SERVICE MANUAL
MODEL C64 COMPUTER

SEPTEMBER 1985 PN-314001-02

Commodore Business Machines, Inc.
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U.S.A

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CONTENTS

C64 COMPUTER

GENERAL DESCRIPTION	The "All Purpose" Commodore 64 us the complete computer for education, home or small business applications. Supported by quality peripherals and a full range of software, the Commodore 64 is perfect for the family. No other computer can offer such variety of uses and applications at such an affordable price.
MEMORY	64K RAM
ROM	20K ROM Standard (includes operating system and BASIC interpreter)
MICROPROCESSOR	6510A Microprocessor - 1.02 MHz clock Compatible with the 6502
DISPLAY	40 Columns X 25 lines of text
COLORS	16 Background, border and character colors
CHARACTERS	Upper & lower case letters, numerals and symbols Reverse characters All PET graphic characters
DISPLAY MODES	Text characters High resolution graphics
RESOLUTION	320 X 200 Pixels
SPRITES	8 independent sprites Each consists of 24 X 21 pixels and up to 4 colors Each independently expandable horizontally and vertically Collision detection for sprite to sprite and data to sprite collisions
SOUND	6581 Sound Interface Device includes 3 independent tone generators - each with 9 octaves Each voice includes programmable ADSR generator (Attack, Decay, Sustain, Release) and control of sawtooth, triangle, square, variable pulse and noise waveforms Full filtering capabilities with low, high and band pass filters External sound input
KEYBOARD	Full size typewriter style design
KEYS	66 Keys total 2 Cursor control keys 4 Function keys (up to 8 user defined/programmable functions possible) Upper and lower case character set Graphic character set
INPUTS/OUTPUTS	User port Serial port ROM cartridge port 2 Joystick/paddle ports Video port C1530 Cassette drive interface port
FEATURES	Built-in BASIC 2.0 - over 70 commands, statements and functions Full screen editor
PERIPHERALS	C1541 Disk drive C1530 Datasette MPS 801 Dot matrix printer

	MPS 802 Dot matrix printer MPS 803 Dot matrix printer DPS 1101 Daisey wheel printer C1520 Plotter/Printer C1702 Color monitor CM141 Color monitor
POWER REQUIREMENTS	120 Volts, 60 Hz

Specifications subject to change without notice.

PARTS LIST
C-64

PLEASE NOTE: Commodore part numbers are printed for reference only and do not indicate the availability of parts from Commodore. Industry standard parts (Resistors, Capacitors, Connectors) should be secured locally. Approved cross-references for TTL-chips, Transistors, etc. will be available in manual form through the Service Department in November of 1984. Unique or non-standard part will be stocked by Commodore and are indicated on the parts list by a "C".

TOP CASE ASSY

Top Case	C 326113-01
Keyboard	C 326166-02
LED Plate	C 326160-01
Nameplate	C 326161-01
Lamp Hold Set	C 903820-03
LED Assembly	C 1001039-01

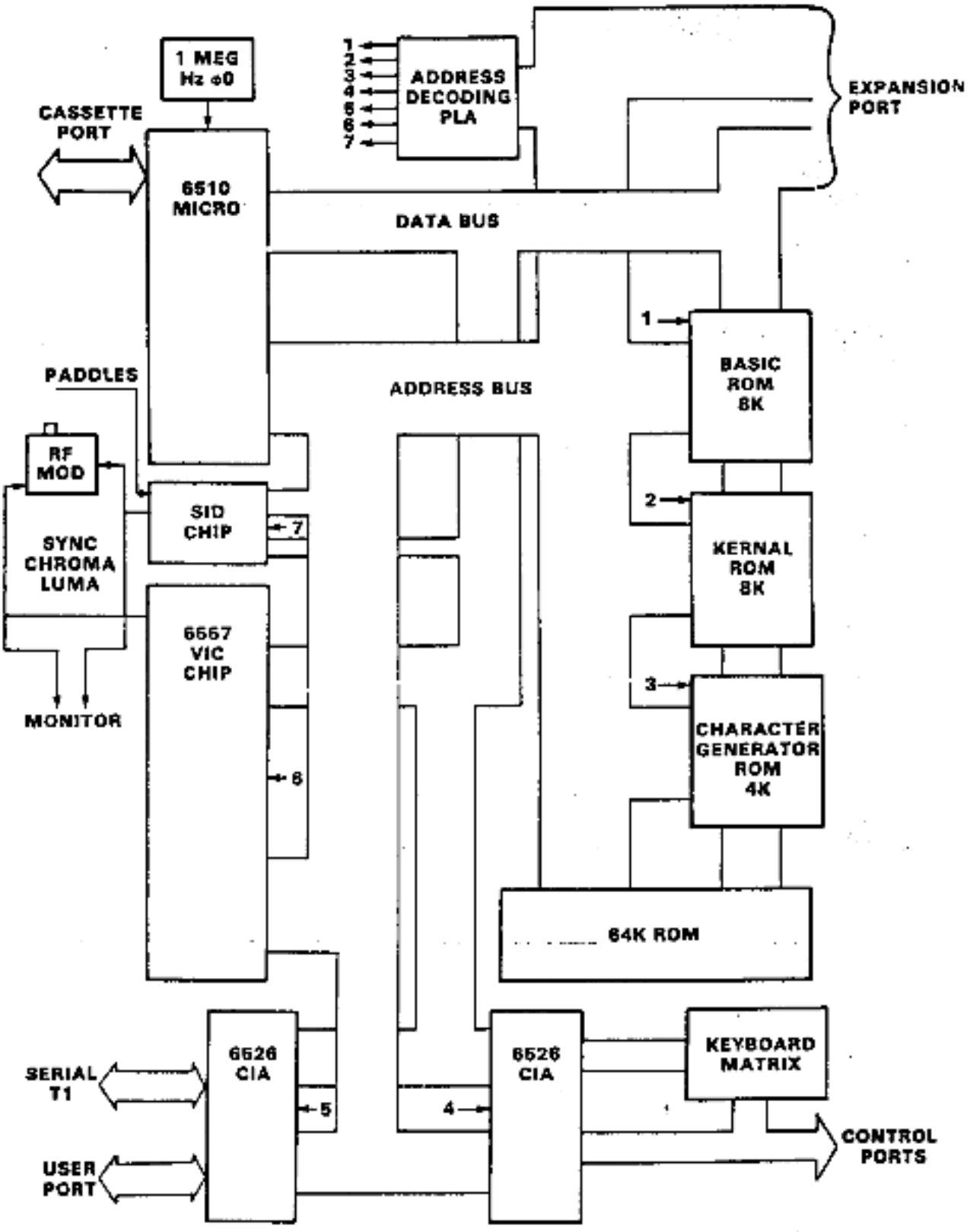
BOTTOM CASE ASSY

Bottom Case	C 326114-01
Foot, Self-Adhesive	C 950157-04
PCB Shield Plate	C 326131-01
PCB Insulation Sheet	C 326288-01

ACCESSORIES

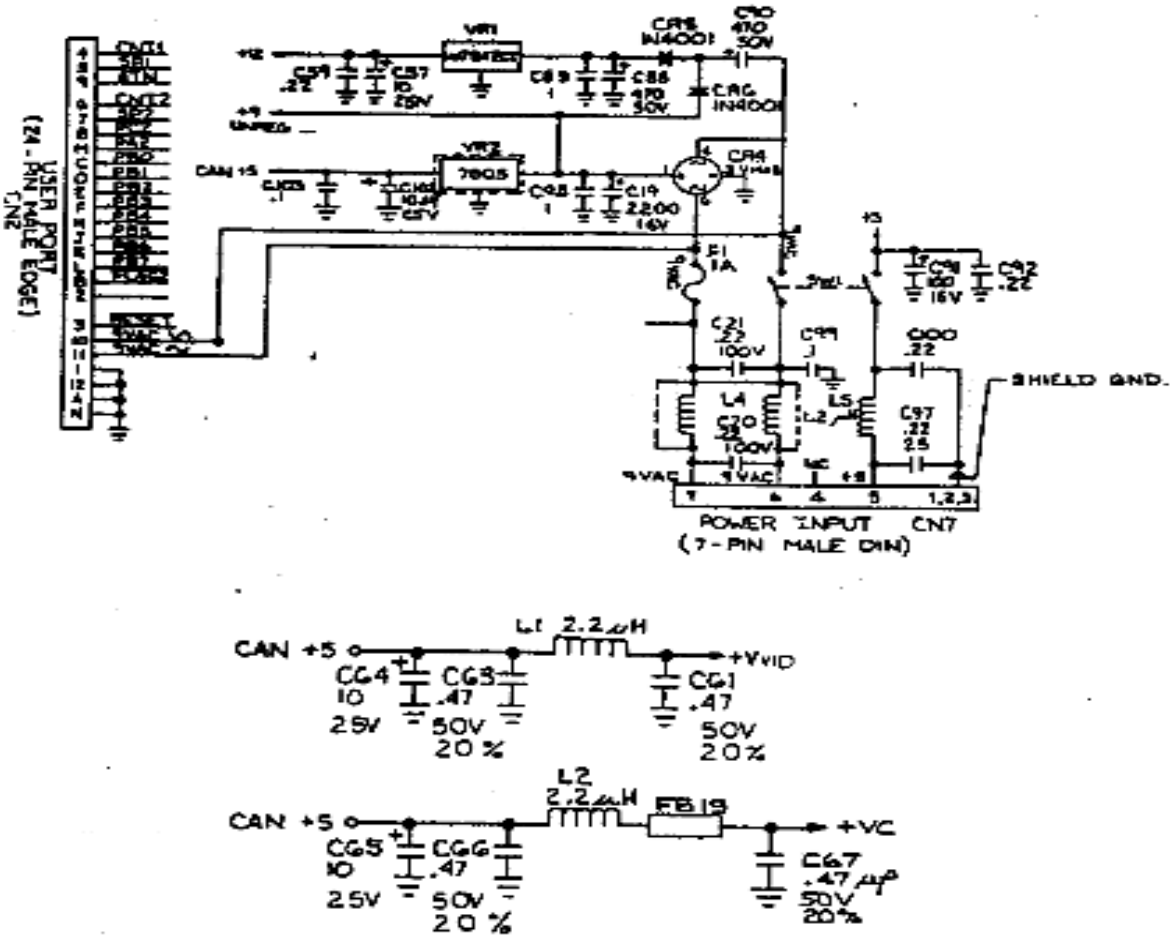
Users Manual	C 320974
Power Supply	C 251053-02
RF Cable	C 326189-01
Switch Box	C 904778-01

C-64 BLOCK DIAGRAM



C64 CIRCUIT THEORY

There are three versions of the C64. The C64 with five pin connector video output (326106). The C64 with an eight pin connector video output (251138), and the C64B which has improved system clock circuit design (251469). Most circuit theory explanations will be the same for all three versions. Refer to schematic 326106 unless noted otherwise.



