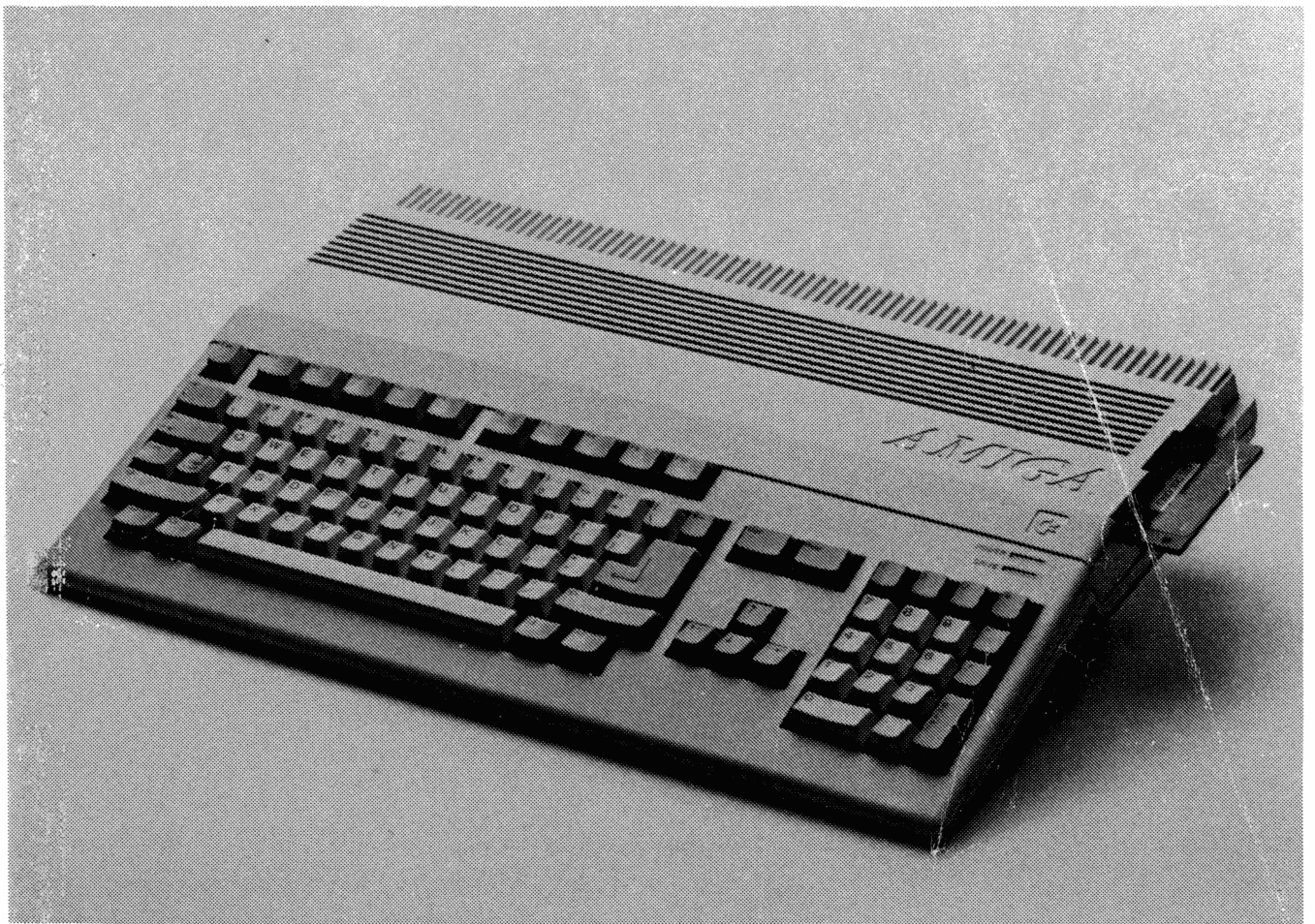


Technical Manual

COMMODORE AMIGA 500



SERVICE MANUAL

A500

JUNE, 1987

PN-314981-01

Commodore Business Machines, Inc.

1200 Wilson Drive, West Chester, Pennsylvania 19380 U.S.A.

Commodore makes no expressed or implied warranties with regard to the information contained herein. The information is made available solely on an as is basis, and the entire risk as to quality and accuracy is with the user. Commodore shall not be liable for any consequential or incidental damages in connection with the use of the information contained herein. The listing of any available replacement part herein does not constitute in any case a recommendation, warranty or guaranty as to quality or suitability of such replacement part. Reproduction or use without expressed permission, of editorial or pictorial content, in any matter is prohibited.

This manual contains copyrighted and proprietary information. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Commodore Electronics Limited.

Copyright © 1987 by Commodore Electronics Limited.
All rights reserved.

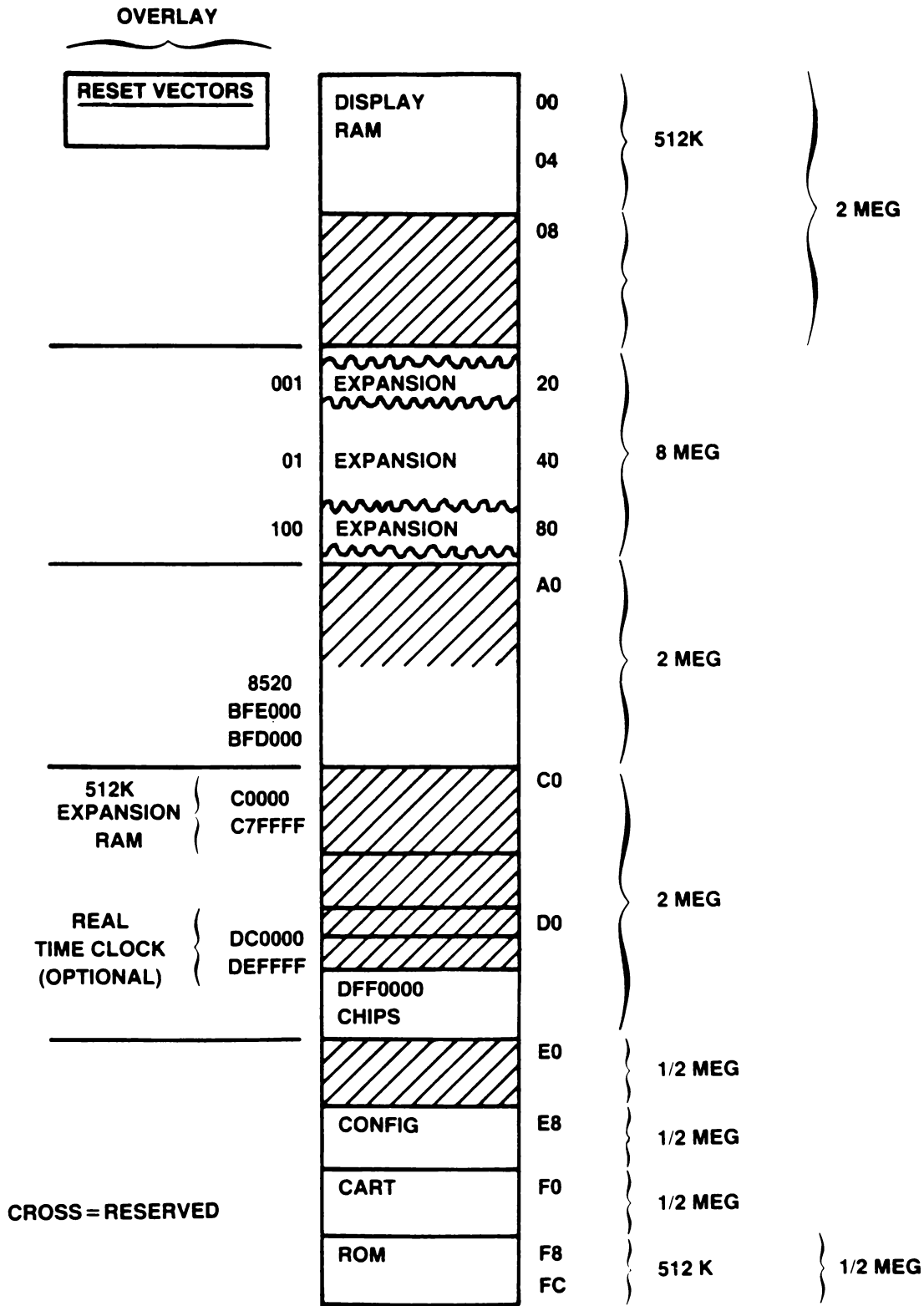
TABLE OF CONTENTS

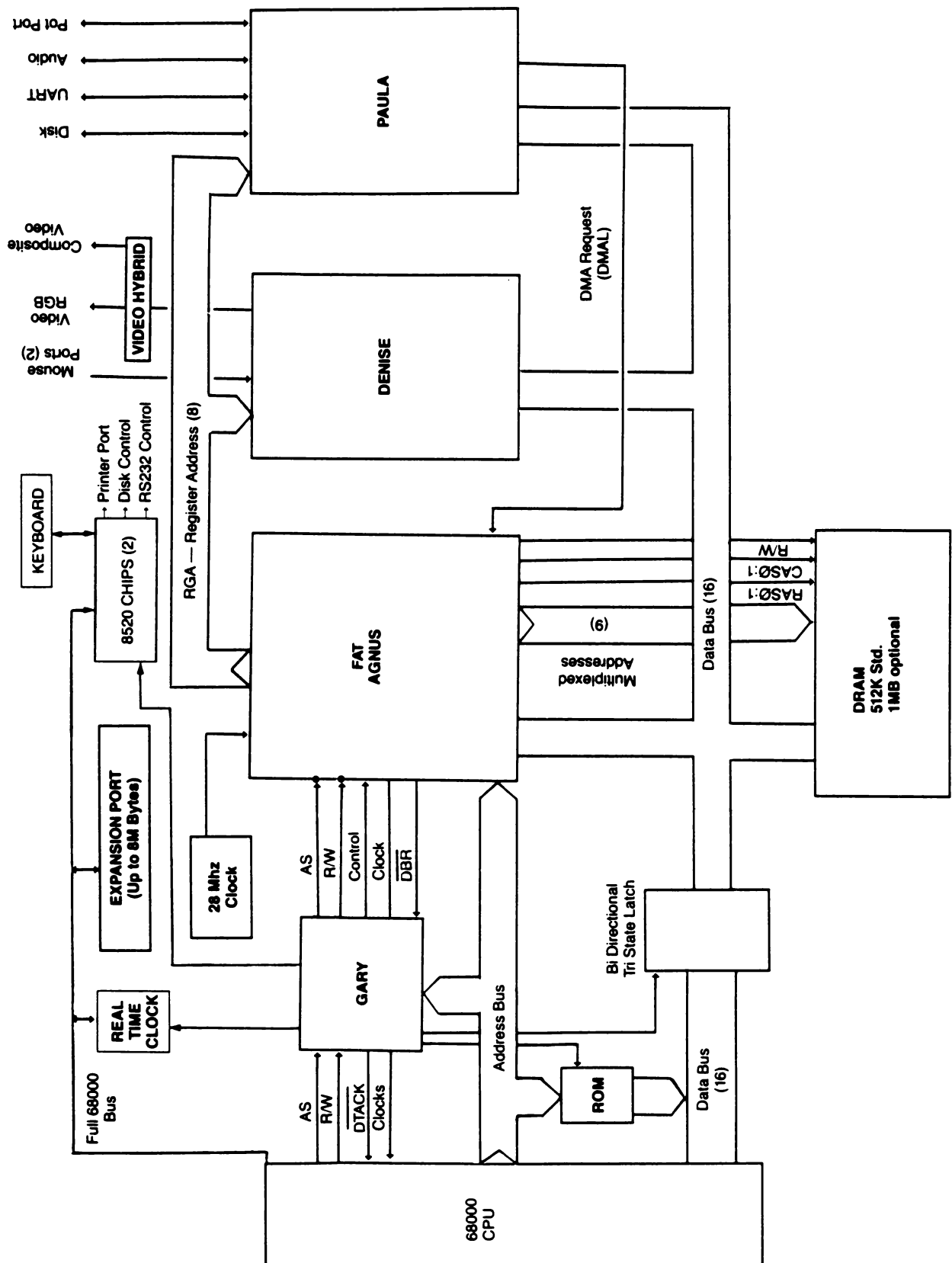
TITLE	PAGE
SPECIFICATIONS.....	1
MEMORY MAP.....	2
SYSTEM BLOCK DIAGRAM.....	3
THEORY OF OPERATIONS.....	4
IC SPECIFICATIONS	
FAT AGNUS.....	8
DENISE.....	10
PAULA.....	12
GARY.....	14
COMPLEX INTERFACE ADAPTER.....	16
I/O CONNECTORS.....	25
SERIAL CONNECTOR.....	26
PARALLEL CONNECTOR.....	27
RGB MONITOR CONNECTOR.....	28
MOUSE/GAME CONTROLLER CONNECTORS.....	29
EXTERNAL DISK CONNECTOR.....	31
POWER SUPPLY CONNECTOR.....	31
EXPANSION 86-PIN CONNECTOR.....	32
MAJOR COMPONENT PARTS LIST.....	33
SERVICE PARTS REFERENCE DIAGRAM.....	33
COMPONENT PARTS LIST.....	34
PCB BOARD LAYOUT.....	36
RAM/CLOCK PCB BOARD LAYOUT.....	37
SCHEMATICS.....	38

Amiga Specifications

Central Processor	Motorola MC68000
Memory	512K bytes RAM expandable to 1M
Disks	3-1/2 inch double-sided double-density microdisks with 880K bytes formatted storage capacity per disk
Mouse	Mechanical, .13 mm/count (200 counts per inch)
Interfaces	RS-232 serial interface Centronics®-compatible parallel interface External disk interface Mouse/Game controller interface Additional game controller interface Keyboard interface Two audio outputs for stereo sound Memory cartridge interface Expansion interface
Supported Monitors	Analog RGB, digital RGB, monochrome (composite video), and standard televisions
Power Requirements	99 to 121 volts AC 54 to 66 Hz
Temperature Requirements	For operation: 5 to 40 degrees Centigrade (41 to 104 degrees Fahrenheit) For storage: -40 to 60 degrees Centigrade (-40 to 140 degrees Fahrenheit)
Humidity Requirements	20% to 90% relative humidity, non-condensing

Amiga 500 Memory Map





Theory of Operation

The AMIGA computer is a high-performance system with advanced graphics and audio features. The principal hardware features consist of the 68000 microprocessor which runs at 7.2 MHz, 512K RAM, expandable to 1MB, and configurable to 8MB, 2 parallel I/O chips, one control chip (GARY) and 3 custom VLSI chips that provide the unique capabilities for animation, graphics and sound.

68000 Microprocessor

The 68000 is the CPU of the system. All other resources are under software control via control data issued from it. All 3 custom chips have control registers that are written by the 68000.

The 68000 communicates with the rest of the computer via its address bus, data bus and control lines. Notice that in the block diagram the 3 custom chips do not reside directly on the 68000 buses. When the 68000 starts a bus cycle that is intended for the custom chips or the display RAM, the bus control chip detects whether or not the display RAM buses are available. The control chip will not assert the acknowledge signal (/DTACK) back to the 68000 until the display RAM buses are available. Once the 68000 receives /DTACK it completes the bus cycle. Connecting the display RAM buses to the 68000 buses is discussed further in the section on bus control. Because the display RAM is capable of approximately twice the bandwidth of the 68000, the 68000 is usually not delayed by waiting for the display buses to become available.

The 68000 can fetch instructions from:

Display RAM
ROM

The 68000 can read and write data directly to:

Display RAM
Parallel I/O Chips
3 Custom I.C.s
ROM

The 68000 transmits data and control to and from the peripherals via the parallel I/O and the 3 custom chips.

/M is the processor clock to the 68000. C1, C3 and CDAC are used to clock the custom chips and determine the timing of signals to the memory arrays.

ROM

The ROM contains the kernel and DOS routines; it is 128K × 16.

Parallel I/O

The 2 multipurpose 8520 I/O chips provide the following:

- I/O to and from the parallel port connector
- Control lines to and from the joystick/mouse ports
- A control line to the front panel LED
- Internal control lines
- Keyboard control lines, clock and data
- Serial port control lines
- Floppy disk interface control lines
- Internal timers

These 2 chips reside on the 68000 buses and are read and written by the 68000.

Clocks Generator

The entire computer board is run synchronous to the 3.579545 MHz color clock. This is accomplished by generating a number of submultiple frequencies from the master 28.63636 MHz NTSC (or 28.37516 MHz for PA) crystal oscillator. All clocks are generated by the Fat Agnus custom chip. The following are the primary clocks:

- C1 3.579545 MHz color clock
- C3 C2 shifted 45 degrees later
- 7M C1 XORed with C3 = 7.15909 MHz
- CDAC 7M shifted 90 degrees later

The 3 Custom Chips

The 3 custom chips provide very fast manipulation of graphics and audio data in the display RAM. All the major functions in the chips are DMA driven; that is, streams of data are moved between the custom chips and display RAM under DMA control. These streams of data are acted upon by the custom chips. Fat Agnus, custom chip #1, contains 25 dedicated purpose DMA counters.

