

SERVICE MANUAL

2031 DISK DRIVE

HIGH AND LOW PROFILE MODELS

DEC. 1985

PN-314011-01





Computer Systems Division
1200 Wilson Drive
West Chester, PA 19380

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Commodore Business Machines, Inc.

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2031 DISK DRIVE PRODUCT SPECIFICATION

GENERAL DESCRIPTION

The 2031 is a single drive, 5-1/4 inch floppy, disk unit. It uses a 35 track, 48 TPI, single headed drive:

High profile — Shugart drive assembly

Low profile — Alps drive assembly

It is an intelligent device, containing its own microprocessor, RAM, ROM and operating systems software.

MAXIMUM STORAGE

170K of data (formatted) — 35 tracks

MEDIA

5-1/4 inch floppy disk. Single sided, single density, soft sectored (double density can be used, but not needed).

INPUT/OUTPUT

IEEE interface

CONTROLLER

MOS 6502 microprocessor — 1 MHz clock

MEMORY

2K RAM, 16K ROM

DATA TRANSFER RATE

Internal 40K Bytes/sec

IEEE-488 Bus 1.2K Bytes/sec

FILE TYPES

Program, sequential, relative, random-access and user

COMPUTERS

PET, 4000 series, 8000 series, B128

MEDIA COMPATIBILITY

1541, 4040

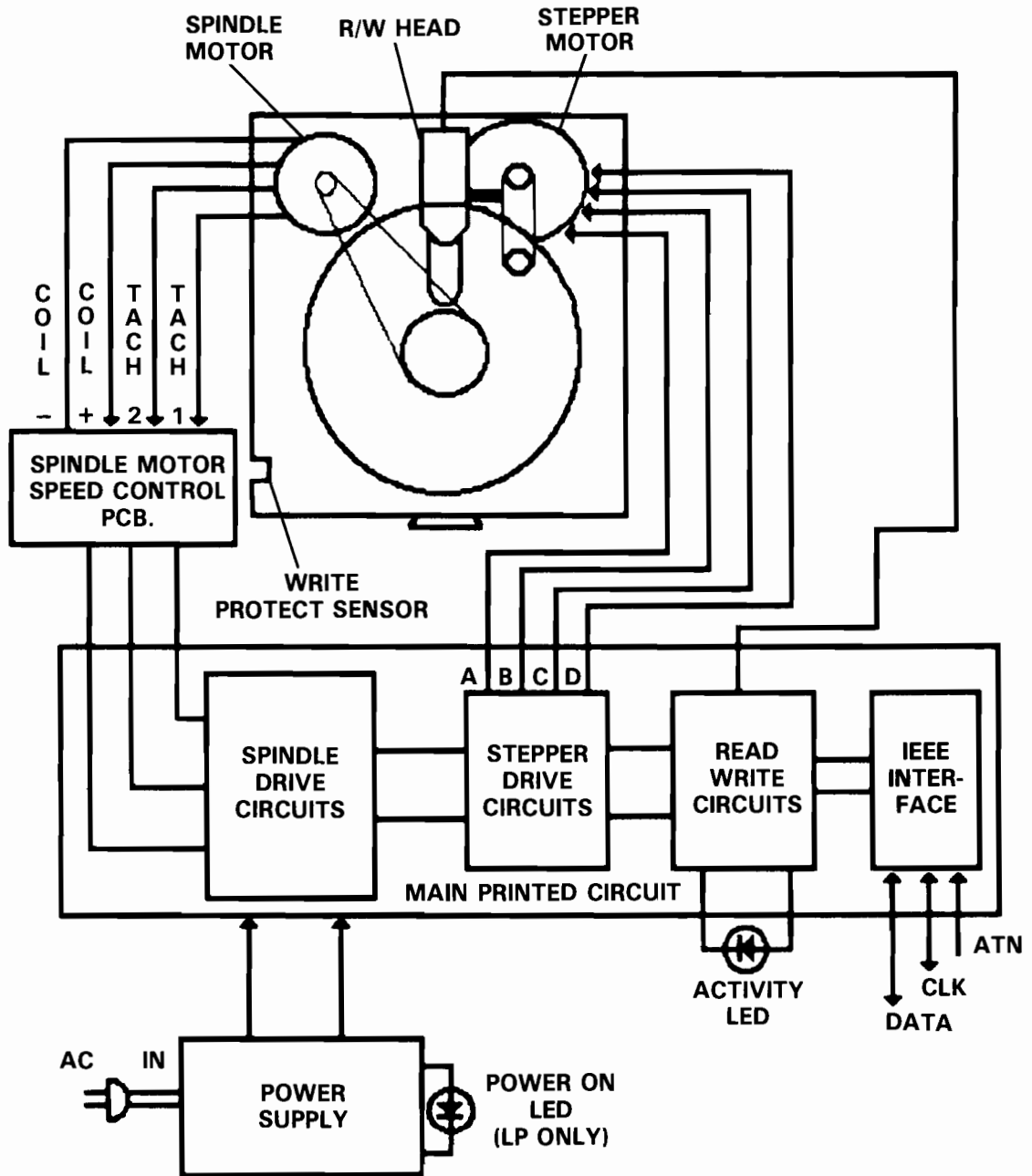
POWER REQUIREMENTS

120 Volts AC, 60Hz — integral power supply with external 1 Amp fuse

POWER CONSUMPTION

40 Watts maximum

BLOCK DIAGRAM



CARE AND MAINTENANCE

- DO NOT use MAGNETIZED tools when repairing or adjusting a disk drive.
- DO NOT place a disk drive near any device which generates "noise" e.g., — motors, radios, televisions.
- DO NOT stack drives upon each other or in any way inhibit air flow around the unit. HEAT BUILD-UP can cause disk failures.
- Periodically CLEAN the read/write head with 90% isopropyl alcohol and a cotton swab. CHECK load pad for excess wear. Clean or replace as necessary.
- Take the following precautions when handling a diskette:
 - ALWAYS store a diskette in its jacket.
 - Use ONLY felt-tip pens when writing on the label of a diskette.
 - Do not bend or physically damage a diskette.
 - Do not place a diskette in the area of a magnetic field.
 - Do not attempt to clean a diskette.
 - Do not touch the exposed area of a diskette.

DIAGNOSTIC and ADJUSTMENT procedures for the 2031 are outlined in detail in the Version 3.0 diagnostic package (Commodore Part # 31405201). This Kit contains a manual that outlines testing, adjustment and alignment procedures and Version 3.0 and 3.5 diagnostic program disks.

DEVICE NUMBER CHANGE

The 2031 drive is shipped from the factory set for device #8. The channel may be hardware altered to device #9, 10 or 11. Channel selection is changed on the main logic board by LIFTING the diodes at locations CR 17/18 and/or CR 19. The following chart indicates the selected device #:

| ADDRESS | LOW PROFILE | HIGH PROFILE |
|---------|-------------|--------------|
| 9 | CR 19 | CR 19 |
| 10 | CR 17 | CR 18 |
| 11 | CR 19 & 17 | CR 19 & 18 |

The diode locations are indicated on the appropriate schematic.

OVERVIEW

The drive is itself an independent memory device. The drive is composed of a media clamp rotating mechanism, a head positioning mechanism and an eject mechanism. All positioning operations, excluding insertion and removal of the diskette, are controlled by the internal guide mechanism. Closing the front door causes the media clamp mechanism to operate. Two operations are performed in the following order:

- a) The diskette is centered.
- b) The diskette is clamped and retained between the spindle and the hub.

The spindle and hub rotate at 300 r.p.m. through a closed-loop control circuit employing a D.C. motor/tachometer. It is important that the relationship between the head and the media is maintained correctly during operation. For this purpose, a pressure pad is used to hold and press down the media (about 12g) from the opposite side of the head. This head assembly is coupled to a four phase stepping motor which performs the track positioning. One step of the stepping motor corresponds to a 1/2 track movement. The control circuit on the logic board selects the direction and number of steps to the desired track.

The Read/Write head uses a glass-bonded, ferrite/ceramic head. Track-to-track erasing is accomplished by the straddle erase method. The surface of the Read/Write head is mirror-ground to minimize wear of the head and media. Also, the head is designed in such a way that the maximum signal can be obtained from the media surface.

The spindle drive motor operates on 12VDC and turns the spindle, through a belt drive, at 300 revolutions per minute. The speed of the drive motor is controlled by a feedback signal from a tachometer, which is housed in the drive motor assembly. The feedback signal controls a servo amp that supplies the 12VDC drive current.

FLASH CODE

The 2031, upon power-up, goes through its own internal diagnostic. If an electronic problem is detected, it is indicated by a FLASH CODE. The LED's will blink a set number of times, pause, and then flash again until the problem is corrected.

| Number of Flashes | Possible Failure |
|-------------------|------------------|
| 1 | Zero Page |
| 2, 3 | DOS ROM's |
| 4 | RAM |

Circuitry associated with these components can also cause the failure code. Therefore, it should be suspected as the next possible defect.

CASEWORK/ACCESSORY PARTS LIST

2031 LOW PROFILE (PLASTIC CASEWORK)

| | |
|--|--------------|
| 2031 TOP CASE (IVORY) | C 1540014-05 |
| 1540/41/2031 BOTTOM CASE (IVORY) | C 1540015-00 |
| SHIELD COVER | 1540013-01 |
| LED ASSEMBLY | 1540003-01 |
| SELF ADHESIVE FOOT | C 950150-02 |
| POWER CORD..... | C 903508-04 |
| USER'S MANUAL | C 1540042-01 |

2031 HIGH PROFILE (METAL CASEWORK)

REPLACEMENT CASEWORK FOR METAL UNITS IS NO LONGER AVAILABLE.

| | |
|-------------------------------------|--------------|
| POWER CORD | C 903501-01 |
| USER'S MANUAL | C 2031036-01 |
| DEMO DISKETTE | C 1540041-01 |
| IEEE TO IEEE INTERFACE CABLES | C 905080-01 |
| PET TO IEEE INTERFACE CABLES | C 320101-01 |

TROUBLESHOOTING GUIDE

NOTE: Always check for latest ROM/ECO upgrade. If socketed IC is suspected bad, be sure to check socket with ohmmeter.

| SYMPTOM: | POSSIBLE SOLUTION: |
|---|---|
| No LED's on power up. | Is Power cord plugged into wall outlet correctly? Is Power cord plugged into the disk drive correctly? Check line fuse. Check power switch. Check clock on 6502 pin 37. Check +5 and +12 volt lines. |
| Error LED flashes on power up. | Check all RAM and ROM locations. |
| Error LED stays on all the time. | Check 6502 microprocessor. Check ROMs. |
| Drive motor runs continuously and red LED stays on. | Check +12V. Check 6502, logic gates. |
| Drive motor runs continuously and red LED stays off. | Check ROM Check drive motor PCB. |
| Drive motor runs continuously. | Check VR2 (5V Regulator). Check Power Transformer. |
| After the drive warms up the motor runs continuously. | Check 6522s. Check motor control PCB. |
| Loads programs with red LED flashing. | Check drive speed. Check stepper motor. |
| Loading is intermittent. | Check ROMs. Check drive alignment. |
| Does not load when hot or LED flashed 3 times. | Check ROMs. |
| Searches with LED flashing continuously. | Check ROMs. |
| Searching with no red LED. | Check 6522s, logic gates. |
| Message of 'FILE NOT FOUND' is displayed. | Clean drive head w/alcohol. Check Ø stop adjustment. Check alignment. |
| Drive fails to read. | Check the 311, 9602, and 592s. There are two +12 volt sources for stepper output and read circuit, make sure both are good. |

TROUBLESHOOTING GUIDE (Continued)

| SYMPTOM: | POSSIBLE SOLUTION: |
|---|--|
| Fails to format disk. | Check components related to connector P7. Check 6522s. Check write circuits. |
| Stepper Motor does not step forward. | Check 6502, 6522s, stepper logic. |
| Drive speed will not stabilize. | Check DC motor. |
| Will not save when the drive heats up. | Check 6502 microprocessor. |
| Locks-up when loading. | Check IEEE interface components. Check ROM. |
| Fails the performance test and displays a 21 read error. | Check test diskette. Check Drive Motor. |
| Fails the performance test and displays a 27 read error. | Check stop adjust. |
| Passes performance test to track 18 then displays 21 read errors. | Check read/write head. |
| Passes the performance test but will not load certain programs. | Check stepper motor. |

HIGH PROFILE

PARTS LIST

PCB ASSEMBLY #2031040-01

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. Unique or non-standard parts will be stocked by Commodore and are indicated on the parts list by a "C". Vendor Name and part number have been provided for your convenience in ordering custom or unique parts.