The Power Supply

The external power supply generates a regulated 5VDC and 9VAC. 5VDC is applied to pins 5 and 1 of CN7 on the C64 pcb. Filtered by L5, C97, and C100 it is then controlled by on/off switch S1. This 5VDC output supplies the microprocessor logic.

9VAC is applied to pins 6 and 7 of CN7 on the C64 pcb. +12VDC, +5VDC CAN and 9VAC unregulated are outputs that are derived from this 9VAC supply. The 9VAC supply is made available on pins 10 and 11 of the USER PORT CN2.

12VDC Generation

9VAC is added to 9VDC through CR6, and rectified by CR5. The unregulated DC output is filtered by C88 and C89 then regulated at 12VDC by VR1. The regulated output is filtered by C57 and C59. The 12VDC supplies the VIC and SID IC, and the audio amplifiers.

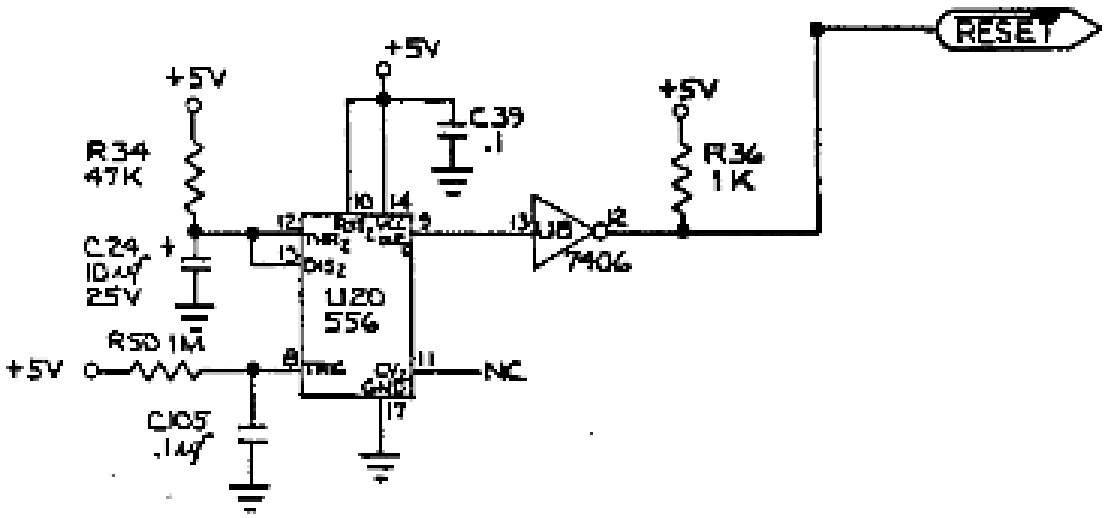
+5VDC CAN Generation

9VAC is rectified by CR4. The unregulated DC output is filtered by C19, and C95 then regulated at 5VDC by VR2. The regulated output is filtered by C102 and C103. The output called 5VDC CAN is separated and individually filtered into two outputs called Vvid and Vc. Vvid is the 5VDC supply for video circuits, and Vc is the 5VDC supply for the clock circuits.

9VDC Unregulated Generation

CR4 rectifies the 9VAC input. The output is 9VDC unregulated. This supply powers the cassette motor transistor amplifier circuits, and the RF modulator on the C64B version.

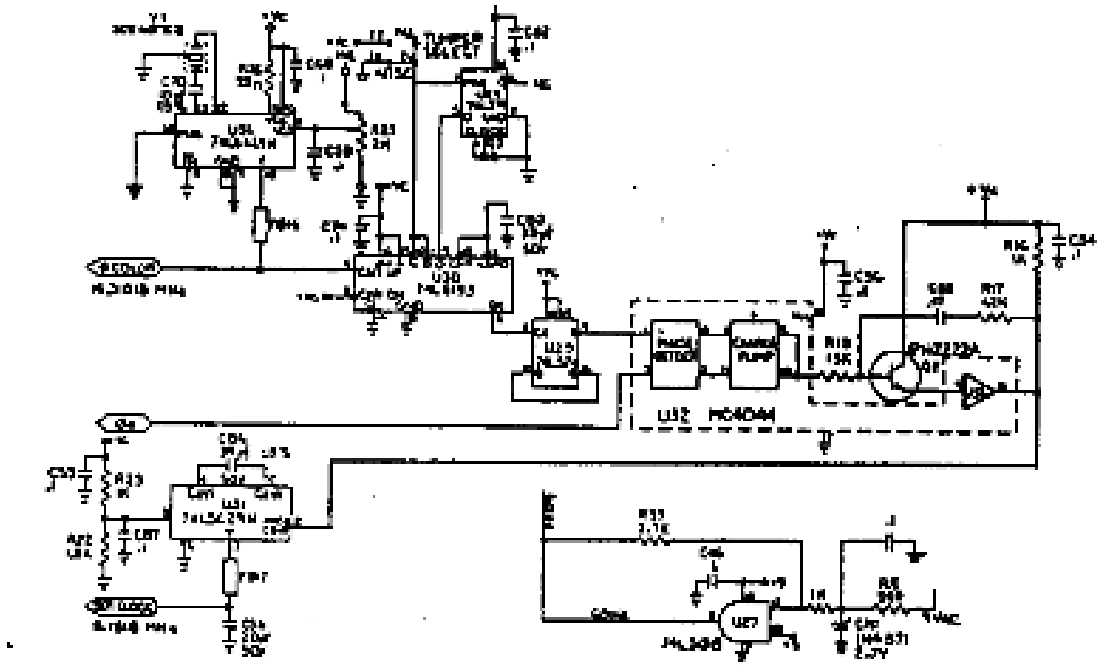
C64 CIRCUIT THEORY



Reset Logic Circuits

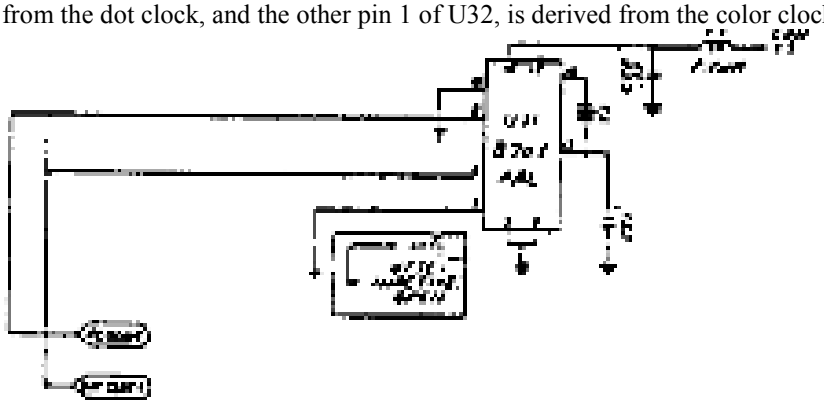
U20 is a 556 timer configured as a one shot multivibrator. The output pulse width is determined by the size of R34 and C24. Pulse width = 1.1 x R34 x C24 = .5 seconds. The output on pin 9 is "high" active. The output of U8 is "low" active. Reset initializes all the processor logic and causes the processor to load the program counter register with the address of the first instruction of the operating system program called the KERNAL. The starting address is stored in locations $FFFC and $FFFD. The first instruction is decode and executed giving KERNAL control of the computer operations. The reset pulse occurs when turning the power on to the computer.

C64 CIRCUIT THEORY



The C64 Clock Circuits.

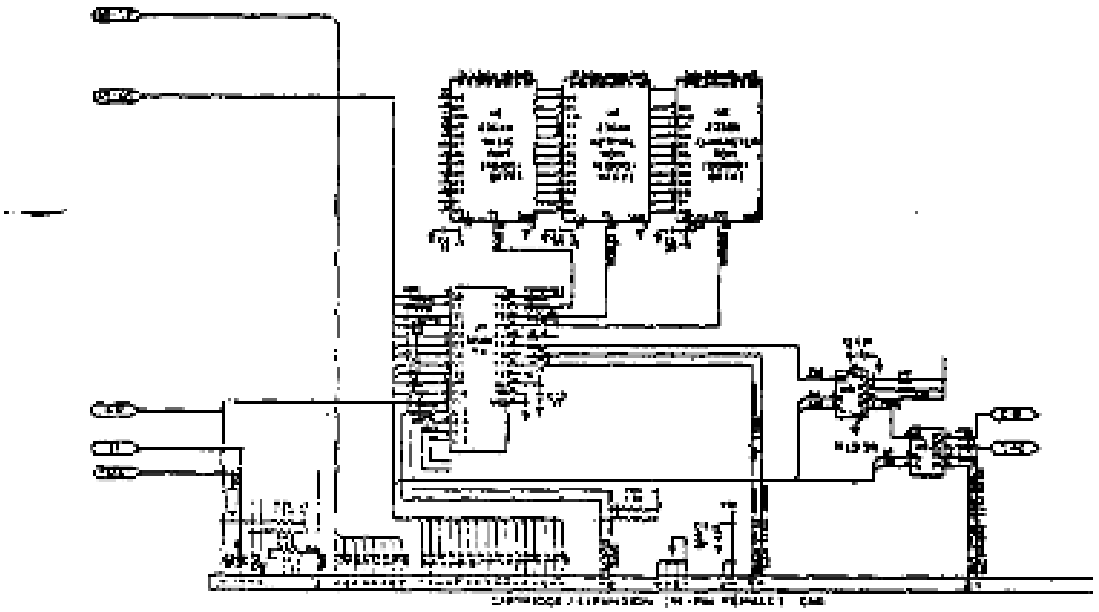
Crystal Y1 develops a 14.31818MHz fundamental frequency clock signal. U31 is a Dual Voltage Controlled Oscillator. The output on pin 10 is a 14.31818 MHz clock signal called the color clock. R27 can be adjusted to obtain exact output frequency. U30 is a frequency divider that outputs a 2MHz signal on pin 6. U29 is a D flip flop which outputs a 1MHz signal on pin 9. U32 is a Phase/Frequency Detector which compares the output of the U29 to the phase 0 clock, and outputs a dc voltage on pin 8 that is proportional to the phase difference between the inputs. The second half of the Dual Voltage Controller Oscillator U31 generates an 8.1818MHz clock signal called the DOT Clock. The VIC IC divides the DOT clock by eight and outputs this as the phase 0 clock on pin 17. The output of the Phase/Frequency Detector is applied to the frequency control input pin 2 of U31. This causes tracking of the dot clock and the color clock because one input, pin 4 of U32, is the phase 0 clock which is derived from the dot clock, and the other pin 1 of U32, is derived from the color clock.