The 3 chips have control registers which are usually loaded by the 68000. However, Fat Agnus also has the capability of loading control registers in the other 2 custom chips. When Fat Agnus performs a bus cycle, it outputs a code on the Register Address Bus telling the other 2 chips the nature of the bus cycle. This is necessary because many of the bus cycles provide data to or from the other 2 chips, thus they must cooperate appropriately.

In addition to manipulating data in the display RAM, the custom chips output streams of data to the video output circuits and audio output circuits, and they move data to and from the floppy disks and serial port.

Note that the display RAM buses can be completely isolated from the 68000 buses by Fat Agnus and Data Bus drivers. Thus, Fat Agnus can be performing a bus cycle on the display buses simultaneously with the 68000 performing a bus cycle on its buses. This parallelism increases throughout.

Bus Control, Address/Data MUX, Address Driver

The bus control logic resides in the control chip (GARY) and Fat Agnus. They provide 3 major functions, they:

- Synchronize the 68000 to the current phase of C1
- Arbitrate between the 68000 and Fat Agnus for the display buses
- Generate DRAM timing for the video RAM bus drivers appropriate to the current cycle

Synchronizing the 68000 to C1 is straightforward, since the 68000 is clocked by 7M which is twice the frequency and synchronous to C1. If the 68000 starts a bus cycle in the wrong phase of C1, the bus control chip merely delays /DTACK long enough so that the 68000 will complete the bus cycle in the desired phase relationship to C1. This phase relationship is necessary because the custom chips and the display RAM are clocked by C1.

Arbitration is very simple. Fat Agnus tells the bus control prior to taking the display RAM buses by asserting an input to the control chip (GARY) called /DBR. Whenever Fat Agnus has the display buses and the 68000 wants them, the 68000 is held off by not giving it /DTACK. In this state the 68000 has no effect on the display buses until the bus controller enables the bus drivers.

Fat Agnus generates the DRAM timings and does all address multiplexing. If the 68000 is running a video memory cycle, its addresses are routed through Fat Agnus onto the multiplexed address lines. If the custom chips are running a memory cycle the addresses are routed to the multiplexed address lines from internal address register.

Display RAM

The display RAM is a 512K read/write memory that resides on the RAM address and RAM data buses. It is expandable to 1M bytes by the addition of the RAM expansion module. It is implemented using standard 256K × 1 dynamic RAMs, refreshed by Fat Agnus.

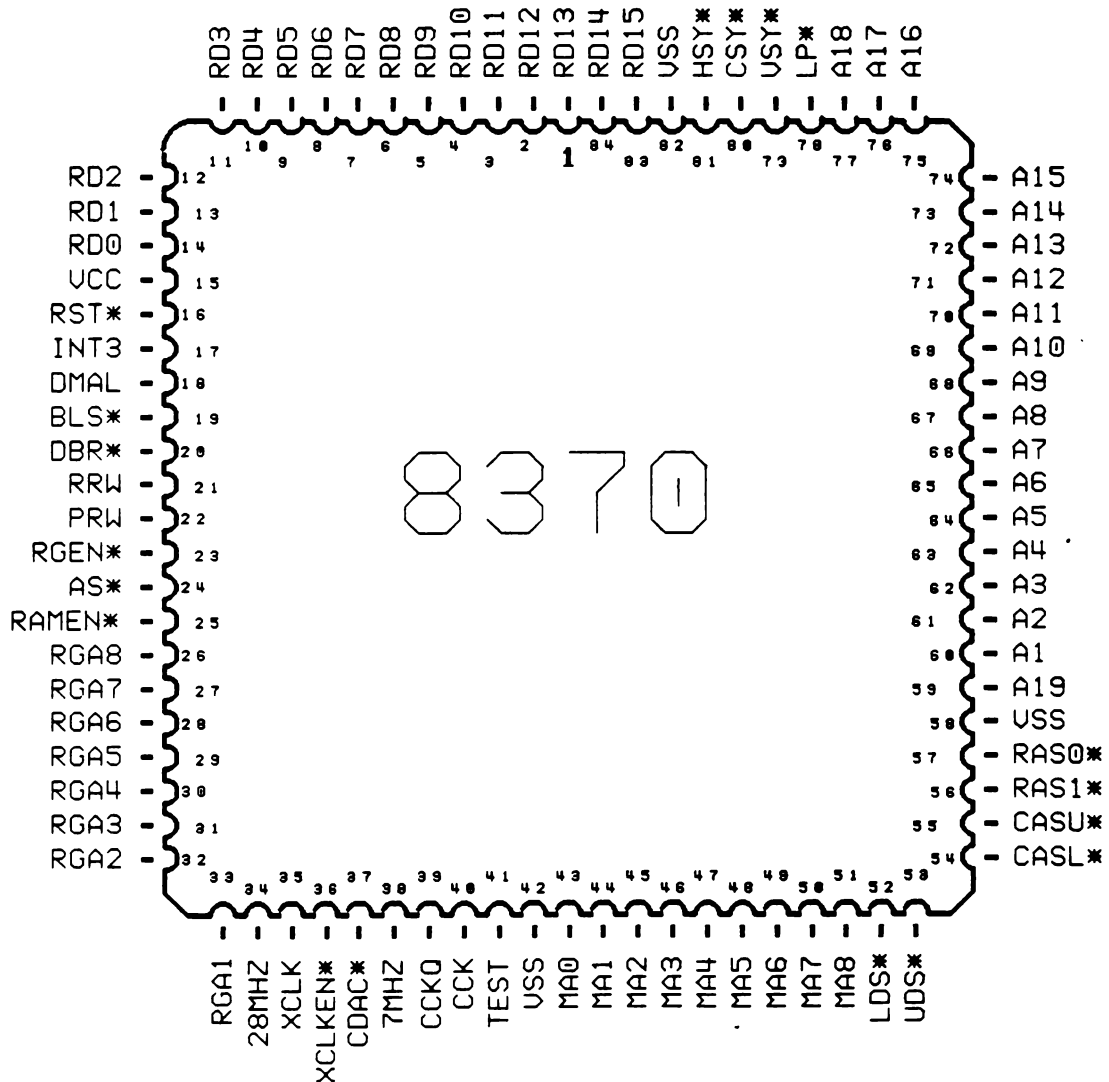
The display RAM is really used for much more than just holding graphics data. It also stores code and data for the 68000.

Custom Control Chips

The Amiga's animation, graphics and sound are produced by three custom chips. Fat Agnus (8370), Denise (8362) and Paula (8364). A fourth custom chip, Gary serves as the control chip. The following pages include pin diagrams, feature lists, and block diagrams for these chips.

Custom Animation Chip

Fat Agnus



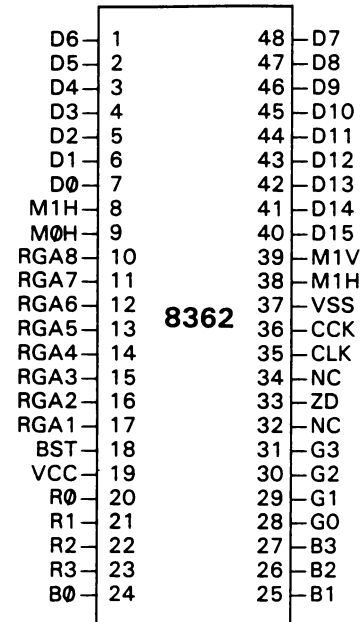
Features:

- Bit Blitter—Uses hardware to move display data—Allows high speed animation—Frees the CPU for other concurrent tasks
- Display Synchronized Coprocessor
- Controls 25 DMA Channels—Allows the disk and sound to operate with minimal CPU intervention
- Generates all system clocks from the 28 Mhz oscillator
- Generates all control signals for the video RAM and expansion RAM card
- Provides the address to the video and expansion RAM multiplexing

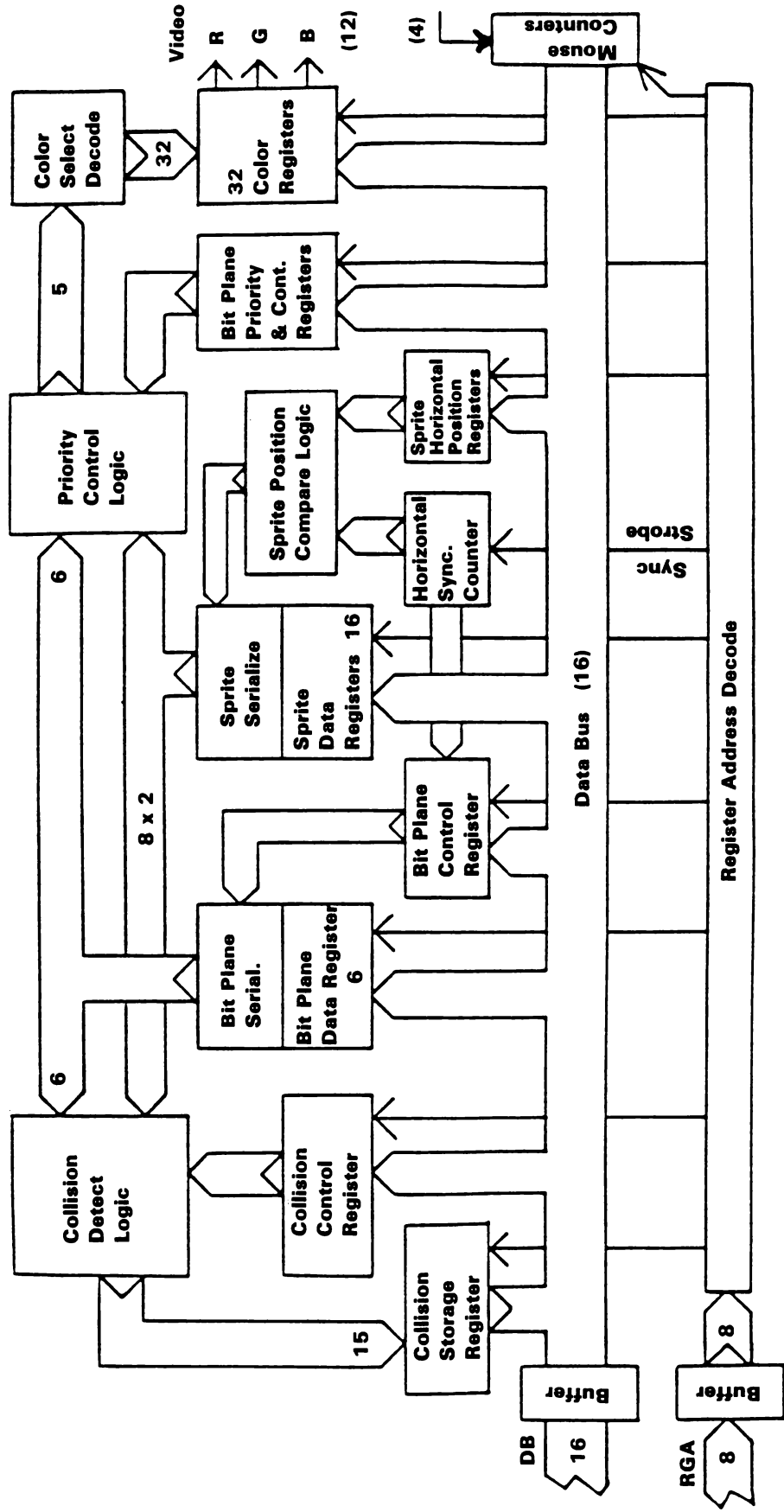
Custom Graphics Chip Denise

Features:

- Many different resolutions
320 × 200 up to 640 × 400
- 4096 colors on a TV or RGB monitor
- Eight re-usable sprite controllers
- 60 or 80 column text
- Same software for all TVs and monitors



Pin	Name	Description	Type
1-7	D0-D6	Data Bus Lines 0-6	I/O
8	M1H	Mouse 1 Horizontal	I
9	M0H	Mouse 0 Horizontal	I
10-17	RGA1-8	Register Address 1-8	I
18	/BURST	Color Burst	O
19	Vcc	+ 5 VDC	I
20-23	R0-3	Video Red Bit 0-3	O
24-27	B0-3	Video Blue Bit 0-3	O
28-31	G0-3	Video Green Bit 0-3	O
32	N/C	No Connection	N/C
33	/ZD	Background Indicator	O
34	N/C	No Connection	N/C
35	7M	7.15909 MHz Clock	I
36	CCK	Color Clock	I
37	Vss	Ground	I
38	M0V	Mouse 0 Vertical	I
39	M1V	Mouse 1 Vertical	I
40-48	D7-D15	Data Bus Lines 7-15	I/O

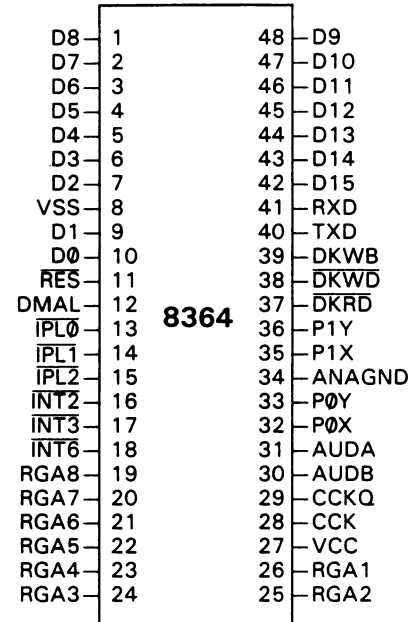


Denise Block Diagram

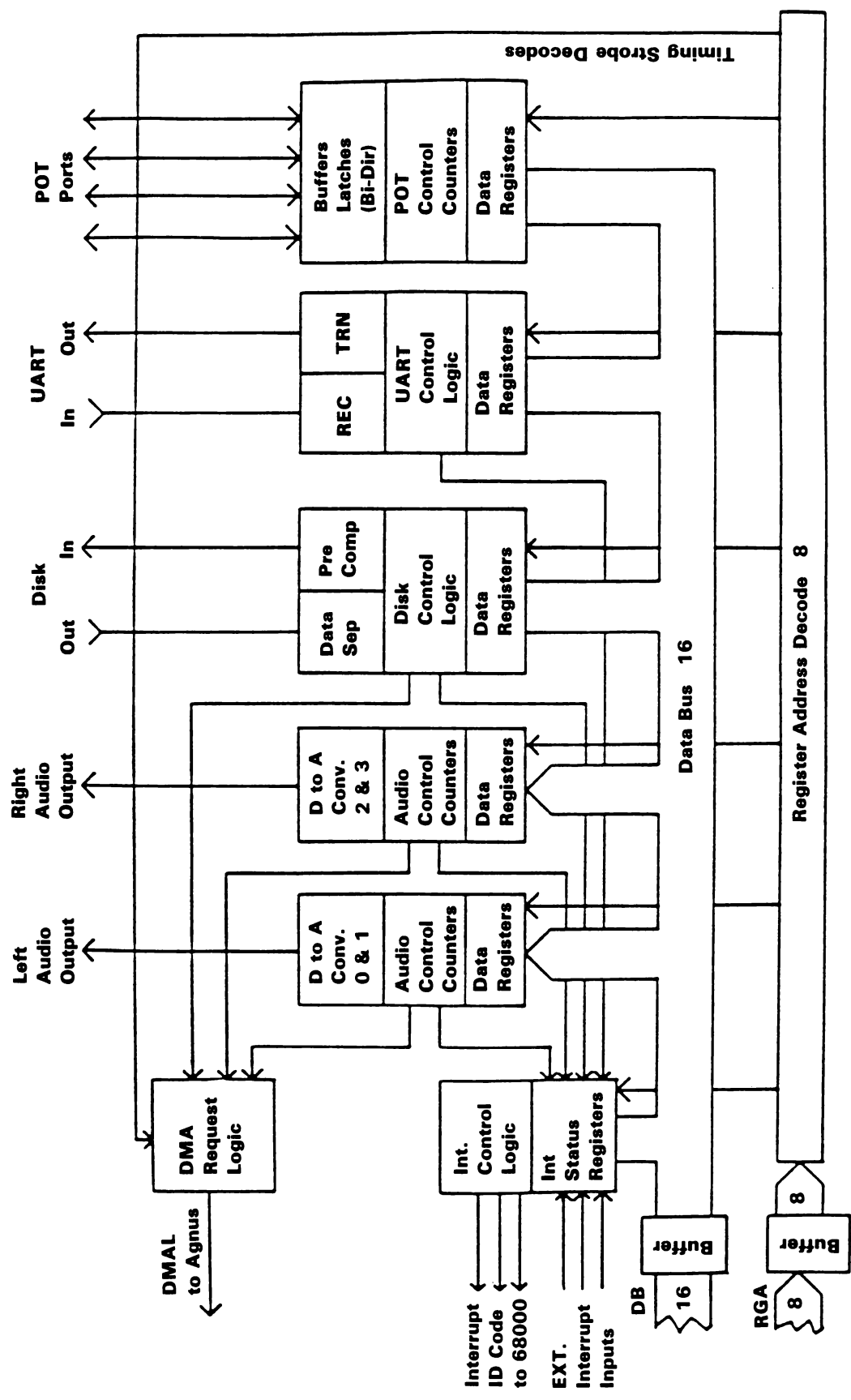
Custom Sound/Peripherals Chip Paula

Features:

- Four voices of sound output configured as two stereo channels
- Nine octaves
- Complex waveforms
- Uses both amplitude and frequency modulation
- I/O controls for disk data and controller ports
- Microdisk controller
- Interrupt control system



