

Sinclair Spectrum

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SERVICING MANUAL

FOR

ZX SPECTRUM®

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for SINCLAIR RESEARCH LTD

MARCH 1984

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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.

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

— 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.

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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.

SECTION 1

SYSTEM DESCRIPTION

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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.

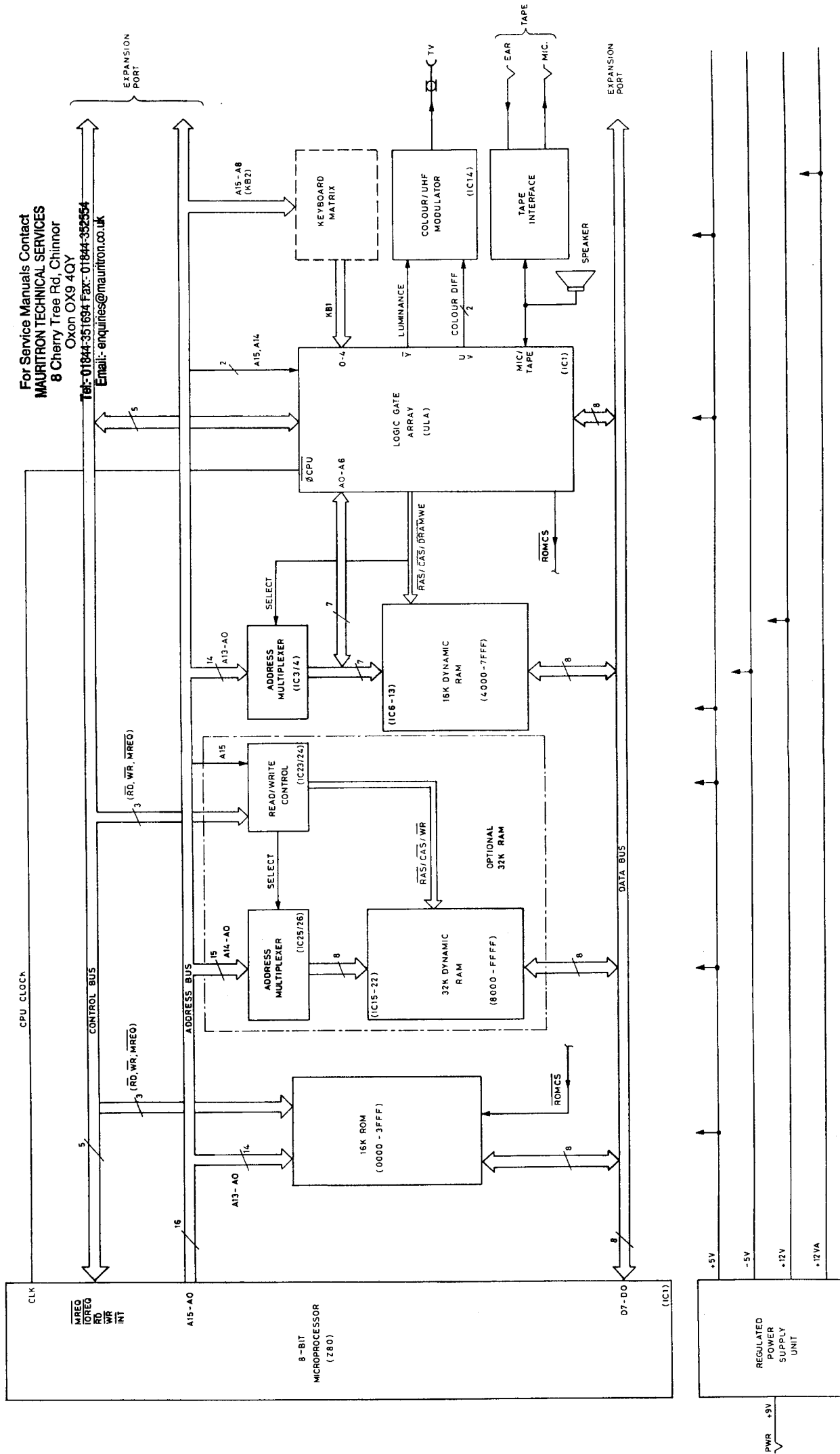
2. ARCHITECTURE

- 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 μ 780 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 ($\overline{\text{MREQ}}$), 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 ($\overline{\text{IORQ}}$) 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 ($\overline{\text{RD}}$ and $\overline{\text{WR}}$) 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 ($\overline{\text{INT}}$). 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.

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ZX SPECTRUM BLOCK DIAGRAM FIG 1.1

- 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.

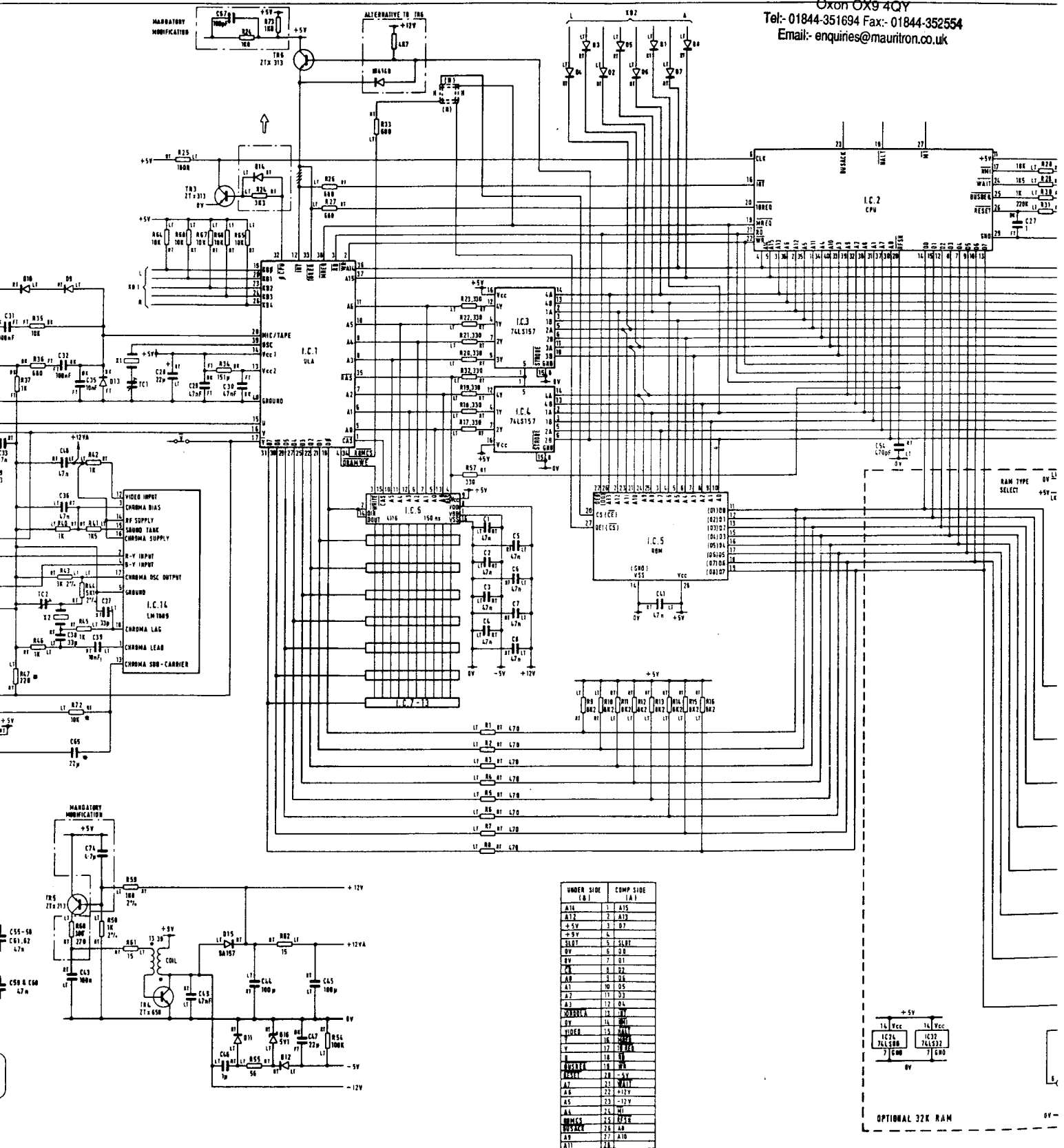
4. MEMORY ORGANISATION

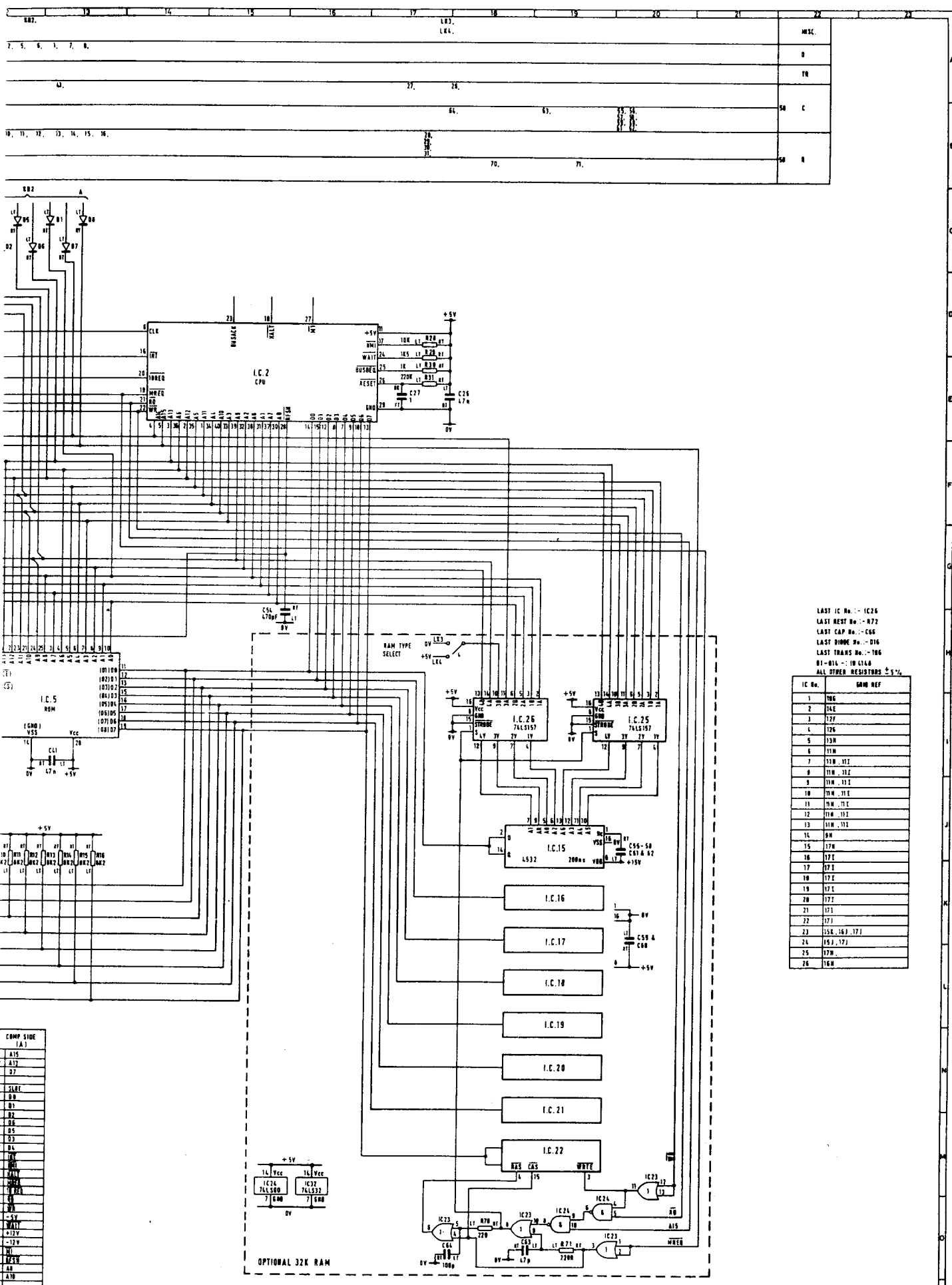
- 4.1 In the standard 16k Spectrum there are 32k bytes of addressable memory equally divided between ROM and RAM.
- 4.2 The lower 16k bytes of memory (addresses 0000 - 3FFF) are implemented in a single ROM (IC5) which holds the monitor program. This program is a complex Z80 machine code program divided 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. MREQ and RD enable the ROM and the ROM outputs respectively. A third input (CS) derived by the ULA (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 ROMCS output is effectively inhibited. Interface 1 uses this