The C64B Clock Circuits. Refer to schematic 251469

Crystal Y1 develops the fundamental 16Mhz clock signal. U31 is a Clock Generator IC that outputs the 8.1818MHz DOT clock on pin 6, and the 14.31818 MHz color clock on pin 8.

C64 CIRCUIT THEORY



I/O and ROM Address Decoding and Expansion Port.

I/O Address Decoding Logic

U17 is a Programmable logic array (PLA). The output F5 on pin 12 called I/o goes "low" when any of the I/O devices controlled by U15 are selected. The addresses are listed below for each device.

VIC IC	$D000 - $D02E
SID IC	$D400 - $D7FF
Color Ram	$D800 - $DBFF
CIA 1	$DC00 - $DC0F
CIA 2	$DD00 - $DD0F
I/O 1	$DE00 - $DEFF
I/O 2	$DF00 - $DFFF

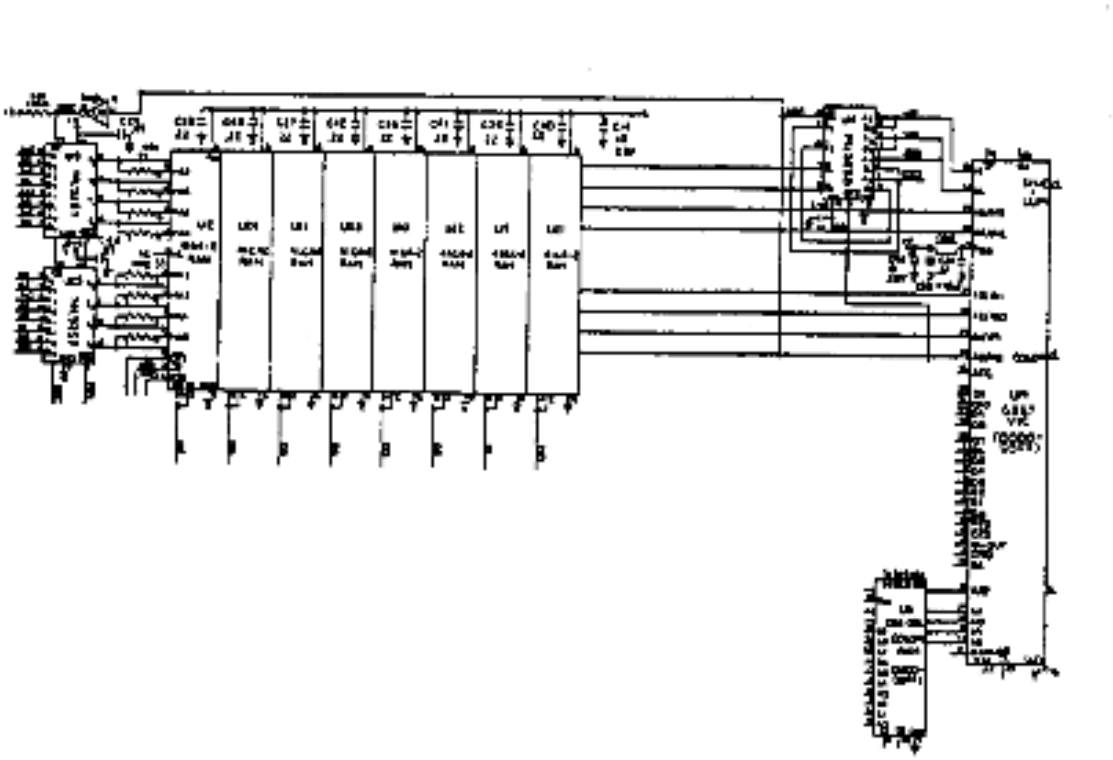
ROM Address Decoding.

Basic ROM resides at locations $A000 - $BFFF. The output F1 pin 17 of the PLA U17 goes "low" when the BASIC ROM is selected. The KERNAL ROM resides at locations $E000 - $FFFF. The output F2 pin 16 of the PLA U17 goes "low" when the KERNAL ROM is selected. The CHARACTER GENERATOR ROM resides at locations $D000 - $DFFF. The output F3 pin 15 of the PLA U17 goes "low" when the Character Generator ROM is selected.

The Expansion Port Connections.

The expansion port is an extension of the microprocessor address, data, and control bus. ROML decodes addresses $8000 - $9FFF, and ROMH decodes addresses $E000 - $FFFF. These are outputs from the PLA used to select the catridge inserted in the expansion port. I/O 1 input from U15 decodes addresses $DE00 - $DEFF. I/O 2 output from U15 decodes addresses $DF00 - $DFFF.

C64 CIRCUIT THEORY

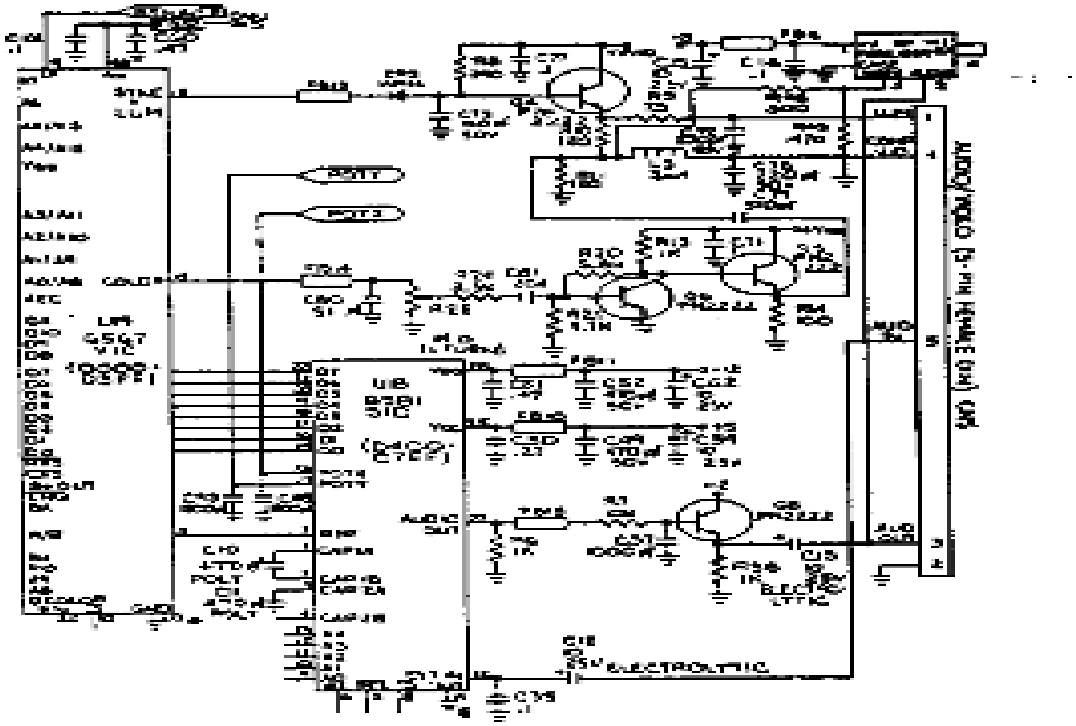


RAM Control Logic.

U13 and U25 are multiplexers. The address output from the microprocessor are passed to RAM via U13 and U25 when the output Address Enable Control (AEC) from the VIC IC is "high". When AEC is "low" the VIC IC outputs refresh addresses on pins 24 - 31. AEC goes "low" when the system clock, phase 2, is "low". Since all I/O decoding occurs when phase 2 is "high", refresh is transparent to the processor.

Eight 4164 DRAMS provide 64k bytes of memory. One 2114 RAM (U6) provides 512 bytes of memory allocated for screen color data storage.

