 ppm per year.)
- (7) On Issue 3B boards, the d.c. converter design has improved reliability. R60 is changed from 270 $\Omega$  to 68 $\Omega$  and C49 is changed from 47 $\mu$ F to 560 $\mu$ F. Capacitor C77 (100nF) has been added.

2.1 General Capacitor Change. Early Issue 2 units were manufactured using a considerable number of 47 nF and 100 nF disc capacitors. Where these occur the service engineer should take the opportunity to replace C41 and C49 with axial types.

TABLE 5.1 CASE ASSEMBLY

DESCRIPTION	MANUFACTURER
Assembled board as appropriate (Table 5.2)	
Moulded Upper Case	
Moulded Lower Case	
Keyboard Mat (Rubber)	
Keyboard Membrane	N.F.I.
Keyboard Template	
Rubber Feet	
Self Tap Screws (case fixings); 5 off	
Double-sided adhesive tape - 12 mm wide; Tesafix 959	B.D.F. Tesa
Double sided adhesive tape - 6 mm wide; Tesafix 959	B.D.F. Tesa
Self Tap Screw (board fixing); 1 off	

TABLE 5.2 BOARD ASSEMBLY

Circuit Reference	Issue 2	Issue 2 Mod	Notes	Issue 3	Rating/Tol	Manufacture Type
CAPACITORS (Unless otherwise stated all capacitors are axial types)						
C1-C8	47 nF			47 nF	25V, 10%	Ceramic
C25	22 $\mu$ F			22 $\mu$ F	10V, -10%+80%	Elect.
C26	47 nF			47 nF	25V, 10%	Ceramic
C27	1 $\mu$ F			1 $\mu$ F	50V, -10%	Ceramic
C28	22 $\mu$ F			22 $\mu$ F	10V, -10%+80%	Elect.
C29/C30	47 nF			47 nF	25V, 10%	Ceramic
C31/C32	100nF			100nF	25V, 10%	Ceramic
C33	47 nF			47 nF	25V, 10%	Ceramic
C34	22 $\mu$ F			22 $\mu$ F	10V, -10%+80%	Elect.
C35	10 nF			10 nF	25V, 10%	Ceramic
C36	47 nF			-	25V, 10%	Ceramic
C37/C38	33 pF			33 pF	25V, 10%	Ceramic
C39	10 nF			10 nF	25V, 10%	Ceramic
C40/C42	47 nF			47 nF	25V, 10%	Ceramic
C43	100nF			100nF	25V, 10%	Ceramic
C44/C45	100 $\mu$ F			100 $\mu$ F	16V, 10%+80%	Ceramic
C46	1 $\mu$ F			1 $\mu$ F	50V, -10%+80%	Elect.
C47	22 $\mu$ F			22 $\mu$ F	10V, -10%+80%	Elect.
C48	47 nF			47 nF	25V, 10%	Ceramic
C49	47 nF		(7)	47/560pF	25V, 10%	Ceramic
C50	22 $\mu$ F			22 $\mu$ F	10V, -10%+80%	Elect.
C51	-			-	-	-
C52/C53	150pF			150pF	25V, 10%	Ceramic
C54	470pF			-	25V, 10%	Ceramic
C55-C62	47 nF			47 nF	25V, 10%	Ceramic
C63	47 pF			47 pF	25V, 10%	Ceramic
C64	100pF			100pF	25V, 10%	Ceramic
C65	100 $\mu$ F	22 $\mu$ F	(2)	22 $\mu$ F	20V, 10%+80%	Elect.
C66	47 nF			47 nF	25V, 10%	Ceramic
C67	-	100pF	(4)	100pF	25V, 10%	Ceramic
C68-C71	-	-		100nF	25V, 10%	Ceramic
C72/C73	-	-		16 pF	25V, 10%	Ceramic
C74	-	4.7 $\mu$ F	(3)	4.7 $\mu$ F	5V min	Elect.
C75	-	-		100nF	25V, 10%	Ceramic
IC1/IC2	-	-		-	-	-
C76	-	-		47 nF	25V, 10%	Ceramic
C77	-	-	(7)	100nF	25V, 10%	Ceramic

COIL

Circuit Reference	Issue 2	Issue 2 Mod	Notes	Issue 3	Rating/Tol	Manufacture Type
Coil	SPECTRUM	-	-	SPECTRUM	-	1703

## CONNECTORS

Reference	Description	Manufacturer/ Part Number
EAR	3.5 mm jack socket	
MIC	3.5 mm jack socket	
PWR	2.1 mm co-axial socket	
KB1	5-way ribbon connector	Molex 5229-05CPB
KB2	8-way ribbon connector	Molex 5229-08CPB

## CRYSTALS

Circuit Reference	Issue 2	Issue 2 Mod	Notes	Issue 3	Manufacture Type
X1	14.000000MHz	-	Note (6)	14.000000MHz	
X2	4.433619MHz	-		4.433619MHz	

## DIODES

Circuit Reference	Issue 2	Issue 2 Mod	Notes	Issue 3	Manufacture Type
D1-D9	1N4148	-	-	1N4148	Signal
D10	1N4148	-	-	-	Signal
D11-D13	1N4148	-	-	1N4148	Signal
D14	1N4148	-	(4)	-	Signal
D15	BA157	-	-	BA157	Rectifier
D16	5V1	-	-	5V1	Zener

## INTEGRATED CIRCUITS

Circuit Reference	Issue 2	Issue 2 Mod	Notes	Issue 3	Manufacture Type
IC1(ULA)	5C102	5C112	(1)	6C0001	Ferranti
IC2(CPU)	Z80A/ $\mu$ 780	-		Z80A/ $\mu$ 780	-
IC3/IC4	74LS157N	-	-	74LS157N	Not National
IC5(ROM)	SPECTRUM	SPECTRUM	-	SPECTRUM	NEC/Hitachi
IC6-IC13	4116	-	-	4116	150 ns
IC14	LM1889	-	-	LM1889	
IC15-IC22	T14532	-	-	T14532/ 48k only	Texas/ OKI
IC23	74LS32N	-	-	74LS32N 48k only	
IC24	74LS00N	-	-	74LS00N 48k only	
IC25/IC26	74LS157N	-	-	74LS157N 48k only	Not National