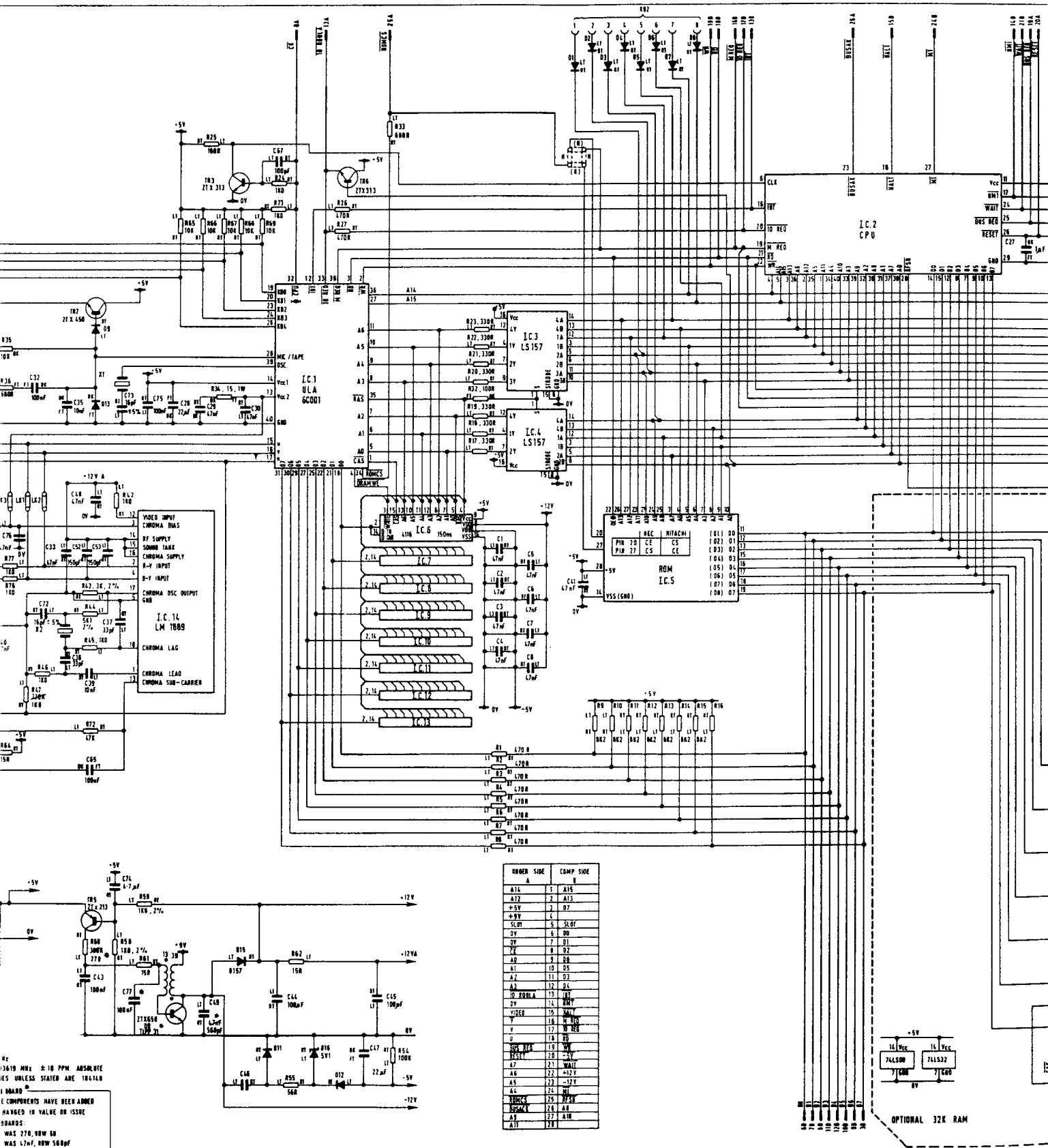
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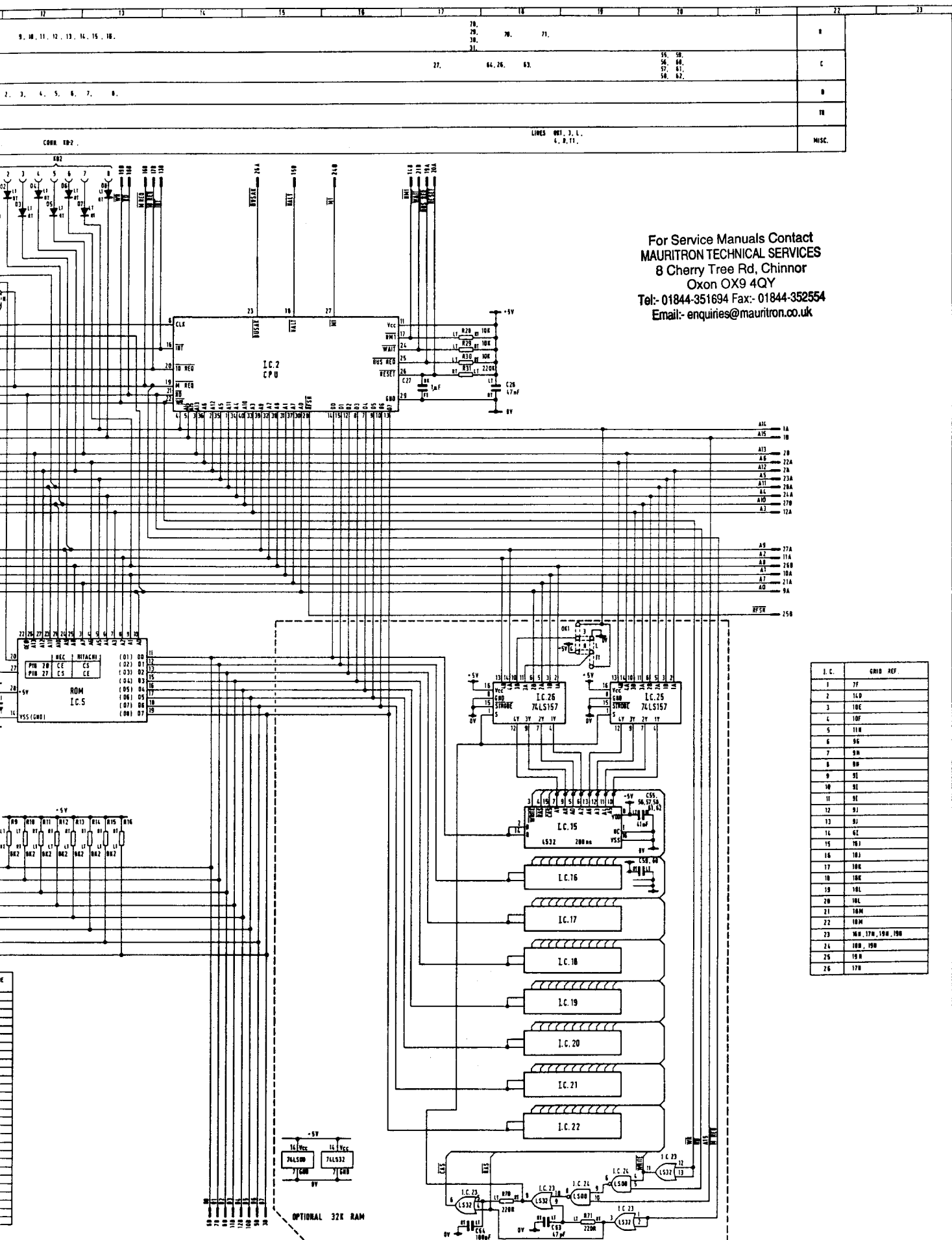


ZX SPECTRUM (ISSUE 2) FIG.1.4
CIRCUIT DIAGRAM ESK 12740
ISSUE 1A

35	5	6	7	8	9	10	11	12	13	14	15	16	17
36	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
101	102	103	104	105	106	107	108	109	110	111	112	113	114
115	116	117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140	141	142
143	144	145	146	147	148	149	150	151	152	153	154	155	156
157	158	159	160	161	162	163	164	165	166	167	168	169	170
171	172	173	174	175	176	177	178	179	180	181	182	183	184
185	186	187	188	189	190	191	192	193	194	195	196	197	198
199	200	201	202	203	204	205	206	207	208	209	210	211	212
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227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254
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381	382	383	384	385	386	387	388	389	390	391	392	393	394
395	396	397	398	399	400	401	402	403	404	405	406	407	408
409	410	411	412	413	414	415	416	417	418	419	420	421	422
423	424	425	426	427	428	429	430	431	432	433	434	435	436
437	438	439	440	441	442	443	444	445	446	447	448	449	450
451	452	453	454	455	456	457	458	459	460	461	462	463	464
465	466	467	468	469	470	471	472	473	474	475	476	477	478
479	480	481	482	483	484	485	486	487	488	489	490	491	492
493	494	495	496	497	498	499	500	501	502	503	504	505	506
507	508	509	510	511	512	513	514	515	516	517	518	519	520
521	522	523	524	525	526	527	528	529	530	531	532	533	534
535	536	537	538	539	540	541	542	543	544	545	546	547	548
549	550	551	552	553	554	555	556	557	558	559	560	561	562
563	564	565	566	567	568	569	570	571	572	573	574	575	576
577	578	579	580	581	582	583	584	585	586	587	588	589	590
591	592	593	594	595	596	597	598	599	600	601	602	603	604
605	606	607	608	609	610	611	612	613	614	615	616	617	618
619	620	621	622	623	624	625	626	627	628	629	630	631	632
633	634	635	636	637	638	639	640	641	642	643	644	645	646
647	648	649	650	651	652	653	654	655	656	657	658	659	660
661	662	663	664	665	666	667	668	669	670	671	672	673	674
675	676	677	678	679	680	681	682	683	684	685	686	687	688
689	690	691	692	693	694	695	696	697	698	699	700	701	702
703	704	705	706	707	708	709	710	711	712	713	714	715	716
717	718	719	720	721	722	723	724	725	726	727	728	729	730
731	732	733	734	735	736	737	738	739	740	741	742	743	744
745	746	747	748	749	750	751	752	753	754	755	756	757	758
759	760	761	762	763	764	765	766	767	768	769	770	771	772
773	774	775	776	777	778	779	780	781	782	783	784	785	786
787	788	789	790	791	792	793	794	795	796	797	798	799	800
801	802	803	804	805	806	807	808	809	810	811	812	813	814
815	816	817	818	819	820	821	822	823	824	825	826	827	828
829	830	831	832	833	834	835	836	837	838	839	840	841	842
843	844	845	846	847	848	849	850	851	852	853	854	855	856
857	858	859	860	861	862	863	864	865	866	867	868	869	870
871	872	873	874	875	876	877	878	879	880	881	882	883	884
885	886	887	888	889	890	891	892	893	894	895	896	897	898
899	900	901	902	903	904	905	906	907	908	909	910	911	912
913	914	915	916	917	918	919	920	921	922	923	924	925	926
927	928	929	930	931	932	933	934	935	936	937	938	939	940
941	942	943	944	945	946	947	948	949	950	951	952	953	954
955	956	957	958	959	960	961	962	963	964	965	966	967	968
969	970	971	972	973	974	975	976	977	978	979	980	981	982
983	984	985	986	987	988	989	990	991	992	993	994	995	996
997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010