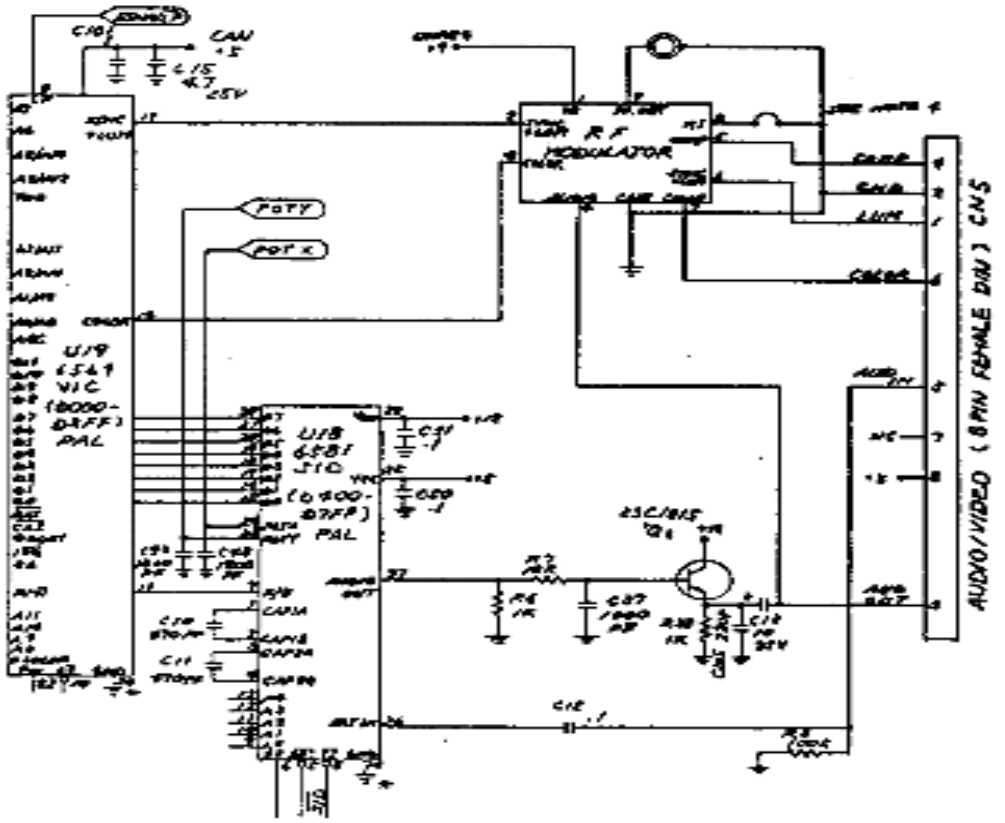
C64 CIRCUIT THEORY



5 Pin Video and Audio Output Circuits

Pin 15 of the VIC IC is the sync/luminance output. Pin 14 is the color output. A composite video output is created by mixing sync/luminance and color. The composite output is applied to the RF modulator, and also passed to the monitor connector CN5 on pin 4. The color output is not made available on the monitor connector CN5 as on the 8 pin version, and the RF modulator mixes audio with the composite video producing the TV RF output, unlike the 8 pin version RF modulator which creates the composite video output.

C64 CIRCUIT THEORY

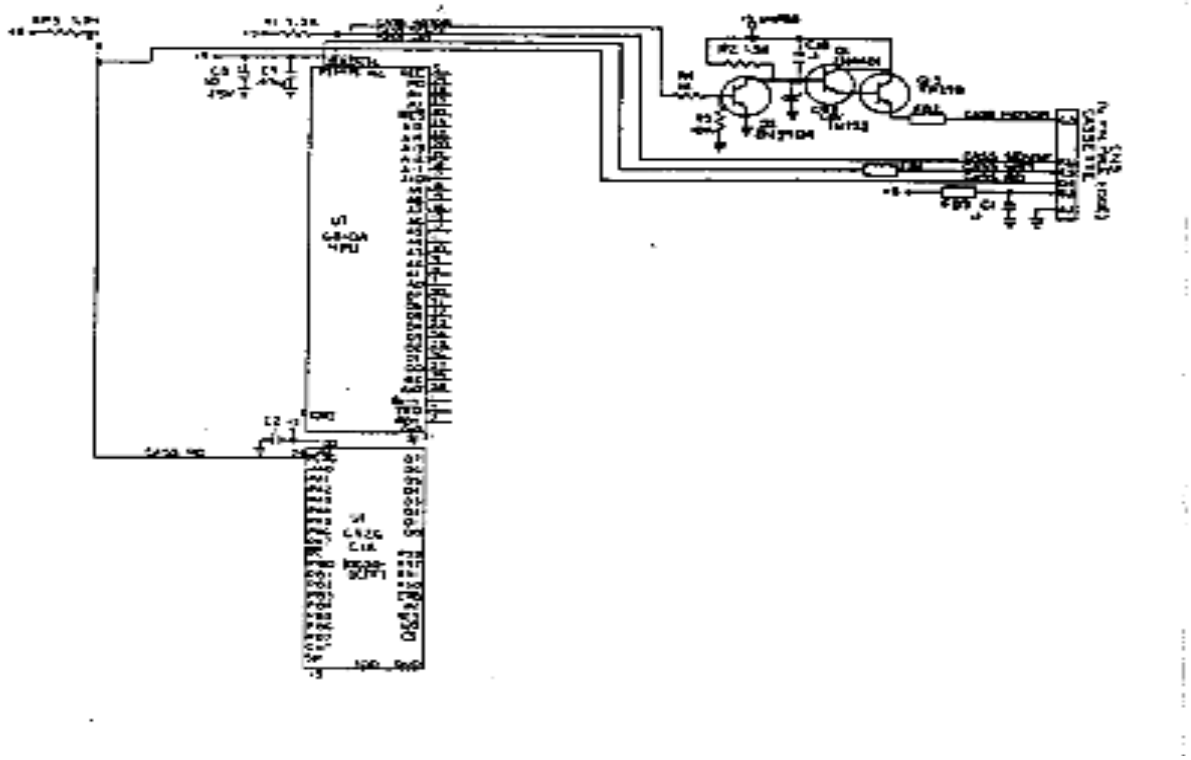


8 Pin Video and Audio Output Circuits. Refer to schematic 251469

8 Pin Video and Audio Output Circuits. Refer to schematic 21469

U19 is the Video Interface Chip (VIC). Sync (horizontal and vertical), and luminance (video) is output on pin 15. This signal is passed to pin 2 of the RF modulator. Color is output on pin 14, and passed to pin 3 of the modulator. Light pen inputs are sensed by the VIC IC on pin 9. U18 is the Sound Interface Device (SID). The audio output is on pin 27, and audio input is on pin 26. The RF modulator mixes sync/luminance, color, and audio out, generating a TV composite signal on pin 5. The RF modulator also passes the VIC outputs to the monitor connector CN5. Audio out on pin 27 is amplified by Q2, and output on pin 3 of CN5. Audio in is applied to pin 5 of CN5, then to pin 26 of the SID IC. Inputs from paddles connected to on of the control ports are monitored by the SID IC on pins 23 and 24.

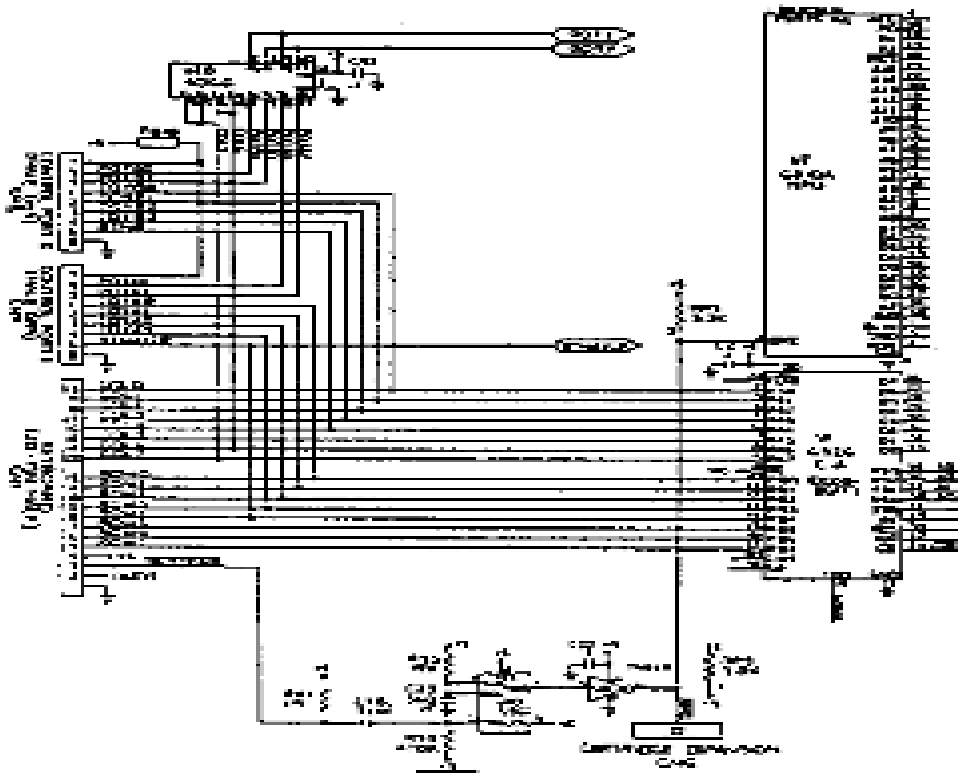
C64 CIRCUIT THEORY



The Cassette Interface Circuits.

U7 is a 6510 microprocessor. One of the features of the 6510 is a built in parallel I/O port (P0-P5). P3 - P5 control most of the cassette interface circuitry. P3 pin p6 of U7 outputs the write data signal to connector CN3 on pins E and 5. P4 is an input that senses the play switch depressed on the cassette deck. P5 is on output that controls the cassette motor. When P5 goes "low", Q2 cuts off, CR2 regulates Vb of Q1 at 7.5 volts, this forward biases Q1 and Q3, passing current through the cassette motor coil. U1 is a Complex Interface Adapter (CIA). Parallel ports, serial outputs, and Timers are standard features of the CIA. Read data enters on pins D, 4 of CN3. U1 accepts the read data signal on the FLAG input pin 24.