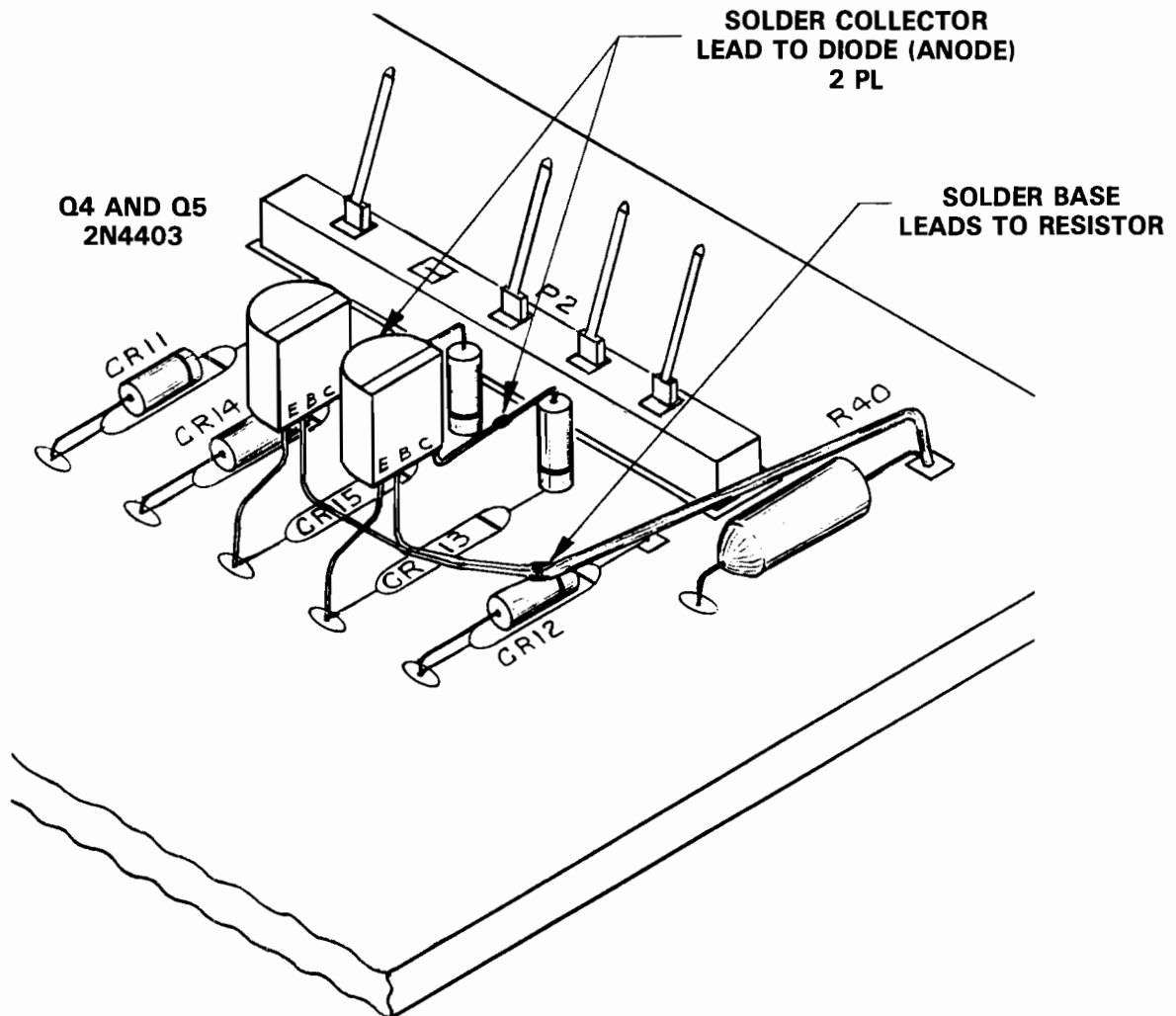
| INTEGRATED CIRCUITS | | | RESISTORS — All Values are in ohms- 1/4 W 5% unless noted otherwise. | | | |
|---------------------|------------------------------|-------------|---|-------------------------|---------|------------------|
| U1A | 75161 Transceiver | 901494-01 | R1 | 2K | R31,32 | 1.5K |
| U1B | 74LS14 | 901521-30 | R2-5 | 150 | R33 | 1K |
| U1C | 7406 | 901522-06 | R6 | 680 | R34 | 680 |
| U1N | 7406 | 901522-06 | R13 | 5.1K | R35,36 | 220 |
| U1P | 74LS139 | 901521-18 | R14 | 330 | R37 | 2K |
| U1S | 75160 Transceiver | 901493-01 | R15 | 510 | R38,39 | 9.09K, 1/4 W, 1% |
| U2K | 74LS164 | 901521-28 | R18-20 | 2K | R40 | 1K |
| U2L | 74LS133 | 901521-15 | R21 | 22K | R41 | 180 |
| U2M | 74LS02 | 901521-21 | R22,23 | 470 | R42 | 270 |
| U2N | 74LS193 | 901521-26 | R24 | 430 | R43 | 47 |
| U2P | 74LS86 | 901521-32 | R25 | 330 | R44 | 2.2K |
| U2R | 311 OP Amp | 901523-04 | R26,27 | 2.2K | R45,46 | 1M |
| U3A | 74LS04 | 901521-02 | R28,29 | 150 | R47 | 4.7K |
| U3B,C,D,E | 2114 Static RAM | 901453-04 | R30 | 300 | R48 | 6.19K, 1/4 W, 1% |
| U3F | 6502 Microprocessor | C 901435-01 | | | | |
| U3H | 6522 | C 901437-01 | CAPACITORS | | | |
| U3J | 6522 | C 901437-01 | C1,2 | Low Leak Elect | 4700μF | 25V |
| U3K | 74LS245 | 901521-46 | C3,4 | Low Leak Elect | 47μF | 16V |
| U3L | 74LS165 | 901521-12 | C5,C6 | Low Leak Elect | 1μF | 50V |
| U3M | 74LS74 | 901521-06 | C7-10 | Ceramic | .1μF | 50V |
| U3N | 9602 One Shot | 901510-01 | C12-18 | Ceramic | .1μF | 50V |
| U3R | 592 | 901523-08 | C20-25 | Ceramic | .1μF | 50V |
| U3S | 555 Timer | 901523-01 | C26 | Ceramic | 22pF | 50V |
| U4C | 7400 | 901522-04 | C27 | Ceramic | 750 pF | 50V |
| U4D | 74LS193 | 901521-26 | C28,29 | Ceramic | 330 pF | 50V |
| U5F | 2364 ROM | C 901484-05 | C30,31 | Ceramic | .022μF | 50V |
| U5H | 2364 ROM | C 901484-03 | C32 | Ceramic | 1000 pF | 50V |
| U5J | 74LS04 | 901521-02 | C33-37 | Ceramic | .1μF | 50V |
| U5K | 74LS00 | 901521-01 | C38,39 | Ceramic | 750 pF | 50V |
| U5L | 74LS191 | 901521-40 | C41-44 | Ceramic | .1μF | 50V |
| U5M | 74LS193 | 901521-26 | C45 | Low Leak Elect | 10μF | 25V |
| U5N | 74LS74 | 901521-06 | C46,47 | Low Leak Elect | .47μF | 50V |
| U5R | 592 | 901523-08 | C48 | Tantalum | 3.3μF | 35V |
| U6F | 74LS04 | 901521-02 | C49-52 | Ceramic | .1μF | 50V |
| U6H | 74LS42 | 901521-17 | C53-54 | Ceramic | 47 pF | |
| U6K | 74LS10 | 901521-24 | C55,56 | Ceramic | .1μF | 50V |
| U6L | 74LS04 | 901521-02 | C57 | Ceramic | 1.0μF | 50V |
| U6M | 74LS00 | 901521-01 | C58 | Ceramic | .01μF | 50V |
| U6N | 7406 | 901522-06 | C59-71 | Ceramic | 47 pF | |
| TRANSISTORS | | | C72,73 | Ceramic | .1μF | 50V |
| Q1 | 2N4401 | | C74 | Ceramic | 100 pF | |
| Q2 | 2N4400 | | C75 | Ceramic | 220 pF | |
| Q3,4,5 | 2N4403 | | C76 | Ceramic | .047μF | |
| DIODES | | | C77 | Ceramic | 47 pF | |
| CR1 | 1.5 A, 50V, Bridge Rectifier | 900756-01 | MISCELLANEOUS | | | |
| CR2 | 4 A, 200V, Bridge Rectifier | 900755-01 | P1 | RT Angle CNNCT IEEE | | 903206-01 |
| CR3,4 | 1N4005 | | P2 | Header — R/W Head CNNCT | | |
| CR6-9 | 1N4005 | | P3 | Header — PWR CNNCT | | |
| CR10 | 1N5231, 5.1 V Zener | | L1-3 | Choke 100μH | | |
| CR11-16 | 1N4148 | | L4,5 | Choke 22μH | | |
| CR17 | 1N5226B, 13.3 V Zener | | L6 | Inductor 2.2μH | | |
| CR18,19 | Germanium 1N270 | | VR1 | Voltage Regulator LM323 | | |
| | | | VR2 | Voltage Regulator LM340 | | |
| | | | Y1 | Crystal 16 MHz | | 900556-02 |
| | | | | Shield Box | | 4022048-01 |
| | | | | Shield Cap | | 4022047-01 |

2031 HP UPGRADE NOTES

A design error was present in the original 2031 High Profile Single Disk Drive. The write circuit was modified to correct the problem, however, it is possible that some units still need to be revised.

Revision to correct write circuit:

1. Lift Diodes, CR13 & CR15 as shown.
2. Install Transistors, solder the Collector Lead to Diodes.
3. Solder the Center Leads of Transistors together, to R40 Resistor as shown. (Use 20 AWG wire for mechanical strength.)
4. Solder Emitter Leads to feed thru.
5. Change R31 & R32 from 2.7K Ω to 1.5K Ω .



2031 HP CIRCUIT THEORY

Microprocessor/VIA Logic

U3J is a VIA, Versatile Interface Adapter. During a write operation, the microprocessor passes the data to be recorded to Port A of U3J. The data is loaded into the shift register U3L. It is converted from parallel to serial data and output to the write amplifier circuit. During a read operation, serial data is received from the read amplifier circuit.

The stepper motor is controlled by two outputs on port B of U3J, STP0, and STP1. A binary four count is developed from these two lines by U1P, see Sheet 4. The MTR output on pin 12 controls the spindle motor, refer to the motor control schematic on page 18. The write protect switch, WPS, is monitored at pin 14 of U3J and the red activity LED is controlled at pin 13.

Varying Frequency Clock

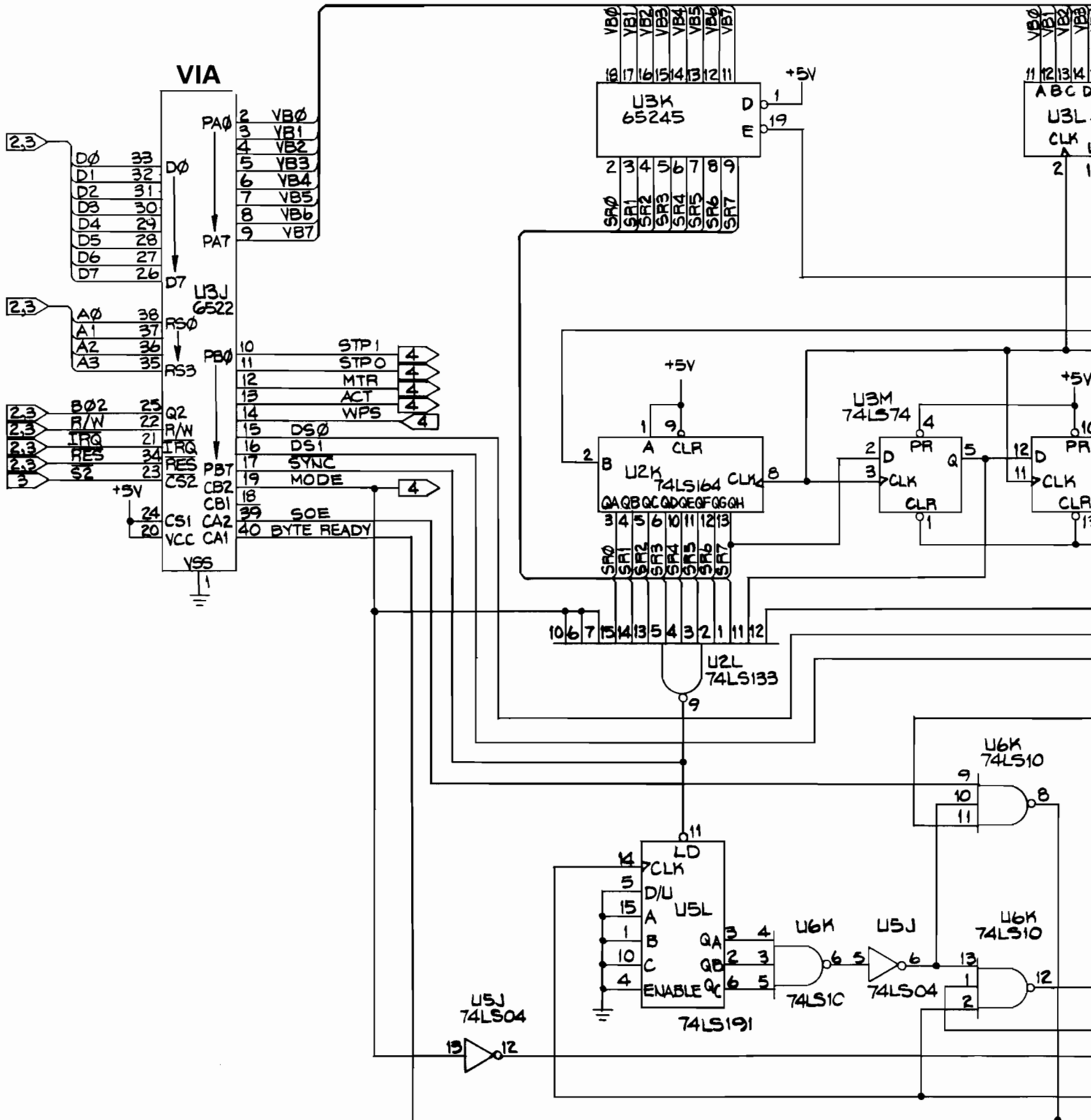
The DS0 and DS1 outputs of U3J, pins 15 and 16, are input at pins 1 and 15 of U5M. U5M is a programmable counter ($\div 16$, $\div 15$, $\div 14$, $\div 13$) that outputs a varying frequency clock used to compensate for the difference in recording area/sector for sectors on inner tracks (Trks 1,2,3) as compared to sectors on out most tracks (Trks 33,34,35). The area/sector for inner tracks is less than the area/sector for outer tracks, so the recording clock frequency is increased when writing on inner tracks to keep the flux density constant. This clock output is on pin 12 of U5M and is used to clock the data from the read amplifier circuits.

| Tracks | Clock Frequency | Divide By |
|--------|-----------------|-----------|
| 1-17 | 1.2307 MHz | 13 |
| 18-24 | 1.1428 MHz | 14 |
| 25-30 | 1.0666 MHz | 15 |
| 31-35 | 1 MHz | 16 |

Read/Write Control Logic

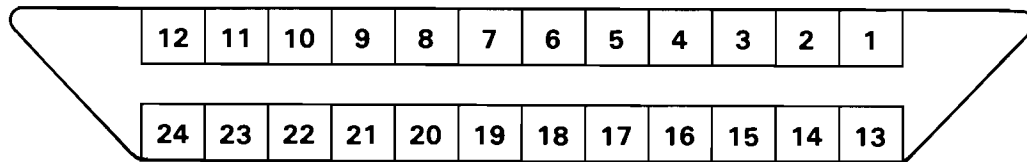
During a write operation, U3L converts parallel data into serial data. The output on pin 9 is input to 'NAND' gate U6M pin 5. U6M outputs the serial data on pin 6 at the clock rate determined by the input signal on pin 4. The output clocks the D flip flop U5N (see Sheet 4). The outputs of U5N, Q and \bar{Q} , drive the write amplifiers.

During a read operation, data from the read amplifiers is applied to the CLR input of counter U2N. The outputs, C and D, are shaped by the 'NOR' gate U2M. U2M outputs the serial data on pin 1, then it is converted to parallel data by U2K. The output of U2K is latched by U3K. The serial bits are counted by U5L. When 8 bits have been counted, U6K pin 6 goes "low", U5J pin 6 goes "high", and U6K pin 8 goes "low" indicating byte is ready to be read by the processor. U2L monitors the parallel output of U2K. When all 8 bits are "1", the output pin 9 goes "low" indicating a sync bit has been read.