R1: 2K, 10%
 R2: 10K, 10%
 R3: 10K, 10%
 R4: 10K, 10%
 R5: 10K, 10%
 R6: 10K, 10%
 R7: 10K, 10%
 R8: 10K, 10%
 R9: 10K, 10%
 R10: 10K, 10%
 R11: 10K, 10%
 R12: 10K, 10%
 R13: 10K, 10%
 R14: 10K, 10%
 R15: 10K, 10%
 R16: 10K, 10%
 R17: 10K, 10%
 R18: 10K, 10%
 R19: 10K, 10%
 R20: 10K, 10%
 R21: 10K, 10%
 R22: 10K, 10%
 R23: 10K, 10%
 R24: 10K, 10%
 R25: 10K, 10%
 R26: 10K, 10%
 R27: 10K, 10%
 R28: 10K, 10%
 R29: 10K, 10%
 R30: 10K, 10%
 R31: 10K, 10%
 R32: 10K, 10%
 R33: 10K, 10%
 R34: 10K, 10%
 R35: 10K, 10%
 R36: 10K, 10%
 R37: 10K, 10%
 R38: 10K, 10%
 R39: 10K, 10%
 R40: 10K, 10%
 R41: 10K, 10%
 R42: 10K, 10%
 R43: 10K, 10%
 R



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

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

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- 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 (ϕCPU) 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.

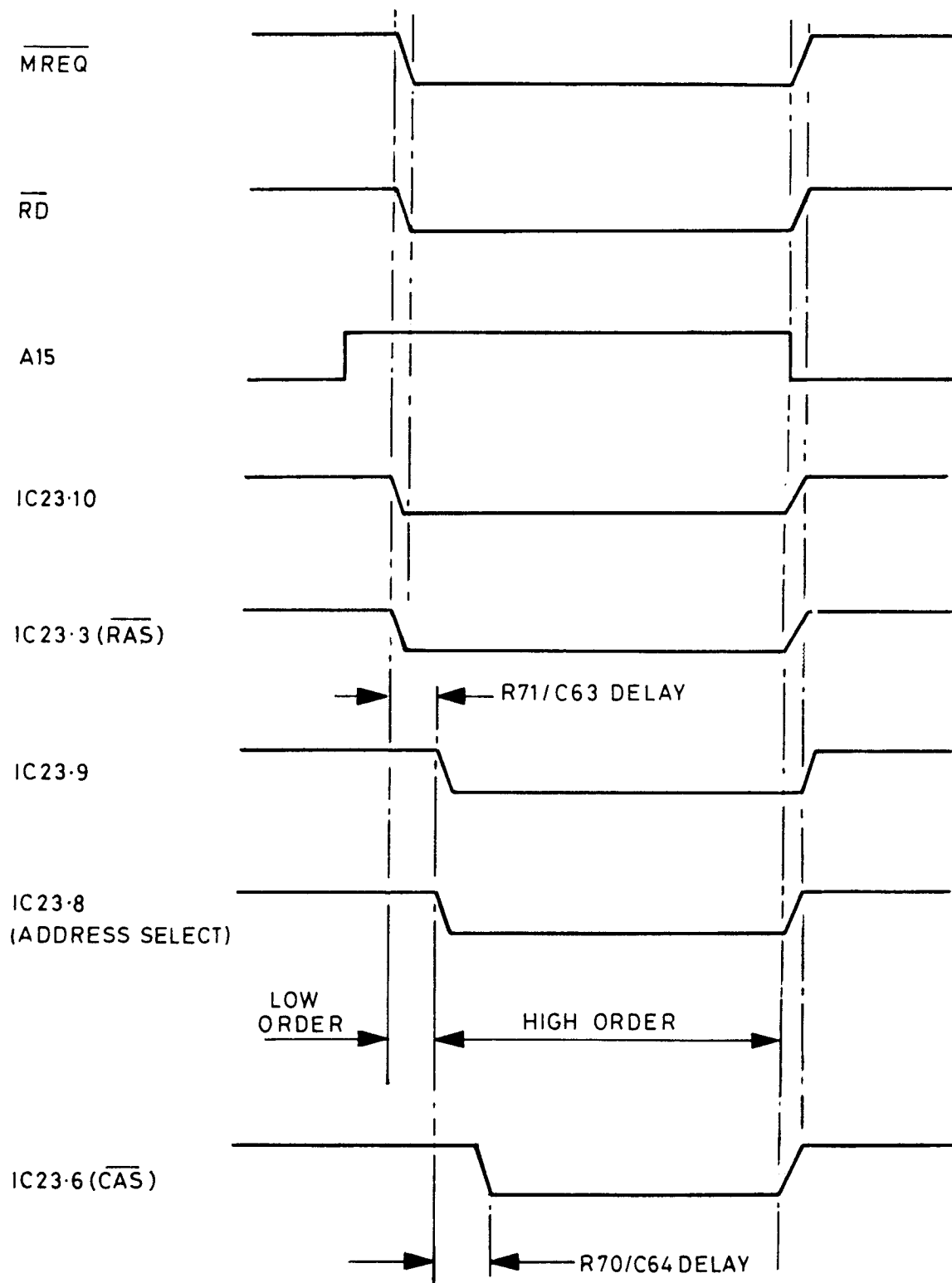


FIG 1.2 EXPANSION RAM $\overline{\text{RAS}}/\overline{\text{CAS}}$ TIMING (READ CYCLE SHOWN)

- 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 waveforms 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 Y 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 KB0 to KB4 remain high.

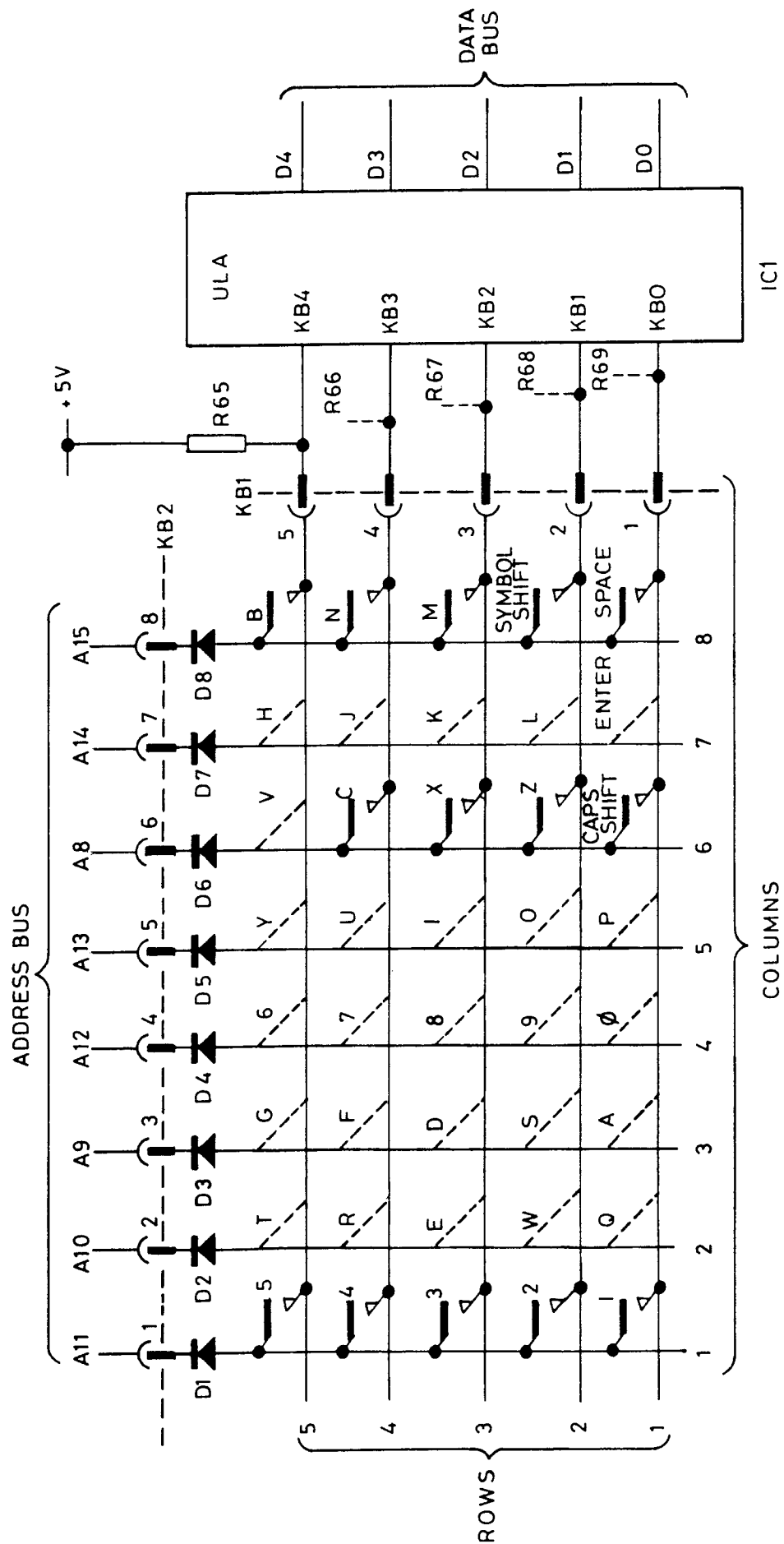


FIG 1.3 KEYBOARD MATRIX INTERCONNECTIONS

- 5.3.2 When the keyboard scanning routines are entered the CPU performs successive I/O read cycles setting the I_OREQ and R_D lines to the ULA, low. At the same time, the I/O port addresses placed on the upper half of the address bus are modified with each cycle such that each of the address lines A15 through A8 is set low in turn, the other lines remaining high.
- 5.3.3 The sequence starts with I/O port address FE driving address line A8 low. The keyboard matrix also sees this potential on column 6 applied via D6 and the ribbon cable KB2. Thus, when any of the switches on the inter-section with column 6 is pressed, the corresponding row output supplying the ULA via the second ribbon cable (KB1), is pulled low. The row signal(s) is subsequently inverted by the ULA and placed on one of the five low order data bus lines. For example, if the CAPS SHIFT key is pressed row one output drives data bus D0 high and so on. The sequence ends with I/O address 7F when column 8 is addressed. In this instance, operation of the SPACE key drives D0 high. Clearly, the keyboard scanning routines make the distinction between the CAPS SHIFT and SPACE key by knowing which address line is being driven.