Pin	Name	Description	Type
1-7	D2-D8	Data Bus Lines 2-8	I/O
8	Vss	Ground	I
9,10	D0,D1	Data Bus Lines 0,1	I/O
11	/RES	System Reset	I
12	DMAL	DMA Request Line	O
13-15	/IPL0-2	Interrupt Line 0-2	O
16-18	/INT2,3,6	Interrupt Level 2,3,6	I
19-26	RGA1-8	Register Address 1-8	I
27	Vcc	+ 5 VDC	I
28	CCK	Color Clock	I
29	CCKQ	Color Clock Delay	I
30	AUSB	Right Audio	O
31	AUDA	Left Audio	O
32	POT0X	Pot 0X	I/O
33	POT0Y	Pot 0Y	I/O
34	VSSANA	Analog Ground	I
35	POT1X	Pot 1X	I/O
36	POT1Y	Pot 1Y	I/O
37	/DKRD	Disk Read Data	I
38	/DKWD	Disk Write Data	O
39	DKWE	Disk Write Enable	O
40	TXD	Serial Transmit Data	O
41	RXD	Serial Receive Data	I
42-48	D9-15	Data Bus Lines 9-15	I/O

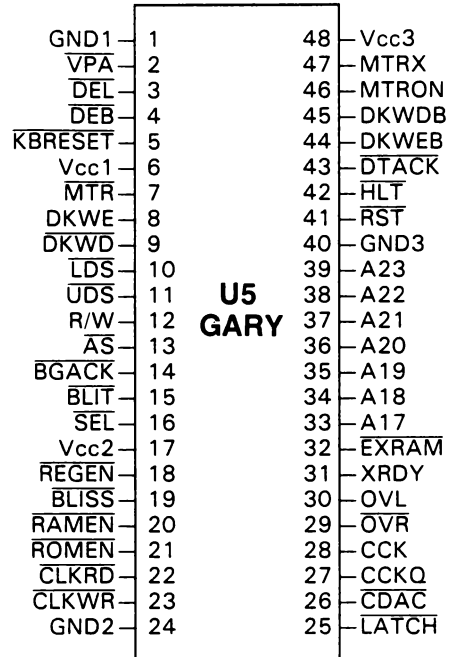


Paula Block Diagram

Custom Control Chip Gary

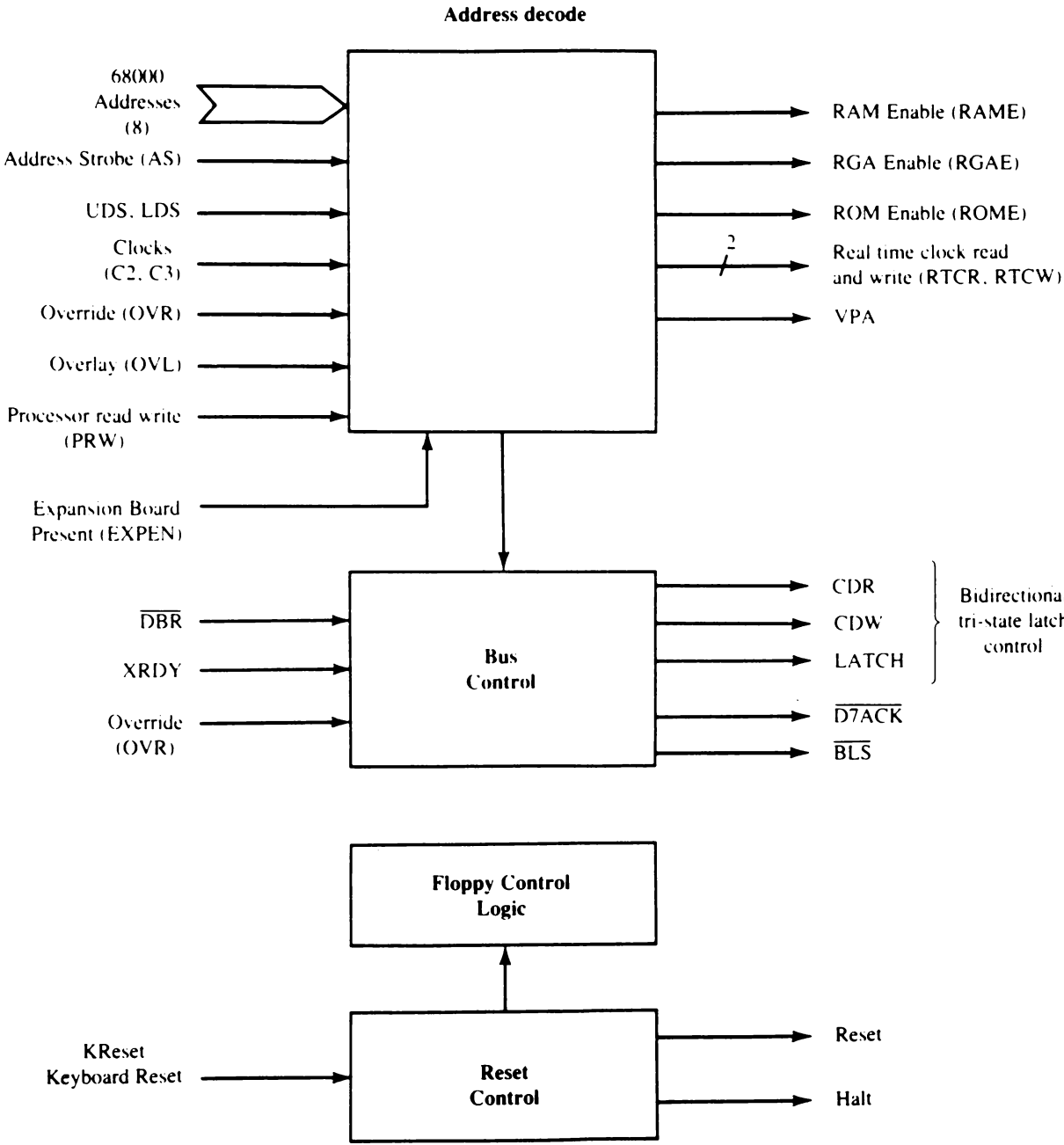
Features:

- Provides all bus control signals.
- Provides all address decoding.
- Generates the 68000 VPA signal.
- Handles some of the floppy circuitry.
- Provides keyboard reset interface.

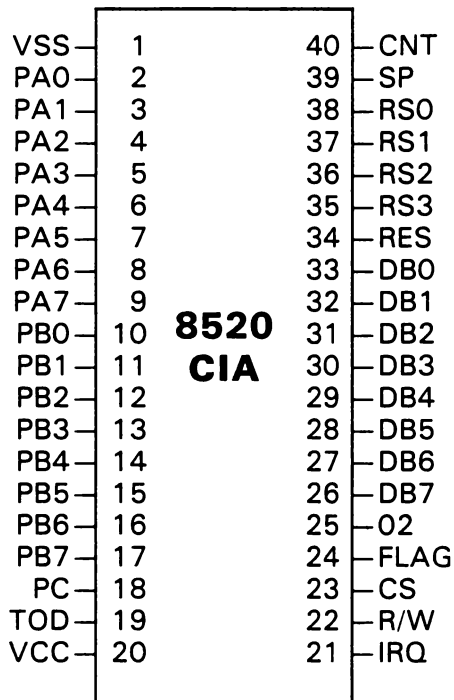


For signal descriptions see Schematic #312511 (sheet 1 of 9)

Gary Block Diagram



Complex Interface Adapter



INTERFACE SIGNALS

O2 Clock Input

The O2 clock is a TTL, compatible input used for internal device operation and as a timing reference for communicating with the system data bus.

CS — Chip Select Input

The CS input controls the activity of the 8520. A low level on CS while O2 is high causes the device to respond to signals on the R/W and address (RS) lines. A high on CS prevents these lines from controlling the 8520. The CS line is normally activated (low) at O2 by the appropriate address combination.

R/W — Read/Write Input

The R/W signal is normally supplied by the microprocessor and controls the direction of data transfers of the 8520. A high on R/W indicates a read (data transfer out of the 8520), while a low indicates a write (data transfer into the 8520).

RS3-RS0 — Address Inputs

The address inputs select the internal registers as described by the Register Map.

DB7-DB0 — Data Bus Inputs/Outputs

The eight bit data bus transfers information between the 8520 and the system data bus. These pins are high impedance inputs unless CS is low and R/W and O2 are high, to read the device. During this read, the data bus output buffers are enabled, driving the data from the selected register onto the system data bus.

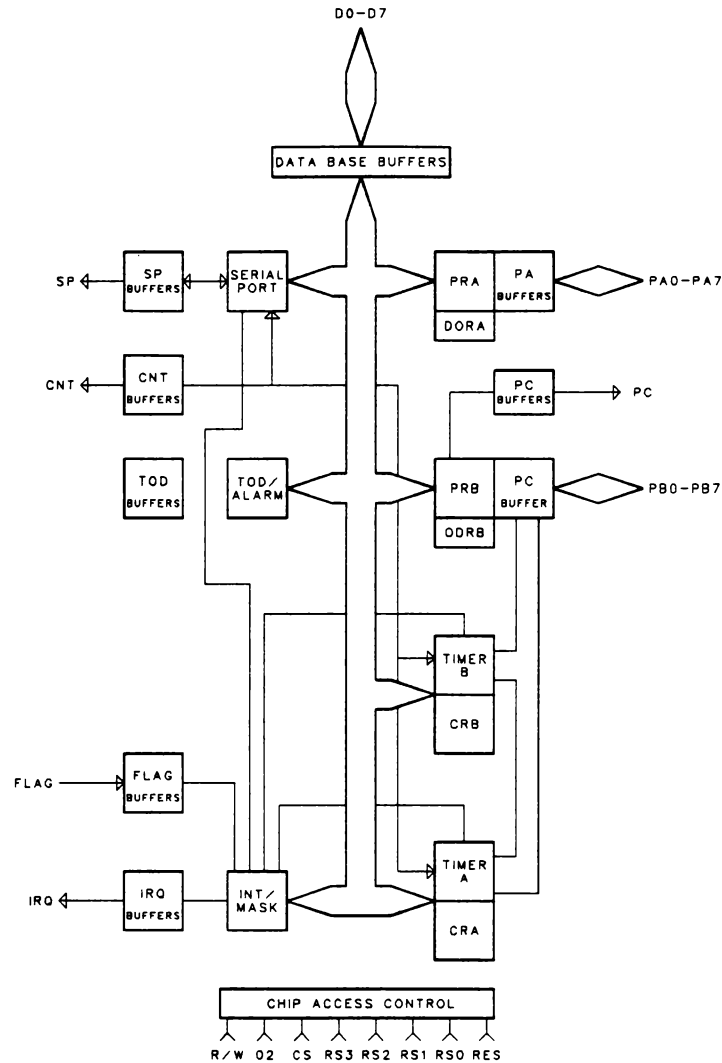
IRQ — Interrupt Request Output

IRQ is an open drain output normally connected to the processor interrupt input. An external pullup resistor holds the signal high, allowing multiple IRQ-outputs to be connected together. The IRQ output is normally off (high impedance) and is activated low as indicated in the functional description.

RES — Reset Input

A low on the RES pin resets all internal registers. The port pins are set as inputs and port registers to zero (although a read of the ports will return all highs because of passive pullups). The timer control registers are set to zero and the timer latches to all ones. All other registers are reset to zero.

REGISTER MAP



RS3	RS2	RS1	RS0	REG		
0	0	0	0	0	PRA	Peripheral Data Reg. A
0	0	0	1	1	PRB	Peripheral Data Reg. B
0	0	1	0	2	DDRA	Data Direction Reg. A
0	0	1	1	3	DDRB	Data Direction Reg. B
0	1	0	0	4	TA LO	Timer A Low Register
0	1	0	1	5	TA HI	Timer A High Register
0	1	1	0	6	TB LO	Timer B Low Register
0	1	1	1	7	TB HI	Timer B High Register
1	0	0	0	8		Event LSB
1	0	0	1	9		Event 8-15
1	0	1	0	A		Event MSB
1	0	1	1	B		No Connect
1	1	0	0	C	SDR	Serial Data Register
1	1	0	1	D	ICR	Interrupt Control Register
1	1	1	0	E	CRA	Control Register A
1	1	1	1	F	CRB	Control Register B

FUNCTION DESCRIPTION**I/O Ports (PRA, PRB, DDRA, DDRB)**

Ports A and B each consist of an 8-bit Peripheral Data Register (PR) and an 8-bit Data Direction Register (DDR). If a bit in the DDR is set to the corresponding bit in the PR it is an output. If a DDR bit is set to zero, the corresponding PR bit is defined as an input. On a READ, the PR reflects the information present on the actual port pins (PA0-PA7, PBO-PB7) for both input and output bits. Port A has both passive and active pullup devices, providing both CMOS and TTL compatibility. It can drive 2 TTL loads. Port B has only passive pullup device and has a much higher current-sinking capability.

Handshaking

Handshaking on data transfers can be accomplished using the PC output pin and the FLAG input pin. PC will go low on the 3rd cycle after a PORT B access. This signal can be used to indicate "data ready" at PORT B or "data accepted" from PORT B. Handshaking on a 16-bit data transfers (using both PORT A and PORT B) is possible by always reading or writing PORT A first. FLAG is a negative edge sensitive input which can be used for receiving the PC output from another 8520 or as a general purpose interrupt input. Any negative transition on FLAG will set the FLAG interrupt bit.

Reg	Name	D7	D6	D5	D4	D3	D2	D1	D0
0	PRA	PA7	PA6	PA5	PA4	PA3	PA2	PA1	PA0
1	PPB	PB7	PB6	PB5	PB4	PB3	PB2	PB1	PB0
2	DDRA	DPA7	DPA6	DPA5	DPA4	DPA3	DPA2	DPA1	DPA0
3	DDRB	DPB7	DPB6	DPB5	DPB4	DPB3	DPB2	DPB1	DPB0

Interval Timers (Timer A, Timer B)

Each interval timer consists of a 16-bit read-only Timer Counter and a 16-bit write-only Timer Latch. Data written to the timer is latched in the Timer Latch, while data read from the timer are the present contents of the Timer Counter. The timers can be used independently or linked for extended operations. The various timer modes allow generation of long time delays, variable width pulses, pulse trains and variable frequency waveforms. Utilizing the CNT input, the timers can count external pulses or measure frequency, pulse width and delay times of external signals. Each timer has an associated control register, providing independent control of the following functions.

Start/Stop

A control bit allows the timer to be started or stopped by the microprocessor at any time.

PB On/Off

A control bit allows the timer output to appear on a PORT B output line (PB6 for TIMER A and PB7 for TIMER B). This function overrides the DDRB control bit and forces the appropriate PB line to an output.

Toggle/Pulse

A control bit selects the output applied to PORT B. On every timer underflow the output can either toggle or generate a single positive pulse of one cycle duration. The toggle output is set high whenever the timer is started and is set low by RES.

One-Shot/Continuous

A control bit selects either timer mode. In one-shot mode, the timer will count down from the latched value to zero, generate an interrupt, reload the latched value, then stop. In continuous mode, the timer will count from the latched value to zero, generate an interrupt, reload the latched value and repeat the procedure continuously. In one-shot mode: a write to Timer High (registers 5 for TIMER A, 7 for TIMER B) will transfer the timer latch to the counter and initiate counting regardless of the start bit.

Force Load

A strobe bit allows the timer latch to be loaded into the timer counter at any time, whether the timer is running or not.

Input Mode

Control bits allow selection of the clock used to decrement the timer. TIMER A can count 02 pulses or external pulses applied to the CNT pin. TIMER B can count 02 pulses, external CNT pulses, TIMER A underflow pulses or TIMER A underflow pulses while the CNT pin is held high.

The timer latch is loaded into the timer on any timer underflow, on a force load or following a write to the high byte of the prescaler while the timer is stopped. If the timer is running, a write to the high byte will load the timer latch, but not reload the counter.

READ (TIMER)

REG	Name								
4	TA LO	TAL7	TAL6	TAL5	TAL4	TAL3	TAL2	TAL1	TAL0
5	TA HI	TAH7	TAH6	TAH5	TAH4	TAH3	TAH2	TAH1	TAH0
6	TB LO	TBL7	TBL6	TBL5	TBL4	TBL3	TBL2	TBL1	TBL0
7	TB HI	TBH7	TBH6	TBH5	TBH4	TBH3	TBH2	TBH1	TBH0

WRITE (PRESCALER)

REG	Name								
4	TA LO	PAL7	PAL6	PAL5	PAL4	PAL3	PAL2	PAL1	PAL0
5	TA HI	PAH7	PAH6	PAH5	PAH4	PAH3	PAH2	PAH1	PAH0
6	TB LO	PBL7	PBL6	PBL5	PBL4	PBL3	PBL2	PBL1	PBL0
7	TB HI	PBH7	PBH6	PBH5	PBH4	PBH3	PBH2	PBH1	PBH0

TOD

TOD consists of a 24 bit binary counter. Positive edge transitions on this pin cause the binary counter to increment. The TOD pin has a passive pull-up on it. A programmable ALARM is provide for generating an interrupt at a desired time. The ALARM registers are located at the same addresses as the corresponding TOD register. Access to the ALARM is governed by a Control Register bit. The ALARM is write-only; any read of a TOD address will read time regardless of the state of the ALARM access bit.