READ/WRITE LOGIC

2031 HP CIRCUIT THEORY



IEEE Interface

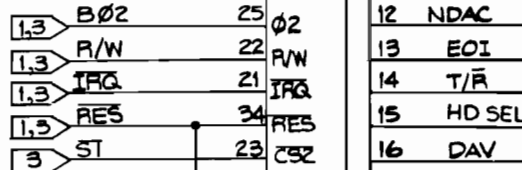
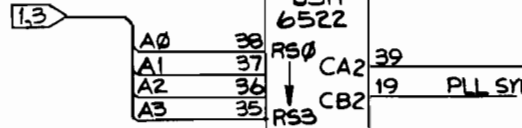
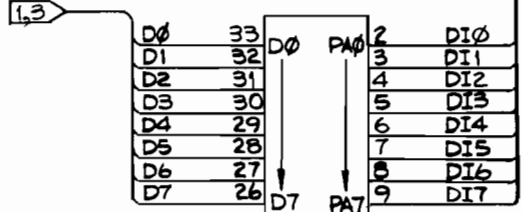
All of the signals on the interface are controlled by the I/O device U3H. Eight parallel bi-directional data lines, PA0-PA7, are used as the parallel data bus for the interface. U1S is an octal bus transceiver used to provide communication on the general purpose interface bus, GPIB, between operating units of the system. The data transfer and bus-management signals are communicated by U1A, thus completing the 16-line interface of the IEEE-488 bus.

| | | |
|-----|--------------------|--|
| DAV | Data Valid | DAV low signifies data is valid on the data bus. |
| EOI | End or Identify | CBM always sets EOI low while the last data byte is being transferred. |
| DAC | Data Not Accepted | DAC is low when data is being read and returned high after the last data byte is read. |
| RFD | Not Ready For Data | RFD is low until all receivers are ready to accept data, then the line will go high. |
| SRQ | Service Request | Not implemented in BASIC but available to the CBM user. |
| ATN | Attention | The host sets the signal low while sending commands on the data bus. |
| REN | Remote Enable | REN is held low by the bus controller and the host has this pin permanently grounded. |
| IFC | Interface Clear | The host sends its internal reset signal as IFC low to initialize all devices. |

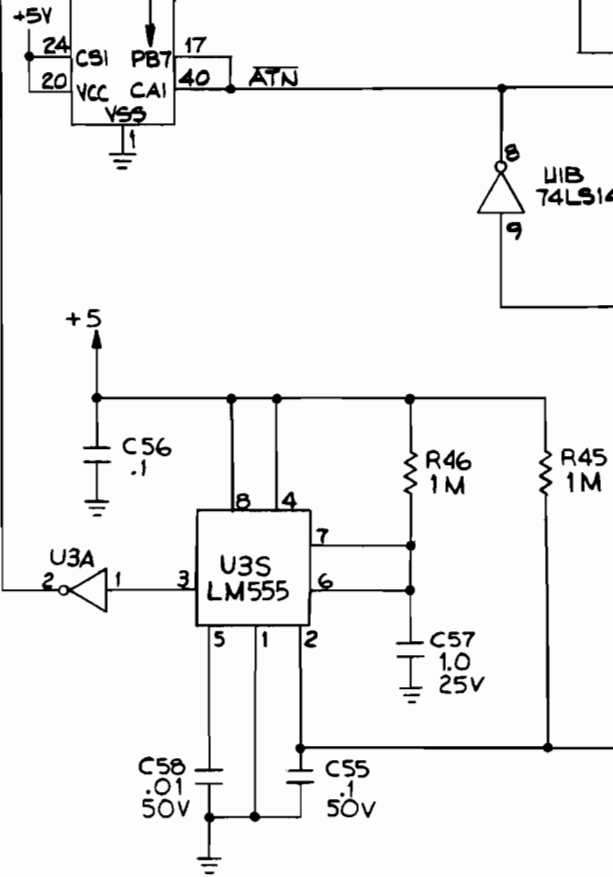
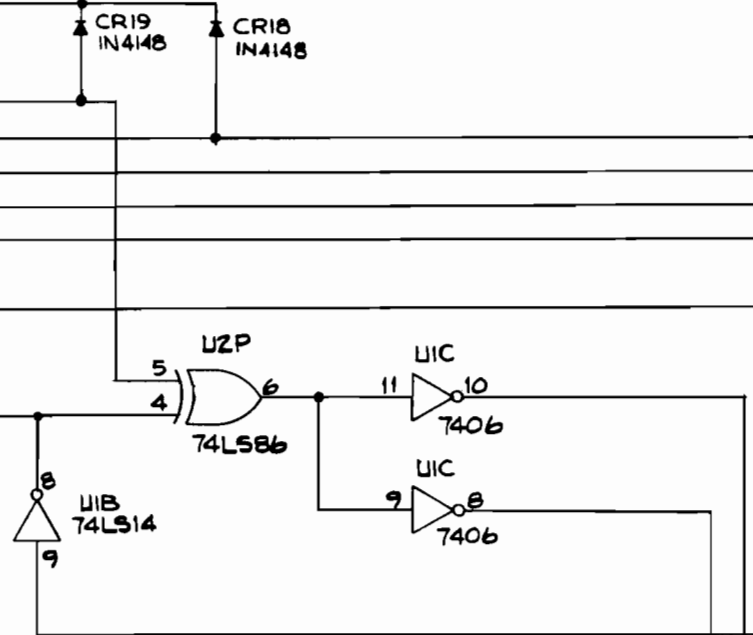
Reset Logic

The 2031 disk drive is automatically reset on power up by U3S, a 555 timer, when triggered by the 5V applied at pin 8. A reset can also be set by the IFC line on the IEEE interface. The output pulse width is determined by the values of R43 and C36. The pulse width = $1.1 \times R43 \times C36 \approx 1$ second. The output on pin 3 of U3S is an active "high". It is inverted by U3A to active "low". A low output at U3A pin 2, resets the unit and initializes all of the microprocessor logic.

VIA



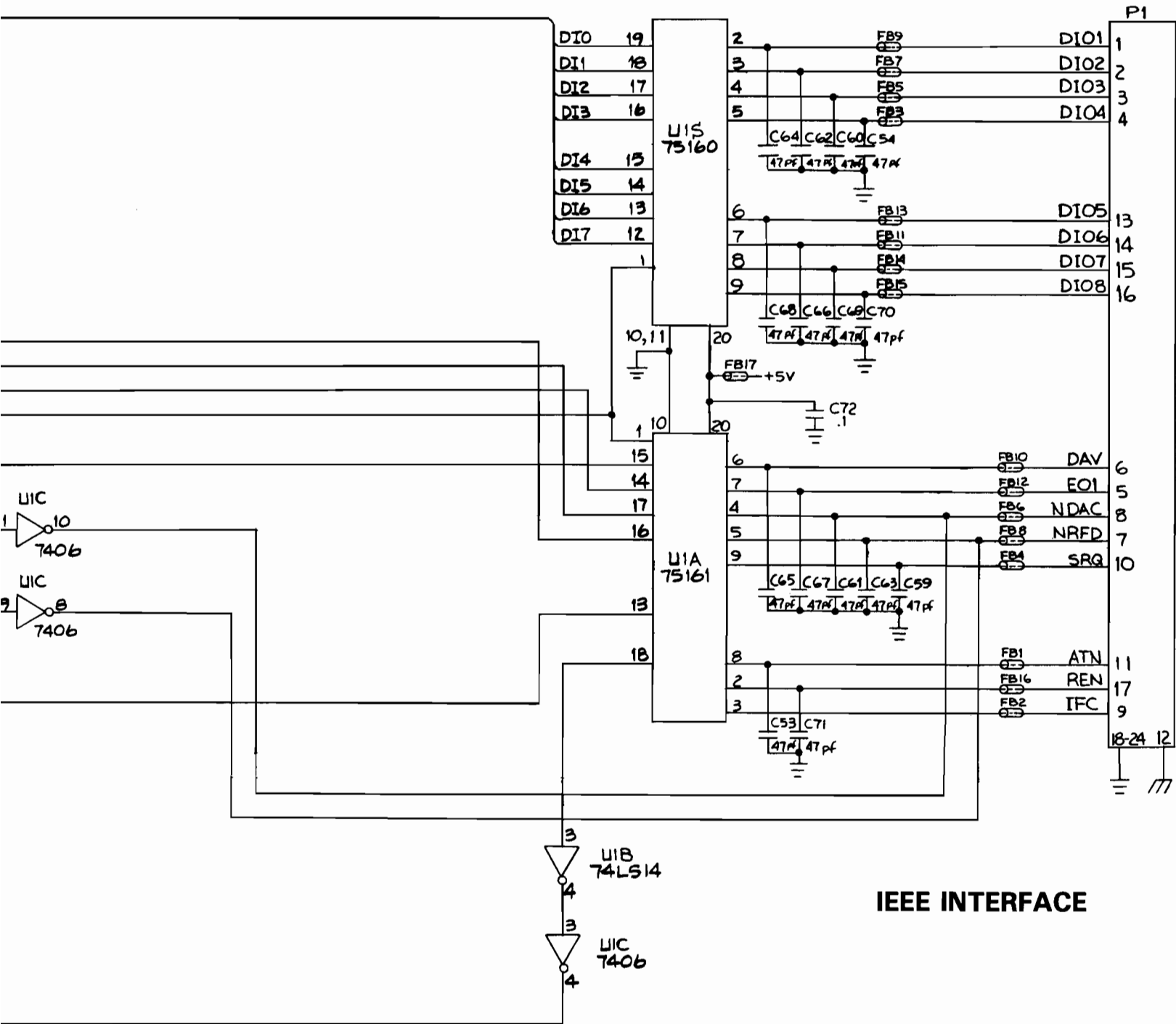
DEVICE # SELECTION



POWER ON RESET

SCHEMATIC 2031038

SHEET 2 of 4



2031 HP CIRCUIT THEORY

Microprocessor Control of RAM and ROM

U5F and U5H are 8192 x 8 bit ROMS that store the Disk Operating System (DOS). U5F resides at memory locations \$C000-\$DFFF. U5H resides at memory locations \$E000-\$FFFF. U5J and U5K decode the addresses output from the microprocessor when selecting these ROMS.

U3B, C, D and E are 2114 Static RAMS (24 x 4). They reside at memory locations \$0000-\$07FF. This memory is used for processor stack operations, general processor housekeeping, user program storage, and 4 temporary buffer areas. U5J, U5K, and U6J decode the addresses output from the processor when selecting RAM. U6J also decodes the address selection of the VIAs, U3J and U3H.

The Clock Circuit

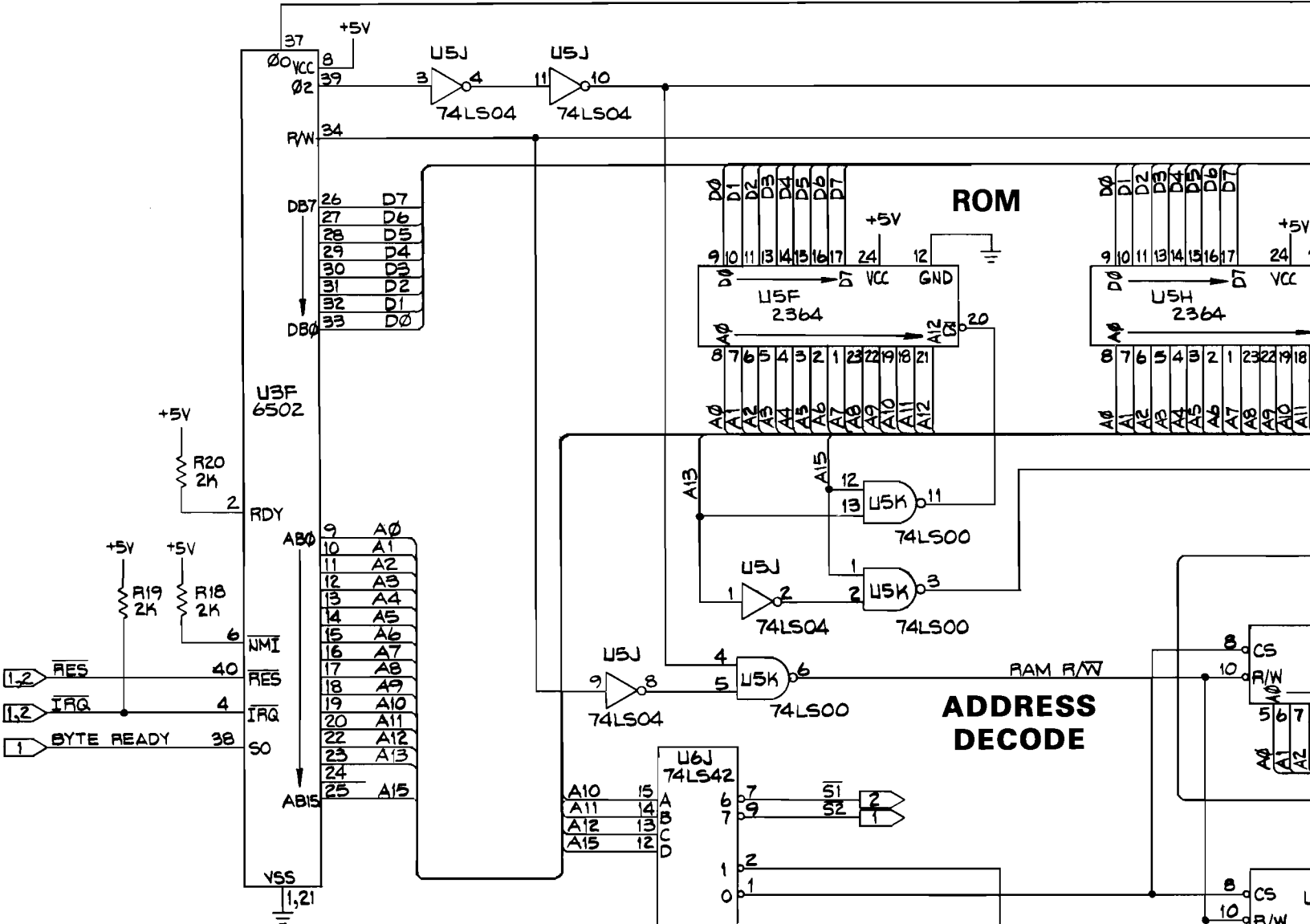
The clock circuit outputs a 16 MHz clock signal at U4C pin 11. This is input to U4D on pin 5. U4D is configured as a $\div 16$ frequency divider. The output of U4D pin 7 is a 1 MHz clock signal used as the system clock (Phase 0) for the microprocessor. The 16 MHz clock signal is also used for the varying frequency clock circuit, see Sheet 1.

The Power Supply

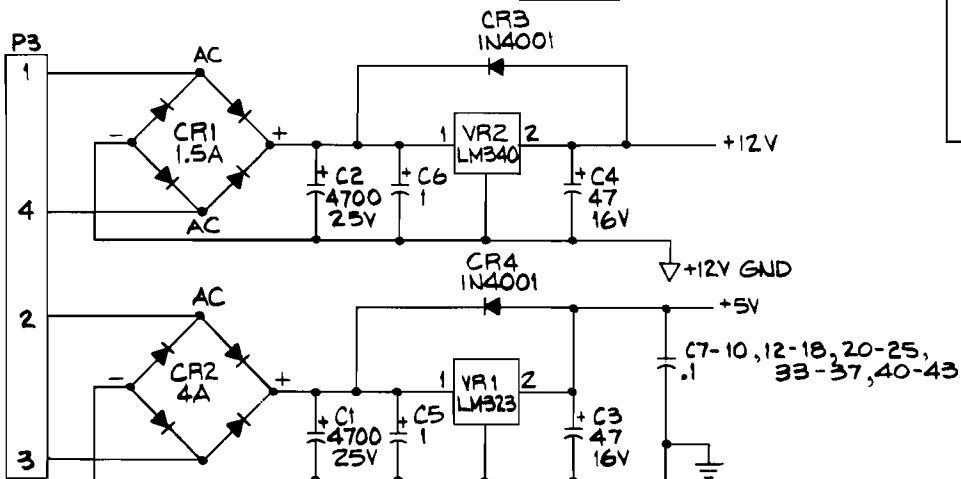
THE CHASSIS: When the switch is closed, the AC voltage input is applied to the primary winding of the transformer. Circuit protection is provided by a .5 amp fuse. The transformer steps down the AC input voltage into two smaller AC voltages: One secondary output (approx. 16VRMS) is applied at connector P3 pins 1 and 4, the other secondary output (approx. 9VRMS) is applied at P3 pins 2 and 3.

THE PCB: The 16VRMS AC applied between pins 1 and 4 is converted to DC by the full wave bridge rectifier CR1. The DC output of CR1 is regulated at +12VDC by VR2. High frequency filtering is provided by C6, low frequency filtering by C2 and C4. The 9VRMS AC applied between pins 2 and 3 is converted to DC by the full wave bridge rectifier CR2. The DC output is regulated at +5VDC by VR1. High frequency filtering is provided by C5, low frequency filtering by C1 and C3.