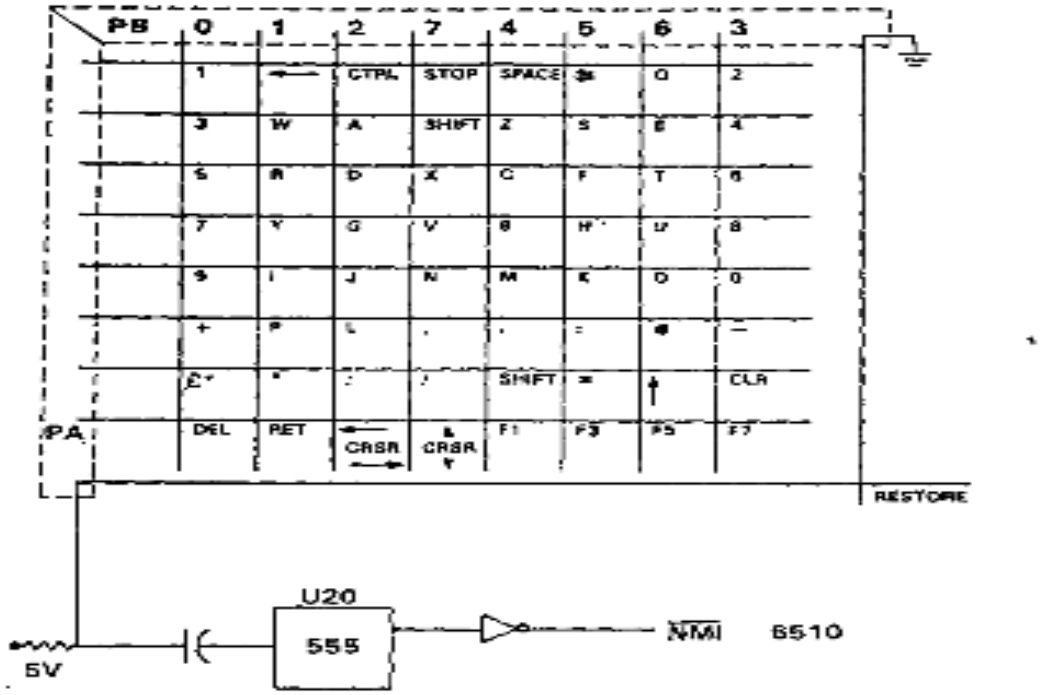
C64 CIRCUIT THEORY



Keyboard, Joystick, and Paddle Interface Circuits.

Keyboard Interface

U1 is a Complex Interface Adapter (CIA). Both parallel ports are used to decode the keyswitches on the keyboard. Parallel port A signals (PA0 - PA7) are outputs. PArallel port B signals (PB0 - PB7) are inputs. A "0" bin is shifted through the parallel port A, when a key is depressed on the keyboard the "0" bit is returned on one of the parallel port B inputs. A program in the KERNAL ROM generates the shifting "0" bit output on parallel port A, and decodes the signals returning on the parallel port B inputs. Depressing the restore key causes U20 to trigger. U9 pin 6 goes "low" generating a Non- Maskable Interrupt (NMI) at the processor. This causes the processor to execute a subroutine which initializes the I/O interfaces. If the STOP key is depressed at the same time, BASIC flags are initialized.



KEYBOARD MATRIX

Joystick Interface

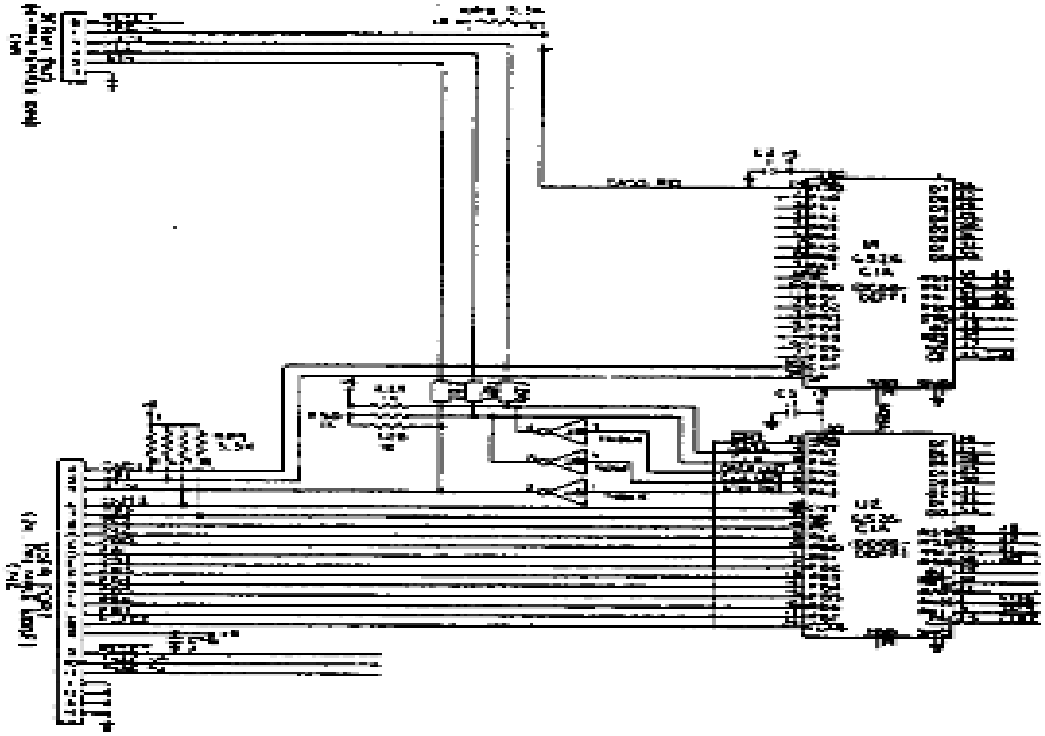
U1 also controls the joystick. Parallel port A accepts inputs from the B joystick connected to control port 2. Parallel port B accepts inputs from the A joystick connected to control port 1. When the joystick is moved up, down, left, right, or the fire button is depressed, a ground potential is applied to the appropriate input of U1.

Paddle Interface

A Variable resistor is connected to adjusting knob on the paddle. When the knob is rotated, the resistance varies controlling the time constant of an RC network. The Voltage developed across the capacitor is input to an A/D converter internal to the SID chip U18. The digital output is stored in one of the SID registers. The paddle position can be determined by the reading the contents of the appropriate register. U28 is a 4066 CMOS switch. The signals from the paddles are passed to the SID chip when the Enable inputs (E0 - E3) of U28 are "high".

NOTE: U1 port assignments are incorrect on schematics. Refer to Keyboard Matrix for correct assignments.

C64 CIRCUIT THEORY



The Serial Interface and User Port Circuits

The Serial Interface.

U2 is a Complex Interface Adapter (CIA). Parallel port signals PA3-PA7 control the serial bus interface. PA3 is the Attention (ATN) output. This signal is inverted by U8 before being transmitted to a device on the bus. PA4 is the clock output. Data transmitted from the C64 to a device on the bus is synchronized by this clock signal. U8 inverts the output PA4. PA5 is the data output. U8 inverts this output also. Data transmitted from a device on the bus to the C64 is synchronized by a clock generated by the transmitting device. The Clock signal is input on PA6. Data transmitted from a device on the bus to the C64 is input on PA7. When a device on the bus wants to communicate with the C64, SQR IN goes "low" indicating service is requested.

The User Port

Parallel port B of U2 (PB0 - PB7) is made available on the user port. Parallel data transfers with external device are made very easily through this parallel port. SP2 and SP1 are bi-directional serial ports. CNT1 and CNT2 are bi-directional synchronizing clock signals for each serial bus.

64 TROUBLESHOOTING GUIDE

SYMPTOM	POSSIBLE SOLUTION
Blank screen on power up.	Check External Power Supply U4 (KERNAL ROM), U17 (PLA) U7 (6510 MPU), U3 (ROM) U8 (7406 IC), U19 (VIC II) U9-U12 (4164 RAM) U21-U24 (4164 RAM) BT2, CR4, VR1
Out of memory error on power up.	Check U9-U12 (4164 RAM) U21-U24 (4164 RAM) **** USE DIAGNOSTIC TEST - DISK
No cursor displayed. Intermittent blank screen.	Check U1, U15, U7 Check U2, U7
Powers up with graphics display and blinking cursor	Check U14 (74LS258 IC)
Powers up with all the characters displayed as blocks.	Check U26 (74LS373 IC)
Intermittent display.	Check C88 (Possible Bad Connection)
Powers up with the 'PRESS PLAY ON TAPE' message and the display blanks	Check U7 (6510 MPU) R1 (Possible Bad Connection)
On power up the cursor lock up.	Check U7 (6510 MPU) U20 (556 IC)
When 'RETURN' is pressed after a run command, the cursor goes back to home position.	Check U3 (ROM)
Poke command does not work.	Check U3 (ROM)
Joystick does not operate correctly.	Check U1, U28 (6526 CIA)
Wrong frequency.	Check C70
No character lettering is displayed on the screen.	Check U3 (ROM) U2 (CIA)
Graphic characters instead of letters displayed.	Check U19 (VIC II)
Power up message appears but no cursor.	Check U1, U15, U7 and U4

SYMPTOM	POSSIBLE SOLUTION
Cursor jumps to back to home position.	Check U7 (6510 MPU)
Abnormal colors appear in the letters.	Check U6 (2114 RAM) U16 (4066 IC)
Different characters are displayed and cursor is locked when turned on and off.	Check RAM
System does not reset and the 'RESTORE' key does not work.	Check U20 (556 IC)
White band scrolls down the screen. (60 HZ HUM)	Check External Power Supply VR2 (5V Regulator)
Cursor disappears after the system warms up.	Check U1 (6526 CIA)
SYNTAX ERROR displayed after system warms up.	Check RAM, U3 (ROM)
Wavy screen after the system warms up.	Check External power supply U31 (74LS629 IC) U30 (74LS193 IC)
The system resets when it warms up.	Check U7 (6510 MPU) U3 (ROM)
Keyboard does not operate correctly when the system warms up.	Check U1 (6526 CIA) U3 (ROM)
Black band scrolls through screen when the system warms up.	Check External Power Supply C90, C88, CR4 VR2 (5V Regulator)
Cassette motor keeps running.	Check U7 (6510 MPU)
Cassette motor keeps running even after a program is done loading. The TIP 29 transistor gets extremely hot and the fuse may possibly blow.	Check Cassette Port for Shorts R4 (Possibly Open)
The cursor disappears when the cassette is plugged in.	Check U7 (6510 MPU)
Cassette runs extremely slow. The program seems to load but will not run.	Check U7 (6510 MPU)

SYMPTOM	POSSIBLE SOLUTION
When loading from cassette, the 'SYNTAX ERROR' message is displayed.	Check U20 (556 IC)
DEVICE NOT PRESENT ERROR is displayed when disk is used.	Check U1 (6526 CIA) U7 (6510 MPU) R28, R29, R30
Disk drives continue to search when trying to load.	Check U2 (6526 CIA)
When loading from disk and any key of the 4th row of the keyboard is pressed, the cursor goes to home position.	Check U20 (556 IC) R35 (Possible Bad Connection)
When loading from disk, a 'FILE NOT FOUND' message is displayed.	Check U4 (ROM) U2 (6526 CIA)
OUT OF MEMORY is displayed when disk is used.	Check U20 (556 IC)

C64 BOARD IDENTIFICATION

To date there are 4 version of 64 PCB assemblies in use.