5.4 Tape Interface

- 5.4.1 When LOADING or SAVEing programs using a cassette recorder, the ULA transfers information between the MIC and EAR sockets and the data bus, performing A/D and D/A conversions as required. Since the LOAD and SAVE functions are mutually exclusive, a single pin on the ULA (i.e. pin 28) is used both for input and output. Separate I/O read/write cycles to port address 254 configure the pin accordingly. During the LOAD operation the CPU executes successive I/O read cycles, reading the EAR input off data bus 6. When performing a SAVE operation, the CPU executes successive I/O write cycles, this time writing data to the MIC output via data bus 3.
- 5.4.2 To ensure that I/O cycles are correctly implemented, the I_OREQ line supplying the ULA is gated with address line A0 via TR6. Thus, if any memory transactions occur where A0 is high (i.e. not port address 254) then the I_OREQ input is forced high inhibiting any attempt to perform an I/O cycle.
- 5.4.3 **Loudspeaker (BEEP) Operation.** It should be noted that while SAVEing, the level of the MIC output is barely sufficient to drive the loudspeaker via D9 and TR7 (D10). However, during the execution of a BEEP instruction the CPU writes instead to port 254 on data bus 4. This effectively boosts the MIC output, driving the loudspeaker so that the BEEP tone can be easily heard. During the execution of such an instruction the cassette recorder is not running so there is no conflict at the MIC/EAR sockets.

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 UHF 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.

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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.

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SECTION 3

SETTING UP AND SYSTEM TEST

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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 (mV) Voltage Tolerance		Overall Range (mV)
VR1	4	130 $\pm$ 20	+50	-5	+45 to +150
VR2	2	75 $\pm$ 20	-50	-50 +5	-45 to -100

- 1.4 **Sub-Carrier Oscillator.** The chrominance sub-carrier oscillator frequency should be 4.433619 MHz $\pm$ 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.

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SECTION 4
FAULT DIAGNOSIS AND REPAIR

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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 μ 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

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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 μ F and 100 μ 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 (IN 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	2	2	3
ULA Type	5C112	6C001	6C001
Component			
R47	220 Ω	1 k	1 k
R49	8 k2	10 k	10 k
R56	220 Ω	470 Ω	1 k
R63	220 Ω	470 Ω	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 Ω) must be removed, and the 470 pF capacitor is not required.
- (d) 47 k resistor between pin 13 of LMI889 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 μ 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 Ω to 470 Ω
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 Ω to 270 Ω and connecting a 4.7 μ 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 μ F to 22 μ F

- (b) Early Issue 2 boards were manufactured using a considerable number of 47 μ F and 100 μ 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 Ω to 68 Ω
TR4 can be either ZTX650 or TIPP31

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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 inter-dependence 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 unstabilised 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 TR3 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	-	<u>INT</u>	Pin 17	-	<u>NMI</u>
	Pin 20	-	<u>IOREQ</u>	Pin 24	-	<u>WAIT</u>
	Pin 19	-	<u>MREQ</u>	Pin 25	-	<u>BUS/REQ</u>
	Pin 21	-	<u>RD</u>	Pin 26	-	<u>RESET</u>
	Pin 22	-	<u>WR</u>			
(b) IC22:	Pin 4	-	<u>RAS</u>	Pin 3	-	<u>WRITE</u>
	Pin 15	-	<u>CAS</u>			

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)

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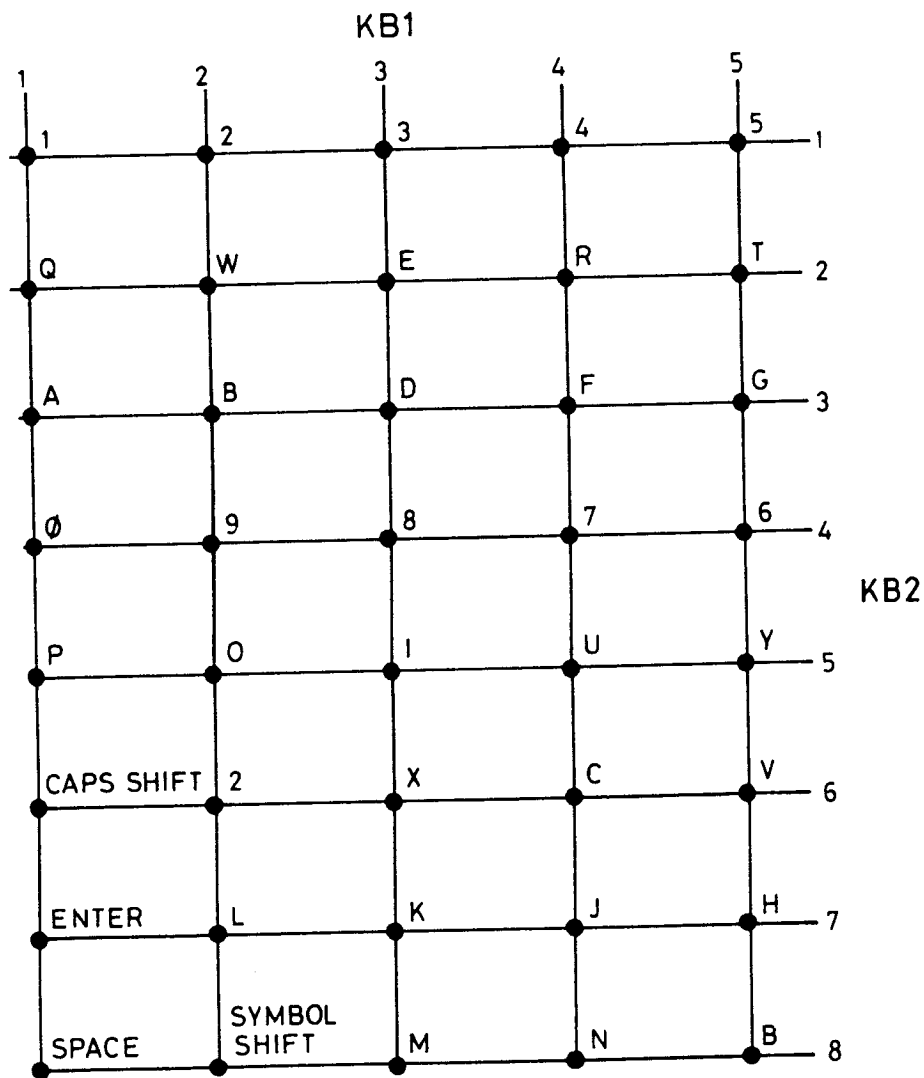
If answer B is anything other than 170 look up in the following table which IC to change (e.g. if answer B is 234 change IC21). Similarly, if answer A is other than 85 refer to the table to find the faulty IC.

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.



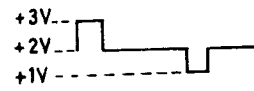
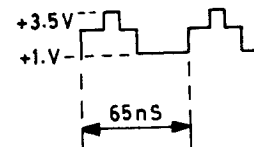
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FIGURE 4.1 KEYBOARD FORMAT

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.	TR4 base-collector shorted. Short persists with TR4 removed. TR4 blows again.	Remove TR4 1. Check TR5 and C44. 2. Visually check track. 3. Check TR4. 1. Change TR4 and TR5 (even though TR5 checks out). 2. Check that TR5 circuit components are to latest specification.
Not initialising.	No '(C)1982 Sinclair Research Ltd' statement.	Follow fault-finding procedure, paragraph 2.2 above.
No video. NOTE: Table 4.1 sets out typical signals found on IC14 pins 1-18 IC14 pins 1-18.	No video. No video after ULA changed. No +5V input. For Service Manuals Contact MAURITRON TECHNICAL SERVICES 8 Cherry Tree Rd, Chinnor Oxon OX9 4QY Tel:- 01844-351694 Fax:- 01844-352554 Email:- enquiries@mauritron.co.uk	1. Change IC1. 2. Check TR1 and TR2. 1. Visually check IC1 and socket. 3. Check for shorting between C65 and R53. 4. Carry out fault-finding procedure, para 2.2 above. 1. Check voltage drop across R64. 2. Check +5V regulator O/P and +9V regulator I/P. 3. Check PWR socket not shorted. 4. Check power unit.

AREA	SYMPTOM	ACTION
No video. (contd)	No VIDEO INPUT at IC14 pin 12.	1. Check waveform at IC14 pin 13. If correct check TR1 and TR2. 2. Check waveforms at IC1 pins 15, 16 and 17: PIN 15  PIN 16  PIN 17  If correct check VR1, VR2 (Issue 1 and Issue 2 boards). 3. Change IC1. 4. If +5V and VIDEO INPUT correct change modulator.
Corrupt Paper, after ULA change.	- No 3 MHz at IC2 pin 6.	1. Check IC1 socket. 2. Check PWR socket is not intermittent. 3. Check IC1 pin 14 for +5V with no discernible ripple. 1. Low amplitude - check R25. 2. Check TR3. 3. Check IC1 pin 32 for 3 MHz. 4. Check IC1 pin 39 for 14 MHz. 5. Check crystal X1. 6. Check IC1 pin 13 for +3V.