CPU

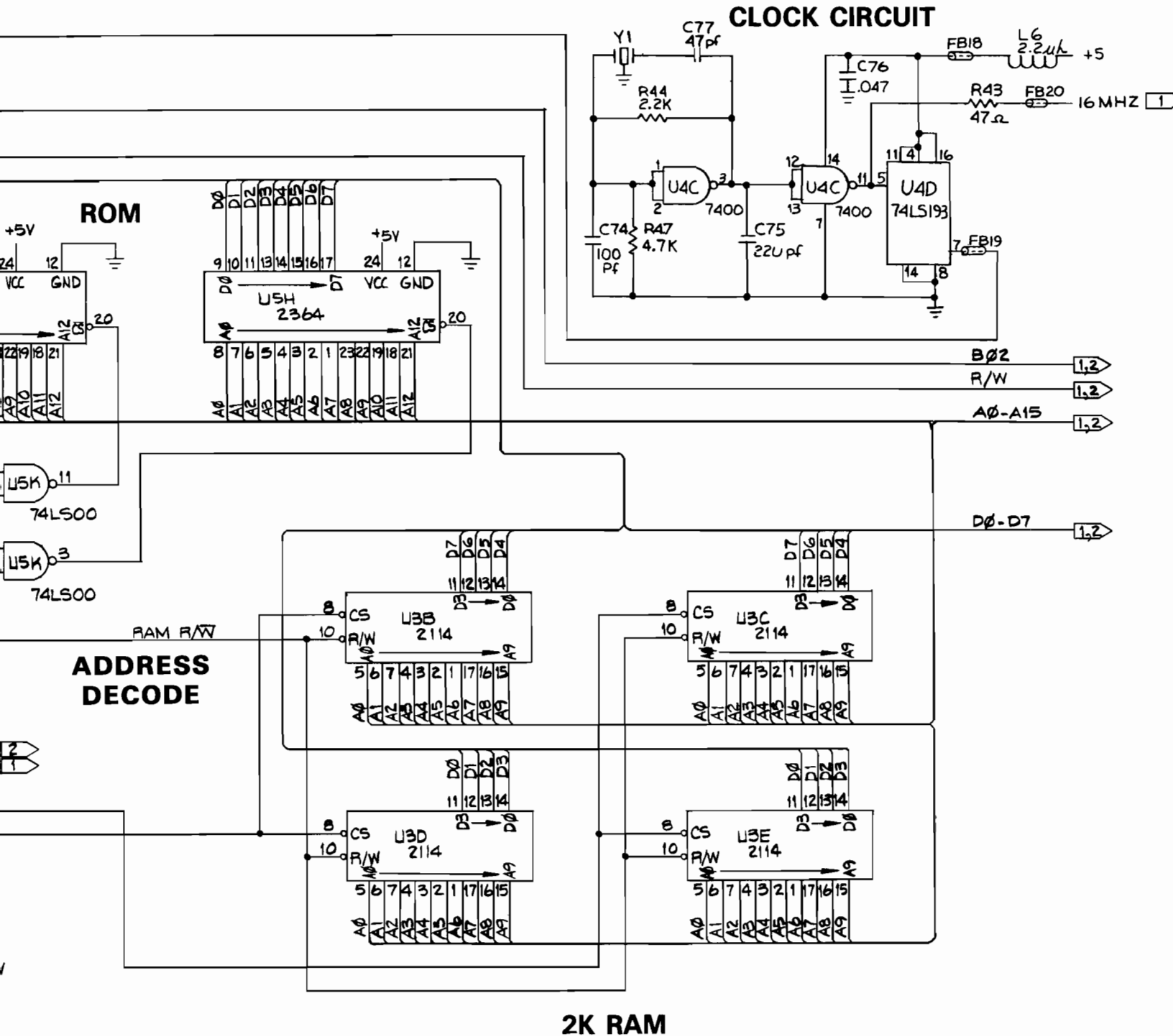


POWER SUPPLY



SCHEMATIC 2031038

SHEET 3 of 4



2-18, 20-25,
33-37, 40-43

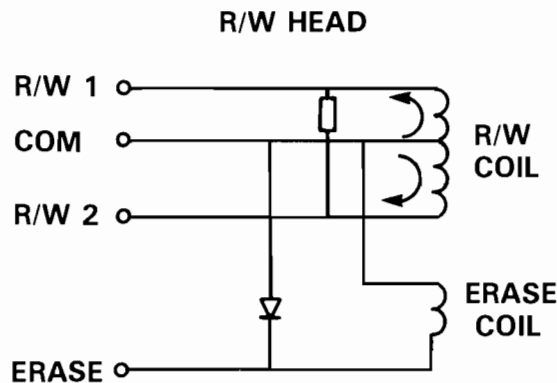
2031 HP CIRCUIT THEORY

Stepper Motor Control Circuits

U1P converts STP0 and STP1 into outputs that create a binary four count. The outputs Y0, Y1, Y2, and Y3 from U1P are inverted by U1N. The outputs of the inverters drive the transistors of U1L. The current output from these transistors drive the individual phase coils in the stepper motor and return to the 12VDC supply. CR6-CR9 suppress the CEMF developed by the motor coils.

Read Amplifier Circuits

When data is recorded on the disk, a "1" bit is represented on the disk by a change in direction of magnetic flux, caused by a change in direction of current passed through the R/W coil in the R/W head. When a "0" bit is to be recorded, no change in current flow direction occurs, causing the direction of the magnetic flux to remain the same on the disk.



When data is being read from the disk, CEMF is induced into the R/W coil by the magnetic fields on the disk, causing current flow which is detected by the read amplifiers. Current flow through the R/W coil will forward bias either CR12 or CR14, depending on the direction. Q1 and CR16 must be forward biased. The first amplifier, U5R, senses this current flow from the R/W coil on one of the inputs and amplifies it. L2, L3, L4, L5 and C39 act as a low pass filter, suppressing noise on the amplified output. U3R is a differential amplifier which amplifies the difference of the two input signals from the filter section. U2R is a peak detector. The output of U2R will pulse "high" when a "1" is read. This signal is the reconstruction of data recorded. The time domain filter, U3N, times out when a "1" bit has been read, so unwanted "1" bits are not added to the actual data. The one shot, U3N, generates the correct data pulse width.

Write Amplifier Circuits

During a write operation, pin 4 of U6N must be "high". This forward biases Q1 and CR16. If pin 5 of U5N, Q, goes "low", Q4 and CR15 become forward biased, passing current flow through R/W 1. If \bar{Q} goes "low", Q5 and CR13 become forward biased, passing current flow through R/W 2.

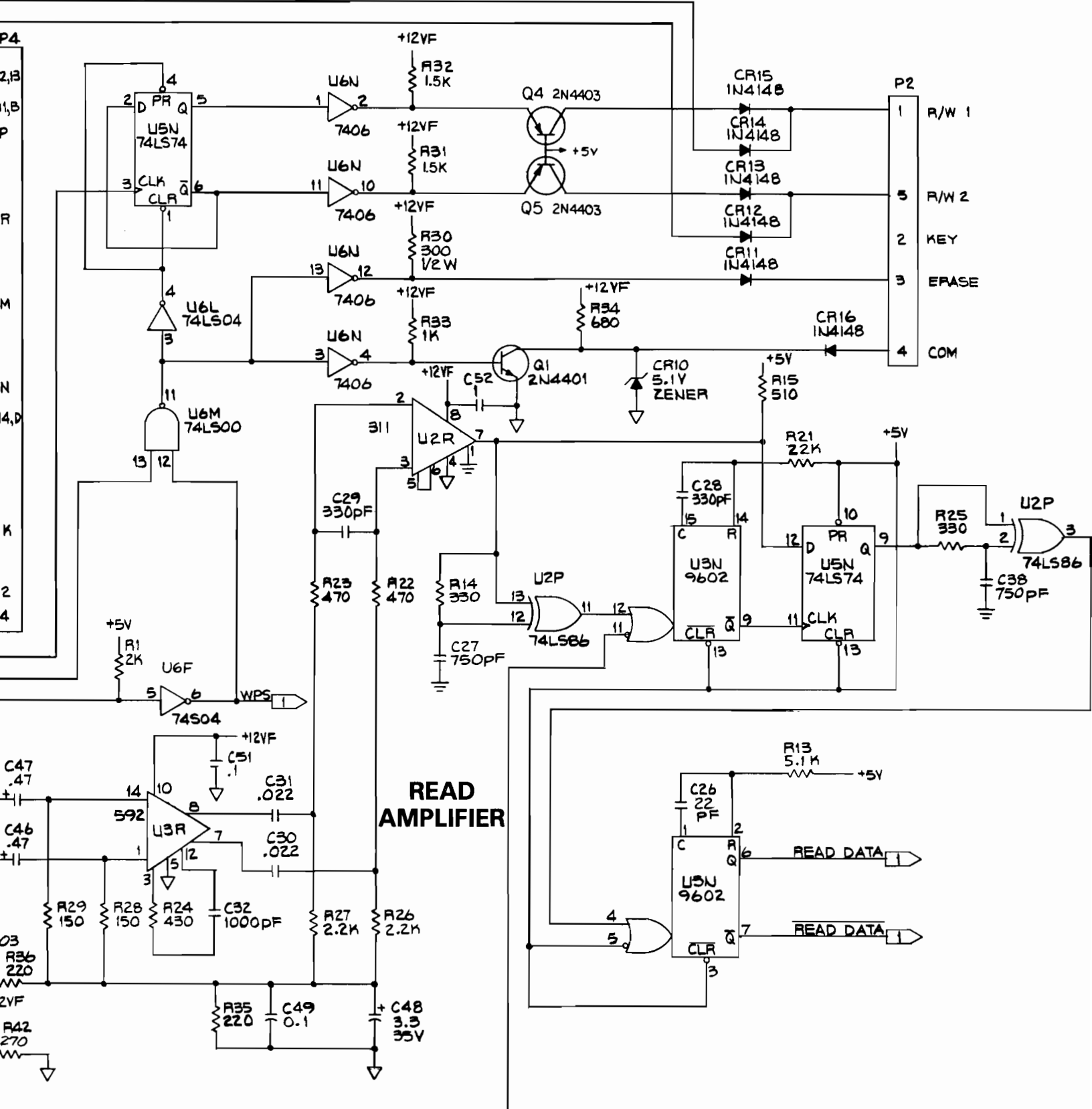
When a write operation occurs, the ERASE coil is energized by forward biasing CR11. This demagnetizes the outer edges of the track, preventing data on one track from bleeding into the next track.

Power Up/Down Write Protection

This circuit prevents erroneous data from being written on the disk during power up/down sequences. During a power up, the 12VDC supply is not applied to the R/W coils and amplifier circuits before the processor has control of the logic. During a power down, the 12VDC supply is removed from the R/W coils and amplifier circuits before the processor loses control of the logic.

Q3 acts as a series pass transistor biased to regulate the 12V output to the R/W coils and amplifier circuits. Q2 is a feedback amplifier monitoring the 5VDC supply. CR17 develops a precise reference voltage for Q2. L1 and C45 delay the 12VDC supply.