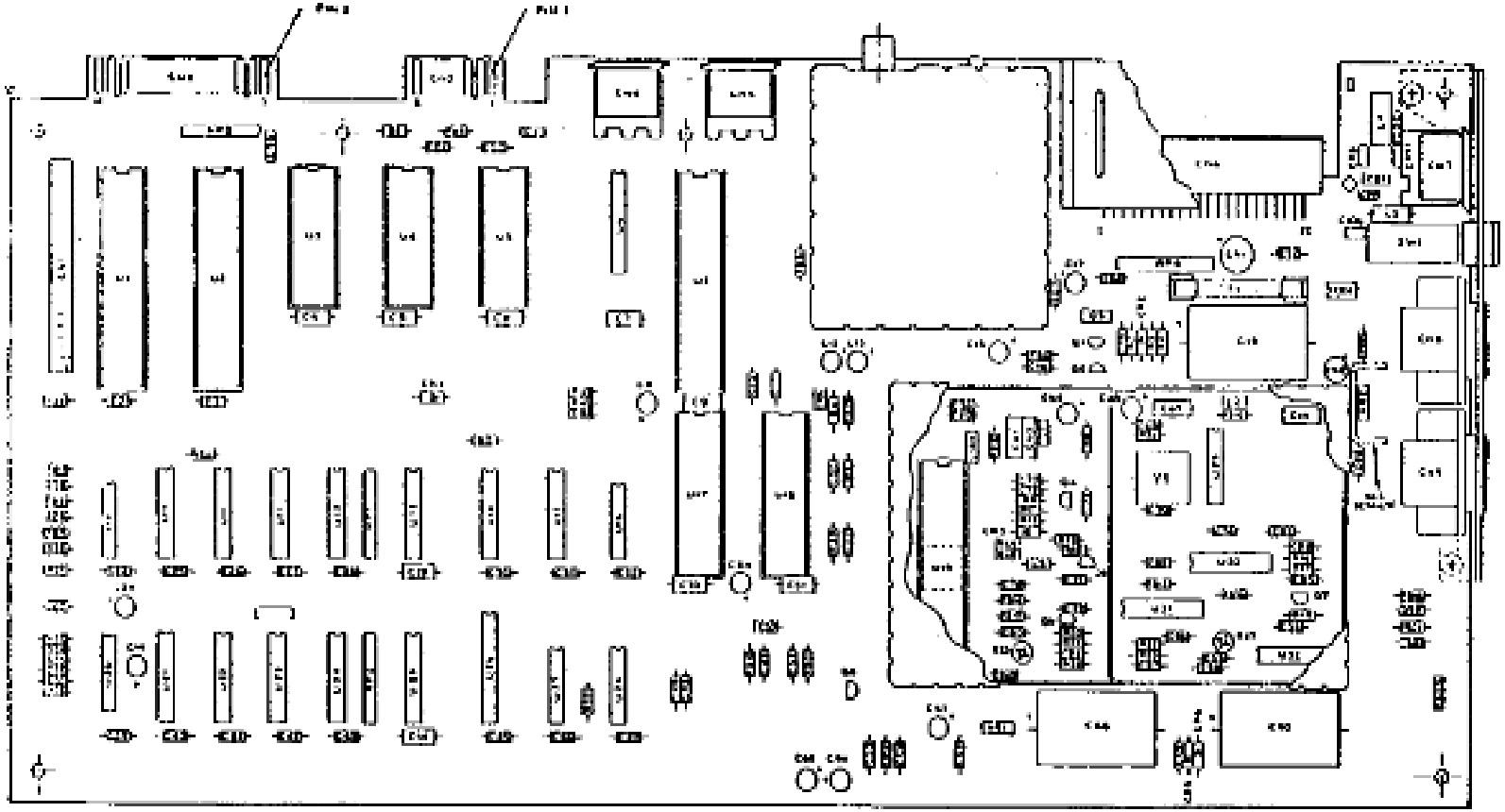
VERSION	IDENTIFYING FACTORS	PCB ASSY #	SCHEMATIC #
Original	5 pin board (CN5-Video port has 5 pins)	326298-01	326106
A (CR)	8 pin board (CN5-Video port has 5 pins)	250407-04	251138
B	8 pin board (Reduced oscillator circuit)	250425	251469
B-2	8 pin board	250441-01*	251469

These boards are interchangeable with casework, keyboard, etc.; however, care must be taken to provide the customer with a unit that is compatible with their monitor and cable.

When component level repairs are necessary, be certain to acquire the appropriate part for the board you are repairing. Most modulators are different, as are many of the components.

* The 4th version of 64 board was recently developed and only a few may be in the field. It is termed the 64B-2. All circuits remain the same as the 64B (Schematic 251469) with a few component location changes:

1) Resistors 28, 29, 30, 36, 48 were reduced to Resistor Pack RP5.
2) Diodes CR100-105 are no longer piggybacked. Their new locations are CR9, 12-16.



BOARD LAYOUT #326298 01

PARTS LIST - PCB ASSEMBLY #326298

C - Indicates Commodore Stocked Part Numbers

INTEGRATED CIRCUITS		
U1,U2	6526 CIA	C 906108-01
U3	2364 Basic ROM	C 901226-01
U4	2364 Kernal ROM	C 901227-03
U5	2364 Char ROM	C 901225-01
U6	2114L-30 RAM	901453-01
U7	6510 uProcessor	C 906107-01
U8	7406	901522-06
U9-U12	4164 (200 nS)	901505-01
U13	74LS257	901521-57
U14	74LS258	901521-58
U15	74LS139	901521-18
U16	4066	901502-01
U17	82S100 PLA	C 906114-01
U18	6581 SID	C 906112-01
U19	6567 VIC II	C 906109-04
U20	LM556	901523-03
U21-U24	4161 (200 nS)	901505-01
U25	74LS257	901521-57
U26	74LS373	901521-29
U27	74LS08	901521-03
U28	4066	901502-01
U29	74LS74	901521-06
U30	74LS193	901521-26
U31	74LS629	901521-68
U32	MC4044	906128-01

TRANSISTORS		
Q1	2N4401	902652-01
Q2	2N3904	902658-01
Q3	TIP29 B	902653-01
Q4-8	2N2222	902686-01

DIODES		
CR1	2.7V Zener IN4371	
CR2	7.5V Zener IN755	

RESISTORS (continued)			
R14	100	R30	1K
R16	1K	R31	180
R17	1.2K	R33	47K
R19	15K	R34	47K
R20	6.8K	R35	470K
R21	4.7K	R37	2.7K
R22	1.5K	R38	1K
R23	1K	R39	390
R24	3.3K	R41	1M
R25	Pot 1K	R43	3.3K
R26	75	R44	3.3K
R27	Pot 2K	R45	3.3K
R28	1K	R46	2K
R29	1K	R51	1.5K

NOTE:	The input video line requires a 470 ohm, 1/4 watt, resistor soldered to ground.

RESISTOR PACKS	
RP1,2	33, 8 Pin (Bourne No. 430BR-102-330)
RP3	33K, 8 Pin (Bourne No. 430BR-101-332)
RP4	3.3K, 10 Pin

CAPACITORS		
C1-3	Ceramic	.1 uF, 50V
C4-7	Ceramic	.47 uF, 50V, 20%
C8	Electrolytic	10 uF, 25V, +50%, -10%
C9	Ceramic	.47 uF, 50V, 20%
C10-11	Ceramic	470 pF, 50V
C12-15	Electrolytic	10 uF, 25V, +50%, -10%
C16	Ceramic	.1 uF, 50V
C17	Electrolytic	10 uF, 25V, +50%, -10%
C18	Ceramic	.1 uF, 50V
C19	Electrolytic	2200 uF, 16V
C20,21	Film	.22 uF, 100V, 20%
C22	Ceramic	.1 uF, 50V