A specific sequence of events must be followed for proper setting and reading of TOD. TOD is automatically stopped whenever a write to the register occurs. The clock will not start again until after a write to the LSB Event Register. This assures TOD will always start at the desired time. Since a carry from one stage to the next can occur at any time with respect to a read operation, a latching function is include to keep all Time of Day information constant during a read sequence. All TOD registers latch on a read of MSB event and remain latched until after a read of LSB Event. The TOD clock continues to count when the output registers are latched. If only one register is to be read, there is no carry problem and the register can be read "on the fly", provided that any read of MSB Event is followed by a read of LSB Event to disable the latching.

READ

REG	Name								
8	LSB Event	E7	E6	E5	E4	E3	E2	E1	E0
9	Event 8-15	E15	E14	E13	E12	E11	E10	E9	E8
A	MSB Event	E23	E22	E21	E20	E19	E18	E17	E16

WRITE

CRB7 = 0

CRB7 = 1 ALARM

(SAME FORMAT AS READ)

Serial Port (SDR)

The serial port is a buffered, 8-bit synchronous shift register system. A control bit selects input or output mode. In input mode, data on the SP pin is shifted into the shift register on the rising edge of the signal applied to the CNT pin. After 8 CNT pulses, the data in the shift register is dumped into the Serial Data Register and an interrupt is generated. In the output mode, TIMER A is used for the baud rate generator. Data is shifted out on the SP pin at 1/2 the underflow rate of TIMER A. The maximum baud rate possible is 02 divided by 6, but the maximum useable baud rate will be determined by line loading and the speed at which the receiver responds to input data. Transmission will start following a write to the Serial Data Register (provided TIMER A is running and in continuous mode). The clock signal derived from TIMER A appears as an output on the CNT pin. The data in the Serial Data Register will be loaded into the shift register then shift out to the SP pin when a CNT pulse occurs. Data shifted out becomes valid on the falling edge of CNT and remains valid until the next falling edge. After 8 CNT pulses, an interrupt is generated to indicate more data can be sent. If the Serial Data Register was loaded with new information prior to this interrupt, the new data will automatically be loaded into the shift register and transmission will be continuous. If no further data is to be transmitted, after the 8th CNT pulse, CNT will return high and SP will remain at the level of the last data bit transmitted. SDR data is shifted out MSB first and serial input data should also appear in this format.

The bidirectional capability of the Serial Port and CNT clock allows several devices to be connected to a common serial communication bus on which one acts as a master, sourcing data and shift clock, while all other chips act as slaves. Both CNT and SP outputs are open drain, with passive pull-ups, to allow such a common bus. Protocol for slave/master selection can be transmitted over the serial bus, or via dedicated handshaking lines.

REG	Name								
C	SDR	S7	S6	S5	S4	S3	S2	S1	S0

Interrupt Control (ICR)

There are five sources of interrupts on the 8520: underflow from TIMER A, underflow from TIMER B, TOD ALARM, Serial Port full/empty and FLAG. A single register provides masking and interrupt information. The Interrupt Control Register consists of a write-only MASK register and a read-only DATA register. Any interrupt which is enabled by the MASK register will set the IR bit (MSB) of the DATA register and bring the IRQ pin low. In a multi-chip system, the IR bit can be polled to detect which chip has generated an interrupt request.

The interrupt DATA register is cleared and the IRQ line returns high following a read of the DATA register. Since each interrupt sets an interrupt bit regardless of the MASK, and each interrupt bit can be selectively masked to prevent the generation of a processor interrupt, it is possible to intermix polled interrupts with true interrupts. However, polling the IR bit will cause the DATA register to clear, therefore, it is up to the user to preserve the information contained in the DATA register if any polled interrupts were present.

The MASK register provides convenient control of individual mask bits. When writing to the MASK register, if bit 7 (SET/CLEAR) of the data written is a ZERO, any mask bit written with a one will be cleared, while those mask bits written with a zero will be unaffected. If bit 7 of the data written is a ONE, any mask bit written with a one will be set, while those mask bits written with a zero will be unaffected. In order for an interrupt flag to set IR and generate an Interrupt Request, corresponding MASK bit must be set.

READ (INT DATA)

REG	Name									
D	IRC	IR	0	0	FLG	SP	ALRM	TB	TA	

WRITE (INT MASK)

REG	Name									
D	IRC	S/C	X	X	FLG	SP	ALRM	TB	TA	

Control Registers

There are two control registers in the 8520: CRA and CRB. CRA is associated with TIMER A and CRB is associated with TIMER B.

CRA:

BIT	NAME	FUNCTION
0	START	1 = START TIMER A, 0 = STOP TIMER A. This bit is automatically reset when underflow occurs during one-shot mode.
1	PBON	1 = TIMER A output appears on PB6, 0 = PB6 normal operation.
2	OUTMODE	1 = TOGGLE, 0 = PULSE
3	RUNMODE	1 = ONE-SHOT, 0 = CONTINUOUS
4	LOAD	1 = FORCE LOAD (this is a STROBE input, there is no data storage, bit 4 will always read back a zero and writing a zero has no effect).
5	INMODE	1 = TIMER A counts positive CNT transitions, 0 = TIMER A counts 02 pulses.
6	SPMODE	1 = SERIAL PORT output (CNT sources shift clock). 0 = SERIAL PORT input (external shift clock required).
7	TODIN	1 = 50 Hz clock required on TOD pin for accurate time. 0 = 60 Hz clock required on TOD pin for accurate time.

CRB:

BIT	NAME	FUNCTION															
		(Bits CRB0-CRB4 are identical to CRA0-CRA4 for TIMER B with the exception that bit 1 controls the output of TIMER B on PB7).															
5.6	INMODE	Bits CRB5 and CRB6 select one of four input modes for TIMER B as:															
		<table> <tr> <th>CRB6</th><th>CRB5</th><th></th></tr> <tr> <td>0</td><td>0</td><td>TIMER B counts 02 pulses.</td></tr> <tr> <td>0</td><td>1</td><td>TIMER B counts positive CNT transitions.</td></tr> <tr> <td>1</td><td>0</td><td>TIMER B counts TIMER A underflow pulses.</td></tr> <tr> <td>1</td><td>1</td><td>TIMER B counts TIMER A underflow pulses while CNT is high.</td></tr> </table>	CRB6	CRB5		0	0	TIMER B counts 02 pulses.	0	1	TIMER B counts positive CNT transitions.	1	0	TIMER B counts TIMER A underflow pulses.	1	1	TIMER B counts TIMER A underflow pulses while CNT is high.
CRB6	CRB5																
0	0	TIMER B counts 02 pulses.															
0	1	TIMER B counts positive CNT transitions.															
1	0	TIMER B counts TIMER A underflow pulses.															
1	1	TIMER B counts TIMER A underflow pulses while CNT is high.															
7	ALARM	1 = writing to TOD registers set ALARM, 0 = writing to TOD registers sets TOD clock.															

ELECTRICAL PARAMETERS

Absolute Maximum Ratings

Stresses above those listed may cause permanent damage to the circuit. Functional operation of the device at these or any conditions other than those indicated in the operating conditions of the specification is not implied. Exposure to the maximum ratings for extended periods may adversely affect device reliability.

Supply Voltage	Vcc	–0.3V to 7.0V	Operating Temp.	Top	0°C to 70°C
Input/Output Voltage	Vin	–0.3V to 7.0V	Storage Temp.	Tstg	–55°C to 150°C

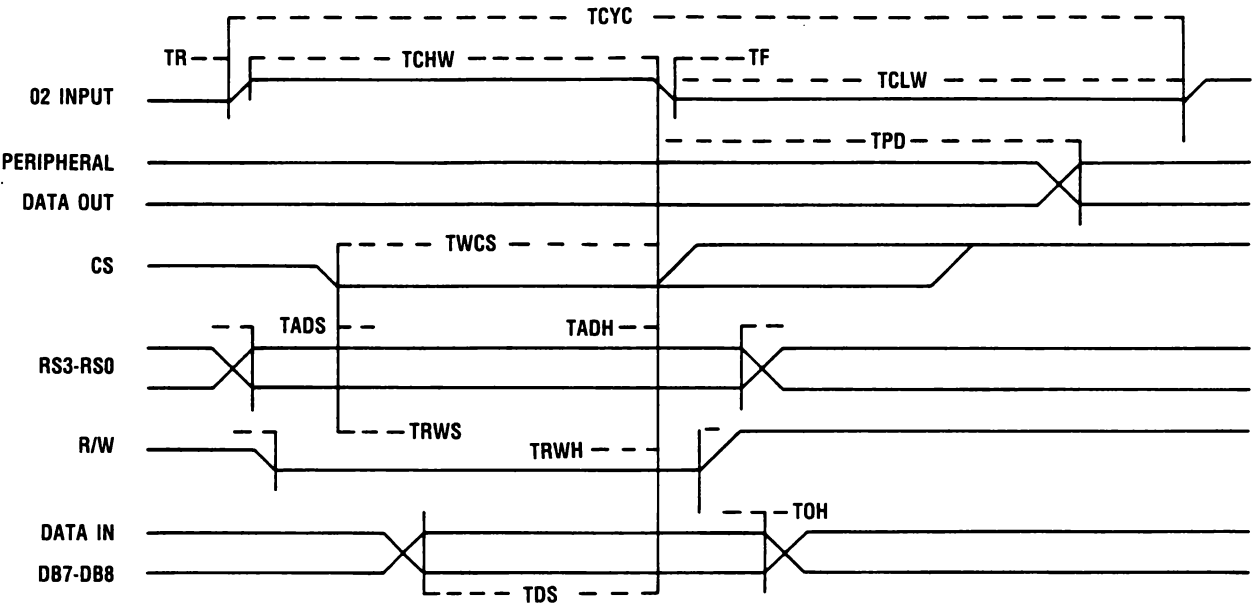
*All inputs contain protection circuitry to prevent damage due to high static discharges. Care should be exercised to prevent unnecessary application of voltages in excess of the allowable limits.

ELECTRICAL CHARACTERISTICS (VCC +/- 5%, VSS = 0v, TA = 0.70 C)

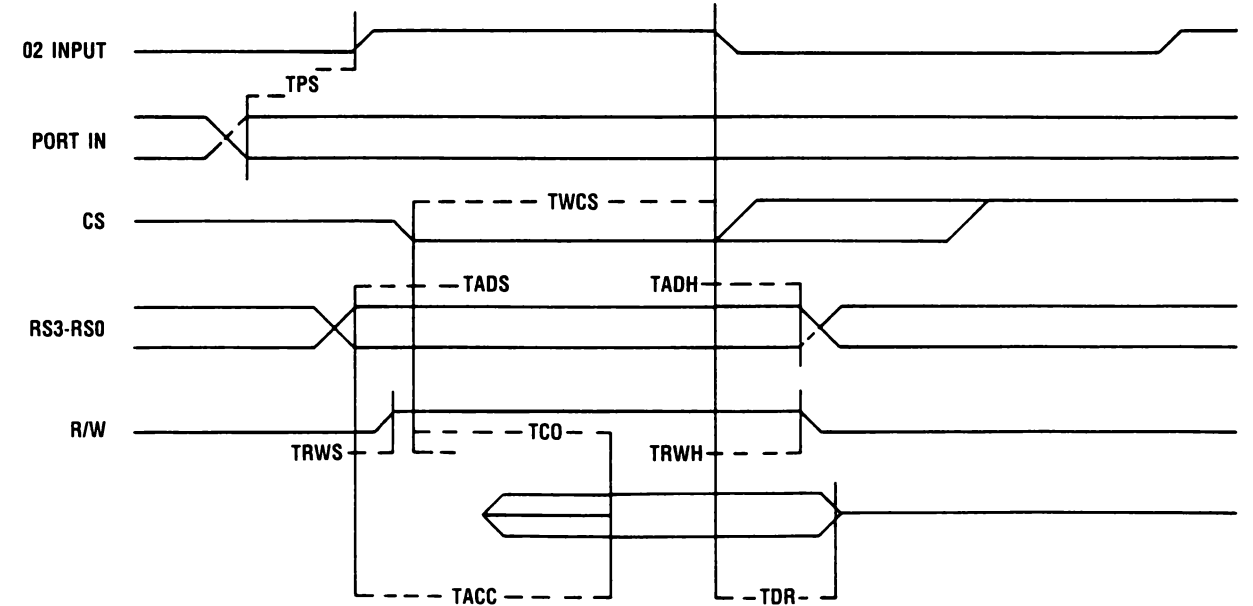
CHARACTERISTICS	SYMBOL	MIN.	TYP.	MAX.	UNIT
Input High Voltage	Vih	+2.4	—	Vcc	V
Input Low Voltage	Vil	–3.0	—	+0.8	V
Input leakage current VIN = VSS + 5V (TOD, R/W, 02, RES, RS0-RS3, CS)	Iin	—	1.0	2.5	μA
PA0-7, PB0-7, TOD, FLAG, SP, CNT	Rpi	3.1	5.0	—	KΩ
Output leakage current for High Impedance State VIN = 4V to 2.4V (DB0-DB7, IRQ)	Itsi	—	±1.0	±10.0	μA
Output High Voltage VCC = MIN, LOAD < –200μA (PA0-PA7, DB0-DB7)	Voh	+2.4	—	Vcc	V
Output Low Voltage (PA0-PA7, DB0-DB7) VCC = MIN, LOAD < 3.2μA	Vol	—	—	+0.40	V
Output High Current (sourcing) VOH > 2.4V (PA0-PA7, DB0-DB7)	Ioh	–200	–1000	—	μA
Output Low Current (sinking) VOL < .4V (PA0-PA7, DB0-DB7)	Iol	3.2	—	—	μA
Output Low Current (sinking) VOL < .4V (PC, PB0-PB7)	Iol	13.0	—	—	μA
Input Capacitance	Cin	—	7	10	pf
Output Capacitance	Cout	—	7	10	pf
Power Supply Current	Icc	—	70	100	μA

TIMING DIAGRAMS

WRITE TIMING DIAGRAM



READ TIMING DIAGRAM



2.2 Timing Characteristics

		1MHZ	
SYMBOL	CHARACTERISTIC	MIN	MAX
02 CLOCK			
TCYC	Cycle Time	1000	10,000
TR, TF	Rise and Fall Time	—	25
TCHW	Clock Pulse Width (High)	440	5,000
TCLW	Clock Pulse Width (Low)	440	5,000
WRITE CYCLE			
TPD	Output Delay From 02	—	960
TWCS	CS low while 02 high	280	—
TADS	Address setup time	58	—
TADH	Address hold time	10	—
TRWS	R/W setup time	58	—
TRWH	R/W hold time	10	—
TDS	Data bus setup time	200	—
TDH	Data bus hold time	15	—
READ CYCLE			
TPS	Port setup time	300	—
TWCS(2)	CS low while 02 high	280	—
TADS	Address setup time	58	—
TADH	Address hold time	10	—
TRWS	R/W setup time	58	—
TRWH	R/W hold time	10	—
TACC	Data access from RS3-RS0	—	300
TCO(3)	Data access from CS	—	240
TDR	Data release time	50	—

*See diagram on page 23 for timing relationships.

*NOTES:

1. All timings are referenced from VIL max and VIH min on inputs and VOL max and VOH min on outputs.
2. TWCS is measured from the later of 02 high or CS low. CS must be low at least until the end of 02 high.
3. TCO is measured from the later of 02 high or CS low. Valid data is available only after the later of TACC or TCO.

Input/Output Connectors

This section lists pin assignments for several input/output connectors on the Amiga. The information in this section is highly technical and is intended only for those expert in connecting external devices to computers. You do not need this information if you use a cable specifically designed for use with the Amiga and the add-on you want to connect.

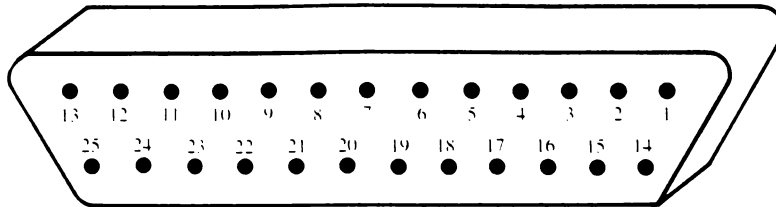
For information about connectors not described in this section, see the *Amiga Hardware Manual*.

If you attach peripherals with cables other than those designed for use with the Amiga, note: some pins on Amiga connectors provide power outputs and non-standard signals. Attempting to use cables not wired specifically for the Amiga may cause damage to the Amiga or to the equipment you connect. The descriptions below include specific warnings for each connector. For more information about connecting add-ons, consult your Amiga dealer.

In the descriptions that follow, an asterisk (*) at the end of a signal name indicates a signal that is active low.

Serial Connector

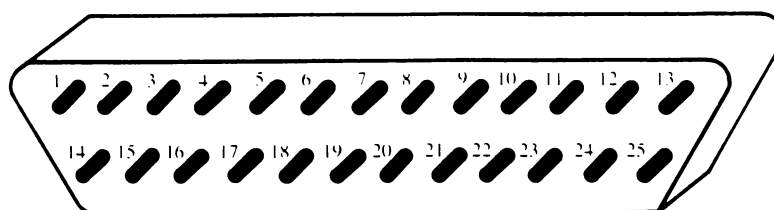
In the following table, the second column from the left gives the Amiga pin assignments. The third and fourth columns from the left give pin assignments for other commonly used connections; the information in these two columns is given for comparison only.