WRITE AMPLIFIER



2031 HP POWER SUPPLY ASSEMBLY PARTS LIST

FUSE HOLDER

ROCKER SWITCH

904507-01

POWER CONNECT FILTER

903467-03

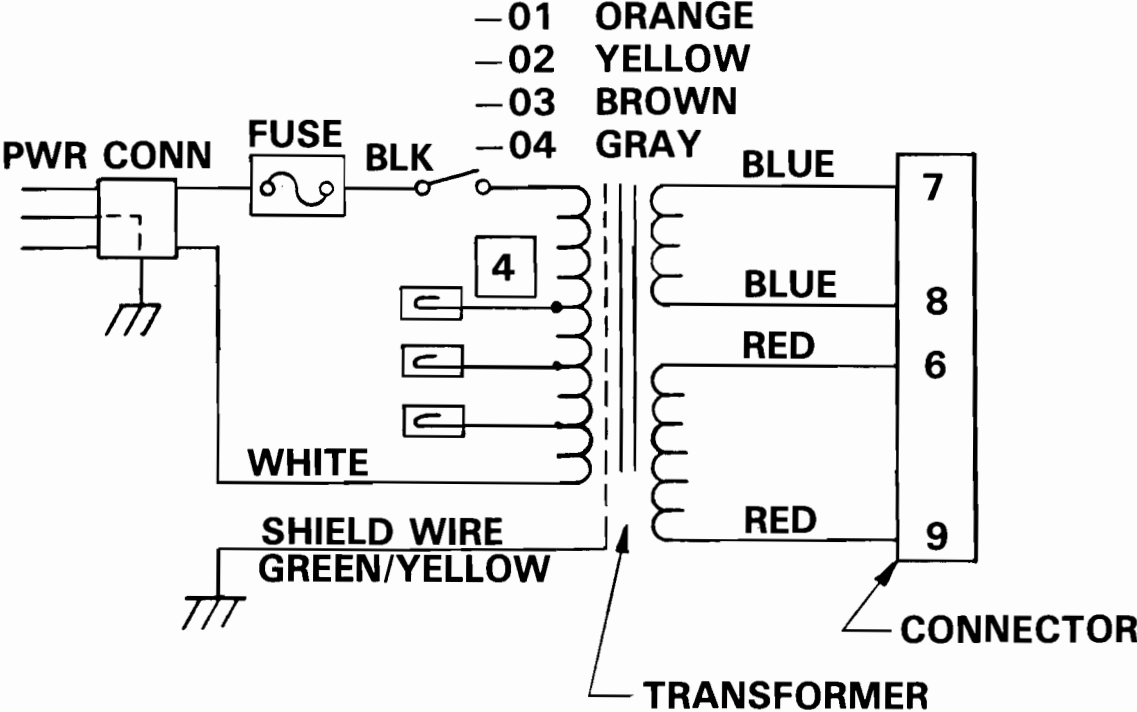
FUSE, SLOW BLO, 250V, .5A

903555-15

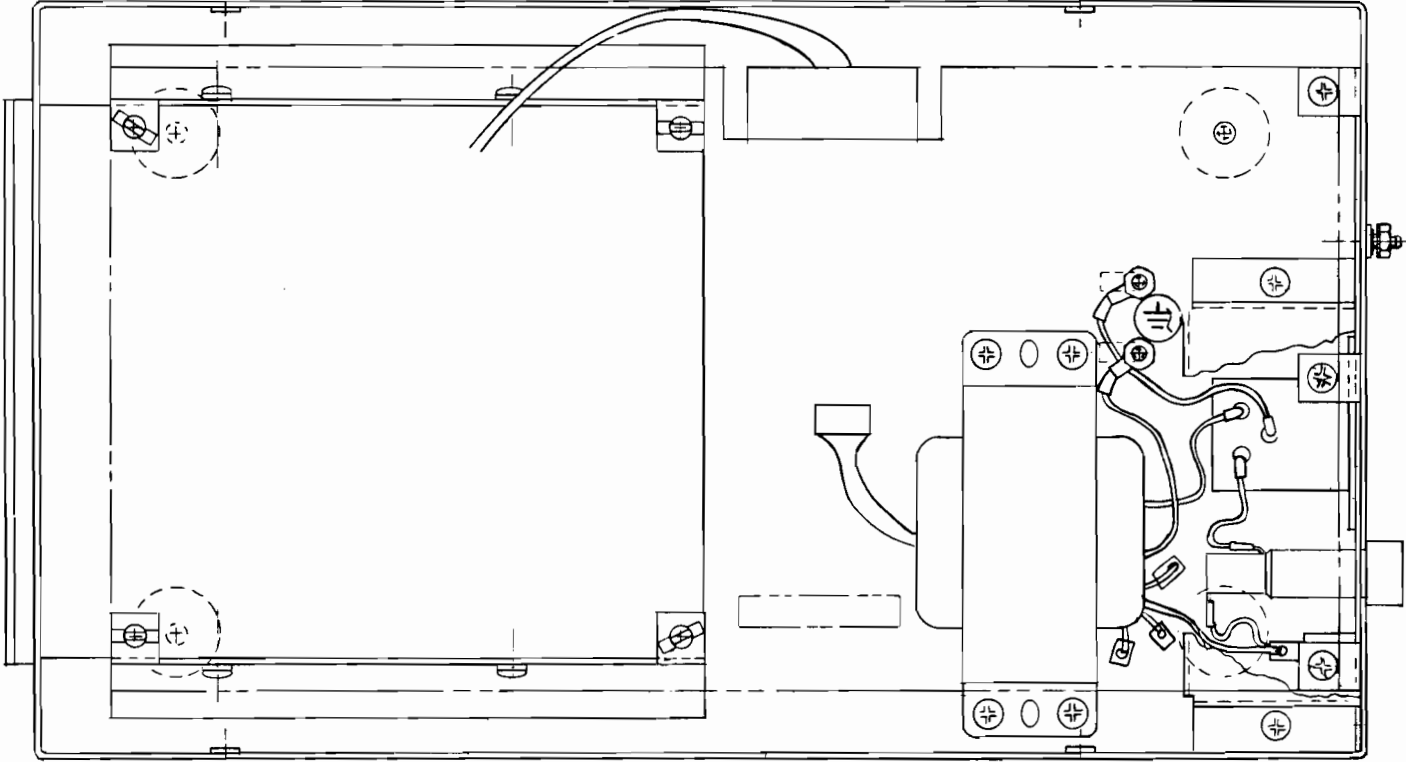
POWER TRANSFORMER

320939-01

2031 HIGH PROFILE POWER SUPPLY #2031002-01



WIRING DIAGRAM



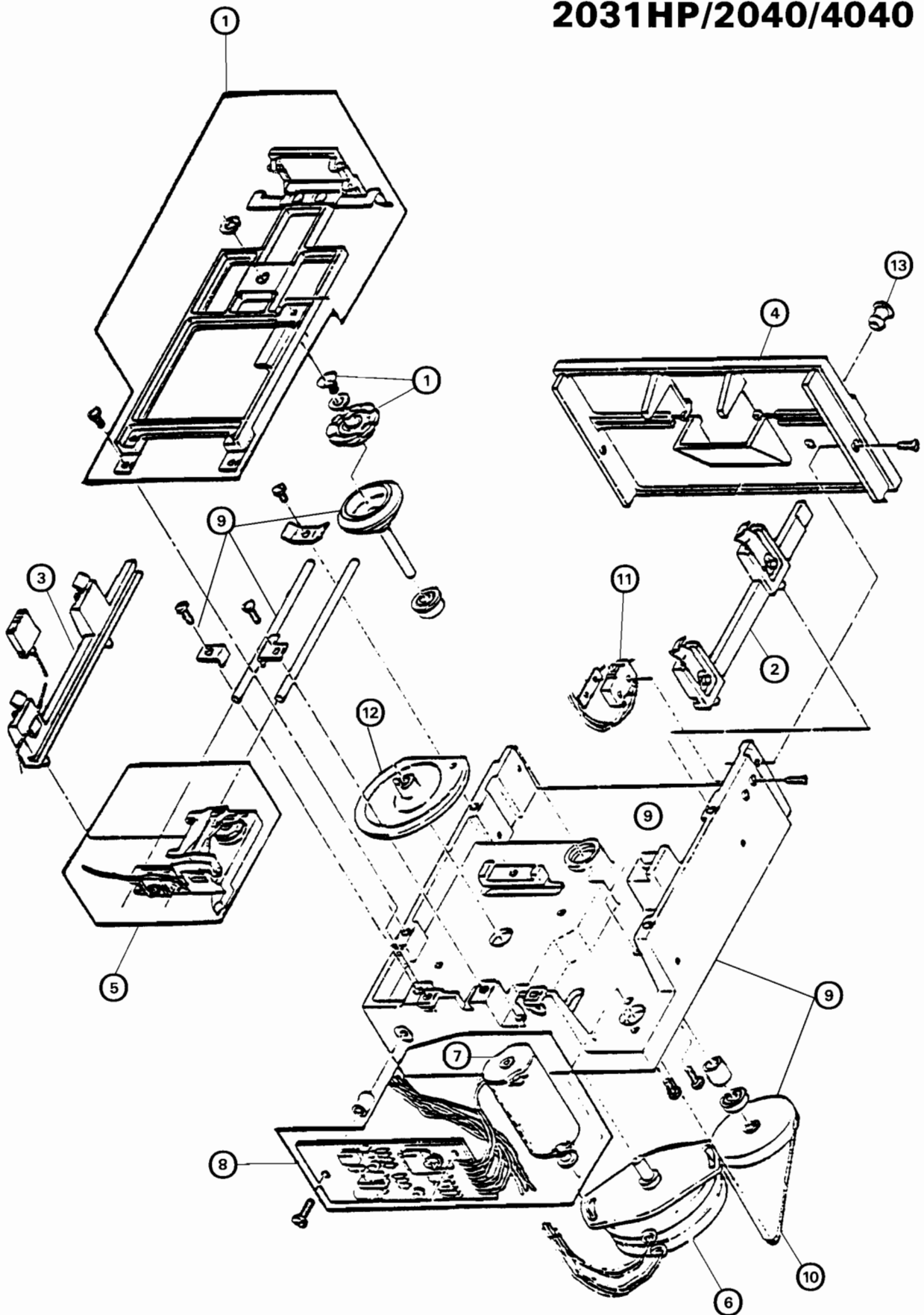
ASSEMBLY DRAWING

PARTS LIST

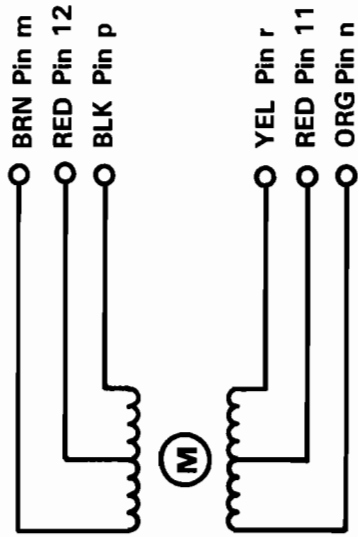
95055000 Shugart Drive Assembly

- ① 31414001 SHU DOOR/HUB ASSEMBLY
1-Door Assy w/Frame
2-Hub/Collet Assy
- ② 31414101 SHU LEFT DISK GUIDE
- ③ 31414201 SHU RIGHT DISK GUIDE
- ④ 31414301 SHU FRONT BEZEL
- ⑤ 31414401 SHU R/W HEAD ASSEMBLY
1-R/W Head w/Harness
2-Load Arm w/Pad
- ⑥ 31414501 SHU STEPPER MOTOR ASSEMBLY
1-Stepper Motor w/Harness
- ⑦ 31414601 SHU D.C. MOTOR
- ⑧ 31414701 SHU MOTOR CONTROL PCB
- ⑨ 31414801 SHU HOUSING/SPINDLE ASSY
1-Housing Base
2-Spindle Assy
3-L/R Guide Shafts
- ⑩ 31414901 SHU DRIVE BELT
- ⑪ 31415001 SHU WRITE PROTECT SWITCH
31415101 SHU HARDWARE
1-Assorted Screws
- ⑫ 31415201 SHU CAM ACTIVATOR
- ⑬ 903820-03 UNIV. LAMP HOLDER SET

SHUGART DRIVE ASSEMBLY 2031HP/2040/4040

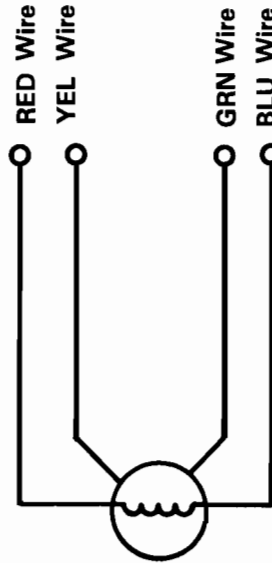


RESISTANCE CHECKS HIGH PROFILE – SHUGART DRIVE



Stepper Motor

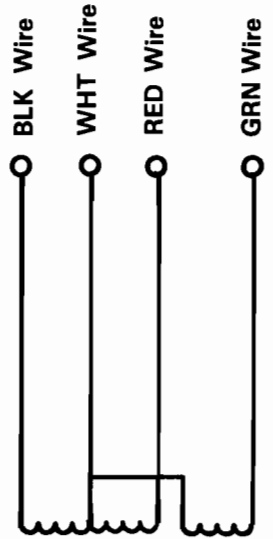
End to end on either coil = 74 ohms
End to centertap = 37 ohms



Spindle Motor

Motor coil (red wire to blue wire) = 71 ohms
Tach coil (green wire to yellow wire) = 175 ohms at rest
Tach coil while rotating spindle = 135 – 195 ohms

Measurements made at connector on motor control pcb.



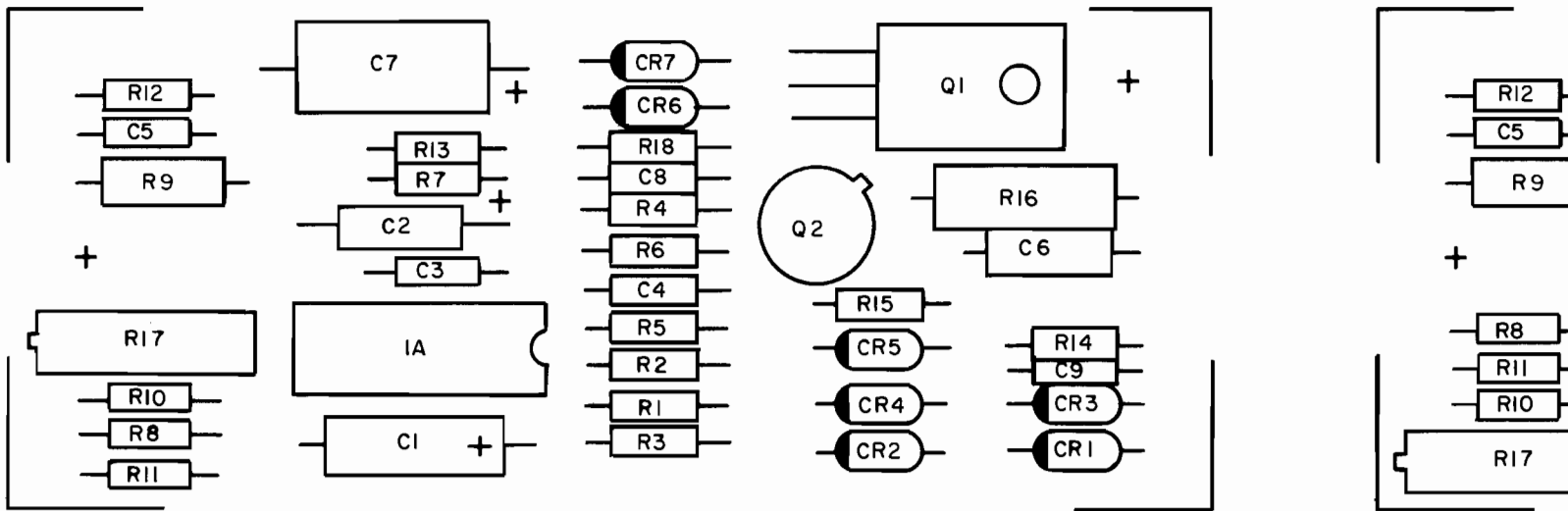
R/W Head

R/W coil (black wire to red wire) = 28.5 ohms
R/W coil (red wire to white wire) = 15 ohms
R/W coil (black wire to white wire) = 15 ohms
Erase coil (green wire to white wire) = 11.9 ohms

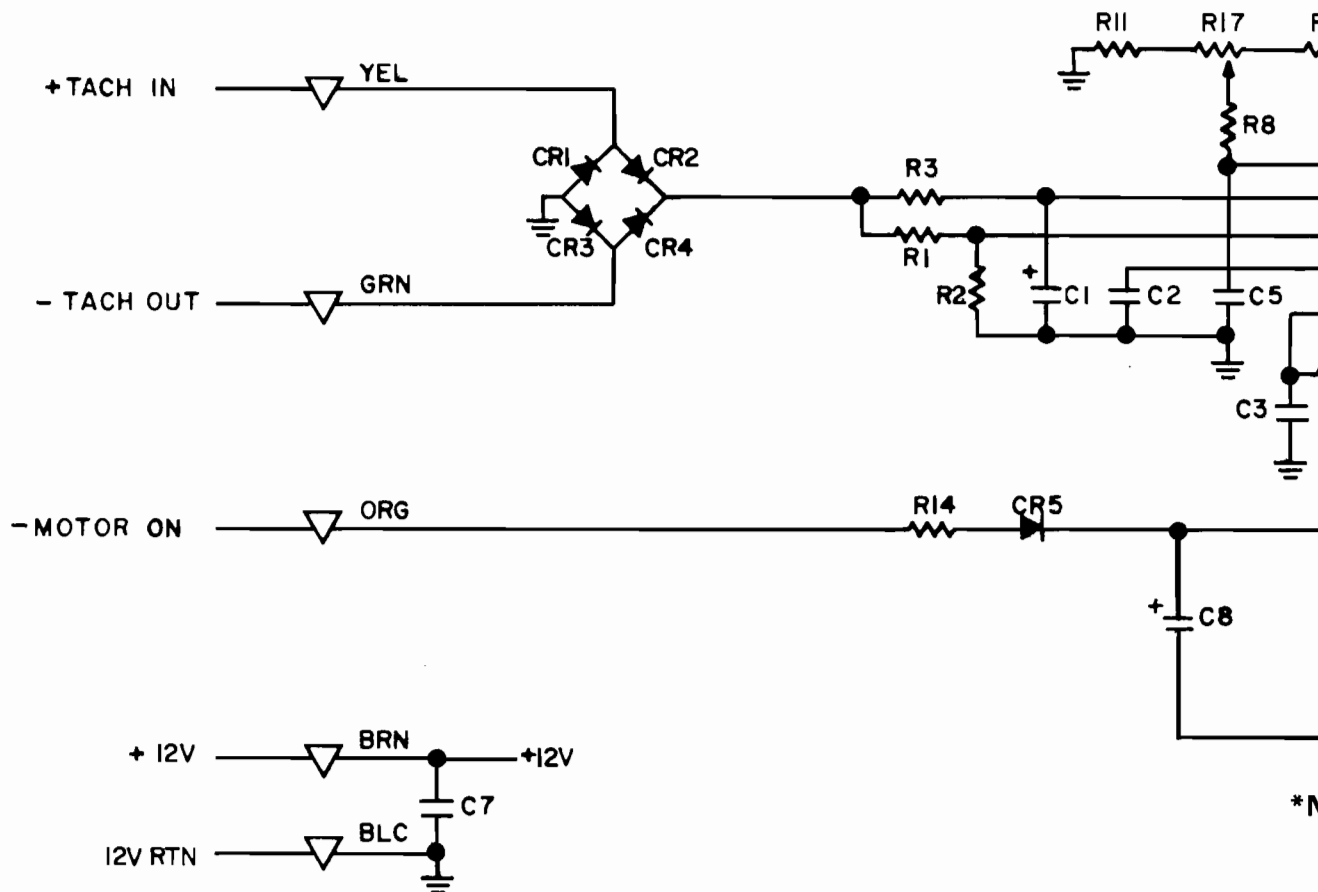
Measurements made at the 5 pin plug at the end of the R/W head cable.
The plug should be disconnected.