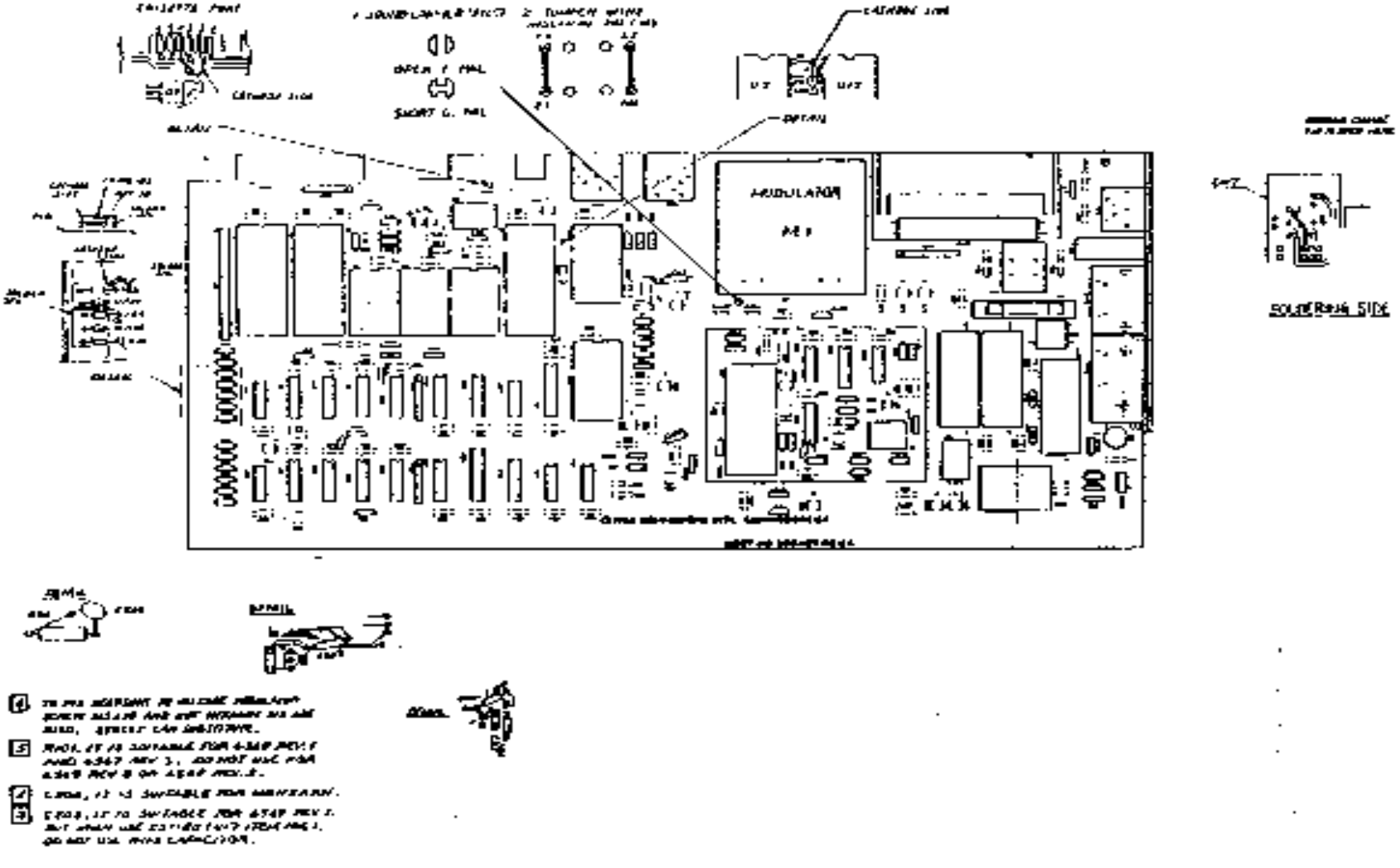
CR3	IN914		C23	Ceramic	360 pF, 50V
CR4	Bridge, Varo VMO8	906129-01	C24	Electrolytic	10 uF, 25V, +50%, -10%
CR5,6	Rectifier IN4001		C25-28	Ceramic	.22 uF, 50V
			C29	Ceramic	.47 uF, 50V, 20%
RESISTORS - All values are in ohms- 1/4W,			C30,31,32	Ceramic	.1 uF, 50V
5%, unless noted otherwise.			C33	Ceramic	.47 uF, 50V, 20%
R1	3.3K	R7	10K	C34	Electrolytic	10 uF, 25V, +50%, -10%
R2	1.5K	R8	390	C35	Ceramic	.1 uF, 50V
R3	10K	R9	75	C36	Ceramic	20 pF, 50V
R4	1K	R10	120	C37	Ceramic	1000 pF, 50V
R5	560	R11	120			
R6	1K	R13	1K			

PARTS LIST - PCB ASSEMBLY #326298 (Continued)

C - Indicates Commodore Stocked Part Numbers

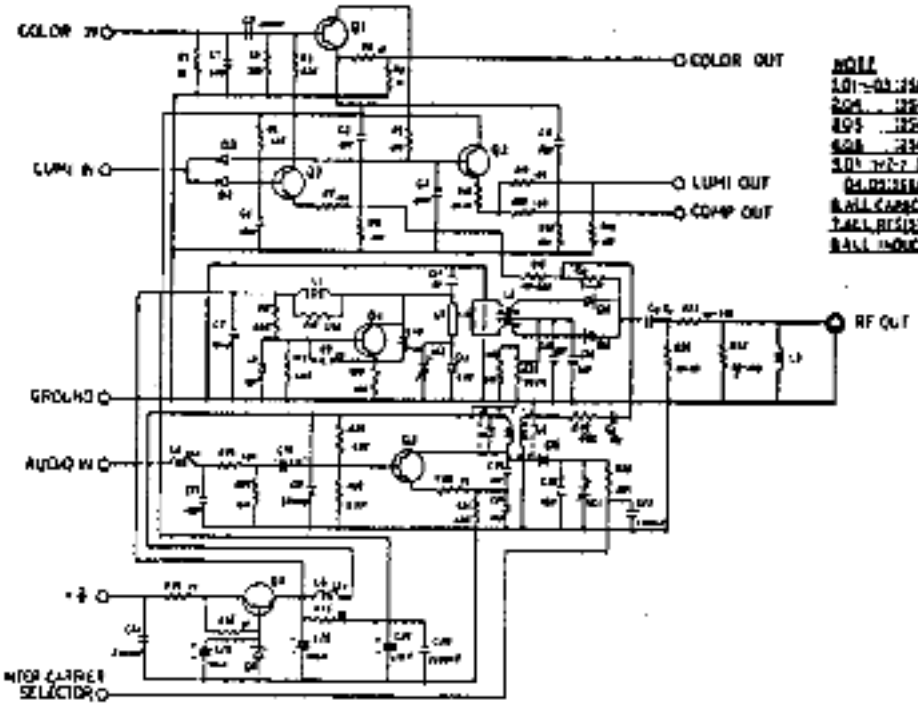
CAPACITORS (Continued)			**CAPACITORS (Continued)**		
C38	Ceramic	51 uF, 50V	C94	Electrolytic	10 uF, 25V, +50%, -10%
C39	Ceramic	.1 uF, 50V	C95,96	Ceramic	.1 uF, 50V
C40-43	Ceramic	.22 uF, 25V, +50%, -10%	C97	Ceramic	.22 uF, 25V
C44	Ceramic	.47 uF, 50V, 20%	C98,99	Ceramic	.1 uF, 50V
C45,46,47	Ceramic	.1 uF, 50V	C100	Ceramic	.22 uF, 25V
C48	Ceramic	1800 uF, 50V	C101	Ceramic	.1 uF, 50V
C49	Ceramic	470 pF, 50V	C102	Electrolytic	10 uF, 25V, +50%, -10%
C50	Ceramic	.22 uF, 50V	C103	Ceramic	.1 uF, 50V
C51	Ceramic	.47 uF, 50V, 20%	C105	Ceramic	.1 uF, 50V
C52,53	Ceramic	470 pF, 50V			
C54	Ceramic	.22 uF, 50V	**CONNECTORS**		
C55	Ceramic	.1 uF, 50V	CN1	Header Assy 20 Pin	903331-20
C56	Ceramic	.1 uF, 50V	CN4	6 Pin Din	C 903361-01
C57	Electrolytic	10 uF, 25V, +50%, -10%	CN5	5 Pin Din	C 903362-01
C58	Ceramic	.1 uF, 50V	CN6	44 Pin Card Edge	C 906100-02
C59	Ceramic	.22 uF, 50V	CN7	7 Pin Din	C 906130-01
C60,61	Ceramic	.47 uF, 50V, 20%	CN8,9	Plug Assy, 8 Pin Rt. Angle	C 906126-01
C62	Electrolytic	10 uF, 25V, +50%, -10%	CN10	Header Assy, 3 Pin	
C63	Ceramic	.47 uF, 50V, 20%			
C64,65	Electrolytic	10 uF, 25V, +50%, -10%	**MISCELLANEOUS**		
C66,67	Ceramic	.47 uF, 50V, 20%	L1,2	Coil Inductor 2.2 uH	901151-17

C68	Ceramic	.1 uF, 50V	L3	Coil Inductor 3.0 uH	901151-21
C69			L4	Filter Line Assy	C 906127-01
C70	Mica	10 pF, 500V, 5%	L5	Coil Inductor 1.2 uH	901152-01
C71	Ceramic	.1 uF, 50V	Y1	Crystal 14.31818 MHz	C 900558-01
C72	Ceramic	220 pF, 50V	SW1	Rocker Switch DPDT	C 904500-01
C73	Ceramic	150 pF, 50V	VR1	Voltage Regulator MC7812CT	
C74	Ceramic	.1 uF, 50V	VR2	Voltage Regulator MC7805CT	
C77	Ceramic	.1 uF, 50V	M1	Modulator	C 326130-01
C78	Ceramic	220 pF, 50V	F1	Fuse, Normal Blo, 250V, 1.5A	
C79	Ceramic	510 pF, 50V	FB1-23	Ferrite Bread	903025-01
C80	Ceramic	51 pF, 50V		Connector Panel	
C81	Ceramic	20 pF, 50V		(ON, OFF, Joystick)	326299-01
C82	Ceramic	.1 uF, 50V		Catridge Guide	326116-01
C83	Mica	.33 pF, 500V, 5%		Shield Box	C 326265-01
C84	Ceramic	.1 uF, 50V		Shield Cap	C 326267-01
C85	Ceramic	.47 uF, 50V, 20%			
C86	Mica	39 pF, 500V, 5%			
C87	Ceramic	.1 uF, 50V			
C88	Electrolytic	470 uF, 50V			
C89	Ceramic	.1 uF, 50V			
C90	Electrolytic	470 uF, 50V			
C91	Electrolytic	100 uF, 16V			
C92	Ceramic	.22 uF, 50V			
C93	Ceramic	1800 uF, 50V			