WARNING: Pins 9 and 10 on the Amiga serial connector are used for external power. Connect these pins **ONLY** if power from them is required by the external device. The table lists the power provided by each of these pins.

Pin	Amiga 500	RS232	HAYES®	Description
1	GND	GND	GND	FRAME GROUND
2	TXD	TXD	TXD	TRANSMIT DATA
3	RXD	RXD	RXD	RECEIVE DATA
4	RTS	RTS		REQUEST TO SEND
5	CTS	CTS	CTS	CLEAR TO SEND
6	DSR	DSR	DSR	DATA SET READY
7	GND	GND	GND	SYSTEM GROUND
8	DCD	DCD	DCD	CARRIER DETECT
9	+ 12V			+ 12 VOLT CARRIER
10	- 12V			- 12 VOLT CARRIER
11	AUDO			AUDIO OUT OF AMIGA
12		S.SD	SI	SPEED INDICATE
13		S.CTS		
14		S.TXD		
15		TXC		
16		S.RXD		
17		RXC		
18	AUDI			AUDIO INTO AMIGA
19		S.RTS		
20	DTR	DTR	DTR	DATA TERMINAL READY
21		SQD		
22	RI	RI	RI	RING INDICATOR
23		SS		
24		TXC1		
25				

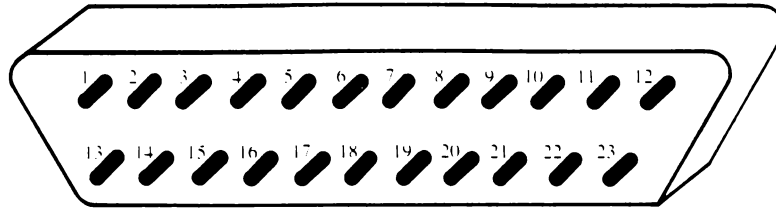
A500 Parallel Connector



WARNING: Pin 14 on the Amiga parallel connector supplies +5 volts of power. Connect this pin **ONLY** if the power from it is required by the external device. **NEVER** connect this pin to an output of an external device or to a signal ground. Pins 17-25 are for grounding signals. **DO NOT** connect these pins directly to a shield ground.

Pin	Name	Description
1	STROBE*	STROBE
2	D0	DATA BIT 0 (Least sign. bit)
3	D1	DATA BIT 1
4	D2	DATA BIT 2
5	D3	DATA BIT 3
6	D4	DATA BIT 4
7	D5	DATA BIT 5
8	D6	DATA BIT 6
9	D7	DATA BIT 7
10	ACK*	ACKNOWLEDGE
11	BUSY	BUSY
12	POUT	PAPER OUT
13	SEL	SELECT
14	+5V PULLUP	+ 5 VOLTS POWER (100 mA)
15	NC	NO CONNECTION
16	RESET*	RESET
17	GND	SIGNAL GROUND
18	GND	SIGNAL GROUND
19	GND	SIGNAL GROUND
20	GND	SIGNAL GROUND
21	GND	SIGNAL GROUND
22	GND	SIGNAL GROUND
23	GND	SIGNAL GROUND
24	GND	SIGNAL GROUND
25	GND	SIGNAL GROUND

RGB Monitor Connector

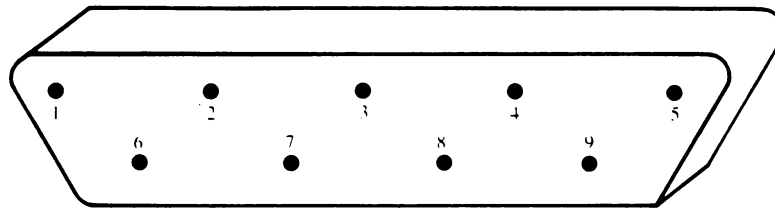


WARNING: Pins 21, 22, and 23 on the RGB monitor connector are used for external power. Connect these pins **ONLY** if power from them is required by the external device. The table lists the power provided by each of these pins.

Pin	Name	Description
1	XCLK*	EXTERNAL CLOCK
2	XCLKEN*	EXTERNAL CLOCK ENABLE
3	RED	ANALOG RED
4	GREEN	ANALOG GREEN
5	BLUE	ANALOG BLUE
6	DI	DIGITAL INTENSITY
7	DB	DIGITAL BLUE
8	DG	DIGITAL GREEN
9	DR	DIGITAL RED
10	CSYNC*	COMPOSITE SYNC
11	HSYNC*	HORIZONTAL SYNC
12	VSYSN*	VERTICAL SYNC
13	GNDRTN	RETURN FOR XCLKEN*
14	ZD*	ZERO DETECT
15	C1*	CLOCK OUT
16	GND	GROUND
17	GND	GROUND
18	GND	GROUND
19	GND	GROUND
20	GND	GROUND
21	- 12V	- 12 VOLTS POWER (50 mA)
22	+ 12V	+ 12 VOLTS POWER (100 mA)
23	+ 5V	+ 5 VOLTS POWER (100 mA)

Mouse/Game Controller Connectors

There are connectors labeled “JOY1” and “JOY2” on the back of the Amiga 500. If you use a mouse to control the Workbench, you must attach it to connector JOY 1. You can attach joystick controllers to either of the connectors. To use a light pen, you must attach it to connector 1. The following tables describe mouse, game controller, and light pen connections.



WARNING: Pin 7 on each of these connectors supplies +5 volts of power. Connect this pin **ONLY** if power from it is required by the external device.

Connectors 1 and 2: Mouse Connections

Pin	Name	Description
1	MOUSE V	MOUSE VERTICAL
2	MOUSE H	MOUSE HORIZONTAL
3	MOUSE VQ	VERTICAL QUADRATURE
4	MOUSE HQ	HORIZONTAL QUADRATURE
5	MOUSE BUTTON 2	MOUSE BUTTON 2
6	MOUSE BUTTON 1	MOUSE BUTTON 1
7	+5V	+5 VOLTS POWER (100 mA)
8	GND	GROUND
9	MOUSE BUTTON 3	MOUSE BUTTON 3

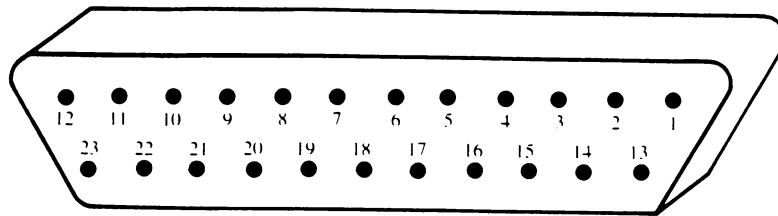
Connectors 1 and 2: Game Controller

Pin	Name	Description
1	FORWARD*	CONTROLLER FORWARD
2	BACK*	CONTROLLER BACK
3	LEFT*	CONTROLLER LEFT
4	RIGHT*	CONTROLLER RIGHT
5	POT X	HORIZONTAL POTENTIOMETER
6	FIRE*	CONTROLLER FIRE
7	+ 5V	+ 5 VOLTS POWER (100 mA)
8	GND	GROUND
9	POT Y	VERTICAL POTENTIOMETER

Connector 2: Light Pen Connection

Pin	Name	Description
1		
2		
3		
4		
5	LIGHT PEN PRESS	LIGHT PEN TOUCHED TO SCREEN
6	LIGHT PEN*	CAPTURE BEAM POSITION
7	+ 5V	+ 5 VOLTS POWER (100 mA)
8	GND	GROUND
9		

External Disk Connector



Pin	Name	Description
1	/RDY	Disk Ready—Active Low
2	/DKRD	Disk Ready Data—Active Low
3-7	GND	Ground
8	/MTRXD	Disk Motor Control—Active Low
9	/SEL2B	Select Drive 2—Active Low
10	/DRESB	Disk RESET—Active Low
11	/CHNG	Disk has been Removed from Drive—Latched Low
12	+5	5 VDC Supply
13	/SIDE B	Select Disk Side—0 = Upper 1 = Lower
14	/WPRO	Disk is Write Protected—Active Low
15	/TKO	Drive Head Position over Track 0—Active Low
16	/DKWE	Disk Write Enable—Active Low
17	/DKWD	Disk Write Data—Active Low
18	/STEPB	Step the Head—Pulse, First Low then High
19	DIRB	Select Head Direction—0 = Inner 1 = Outer
20	/SEL3B	Select Drive 3—Active Low
21	/SEL1B	Select Drive 1—Active Low
22	/INDEX	Disk Index Pulse—Active Low
23	+12	12 VDC Supply

Power Supply Connector

Pin	Name
1	+5Vdc @ 4.3A
2	SHIELD GROUND
3	+12Vdc @ 1.0A
4	SIGNAL GROUND
5	−12Vdc @ .1A

86-Pin Connector

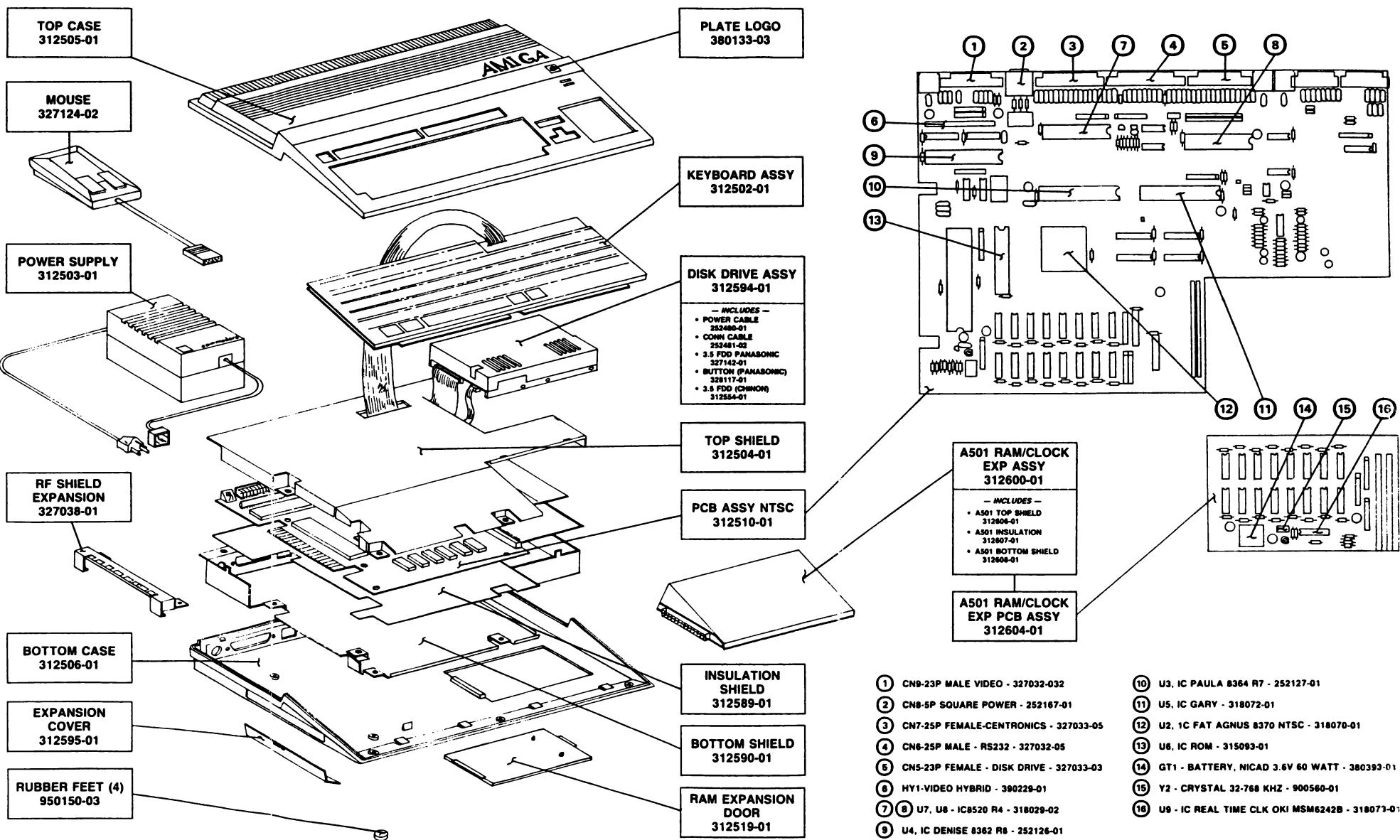
Pin	Name	Pin	Name
1	gnd	44	IPL2*
2	gnd	45	A16
3	gnd	46	BERR*
4	gnd	47	A17
5	+5	48	VPA*
6	+5	49	gnd
7	exp	50	E
8	-12	51	VMA*
9	exp	52	A18
10	+12	53	RES*
11	exp	54	A19
12	CONFIG*	55	HLT*
13	gnd	56	A20
14	C3*	57	A22
15	CDAC	58	A21
16	C1*	59	A23
17	OVR*	60	BR*
18	XRDY	61	gnd
19	INT2*	62	BGACK*
20	PALOPE*	63	PD15
21	A5	64	BG*
22	INT6*	65	PD14
23	A6	66	DTACK*
24	A4	67	PD13
25	gnd	68	PRW*
26	A3	69	PD12
27	A2	70	LDS*
28	A7	71	PD11
29	A1	72	UDS*
30	A8	73	gnd
31	FC0	74	AS*
32	A9	75	PD0
33	FC1	76	PD10
34	A10	77	PD1
35	FC2	78	PD9
36	A11	79	PD2
37	gnd	80	PD8
38	A12	81	PD3
39	A13	82	PD7
40	IPL0*	83	PD4
41	A14	84	PD6
42	IPL1*	85	gnd
43	A15	86	PD5

A500 MAJOR COMPONENT PARTS LIST

Power Cable FDD	C	252480-01
Conn Cable FDD	C	252481-02
Keyboard Assy — USA/Canada	C	312502-01
Power Supply	C	312503-01
Top Shield	C	312504-01
Top Case	C	312505-01
Bottom Case	C	312506-01
PCB Assy — NTSC	C	312510-01
RAM Expansion Door	C	312519-01
Floppy Disk Drive (Chinon)	C	312554-01
Insulation Sheet	C	312589-01
Bottom Shield	C	312590-01
Disk Drive Assy	C	312594-01
Expansion Cover	C	312595-01
A501 RAM/Clock PCB Assy (With Shields)	C	312600-01
A501 RAM/CLK PCB Assy (PCB Only)	C	312604-01
A501 Top Shield		312606-01
A501 Insulation Sheet		312607-01
A501 Bottom Shield		312608-01
Service Manual	C	314981-01
Users Guide, DOS Manual	C	317100-01
Amiga Basic Diskette V1.2	C	317488-02
Workbench Diskette V1.2	C	317608-01
RF Shield Expansion	C	327038-01
Amiga Basic Manual	C	327102-01
Mouse	C	327124-02
Floppy Disk Drive (Panasonic)	C	327142-01
Button (Panasonic)	C	328117-01
Plate Logo	C	380133-03
Rubber Feet	C	950150-03

C - Indicates Commodore Stocked Part Number

SERVICE PARTS REFERENCE DIAGRAM



PARTS LIST

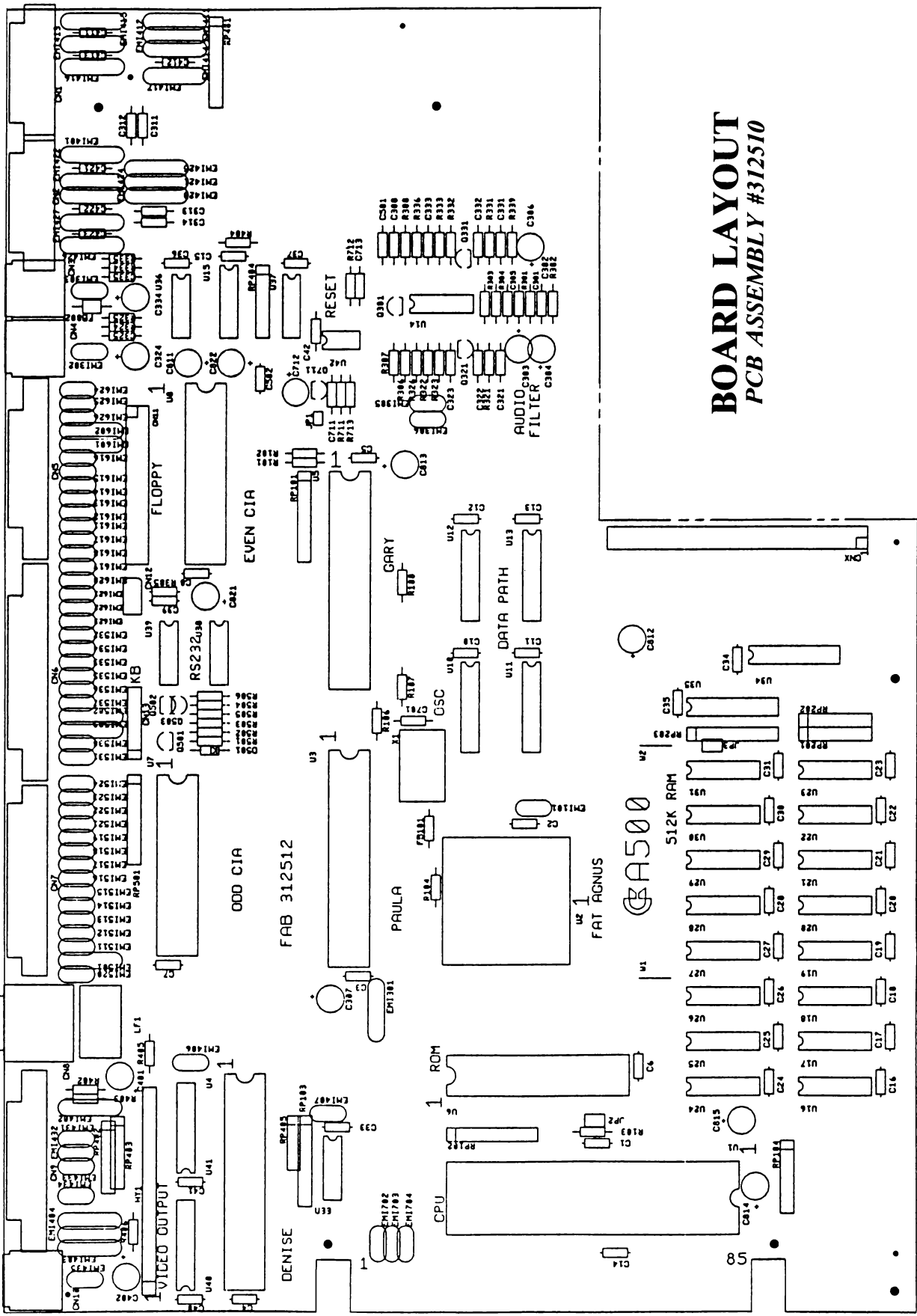
PCB ASSEMBLY #312510-01

PLEASE NOTE: Commodore part numbers are provided 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. are available in manual form through the Service Department, order part #314000-01.