PARTS LIST

| INTERGRATED CIRCUITS | |
|---|----------------------------------|
| 1A | LM 2917N |
| TRANSISTORS | |
| Q1 Q2 | GE 7941 sub: GE 7947 M10060-0 |
| DIODES | |
| CR1-7 | IN4148 |
| CAPACITORS — All values in microfarads | |
| C1 | 4.7 50V Tant |
| C2 | .015 35V 5% |
| C3 | .047 50V |
| C4 | .47 50V Tant |
| C5 | .1 50V |
| C6 | 1 35V |
| C7 | 220 16V Elect |
| C8 | .47 50V Tant |
| C9 | .015 50V (Assy 25181 ONLY) |
| RESISTORS — Ceramic 1/8W All values in ohms at 5% unless otherwise noted | |
| R1 | 100 1%, 1/8W |
| R2 | 909 1%, 1/8W |
| R3 | 10K |
| R4 | 4.7K |
| R5 | 40.2K 1%, 1/8W |
| R6 | 160K |
| R7 | 12 |
| R8 | 27K |
| R9 | 470 |
| R10 | 23.2K 1%, 1/8W |
| R11 | 7.5K 1%, 1/8W |
| R12 | 68 |
| R13 | 68 |
| R14 | 2K |
| R15 | 150 |
| R16 | .68, 5%, 1W |
| R17 | 5K Trim Pot Rectangle, 3/4 in. |
| R18 | 20K |

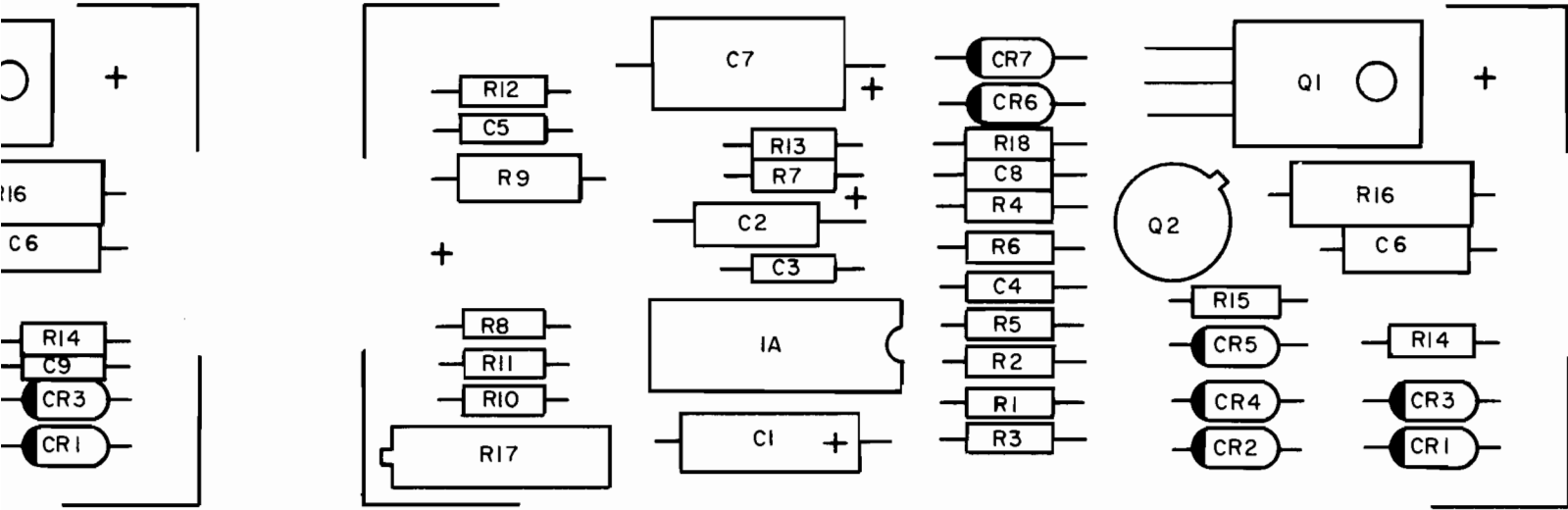


COMPONENT LOCATIONS
MOTOR CONTROL PCB ASSEMBLY P/N 25181

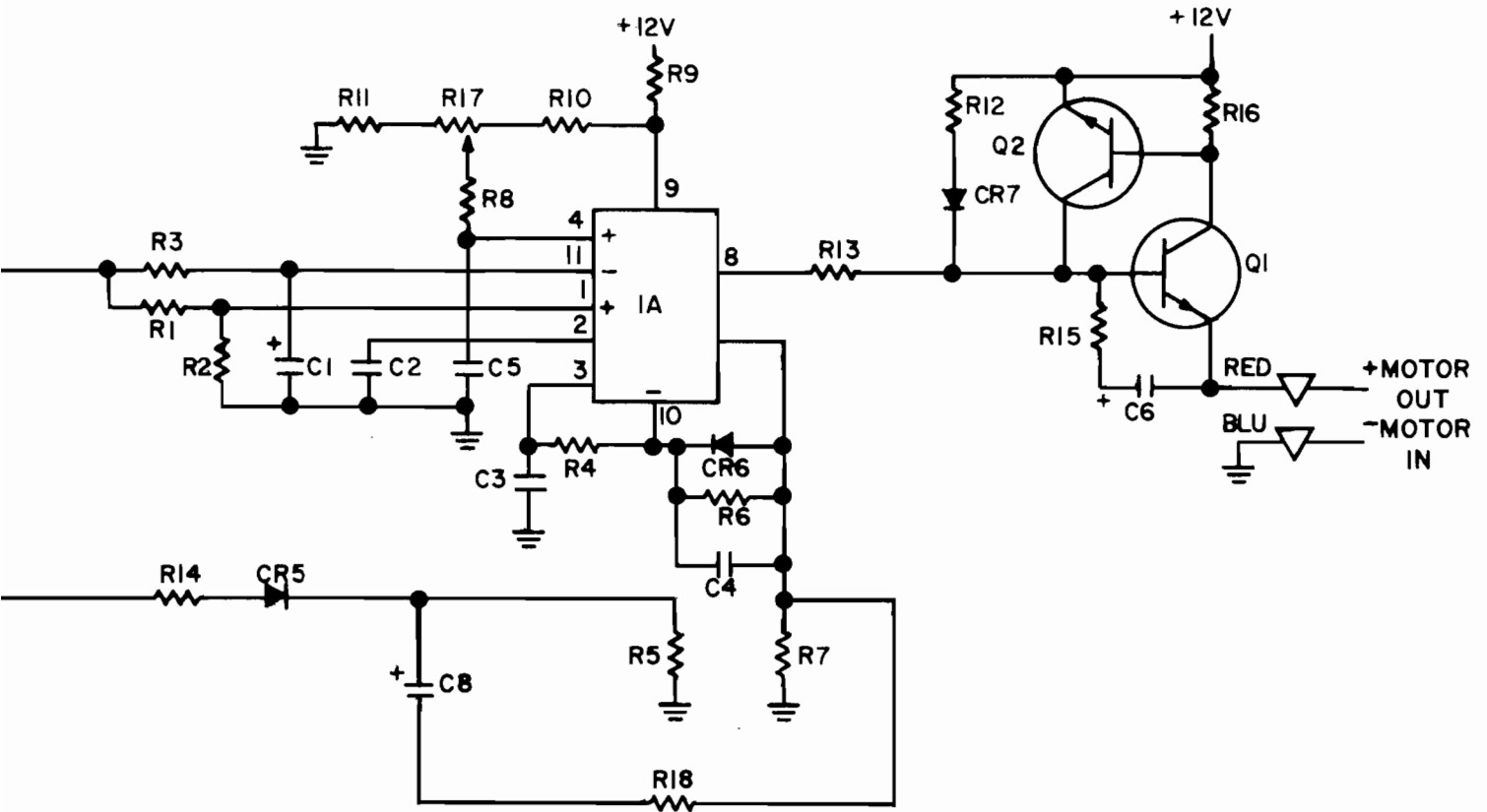


SCHEMATIC

SHUGART SERVO BOARD (COMMODORE PART #31414701)



COMPONENT LOCATIONS
MOTOR CONTROL PCB ASSEMBLY P/N 25129

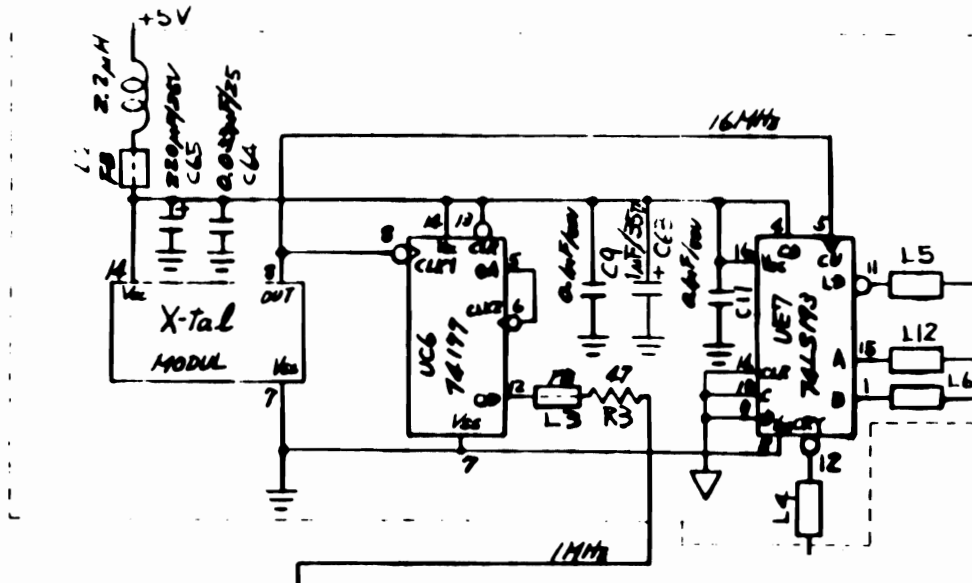


*NOTE: ASSEMBLY P/N 25181
INCLUDES C9 ON
COLLECTOR OF Q1.

SCHEMATIC

LOW PROFILE

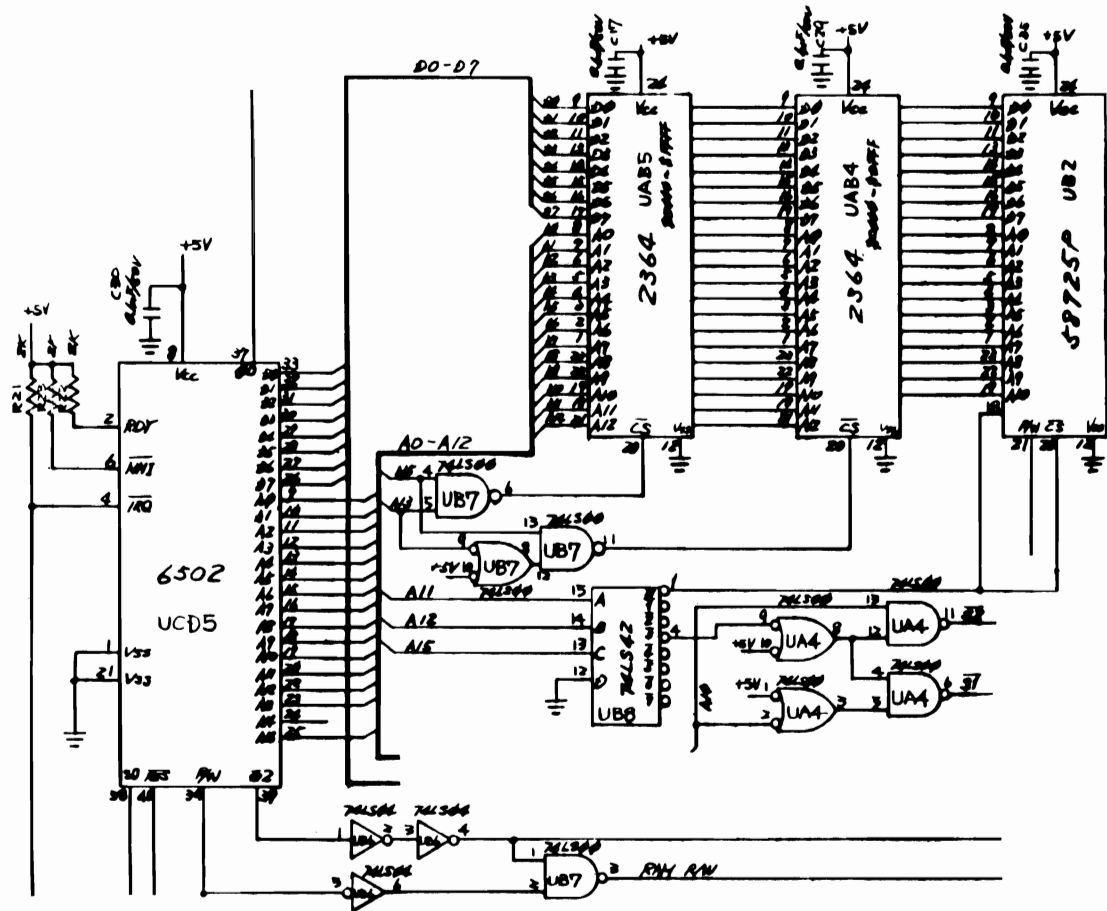
2031 LP CIRCUIT THEORY



The Clock Circuits

Crystal Y1 outputs a 16 MHz clock signal. This is input to UC6 on pin 8. UC6 is configured as a ÷ 16 frequency divider. The output of UC6 pin 12 is a 1 MHz clock signal used as the system clock (Phase 0) for the microprocessor. UE7 is a programmable counter (÷ 16, ÷ 15, ÷ 14, ÷ 13) that outputs a varying frequency clock used to compensate for difference in recording area/sector for sectors on inner tracks (Trks 1,2,3) as compared to sectors on out most tracks (Trks 33,34,35). The area/sector for inner tracks is less than the area/sector for out most tracks, so the recording clock frequency is increased when writing on inner tracks to keep the flux density constant. This clock output is on pin 12 of UE7.

| Tracks | Clock Frequency | Divide By |
|--------|-----------------|-----------|
| 1-17 | 1.2307 MHz | 13 |
| 18-24 | 1.1428 MHz | 14 |
| 25-30 | 1.0666 MHz | 15 |
| 31-35 | 1 MHz | 16 |