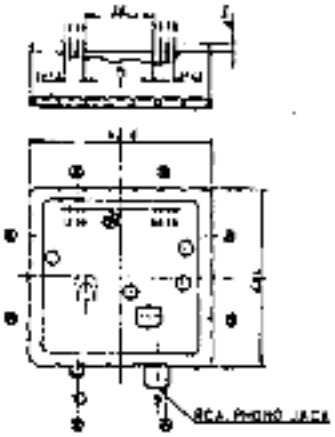


BOARD LAYOUT #250407-04

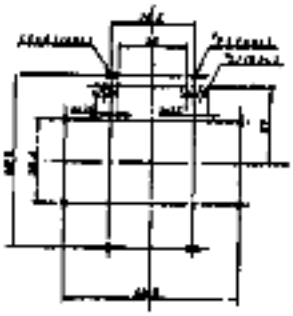
MODULATOR SCHEMATIC #251025

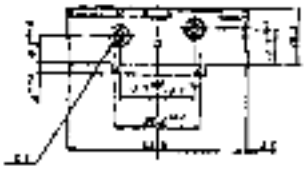


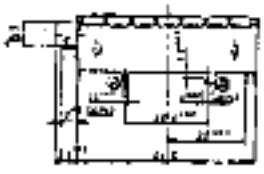
NOTE
1.01~03:2SC1684 OR EQUIVALENT
2.Q04 :2SC1730 OR EQUIVALENT
3.Q05 :2SC460 OR EQUIVALENT
4.Q06 :2SC1730 OR EQUIVALENT
5.D1~D2:1S1588
D4,D5:1S1588 OR 1S920 D6:1S920
6.ALL CAPACITANCE VALUES :P
7.ALL RESISTANCE VALUES :Ω
8.ALL INDUCTANCE VALUES :H



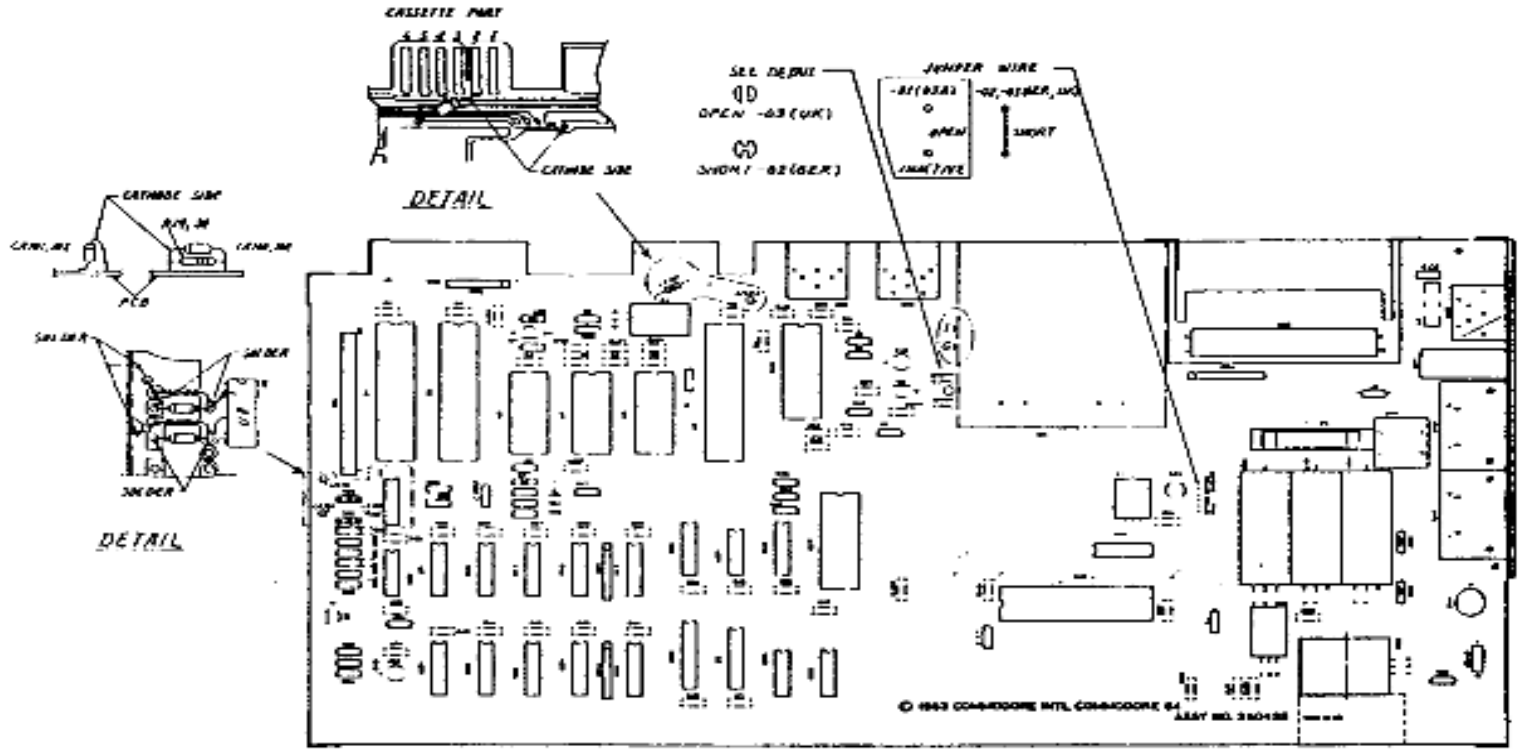
NO	TERMINALS
1	
2	SYNC+LUMI SIG INPUT
3	COLOR SIG INPUT
4	AUDIO SIG INPUT
5	COMP. SIG OUTPUT
6	SYNC+LUMI SIG OUTPUT
7	COLOR SIG OUTPUT
8	INTER CARRIER SELECTOR
9	RF OUTPUT
10	CHANNEL TRIMMER







NOTE
1.RECOMMENDED PC.B HOLE CENTERS (COMPONENT SIDE)
2.ALL DIMENSIONS ARE IN MILLIMETERS
3.RESISTANCE SHORT:0.0Ω
OPEN :1.0MΩ

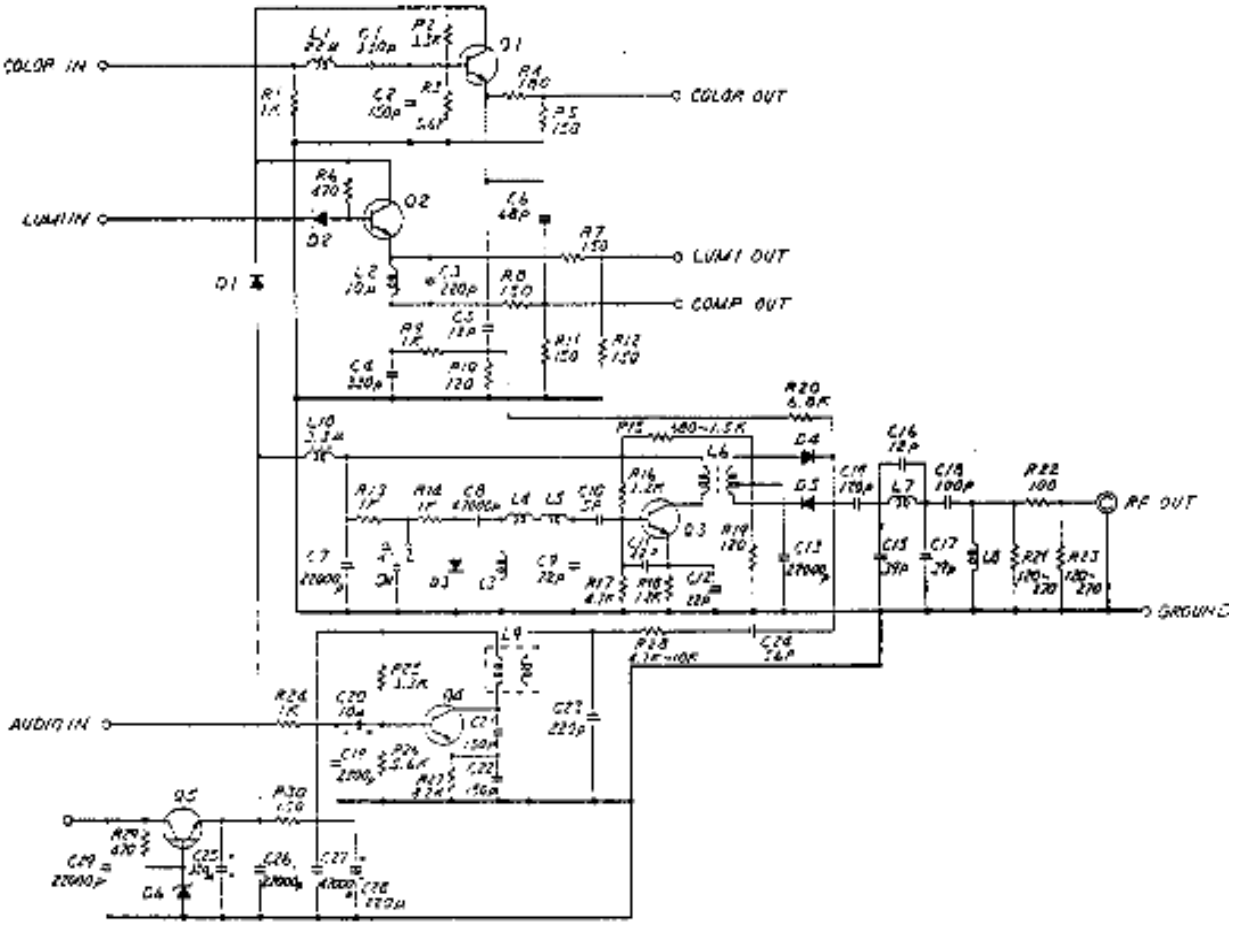


SOUND CARRIER SELECT	MODULATOR				
	NTSC	PAL			
		P/N 251025-01		P/N 251697-01	
		-02 (GER)	-03 (UK)	-02 (GER)	-03 (UK)
JUMPER	DON'T CARE	OPEN	SHORT	DON'T CARE	DON'T CARE
SWITCH	DON'T CARE	DON'T CARE	DON'T CARE	G POSITION	I POSITION

DETAIL 'C' SOUND CARRIER SELECT

BOARD LAYOUT #250425-01

MODULATOR SCHEMATIC #251696



NOTES

1. D1, D2 : MA151K OR EQUIVALENT
2. D3 : MA57 OR EQUIVALENT
3. D4, D5 : 1SS198 OR EQUIVALENT
4. D6 : HZ-7A1 OR EQUIVALENT
5. Q1, Q2 : 2SC2405 OR EQUIVALENT
6. Q3, Q4 : 2SC2778 OR EQUIVALENT
7. Q5 : 2SC2120Y OR EQUIVALENT
8. COMPONENT PARTS VALUE : R=Ω, C=F, L=H