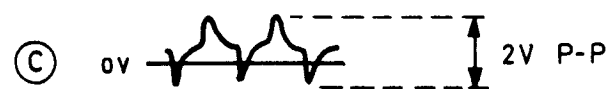
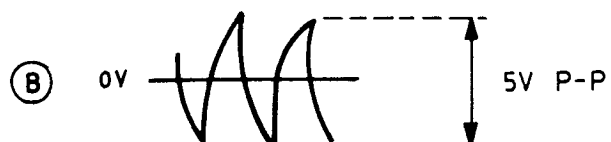
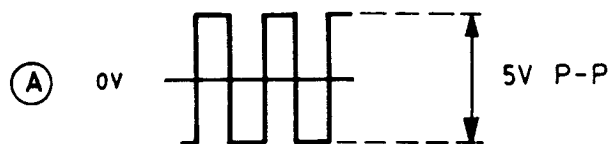
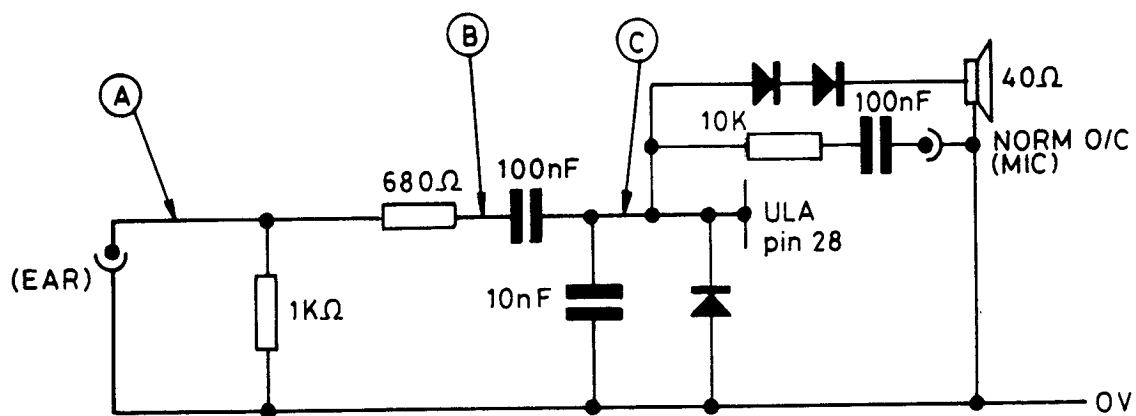
AREA	SYMPTOM	ACTION
Video Incorrect.	Dark Screen.	1. Check tuning. 2. Change modulator.
	Dim 'Sinclair' logo.	1. Check +12V. 2. Check C65 for high impedance. 3. Check R52. 4. Check +5V on IC14 pin 3.
For Service Manuals Contact MAURITRON TECHNICAL SERVICES 8 Cherry Tree Rd, Chinnor Oxon OX9 4QY Tel:- 01844-351694 Fax:- 01844-352554 Email:- enquiries@mauritron.co.uk	Wavy lines across screen.	1. Press down on each electrolytic capacitor to see if lines disappear. If so change that capacitor. 2. Check crystal X2. 3. Check/change TR1 and/or TR2. 4. Check/change IC14.
	Self resetting.	Check TR6.
	Random dynamic squares.	Change C54.
	Paper area too low.	Change IC1.
	Diagonal lines in the border area.	Change R47.
	Distorted video.	1. Check for +3V at IC1 pin 13. 2. Change C30.
Colour tuning faults (Issue 1 and Issue 2 boards)	-	Visually check IC14 circuits.
	VR1 or VR2 fails to adjust IC14 pin 13 waveform.	1. Monitor IC14 pin 2 trimming VR2. 2. Monitor IC14 pin 4 trimming VR1. 3. Change IC14.

AREA	SYMPTOM	ACTION
Colour tuning faults. (cont'd)	VR1 or VR2 d.c. shifts IC14 pin 13 waveform. Alternate dark lines on screen. No colour after trimming TC2: IC14 pin 17 not oscillating IC14 pin 17 oscillating but fails to tune. IC14 pin 17 output correct but still no colour (boards at all Issue Nos).	Change IC14. Change IC14. 1. Check crystal X2. 2. Change IC14. 3. Change X2. 1. Check for broken track. 2. Change TC2. 3. Change IC14. 1. With 'Sinclair' logo on screen IC14 pin 2 and IC14 pin 4 should be as follows: The figure shows two timing diagrams. The top diagram, labeled 'PIN 2', shows a single rectangular pulse. The bottom diagram, labeled 'PIN 4', shows two rectangular pulses. A horizontal double-headed arrow between the peaks of the two pulses is labeled '65nS', indicating the time interval between the pulses. 2. If IC14 pins 2 and 4 are correct, change modulator.
Colour faults (Issue 1 - Issue 3 boards.	Pin screen. Blue haze around 'Sinclair' logo. Screen too yellow.	Change crystal X2. If untunable (Issue 1 and Issue 2 boards) change IC14. Change IC14.

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.	KB1 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.

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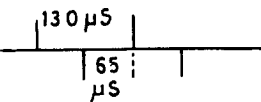
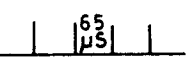
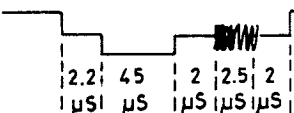
AREA	SYMPTOM	ACTION
Test Program. (cont'd) For Service Manuals Contact MAURITRON TECHNICAL SERVICES 8 Cherry Tree Rd, Chinnor Oxon OX9 4QY Tel:- 01844-351694 Fax:- 01844-352554 Email:- enquiries@mauritron.co.uk	Paper area corrupts during tests.	1. Change IC1. 2. Carry out fault-finding procedure(paragraph 2.2).
	Border colours are striped.	Change IC14.
	Failure messages.	Carry out fault-finding procedure (paragraph 2.2).
	'Test Passed' message not flashing.	Change IC1.
	Reduced memory size.	1. Perform memory test. 2. Change IC1.
Program Loading.	Keyboard does not allow loading.	See keyboard faults.
	Program fails to load.	1. Check jack sockets are fully inserted. 2. If loading stripes in border are unusually wide, check D13. 3. Check/change IC1.
	'Program appears.	Check/Change IC2.



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FIGURE 4.2 SPEAKER LOAD INPUT WAVEFORMS

TABLE 4.1. IC14 (LM1889) PIN SIGNALS

Pin No.	Signal
1	(CHROMA LEAD) SINEWAVE 500mV, 0.2 μ 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 μ s 4V P-P. D.C. 0.8V
18	(CHROMA LAG) SINEWAVE 500mV P-P 2 μ s d.c. 9.5V
6,7,8 9,10, 11	Not Connected
NOTES: (1) Rails and signals taken on switch-on, computer displaying 'Sinclair' logo. (2) No keys pressed (3) All d.c. levels positive wrt 0V	

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)

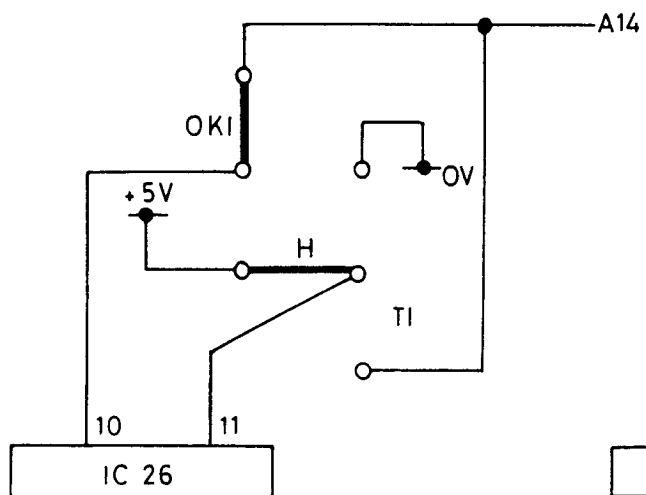
- NOTES: (1) All external RAM ICs must be of the same type (i.e. all -3 or -4 variants).
(2) LINK 3 on the board (IC26, pin 10) should be fitted if IC15-IC22 are type 4532-3.
(3) LINK 4 should be fitted if IC15-IC22 are type 4532-4.

4.3 Issue 3 Board

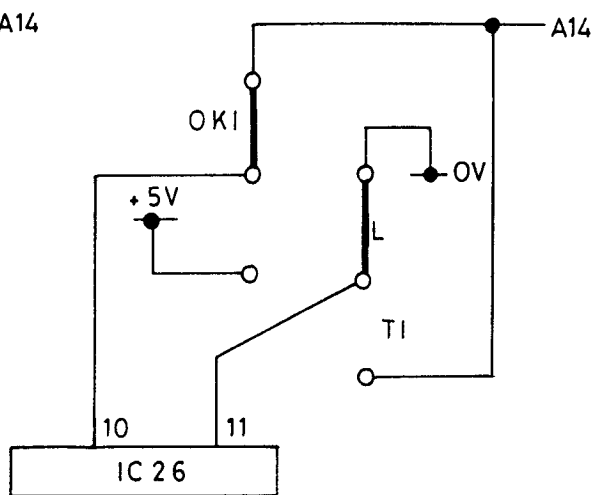
The ICs used on this board are as follows:

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)

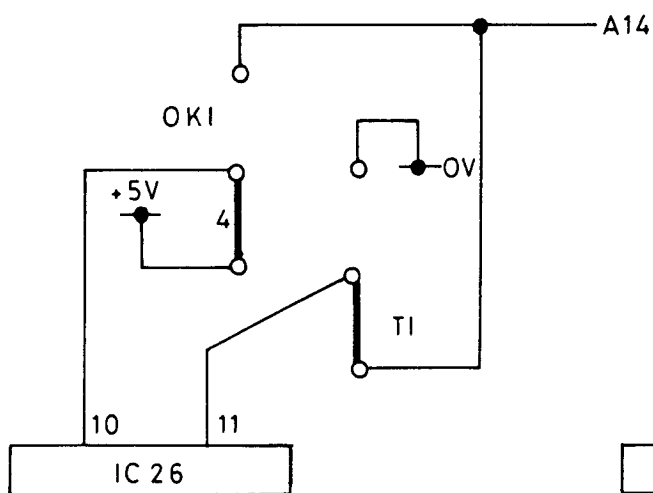
- NOTES: (1) All extension RAM ICs must be of the same type.
(2) Two links must be fitted on the board (grid located between edge connector and m/c jack socket) depending on memory manufacturer and type (high or low enable). See Figure 4.4 for link positions vs manufacturer and IC type.