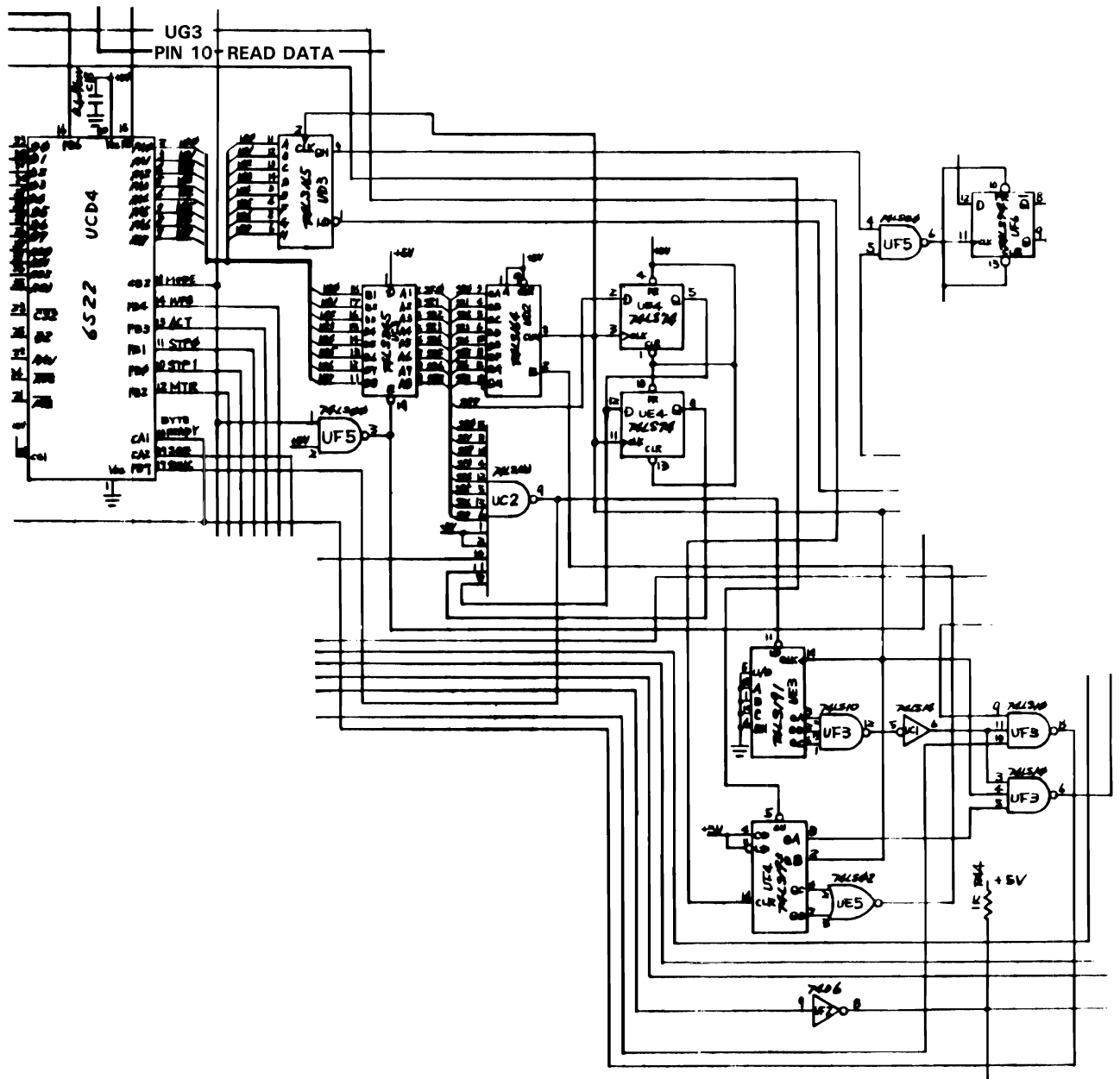


Microprocessor Control of RAM and ROM

UAB4 and UAB5 are 8192 x 8 bit ROMs that store the Disk Operating System (DOS). UAB4 resides at memory locations \$C000-\$DFFF. UAB5 resides at memory locations \$E000-\$FFFF. UB7 decodes the addresses output from the microprocessor when selecting these ROMs.

UB2 is a 2048 x 8 bit RAM. UB2 resides at memory locations \$0000-\$07FF. This memory is used for processor stack operations, general processor housekeeping, user program storage, and 4 temporary buffer areas. UA4, UB6, UB7 and UB8 decode the addresses output from the processor when selecting RAM.

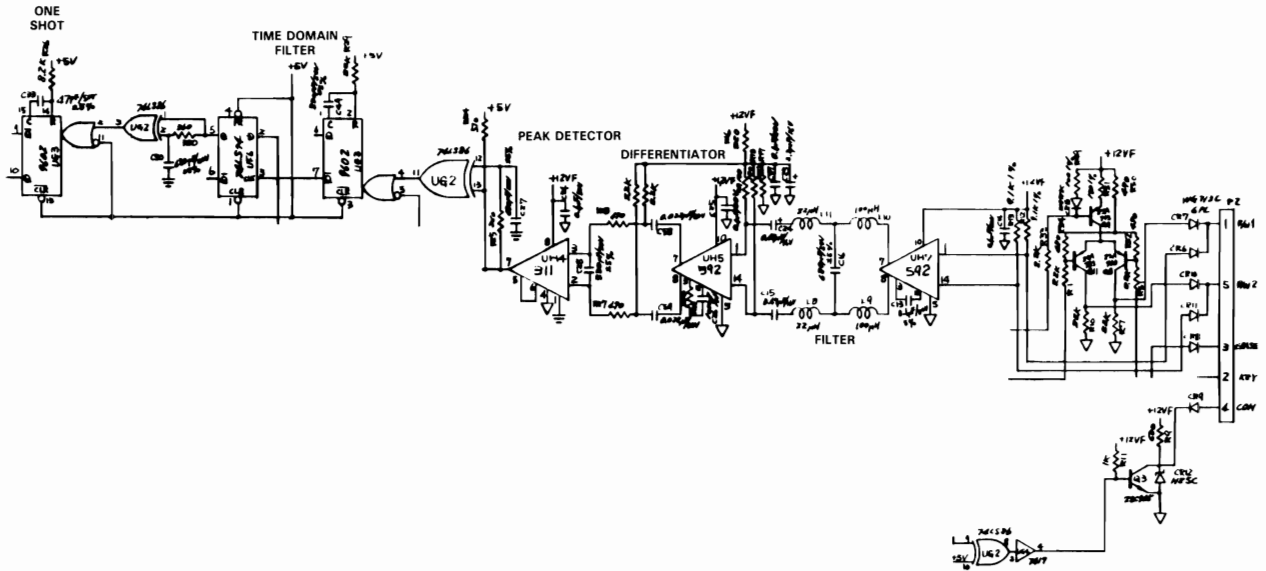
UB8 also controls the chip select line of the VIA, UCD4.



Read/Write Control Logic

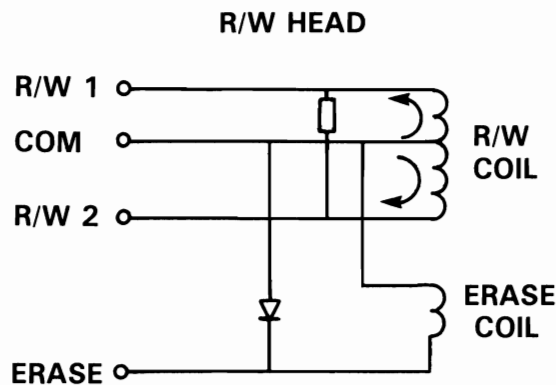
UCD4 is a VIA (Versatile Interface Adapter). During a write operation, the microprocessor passes the data to be recorded to Port A of UCD4. The data is then loaded into UD3 which converts the parallel data into serial data. The output on pin 9 is input to 'NAND' gate UF5 pin 4. UF5 outputs the serial data on pin 6 at the clock rate determined by the input signal on pin 5. The output clocks the D flip flop UF6. The outputs of UF6, Q and \bar{Q} , drive the write amplifiers.

During a read operation, data from the read amplifiers is applied to the CLR Input of counter UF4. The outputs, C and D, are shaped by the 'NOR' gate UE5. UE5 outputs the serial data on pin 1, then it is converted to parallel data by UD2. The output of UD2 is latched by UC3. The serial bits are counted by UE3, when 8 bits have been counted, UF3 pin 12 goes "low", UC1 pin 6 goes "high", and UF3 pin 8 goes "low" indicating byte is ready to be read by the processor. UC2 monitors the parallel output of UD2, when all 8 bits are "1", the output pin 9 goes "low" indicating a sync bit has been read.

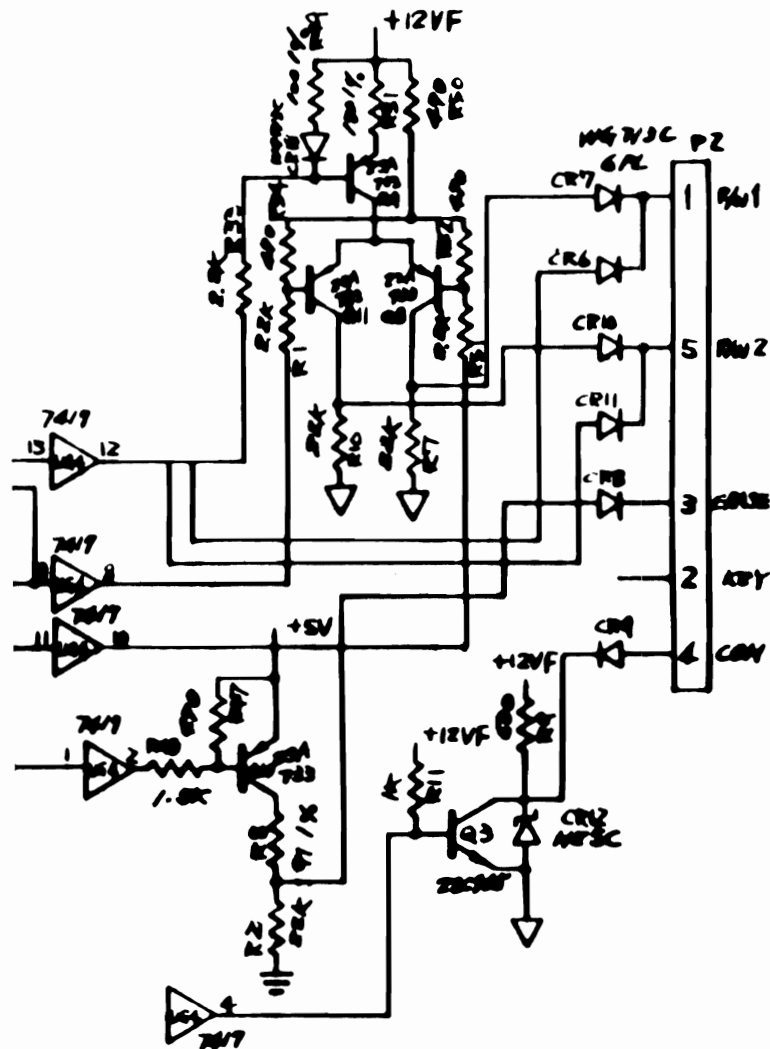


Read Amplifier Circuits

When data is recorded on the disk, a "1" bit is represented on the disk by a change in direction of magnetic flux, caused by a change in direction of current passed through the R/W coil in the R/W head. When a "0" bit is to be recorded, no change in current flow direction occurs, causing the direction of the magnetic flux to remain the same on the disk.



When data is being read from the disk, CEMF is induced into the R/W coil by the magnetic fields on the disk, causing current flow which is detected by the read amplifiers. Current flow through the R/W coil will forward bias either CR6 or CR11, depending on the direction. Q3 and CR9 must be forward biased. The first amplifier, UH7, senses this current flow from the R/W coil on one of the inputs and amplifies it. L8, L9, L10, L11, and C16 act as a low pass filter, suppressing noise on the amplified output. UH5 is a differential amplifier which amplifies the difference of the two input signals from the filter section. UH4 is a peak detector. The output of UH4 will pulse "high" when a "1" is read. This signal is the reconstruction of data recorded. The time domain filter, UG3 times out when a "1" bit has been read, so unwanted "1" bits are not added to the actual data. The one shot, UG3 generates the correct data pulse width so the read/write logic circuits can convert it to parallel for processor control.



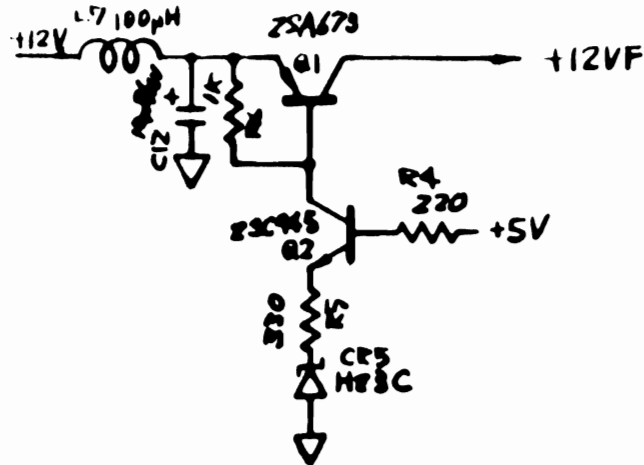
Write Amplifier Circuits

During a write operation, UG4, pin 3, must be "high". This forward biases Q3 and CR9.

If Q₉ of UF6, pin 9, goes "low", Q8 and CR7 become forward biased, passing current flow through R/W 1. If Q₁₀ goes "low", Q11 and CR10 become forward biased, passing current flow through R/W 2.

When a write operation occurs, the ERASE coil is energized by forward biasing Q10. This demagnetizes the outer edges of the track, preventing data on one track from bleeding into the next track.

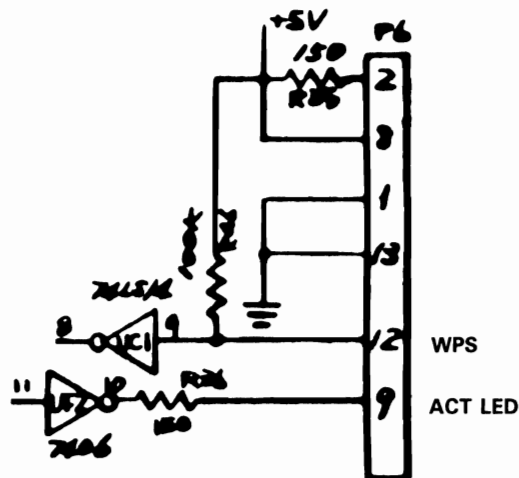
2031 LP CIRCUIT THEORY



Power Up/Down Write Protection

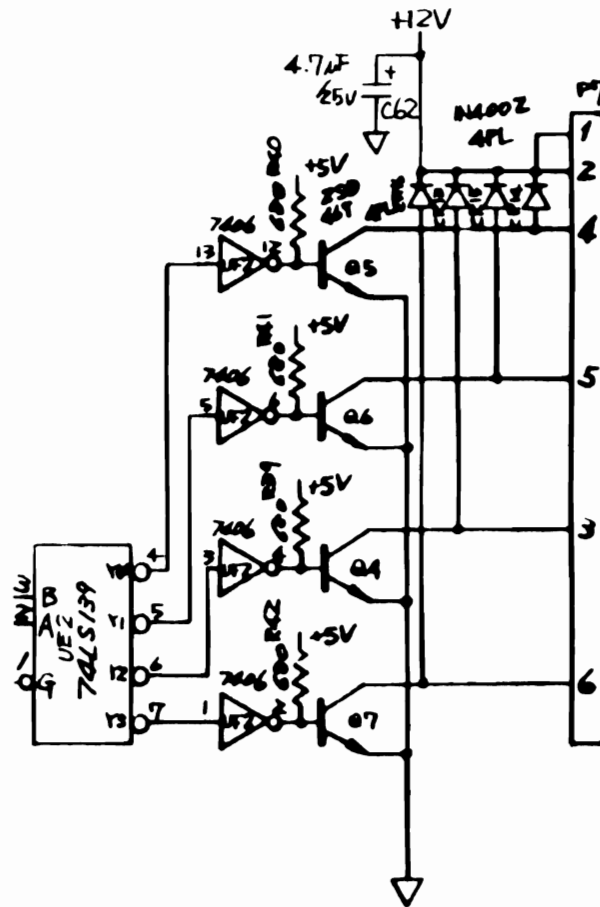
This circuit prevents erroneous data from being written on the disk during power up/down sequences. During a power up, the 12VDC supply is not applied to the R/W coils and amplifier circuits before the processor has control of the logic. During a power down, the 12VDC supply is removed from the R/W coils and amplifier circuits before the processor loses control of the logic.