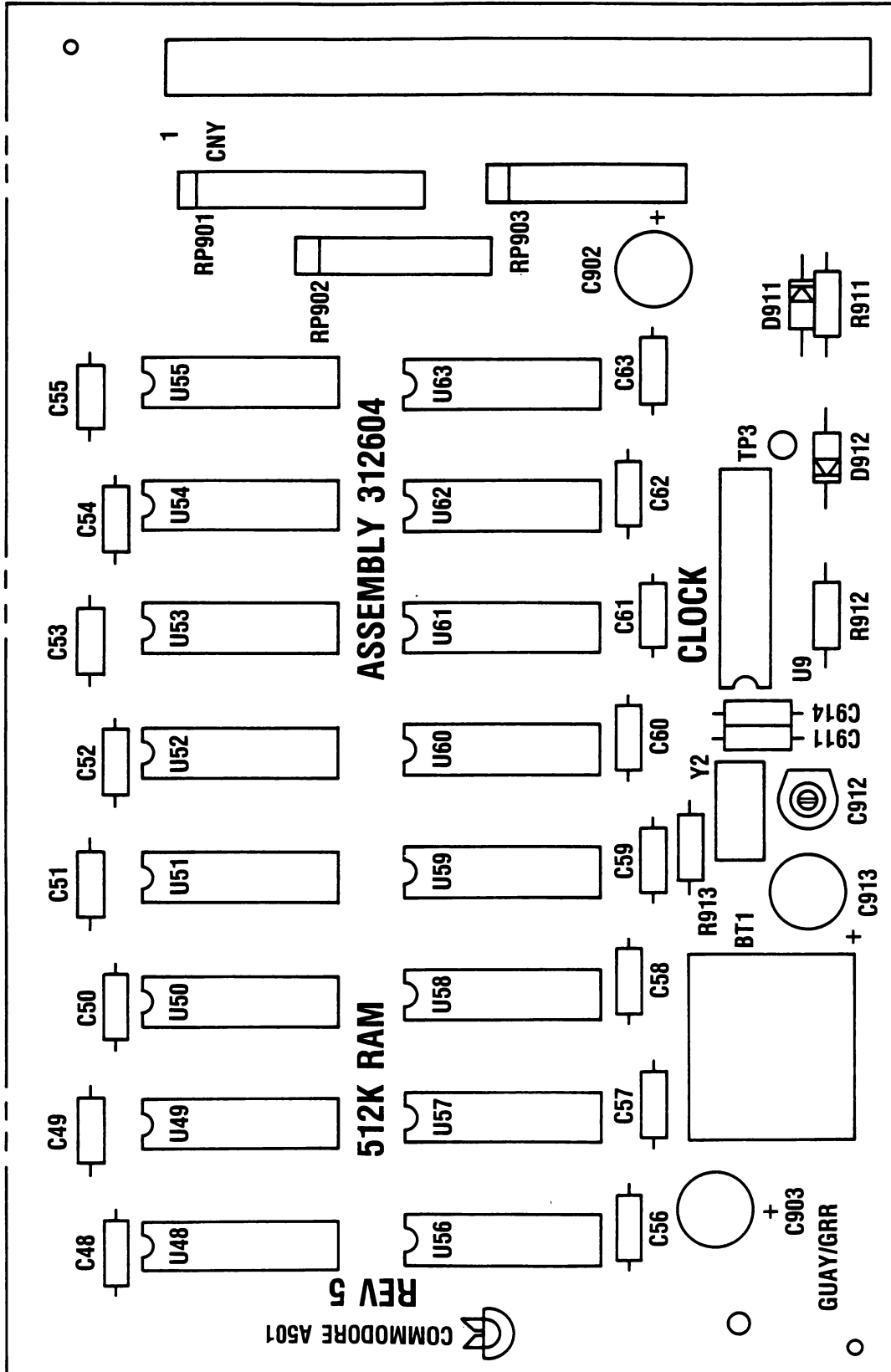
INTEGRATED CIRCUITS			RESISTORS (Continued)		
U1	MC68000	390084-03	RP101, 102	4.7K X9 10PIN	902410-08
U2	FAT AGNUS 8370 R3	318070-01	401, 501		
	NTSC		RP404	68 OHM X4 8PIN	902422-06
U2	FAT AGNUS 8371 R1	318071-01	W1, W2	ZERO OHM	390186-01
	PAL		EMI301, 406	1 OHM	901550-118
U3	PAULA 8364 R7	252127-02	EMI401,	5.1 OHM	901550-129
U4	DENISE 8362 R8	252126-02	R405, 406		
U4	DENISE 8362 R6	252126-01 sub:	R301, 302	10 OHM	901550-64
U5	GARY 5719	318072-01	R101, 102	27 OHM	901550-90
U7, 8	8520R4	318029-02	EMI501-503	47 OHM 5% 1/2W	901600-15
U6	ROM KICKSTART V1.2	315093-01	R331, 321	360 OHM	901550-108
U16-31	DRAM 256KX1 150NS	390026-01	R325, 335	390 OHM	901550-57
U16-31	DRAM 256KX1	380223-01 sub:	R305	470 OHM	901550-56
U38	1488 LINE DRIVER	901882-01	R303, 304,	1K OHM	901550-01
U39	1489 RECEIVER	901883-01	324, 334,		
U14	LF347/TL084	390086-01	713, 305		
U33	74F04	390110-01	R704	1.2K OHM	901550-17
U37	74LS32	901521-31	R701	2.7K OHM	901550-23
U36	74LS38	901521-38	R702	3.9K OHM	901550-39
U32	74F74	390081-01	R402, 403,	4.7K OHM	901550-19
U15	74LS157	901521-11	503, 504		
U34, 35	74F244	318050-01	R322, 323,	10K OHM	901550-20
U10, 12	74LS244	901521-13	332, 333,		
U40, 41	74HC245	310003-01	339, 501,		
U11, 13	74LS373	901521-29	505, 502,		
U42	NE555	901523-01	506		
TRANSISTORS			R703	27K OHM	901550-15
Q701	2N5770 NPN OSC	390239-01	R712	47K OHM	901550-22
Q501, 711	2N3904 NPN GP	902658-01	R711	1M OHM	901550-84
Q502, 503, 301	2N3906 PNP GP	902707-01	R103-108	120 OHM	901550-75
Q321, 331	JFET MPF 102	390252-01	R404	120 OHM	901550-75
Q321, 331	JFET PN 4302	390254-01 sub:	R306, 308	10K OHM	901550-20
DIODES			R307	2.7K OHM	901550-23
D501	1N4148	900850-01	R326, 336	470K OHM	901550-82
RESISTORS — All are carbon 1/4 watt, 5% unless noted			R409	150 OHM	901550-89
RP501	10K X9, 10PIN	902410-18	CAPACITORS		
RP103	22 OHM X5 10PIN	390227-03	C703	39pF MLC, AXIAL NPO	900462-27
RP402, 403	47 OHM X4 8PIN	902422-05	C704	100pF MLC AXIAL NPO	900462-37
RP201, 202	68 OHM X4 8PIN	902422-06	C705	1000pF MLC AXIAL X7R	900463-16
RP203	68 OHM X5 10PIN	390227-05	C411-413, 421-423	1000pF MLC AXIAL X7R	900463-16
RP405	120 OHM X5 6PIN	902441-10	C323, 333	3900pF MLC AXIAL X7R	900463-23
RP104	470 OHM X7 8PIN	902442-17	C322, 332	6800pF MLC AXIAL X7R	900463-26
			C410, 412, 801, 713	.01μF MLC AXIAL Z5U	390082-02
			C308, 713	.01μF MLC AXIAL Z5U	390082-02
			C311-314	.047μF MLC AXIAL X7R	900463-36

PARTS LIST (continued)
PCB ASSEMBLY #312510-01

CAPACITORS (Continued)			MISCELLANEOUS (Continued)		
C7, 8, 10, 11-13, 15, 33-37, 39, 321, 331, 711, 701	.1 μ F MLC AXIAL Z5U	390082-01	X1	CRYSTAL 28.63636MHZ NTSC	325566-14
C325, 335	.22 μ F MLC AXIAL Z5U	390082-05	U6, 7, 8	SOCKET 40 PIN DIP	904150-06
C306, 712	10 μ F ELECT RADIAL	390101-06	U3, 4, 5	SOCKET 48 PIN DIP	251313-01
C303, 304, 307, 324	22 μ F ELECT RADIAL	390101-04	U3, 4, 5	SOCKET 48 PIN DIP	251313-02 sub:
C812-815,	47 μ F ELECT RADIAL	390101-01	U2	SOCKET 84 PIN PLCC	390185-01
C307, 811	100 μ F ELECT RADIAL	390101-02	U1	SOCKET 64 PIN DIP	904150-10
C401, 402	3300 μ F 10V ELECT RADIAL	900100-56	CONNECTORS		
C702	VARIABLE 4.5-45pF	251029-06	CN8	DIN 5PIN SQUARE FEMALE - POWER	252167-01
MISCELLANEOUS			CN1, 2	D-SUB 9PIN MALE RA - JOYSTICK	390242-02
FB802, 101, EMI411-417, 421-427, 402, 431-435	FERRITE BEAD	903025-01	CN9	D-SUB 23PIN MALE RA - VIDEO	390242-03
EMI302-303, 305, 306, 403-407, 511-524, 531-538, 601, 602, 611-626, 701-704	EMI FILTER 100pF	251842-02	CN5	D-SUB 23PIN FEMALE RA - DRIVE	390241-04
HY1	VIDEO HYBRID	390229-01	CN6	D-SUB 25PIN MALE RA - RS232	390242-06
LF1	LINE FILTER 8 PIN	251878-02	CN7	D-SUB 25PIN FEMALE RA - CENTRONICS	390241-06
L701	CHOKE 3.3 μ H	901151-19	CN3	RCA JACK, WHITE	252122-01
			CN4	RCA JACK, RED	252122-02
			CN10	RCA JACK, YELLOW	252122-03
			CN3, 4, 10	RCA JACK, METAL	390248-01 sub:
			CN12	HEADER 4PIN POLARIZED SIL	325516-04
			CN12	HEADER 4PIN SIL	903326-04 sub:
			CN13	HEADER 8PIN SIL	903326-08
			CN11	HEADER 34PIN DIL	903345-17
			CNX	HEADER DUAL RA LONG 56POS MALE	390243-01



BOARD LAYOUT
PCB ASSEMBLY #312510



NOTE: PN #312604-03 — A501 RAM/CLOCK PCB ASSEMBLY — INCLUDES SHIELDS AND INSULATION

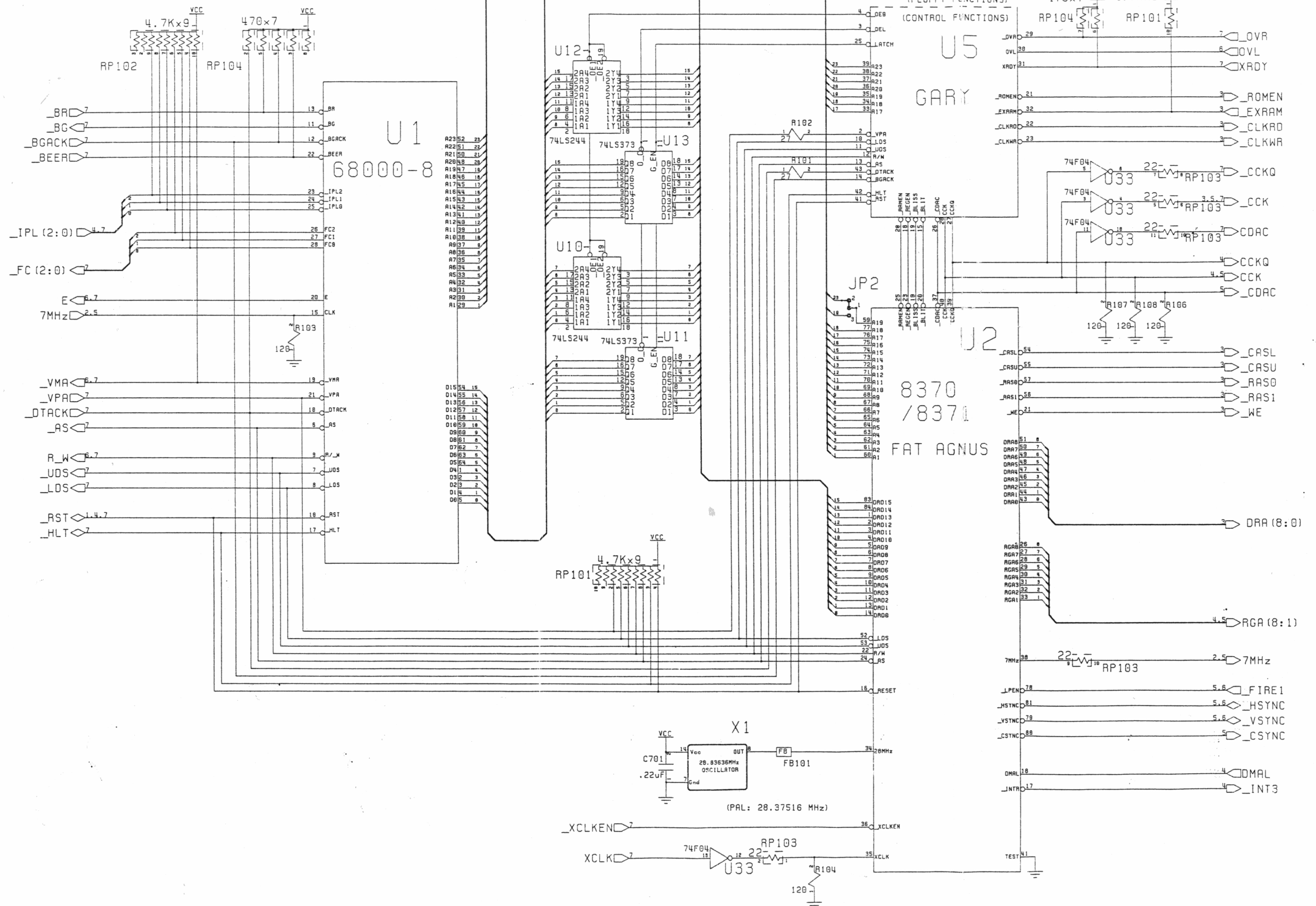
BOARD LAYOUT
A501 RAM/CLOCK EXPANSION
PCB ASSEMBLY #312604-03