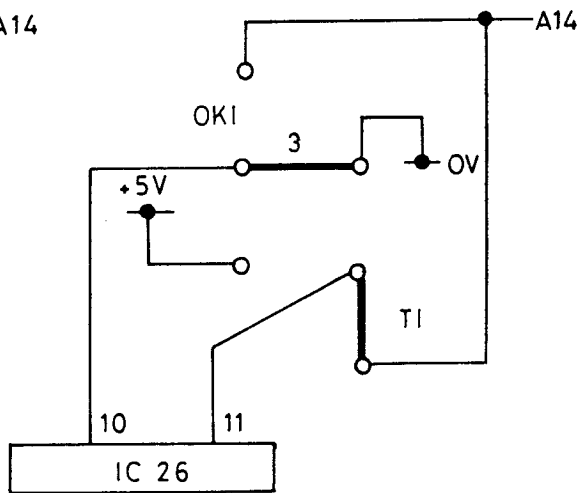
OKI HIGH ENABLE



OKI LOW ENABLE



TI 4532-4



TI 4532-3

FIGURE 4.4 ISSUE 3 LINKS vs IC MANUFACTURER AND TYPE

SECTION 5

PARTS LIST

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

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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 T63 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 (TR6) 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 270Ω to 68Ω and C49 is changed from 47nF to 560pF. 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)	For Service Manuals Contact MAURITRON TECHNICAL SERVICES 8 Cherry Tree Rd, Chinnor Oxon OX9 4QY Tel:- 01844-351694 Fax:- 01844-352554 Email:- enquiries@mauritron.co.uk
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	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
RES	842	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864
RES	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880
RES	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896
RES	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912
RES	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928
RES	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944
RES	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960
RES	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976
RES	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992
RES	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008
RES	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024
RES	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040
RES	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056
RES	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072
RES	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088
RES	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104
RES	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120
RES	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136
RES	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152
RES	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168
RES	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184
RES	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200
RES	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216
RES	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232
RES	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248
RES	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264
RES	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279	1280
RES	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295	1296
RES	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312
RES	1313	1314	1315	1316	1317	1318	1319	1320	1321	1322	1323	1324	1325	1326	1327	1328
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RES	1345	1346	1347	1348	1349	1350	1351	1352	1353	1354	1355	1356	1357	1358	1359	1360
RES	1361	1362	1363	1364	1365	1366	1367	1368	1369	1370	1371	1372	1373	1374	1375	1376
RES	1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387	1388	1389	1390	1391	1392
RES	1393	1394	1395	1396	1397	1398	1399	1400	1401	1402	1403	1404	1405	1406	1407	1408
RES	1409	1410	1411	1412	1413	1414	1415	1416	1417	1418	1419	1420	1421	1422	1423	1424
RES	1425	1426	1427	1428	1429	1430	1431	1432	1433	1434	1435	1436	1437	1438	1439	1440
RES	1441	1442	1443	1444	1445	1446	1447	1448	1449	1450	1451	1452	1453	1454	1455	1456
RES	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471	1472
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RES	1537	1538	1539	1540	1541	1542	1543	1544	1545	1546	1547	1548	1549	1550	1551	1552
RES	1553	1554	1555	1556	1557	1558	1559	1560	1561	1562	1563	1564	1565	1566	1567	1568
RES	1569	1570	1571	1572	1573	1574	1575	1576	1577	1578	1579	1580	1581	1582	1583	1584
RES	1585	1586	1587	1588	1589	1590	1591	1592	1593	1594	1595	1596	1597	1598	1599	1600
RES	1601	1602	1603	1604	1605	1606	1607	1608	1609	1610	1611	1612	1613	1614	1615	1616
RES	1617	1618	1619	1620	1621	1622	1623	1624	1625	1626	1627	1628	1629	1630	1631	1632
RES	1633	1634	1635	1636	1637	1638	1639	1640	1641	1642	1643	1644	1645	1646	1647	1648
RES	1649	1650	1651	1652	1653	1654	1655	1656	1657	1658	1659	1660	1661	1662	1663	1664
RES	1665	1666	1667	1668	1669	1670	1671	1672	1673	1674	1675	1676	1677	1678	1679	1680
RES	1681	1682	1683	1684	1685	1686	1687	1688	1689	1690	1691	1692	1693	1694	1695	1696
RES	1697	1698	1699	1700	1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711	1712
RES	1713	1714	1715	1716	1717	1718	1719	1720	1721	1722	1723	1724	1725	1726	1727	1728
RES	1729	1730	1731	1732	1733	1734	1735	1736	1737	1738	1739	1740	1741	1742	1743	1744
RES	1745	1746	1747	1748	1749	1750	1751	1752	1753	1754	1755	1756	1757	1758	1759	1760
RES	1761	1762	1763	1764	1765	1766	1767	1768	1769	1770	1771	1772	1773	1774	1775	1776
RES	1777	1778	1779	1780	1781	1782	1783	1784	1785	1786	1787	1788	1789	1790	1791	1792
RES	1793	1794	1795	1796	1797	1798	1799	1800	1801	1802	1803	1804	1805	1806	1807	1808
RES	1809	1810	1811	1812	1813	1814	1815	1816	1817	1818	1819	1820	1821	1822	1823	1824
RES	1825	1826	1827	1828	1829	1830	1831	1832	1833	1834	1835	1836	1837	1838	1839	1840
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RES	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872
RES	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888
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RES	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920
RES	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936
RES	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
RES	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
RES	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
RES	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
RES	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RES	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
RES	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048
RES	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064
RES	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080
RES	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096
RES	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112
RES	2113	2114	2115	2116	2117	2118	211									

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 μ F			22 μ F	10V,-10%+80%	Elect.
C26	47 nF			47 nF	25V,10%	Ceramic
C27	1 μ F			1 μ F	50V,-10%	Ceramic
C28	22 μ F			22 μ 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 μ F			22 μ 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 μ F			100 μ F	16V,10%+80%	Ceramic
C46	1 μ F			1 μ F	50V,-10%+80%	Elect.
C47	22 μ F			22 μ F	10V,-10%+80%	Elect.
C48	47 nF			47 nF	25V,10%	Ceramic
C49	47 nF		(7)	47/560pF	25V,10%	Ceramic
C50	22 μ F			22 μ 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 μ F	22 μ F	(2)	22 μ 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 μ F	(3)	4.7 μ F	5V min	Elect.
C75	-	-		100nF	25V,10%	Ceramic
TC1/TC2				-		
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/ μ 780	-		Z80A/ μ 780	-
IC3/IC4	74LS157N	-		74LS157N	-
IC5(ROM)	SPECTRUM	SPECTRUM		SPECTRUM	-
IC6-IC13	4116	-		4116	-
IC14	LM1889	-		LM1889	-
IC15-IC22	TI4532	-		TI4532/ 48k only	Texas/
				MSM3732	OKI
IC23	74LS32N	-		74LS32N	48k only
IC24	74LS00N	-		74LS00N	48k only
IC25/IC26	74LS157N	-		74LS157N	48k only
					Not National

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

Circuit Reference	Issue 2	Issue 2 Mod	Notes	Issue 3	Rating Tol	Issue 3B
R1-R8	470R	1K0	(4)	470R	1/2 or 1W	
R9-R16	8K2			8K2		
R17-R23	330R			330R		
R24	3K3			1K0		
R25	180R			180R		
R26/R27	680R			470		
R28	10K0			10K		
R29	1K5			10K		
R30	1K0			10K		
R31	220K0			220K		
R32	100R			100R		
R33	680R			680R		
R34	15R			15R		
R35	10K0			10K		
R36	680R			680R		
R37	1K0			1K		
R38	3K3			-		
R39	3K3			-		
R40	1K0			-		
R41	1K5			-		
R42	1K0	1K0	(1)	1K0	2%	
R43	3K0			3K0		
R44	5K1			5K1		
R45/R46	1K0			1K0		
R47	220R			1K0		
R48	4K7			2K2		
R49	8K2			10K0		
R50	8K2			4K7		
R51/R52	2K2			2K2		
R53	390R			390		
R54	100K			100K		
R55	56R	470R	(1)	56R	2%	68R
R56	220R			1K0		
R57	330R			-		
R58	1K0			1K0		
R59	1K8			1K8		
R60	100R			270R		
R61/R62	15R			15R		
R63	220R			1K0		
R64	15R			15R		
R65-R69	10K0			10K0		
R70/R71	220R	10K0	(2)	220R		
R72	470Kor18K			10K0		
R73	-			1K0		
R74/R75	-			10K0		
R76/R77	-			1K0		
R78	-			470R		
VR1/VR2	2K2			-		

TRANSISTORS

Circuit Reference	Issue 2	Issue 2 Mod	Notes	Issue 3
TR1/TR2	ZTX313	-	(5)	ZTX313
TR3	ZTX313	-		ZTX313
TR4	ZTX650/TIPP31	-		ZTX650
TR5	ZTX213	-		ZTX213
TR6	ZTX313	-		ZTX313
TR7	-	-		ZTX450
TR8/TR9	-	-		BC184

MISCELLANEOUS

Reference	Description	Manufacturer/ Part Number
REG	5V regulator	7805
MOD	UHF Modulator with E36 vision carrier (UK only)	Astec UM1233
Loudspeaker	40 ohm T.V. Type	1740
Modulator Screen Insulator		
Heatsink	Special (Issue 2 or 3)	
Regulator Fixings(1)	Screw, ch hd. 4BA x 15/16 in	
(2)	Washer, shk prf, 4BA	
(3)	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)	

For Service Manuals Contact
MAURITRON TECHNICAL SERVICES
 8 Cherry Tree Rd, Chinnor
 Oxon OX9 4QY
 Tel:- 01844-351694 Fax:- 01844-352554
 Email:- enquiries@mauritron.co.uk

GENERAL DATA

- Earliest version - very pale brown keys.
- Second version - grey keys
- Third/Fourth versions - grey keys, but heatsink now visible through the edge connector slot
- Early Spectrum plus - same as fourth type.
- Disassembly - after removing the screws, tilt back, face up and carefully lift the top taking care not to break any of the keyboard tails.
- Heatsink - when operating computer with the heatsink removed to obtain access a temporary heatsink must be used made of anything as long as it fits under regulator.
- Circuit Diagram - idealised version on centre pages shows all modifications which should be made. Note that connecting items such as standard capacitors may not be shown.
- Edge Connector - 28 pin double-sided to which no interface may be inserted or removed whilst computer is switched on.
- Plugs & Cables - use onle genuine Sinclair issue or MK plugs, etc.
- Power Supply - Where any possibility of fluctuating mains exists a transient suppressor should be fitted.
- Links - T1/T3 for Texas TMS4532-3; T1/T4 for Texas TMS4532-4
1/H for OKI MSM3732H; 1/L for OKI MSM3732-L.

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Other Service/Repair Manuals by T.I.S. Include:-

Rank A823 CTV Chassis

Philips G8 CTV Chassis

Thorn 3000/3500 CTV Chassis

Thorn 8000/8004/8500/8600 CTV Chassis

Rank T20/20A CTV Chassis

The Tunbridge & McCourt T.V. Repair Manuals

The Tunbridge Video Repair Manuals

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SERVICE DATA

Modification of earplug: Connect a 330 ohm resistor between signal and earth leads of earplug to allow earplug to be left in place while saving a programme.

Inserting or removing such items as joysticks, especially via a Kempston interface, while the computer is switched on will damage the power resistors and regulator.

Modification to voltage generator circuit: Where not fitted already, insert a 22uf capacitor between the TR4 and D15 as shown in the circuit diagram, this will ensure the correct 12v supply. On early models replace R60 by a 270 ohm resistor and fit C74 if missing. Ensure that the 12v supply is 12v.

Manufacturer's advised modifications: In early versions replace all ceramic capacitors by axial ones and replace C46 by a high-temperature 1uf type. All resistors to be changed to show the second value show in centre pages circuit diagram herein; same applies to capacitors.

Weak sound: Only if particularly noticeable should the sound section be changed to same as shown herein.

Tape and Sound Circuits: 5Vp-p at ear socket for 2Vp-p at IC1 verifies IC1.

Alignment: Only needed for early models. Place meter on pin 4 of IC4 and adjust VR1 to obtain 130mV; adjust VR2 to obtain -75mV at pin 2 with a 20mV allowable error either way. Use TC2 to set colour subcarrier frequency to 4.433619MHz to 50Hz either way. TC1 only helpful to improve screen colour pattern.

Alignment: All models. Run the programme to display the eight colours in sequence from black to white. This is normally given as:-

```
10 FOR A=0 TO 7
20 FOR B=0 TO 3
30 PAPER A: PRINT " ";
40 NEXT B
50 NEXT A
60 GOTO 10
```

If this shows incorrect or missing colours then align as stated for early models. See repair data for later models.

REPAIR DATA

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1) GENERAL REPAIR PROCEDURE AND NOTES ON ALL FAULTS

These computers are reportedly very unreliable with some 50% of new ones alleged to have to be returned for replacement. Many faults are due to loose or badly fitted components so that a good checkover is essential for this reason, to determine if a factory failure first.

Check heatsink first for any reported fault, is it loose? Are there overtightened screws? Look for dry joints, cracks in print or cracked boards, badly fitted components, especially ICs; dirty or tarnished contacts, pins, holders, edge connectors; damaged keyboard tails and fins are certainly not uncommon for whatever reason.

Before investigating any fault check any add-ons and interfaces to the computer for broken solder, etc. caused by user wiggling them about. It is also essential to note if add-on is loose or faulty which will give a guide to any damage so caused. This will also determine if fault in add-on not computer. Knowing what add-ons are used can be a good guide to probable fault: for example, suspect TR4 blown and/or destroyed RAMS if a Kempton is used.

Check if customer has been inserting or removing any add-ons without first switching off and point out how this practice has damaged machine and costing him unnecessary expenditure. If this is admitted then check TR4 first then RAMS and see symptom 3.

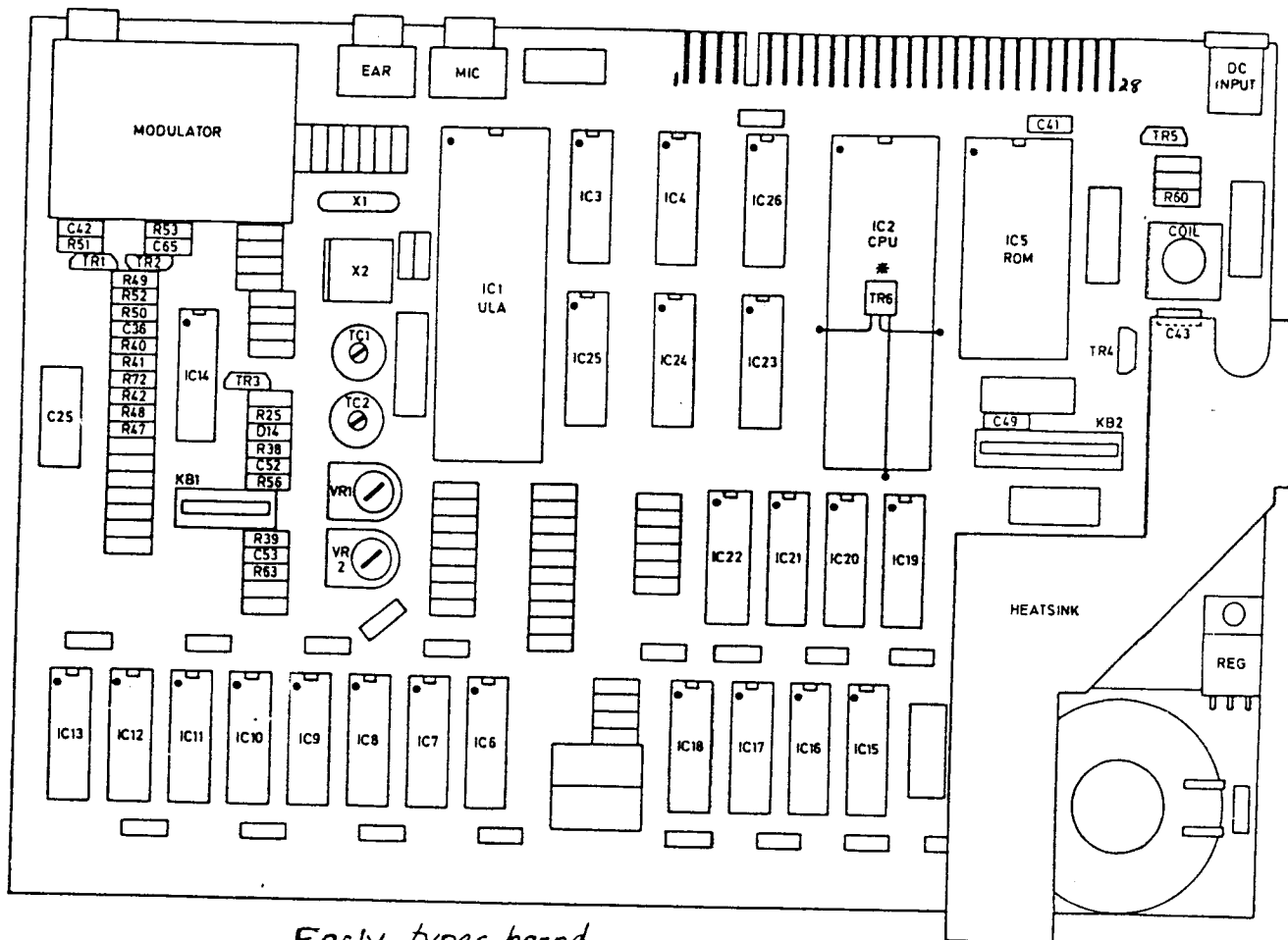
2) WONT LOAD FROM RECORDER

Almost invariably this will be caused by the alignment of the recorder head not being good enough. The recorder will play music, etc. and function well but it will still need adjusted to operate the Spectrum properly and it matters not whether it is an old or just newly bought recorder.

Disconnect Spectrum from recorder and with any tape playing use a long thin-bladed screwdriver to adjust the azimuth screw through the hole normally provided for this purpose. The object is to obtain the sharpest possible sounding note, noting that if note is in the least muffled sounding then there is no chance of the Spectrum loading from it.

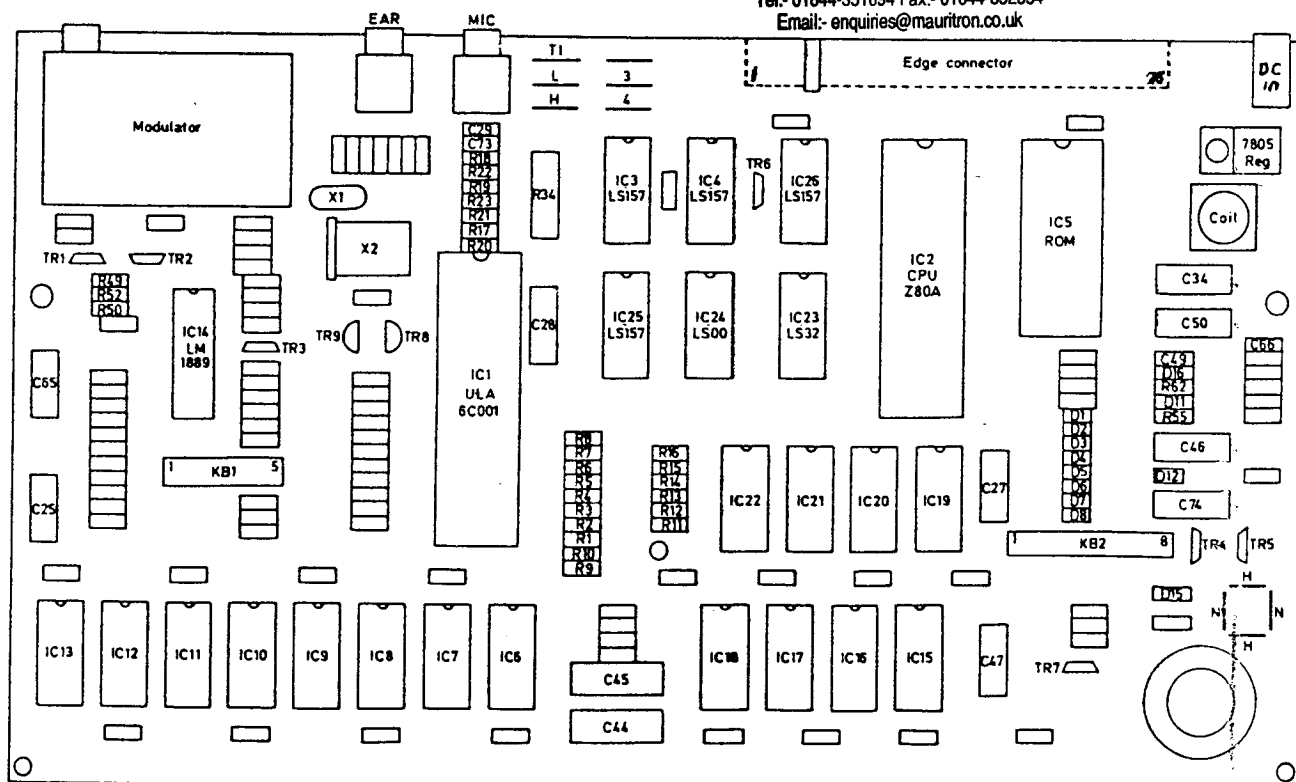
If no hole is provided this should be done with the recorder cover removed. Although it is recommended that volume should be set at midpoint it is far better to vary volume setting to that at which maximum treble is obtained. Finally give head a good clean and recheck setting.

If the adjustment does not cure the problem then save a short programme from the computer (or use one previously saved) and if this doesn't load then it is safe to assume that there is a fault, probably in the computer. In this case, check connections to computer and the circuit from the edge connector to the first I.C.