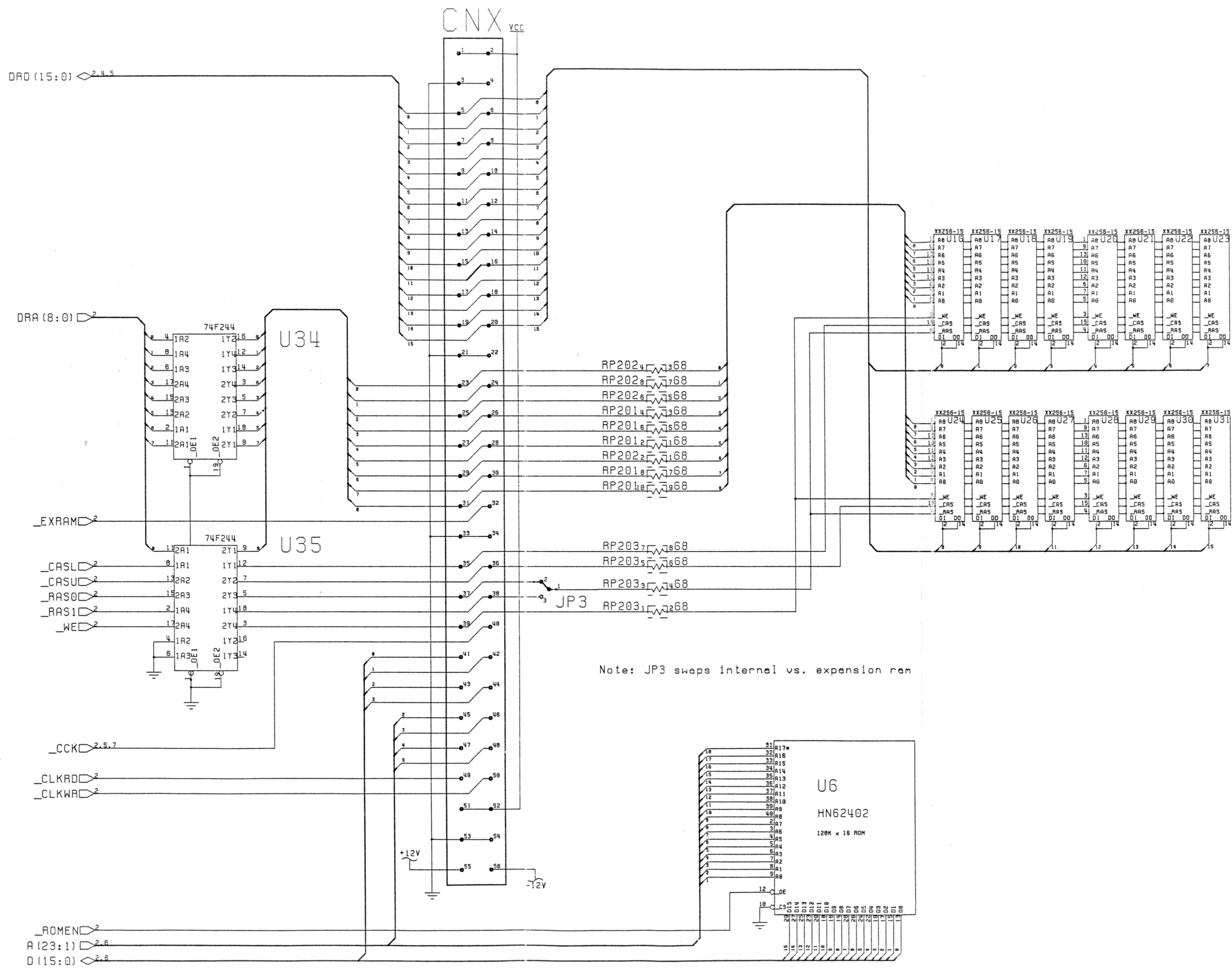
TP1 - 64 Hz Real-Time Clock Test Point

[illegible]

Note: R103-104, 106-108 are from EMI control and may not be loaded in all cases

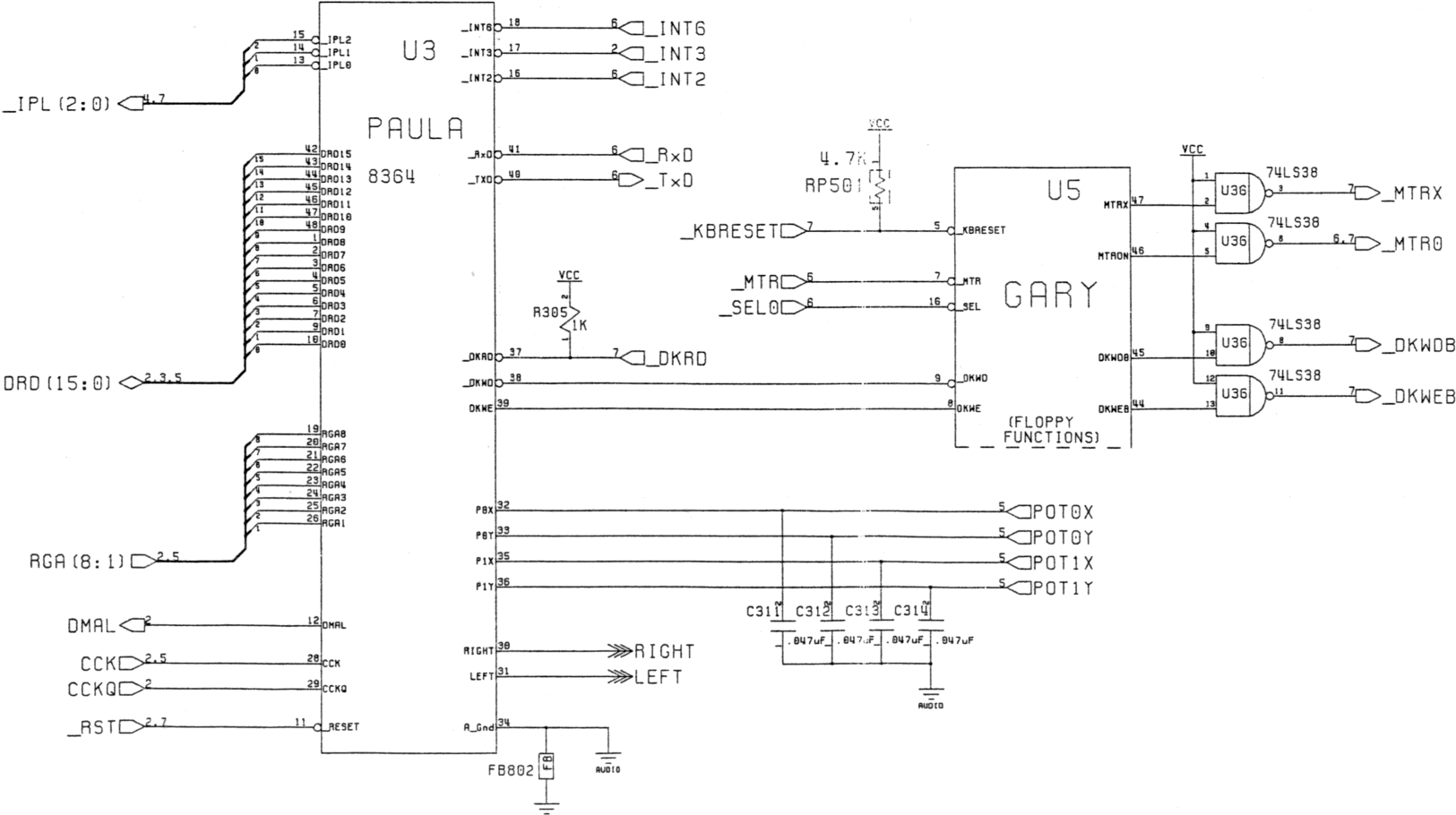
JP2 controls where expansion ram maps to:
A23 -> C00000 (default), A19 -> 080000



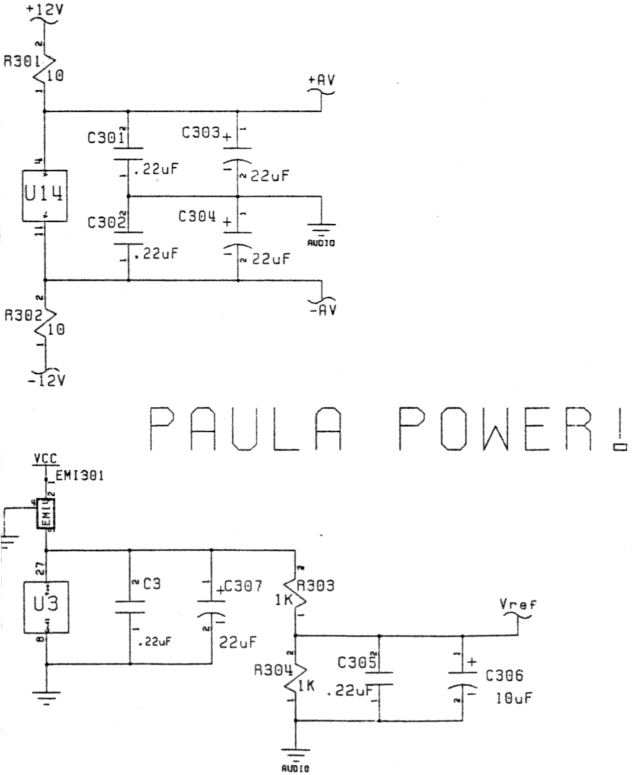
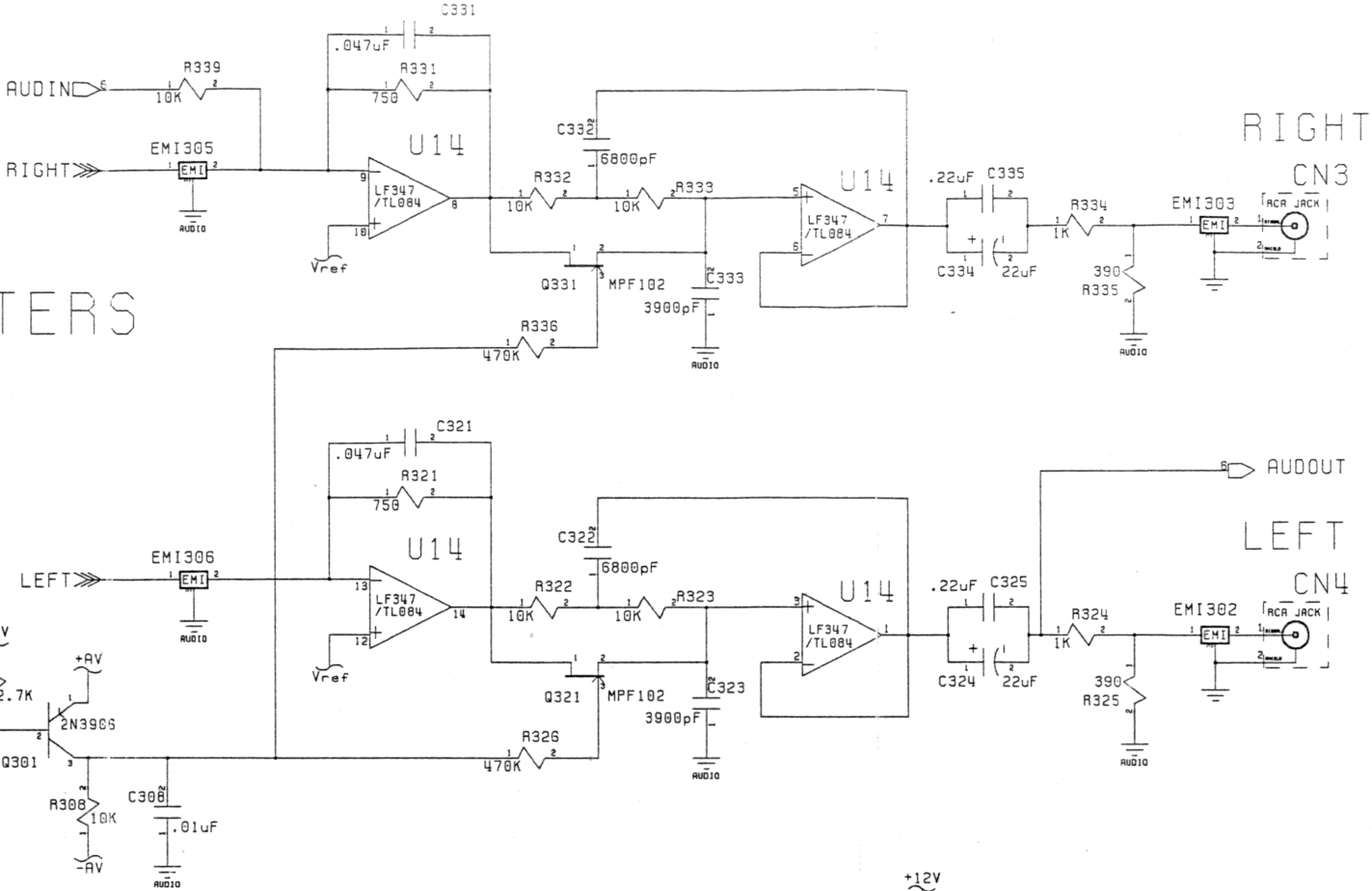