Early types board

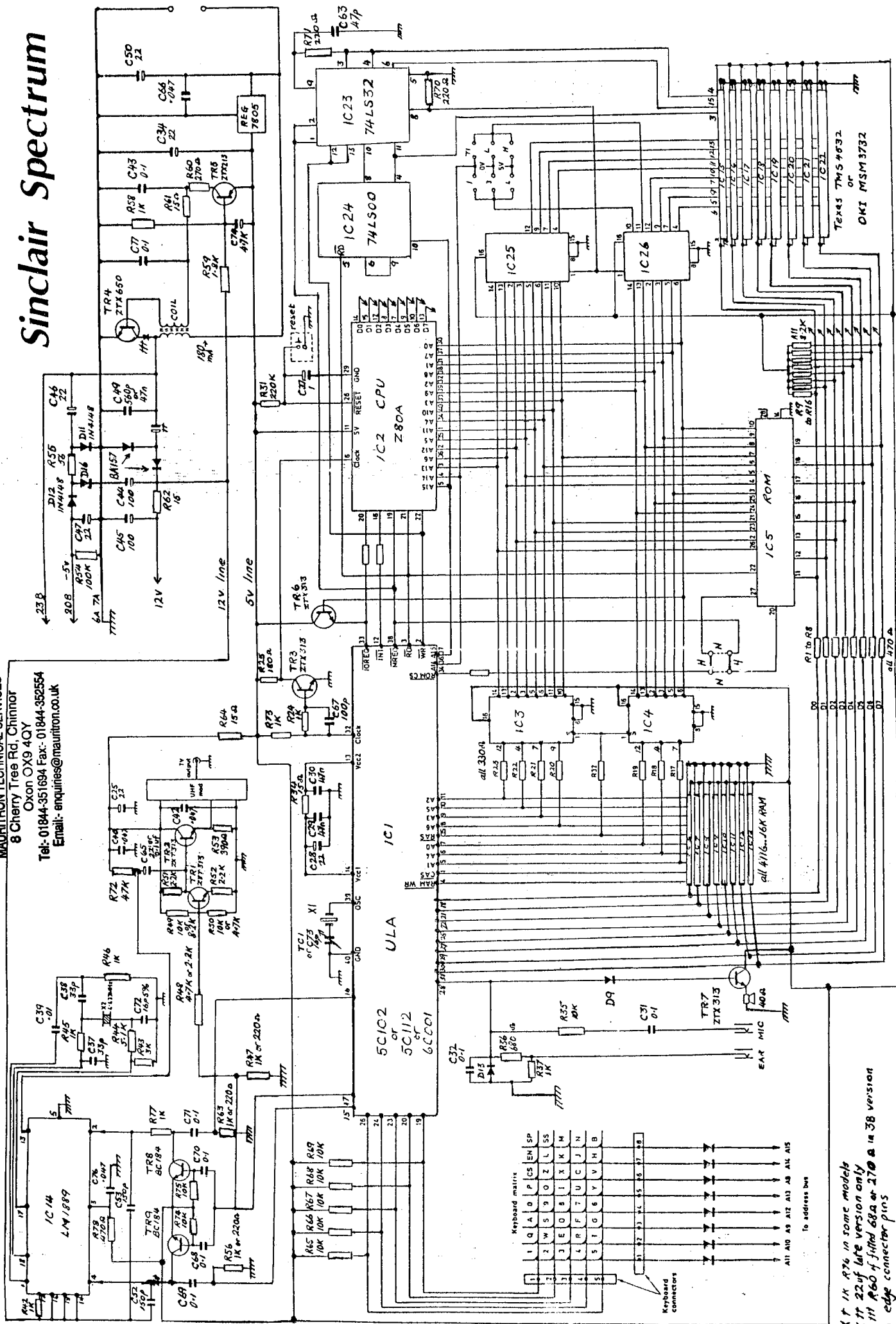
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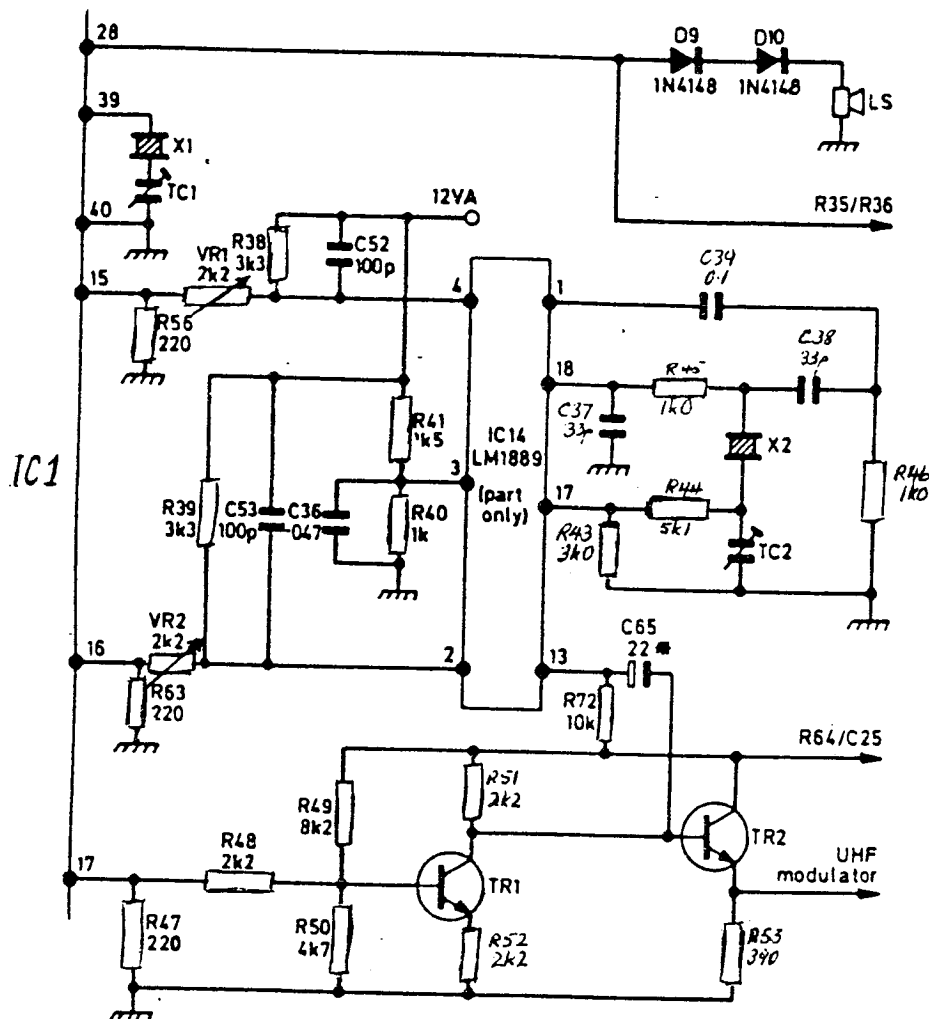
Later types board

Sinclair Spectrum

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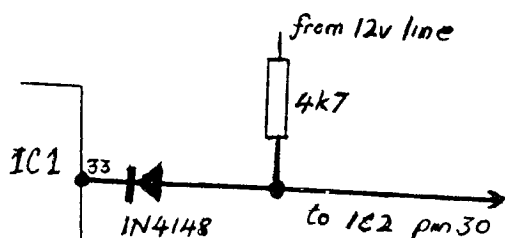


X1 1K R26 in some models
X11 22uf late version only
X111 R60 if fitted 682 or 270 a in 38 version
a edge connector pins

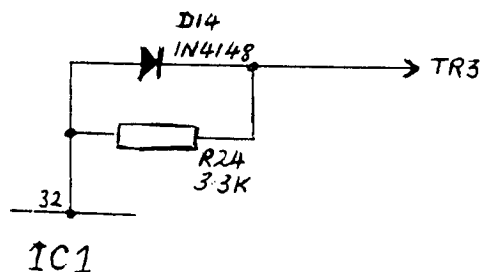


Early circuit showing presets TC1, TC2, VR1 and VR2 to match the early type boards.

Note:- the different pins 16/17 setup from IC1 in the generalised circuit diagram shown in the middle pages.



In very versions, instead of TR6 a somewhat unreliable, resistor/diode was used which should be modified as shown in the centre pages.



This very unreliable circuit was used in very early versions from pin 32 to base of IC1. This circuit should be modified to that shown in the centre pages if not already done.

Modifications associated with IC1

3) NO COIL BUZZ FROM INVERTER, -5V ABSENT

From symptom 1 it should be obvious that TR4 (ZTX650) is very prone to damage and this symptom is a sure indication that TR4 must be replaced. However, before replacing the TR4 check the TR5 (ZTX213) (using a transistor tester is O.K.) and the coil since it is not unknown for all three to have gone at the same time and if only the TR4 is replaced it can fail again immediately if the others are faulty.

Whether or not these three are faulty or not, there can be one or more faulty RAMS as well caused possibly by the same forcing in of an interface during switch on. If all else has been fixed, switch on and check if any RAM gets hot; replace any very hot RAMS either in basic set or in extra board as this is a sure sign of being short circuit. If open circuit, the quickest way to check is to by-pass each RAM in turn using a RAM known to be O.K. When so doing the same RAM must be used as the suspect and it should not be removed after each check for some ten seconds after each switch off or it will fault itself. Use of a 'scope or logic probe is clearly a better alternative if available. Tandy make a good, inexpensive logic probe.

4) DIRECT CHECK FOR A SINGLE FAULTY RAM

Type PRINT PEEK 23732+256 * PEEK 23733 (CR). If computer RAMS O.K. the reply is either 32767 or 65535, if less than either this means that there is a shortage of available RAMS, thus one or more RAMS may be faulty.

Call the reply N and if POKE N+1,85 (CR) then PRINT PEEK N+1 (CR) is typed the reply should be 85 if RAMS O.K., in that case type POKE N+1,170 (CR) then PRINT PEEK N+1 (CR) when a different number to the 170 you have just poked into that address will be printed. 85 and 170 are the easiest binary numbers (01010101 and 10101010) to cover all combinations in an 8-bit chip.

Where a different reply is given to either POKE locate the incorrect IC as follows:-

Where 85 is poked in

IC6 faulty gives 84; IC7 87; IC8 81; IC9 93; IC10 69; IC11 117; IC12 21; IC13 213.

Where 170 is poked in

IC15 faulty gives 171; IC16 168; IC17 174; IC18 162; IC19 186; IC20 138; IC21 234; IC22 42.

5) NO COIL BUZZ FROM INVERTER, REG7805 OPEN CIRCUIT

Before replacing the 7805 check the heatsink to see if faulty or badly fitted. Remedy any physical defect in print or damage around screws, etc. Also check the TR4/5 and coil.

6) CONTINUAL FAILURE OF POWER SUPPLY TRANSISTORS

Ensure that all modifications have been carried out and that the edge connector is O.K. and not loose or damaged. Check for proper fitting of all peripherals and verify that owner is not persistently inserting/removing any of the add-ons, etc. while the computer is switched on. Note that many users are apparently incapable of grasping this simple point. Check the plug/sockets and cable, if not suitable then replace with correct ones. Check the mains and possible interference from other items on same circuit.

If satisfied then check if the 0v is correct on earth. Monitor the 0v while running computer as this may show up an intermittent voltage fault. A systematic check on all capacitors/resistors to earth should find the culprit for this uncommon cause.

7) KEYBOARD FAULTS

It is recommended that keyboards are better replaced completely since they take a lot of battering and replacement is quite inexpensive. If it is decided that the keyboard is worth repairing then the diagram will show which key is faulty according to keys in error.

If the entire keyboard is non-functional then check the 5v supply is reaching it O.K. before replacing the ULA I.C. Probably the commonest fault lies with a faulty 10K resistor (R65 to R69) easily identified according to which keyboard column is faulty.

8) VARIOUS FAULTS WHICH APPEAR ONLY WHEN WARM

Check heatsink thoroughly. If heatsink is O.K. then the ULA I.C. IC1 will be the cause. If IC1 has been replaced before it may be worth adding extra heatsink for it. See also following symptom.

9) INTERMITTENT FAULTS

If such faults show up with a comparatively new Spectrum then it is most likely that they are due to poor contacts/soldering during the manufacturing process. Check all holders and pins for tarnish and dry joints. Replace faulty holders by cutting them out and replacing completely. Check after this for poor contacts or loose contacts, look for items which have been poorly soldered or even where soldering has been omitted. Finally check the boards for hairline cracks and breaks, especially radiating from heatsink screws.

10) TEXAS SN1889 INSTEAD OF LMA889

A few models appeared with the SN version and these may even have been used as replacements during repairs. Although unlikely to find now, if SN types have been used replace completely by LM type.

11) POWER SUPPLY O.K. - COMPUTER NOT WORKING CORRECTLY

If computer is functioning at all check for single RAM failure then multiple RAM failure as already described. If RAMS are O.K. or fault is more serious and RAMS cannot be checked then check if the 5v supply is reaching all I.C.s in order IC1, 2, 24, 23, 3, 4, 26, 25 and 5. Replace the open circuit component cutting off the 5v supply if this is the case.

Faulty or missing sound usually identifies the ULA I.C. IC1 as being faulty and this is the most likely suspect in any case. Flick the clock crystal with your finger, this will quickly determine if it is faulty or not.

Although I.C.s are best checked out systematically using a logic probe or even a 'scope, it is worth noting that after IC1 the most likely culprits are IC2 and IC5, neither of which are particularly reliable and it may even be worth replacing the three automatically as a fast check.

12) PERMANENT I.C. CHECKER FOR LOGIC PROBE USE

If a logic probe is available it is well worth making a table of the results of checking each IC pin with a good computer switched on with keyboard disconnected. Thus when any computer is being tested all that is needed is to compare the readings with your correct set and the different readings will quickly pinpoint the faults.

13) FLICKERING WHITE BACKGROUND - MAY BE CAUSING EYESTRAIN

If resetting the computer doesn't help, which is not uncommon if a CTV is being used, then the only thing is to set up the computer to display a coloured background with white printing. See spectrum manual for this, but green is the most relaxing background. Save this programme and load it every time Spectrum is not being used for games.

14) SPARE PARTS SUPPLIERS

At time of printing the most popular suppliers appear to be:-
CPC Electronic Components, 194 North Road, Preston, Lancs.
PV Tubes, 104 Abbey Street, Accrington, Lancs. BB5 1EE.

This list may be amended in future printings.

NOTES

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