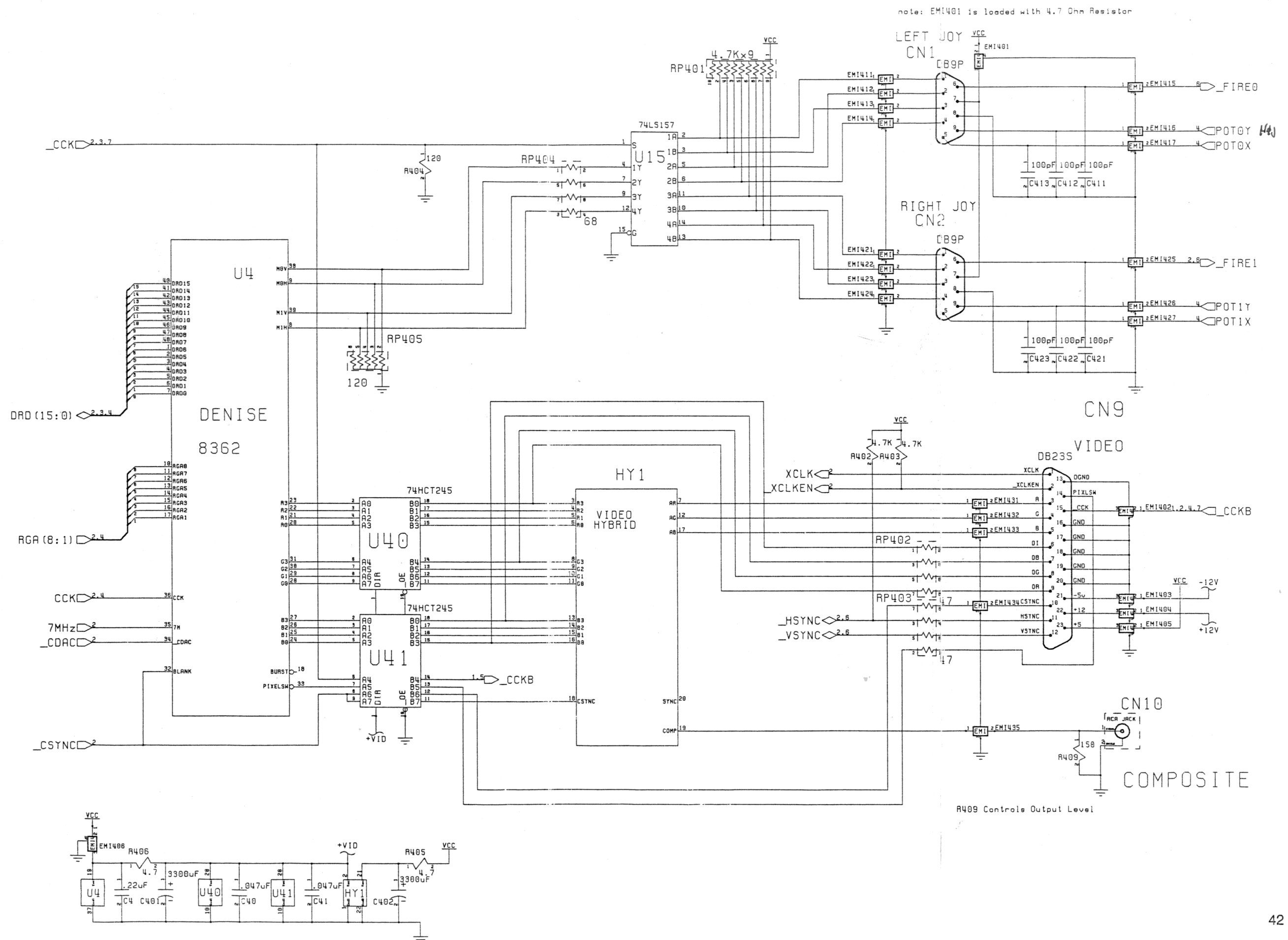
AUDIO FILTERS

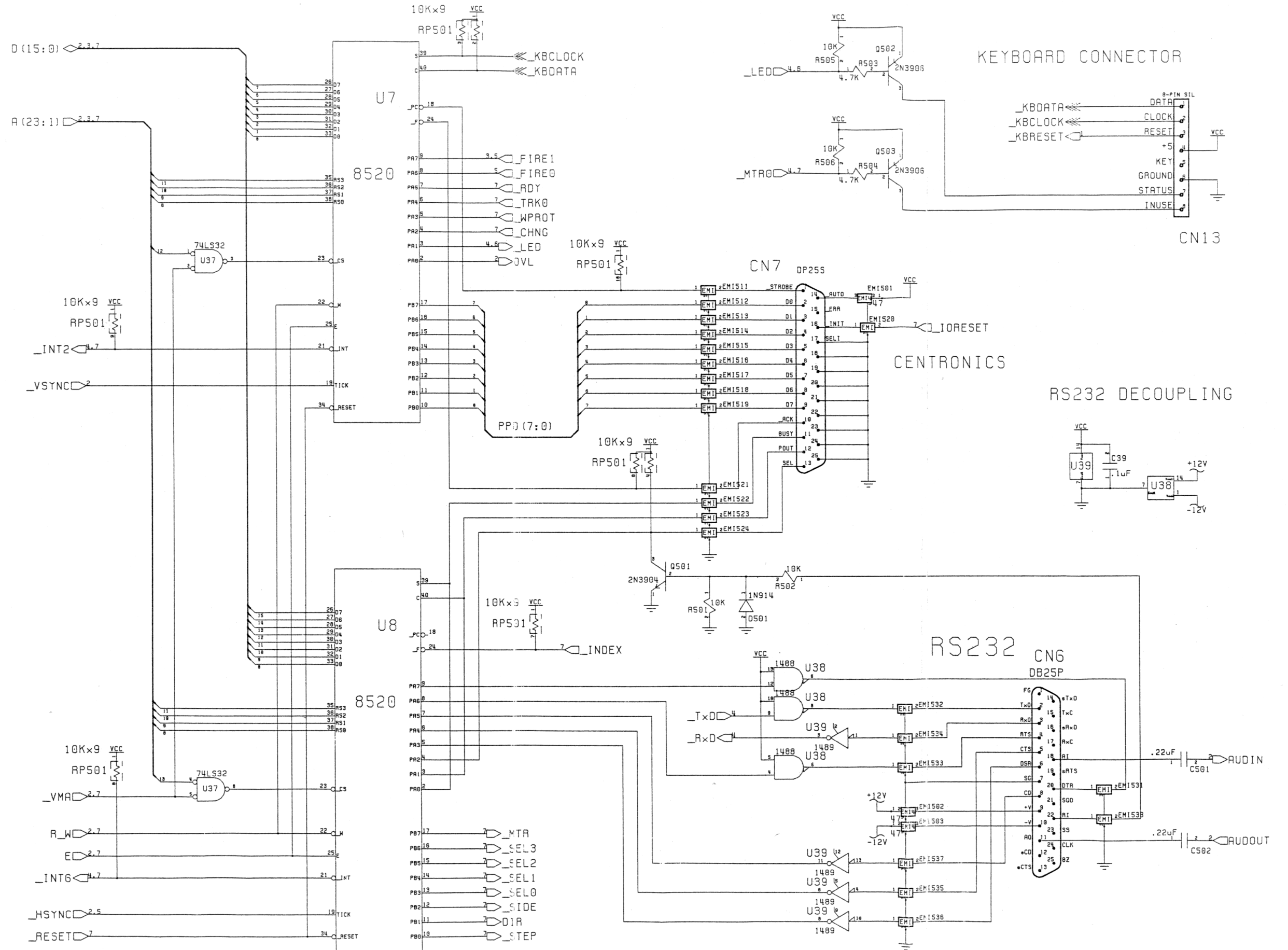
Note: LED off, Filters bypassed



Note: Gound connection at Audio jacks

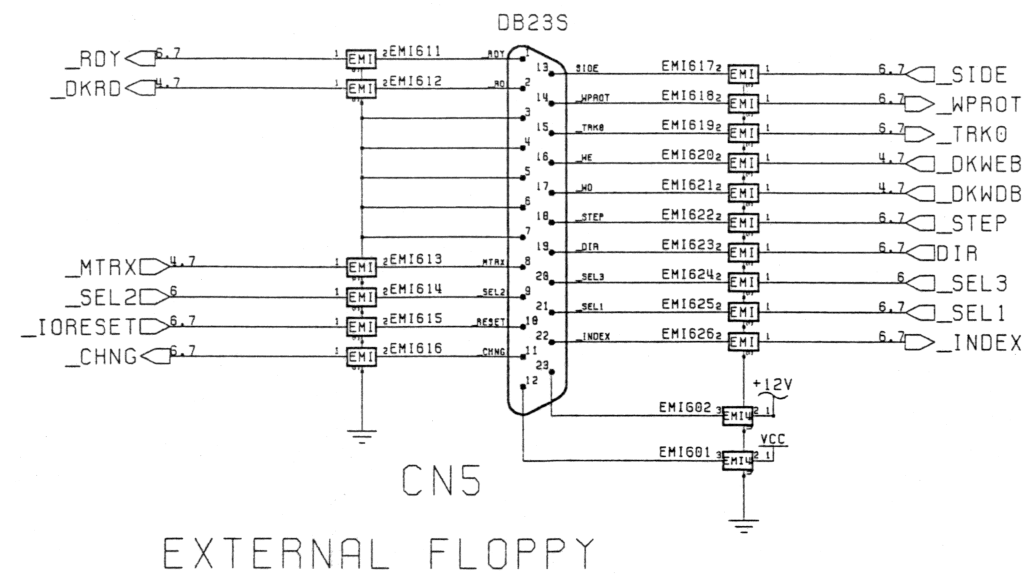




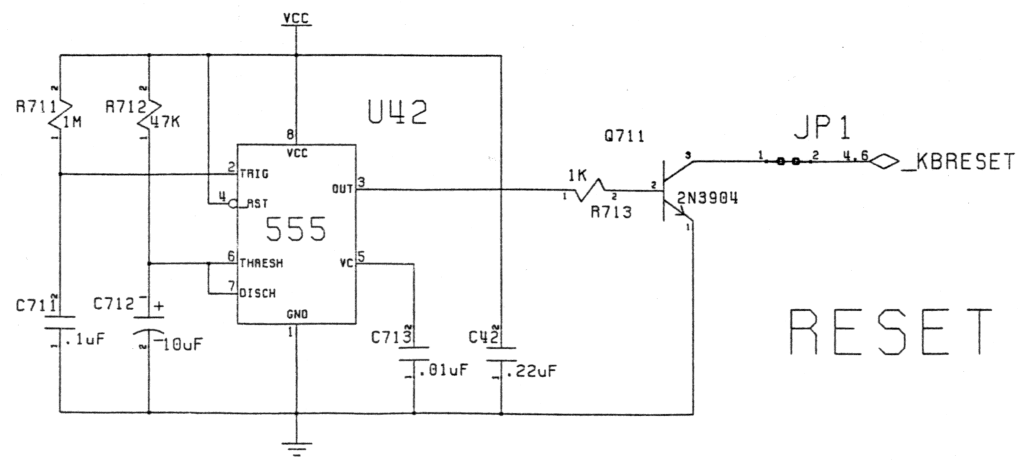
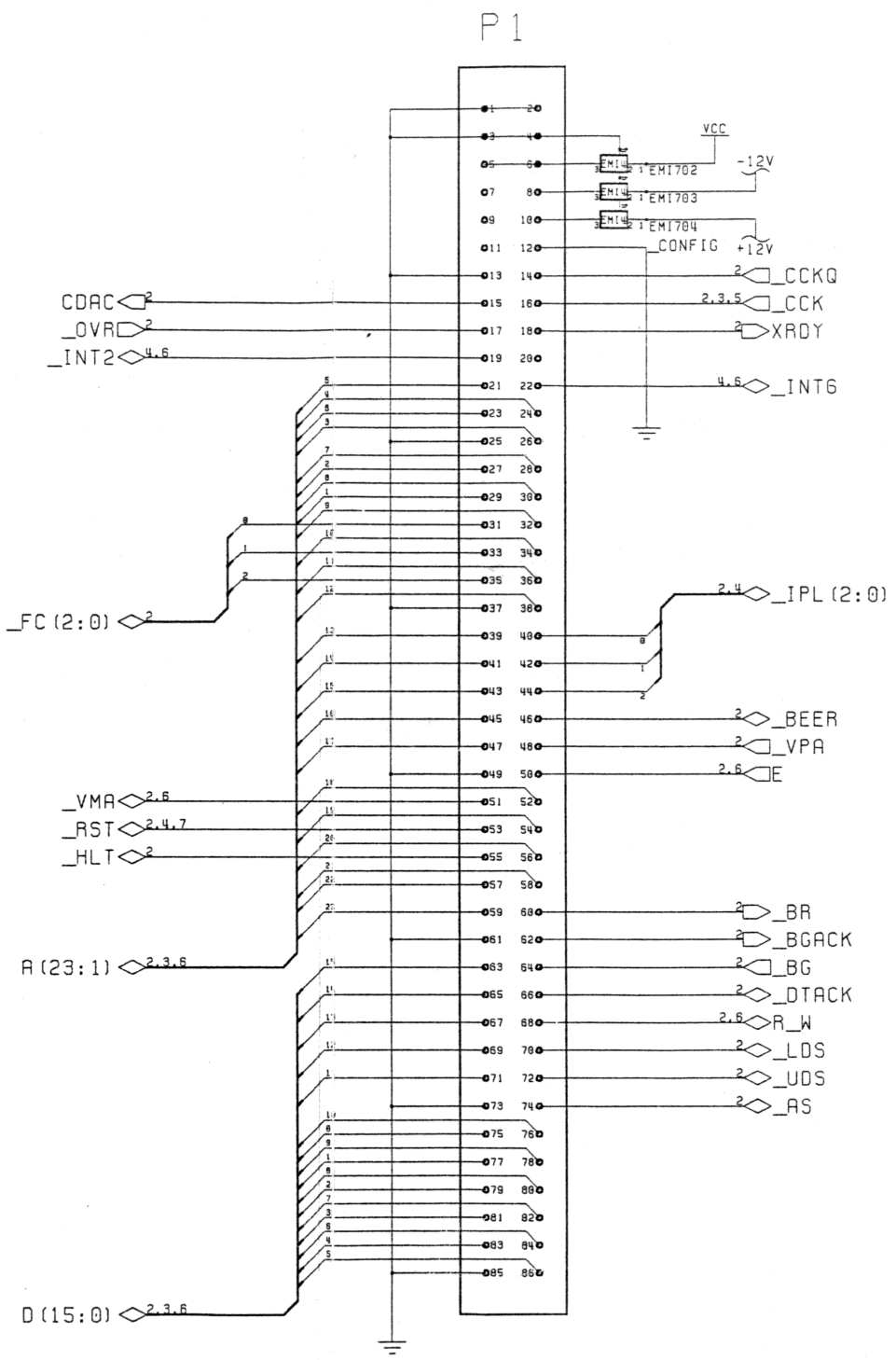
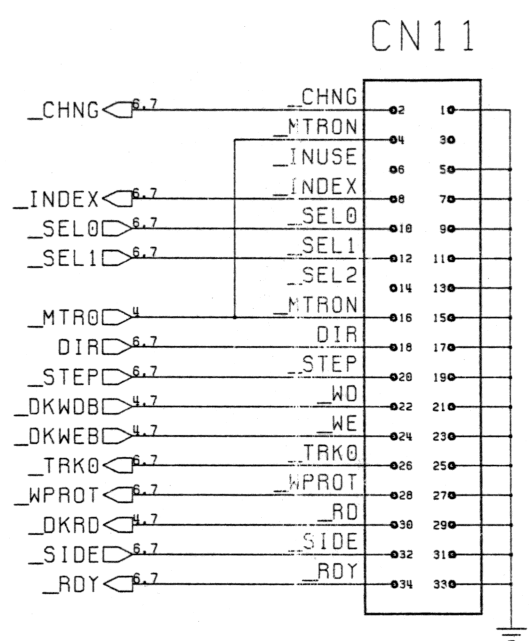


Note: EMI501-503 are loaded with 47 Ohm 1/2 W resistors

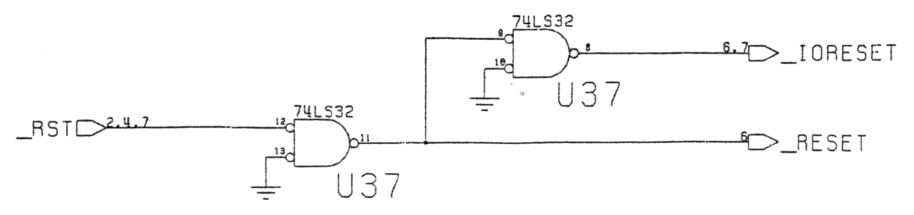
EXPANSION



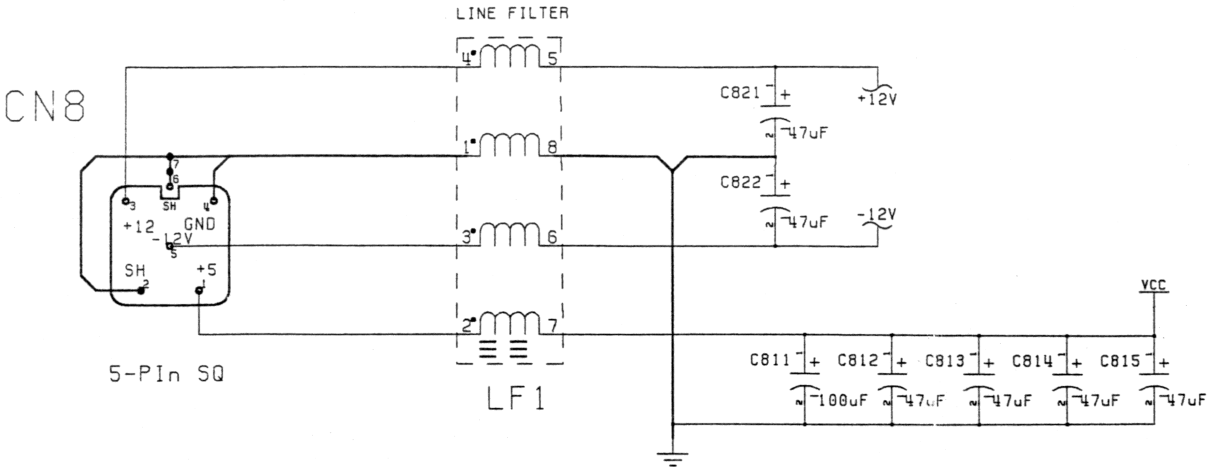
INTERNAL FLOPPY



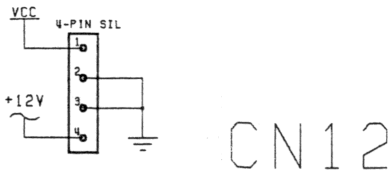
RESET ACTION



POWER INPUT

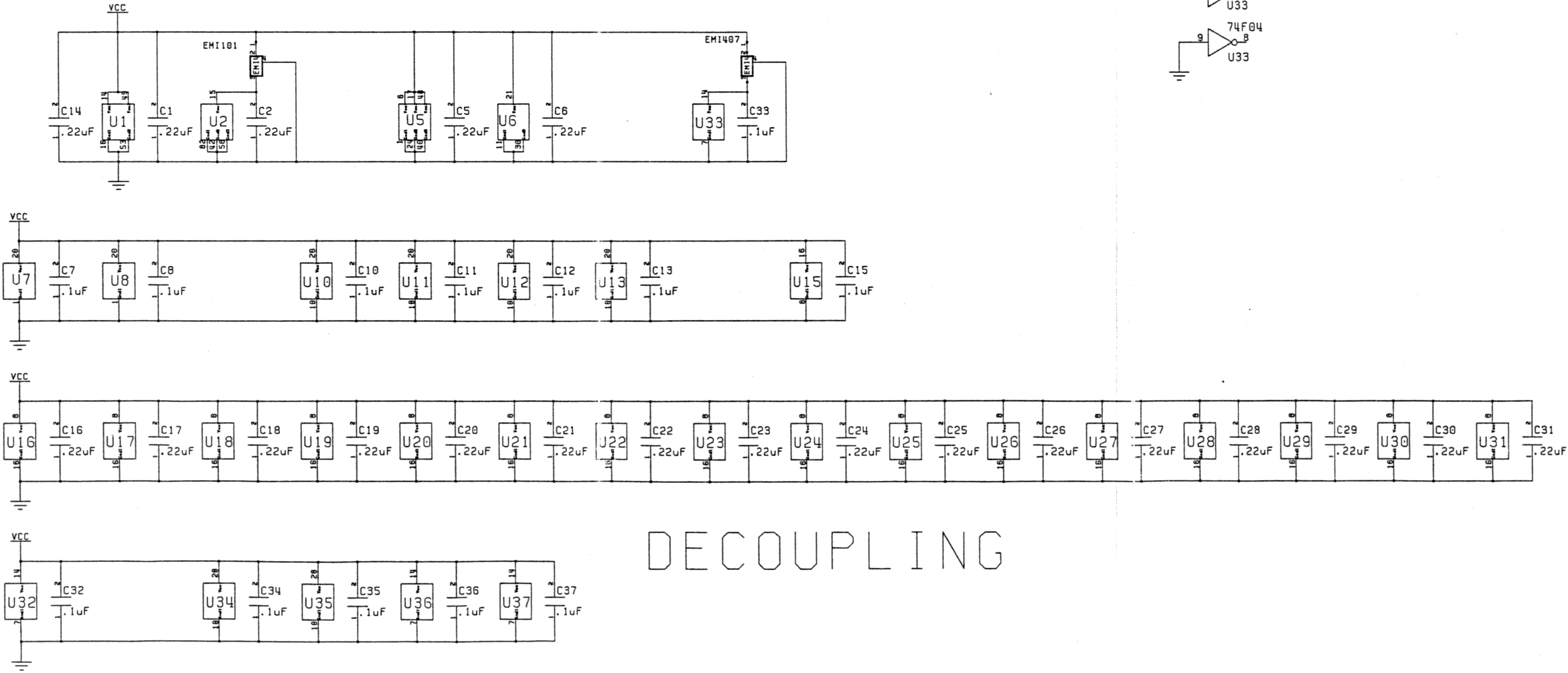
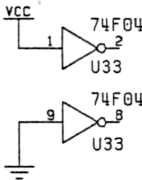


FLOPPY POWER



NOTE: HEAVY LINES INDICATE A
SINGLE POINT CONNECTION

SPARES



DECOUPLING