Q1 acts as a series pass transistor biased to regulate the 12VDC output to the R/W coils and amplifier circuits. Q2 is a feedback amplifier monitoring the 5VDC supply. CR5 develops a precise reference voltage for Q2. L7 and C12 delay the 12VDC supply.



Write Protect Switch

Connector P6 connects the control circuits to the W/P switch and activity light. UCD4, a 6522 VIA, monitors the state of the write protect sensor on pin 14 and controls the red activity LED on pin 13.

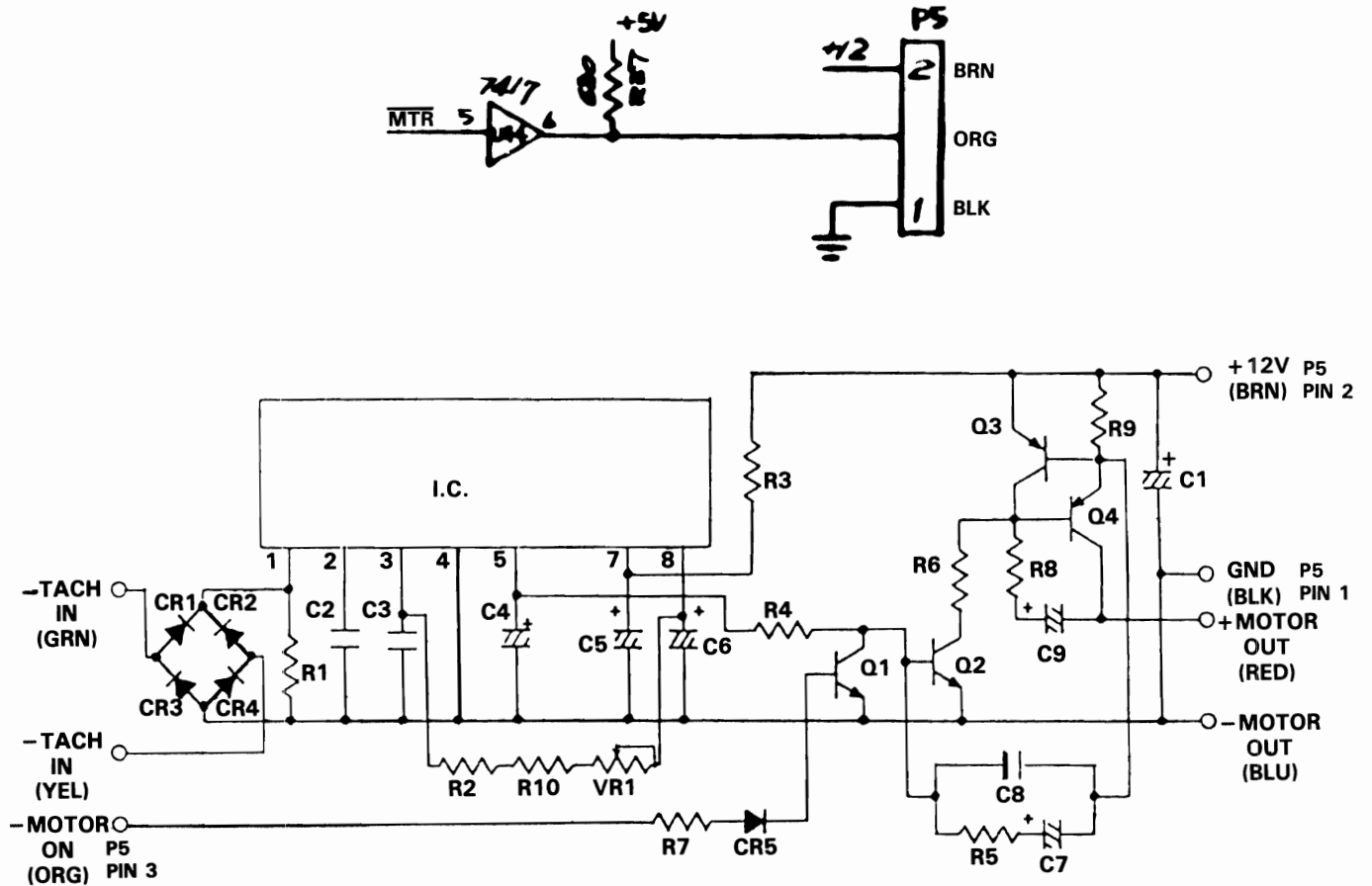


Stepper Motor Control Circuits

The stepper motor is controlled by two outputs on port B of UCD4, the 6522 VIA, STP0 and STP1. These two lines are converted by UE2 to a binary four count to drive the four phases of the stepper motor.

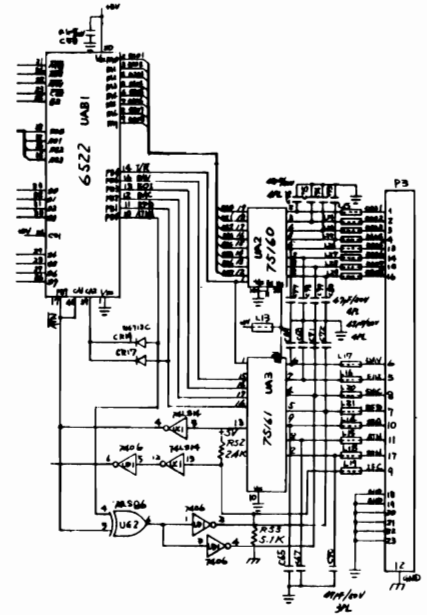
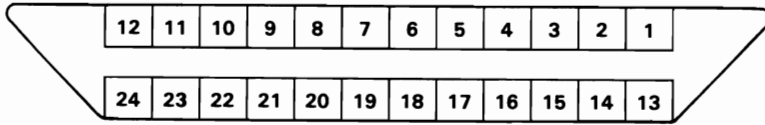
Outputs Y0, Y1, Y2, and Y3 from UE2 are inverted by UF2. The outputs of the inverters drive Q4-Q7. The current output from these transistors drives the individual phase coils in the stepper motor and returns, to the 12VDC supply. CR13-CR16 suppress the CEMF developed by the motor coils.

2031 LP CIRCUIT THEORY



Spindle Motor Control Circuits

$\overline{\text{MTR}}$ output from UF2 pin 8 is passed through current driver UG4 to the motor control PCB. When $\overline{\text{MTR}}$ is "low", Q1 is biased off, and Q2, Q3, and Q4 are biased on, allowing current flow through the spindle motor coil. Attached to the shaft of the spindle motor is an inductive tachometer that generates low level AC voltages, as the motor spins. The output of the tachometer is rectified by CR1-CR4. IC 1 monitors the output of the rectifier and adjusts the bias to Q2, which changes the bias on Q3 and Q4 to regulate motor current for a constant velocity. VR1 is a manual speed adjustment. The speed can be adjusted by watching the 60Hz strobe as the adjustment is made or loading the system test from the diagnostic disk.



IEEE Interface

All of the signals on the interface are controlled by the I/O device UAB1. Eight parallel bi-directional data lines, PA0-PA7, are used as the parallel data bus for the interface. UA2 is an octal bus transceiver used to provide communication on the general purpose interface bus, GPIB, between operating units of the system. The data transfer and bus-management signals are communicated by UA3, thus completing the 16-line interface of the IEEE-488 bus.

| | | |
|-----|--------------------|--|
| DAV | Data Valid | DAV low signifies data is valid on the data bus. |
| EOI | End or Identify | CBM always sets EOI low while the last data byte is being transferred. |
| DAC | Data Not Accepted | DAC is low when data is being read and returned high after the last data byte is read. |
| RFD | Not Ready For Data | RFD is low until all receivers are ready to accept data, then the line will go high. |
| SRQ | Service Request | Not implemented in BASIC but available to the CBM user. |
| ATN | Attention | The host sets the signal low while sending commands on the data bus. |
| REN | Remote Enable | REN is held low by the bus controller and the host has this pin permanently grounded. |
| IFC | Interface Clear | The host sends its internal reset signal as IFC low to initialize all devices. |

PARTS LIST

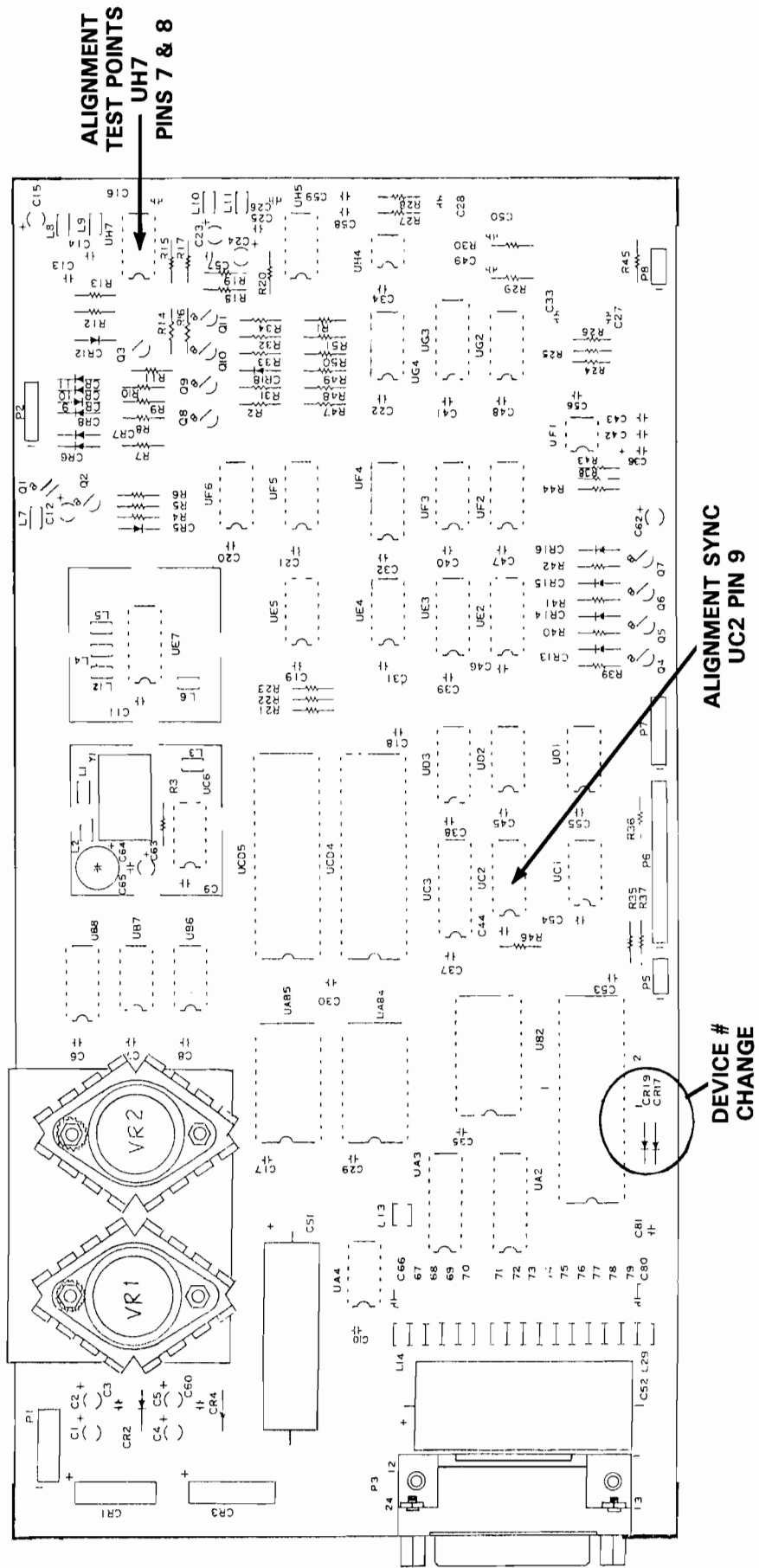
PCB ASSEMBLY #1540033

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. Unique or non-standard parts will be stocked by Commodore and are indicated on the parts list by a "C". Vendor Name and part number have been provided for your convenience in ordering custom or unique parts.

| INTEGRATED CIRCUITS | | | | RESISTORS (Continued) | | | |
|---|----------------------------------|--------|----------------|-----------------------|-------------------------------------|------------------|---------------|
| UAB1 | 6522 VIA | C | 901437-01 | 25 | 360 | R39-42 | 680 |
| UAB4 | ROM \$C000-\$DFFF | C | 901484-03 | R26 | 8.2K | R43 | 47K |
| UAB5 | ROM \$E000-\$FFFF | C | 901484-05 | R27,28 | 470 | R44 | 1K |
| UCD4 | 6522 VIA | C | 901437-01 | R29 | 22K | R45 | 220 |
| UCD5 | 6502 CPU | C | 901435-01 | R30 | 360 | R46 | 100K |
| UA2 | 75160 Transceiver | | 901493-01 | R31 | 150, 1/4W, 1% | R47 | 470 |
| UA3 | 75161 Transceiver | | 901494-01 | R32 | 470 | R48 | 1.5K |
| UA4 | 74LS00 | | 901521-01 | R33 | 2.2K | R49 | 100, 1/4W, 1% |
| UB2 | TMM2016 RAM | | 325502-01 | R34 | 470 | R50 | 470 |
| UB6 | 74LS04 | | 901521-02 | R35,36 | 150 | R51 | 2.2K |
| UB7 | 74LS00 | | 901521-01 | R37 | 680 | R52 | 2.4K |
| UB8 | 74LS42 | | 901521-17 | R38 | 1M | R53 | 5.1K |
| UC1 | 74LS14 | | 901521-30 | | | | |
| UC2 | 74LS133 | | 901521-15 | | | | |
| UC3 | 74LS245 | | 901521-45 | | | | |
| UC6 | 74177 | | 901522-03 | | | | |
| | 74LS197 | | 901521-54 | | | | |
| UD1 | 7406 | | 901522-06 | | | | |
| UD2 | 74LS164 | | 901521-28 | | | | |
| UD3 | 74LS165 | | 901521-12 | | | | |
| UE2 | 74LS139 | | 901521-18 | | | | |
| UE3 | 74LS191 | | 901521-40 | | | | |
| UE4 | 74LS74 | | 901521-06 | | | | |
| UE5 | 74LS02 | | 901521-21 | | | | |
| UE7 | 74LS193 | | 901521-26 | | | | |
| UF1 | 555 Timer | | 901523-01 | | | | |
| UF2 | 7406 | | 901522-06 | | | | |
| UF3 | 74LS10 | | 901521-24 | | | | |
| UF4 | 74LS193 | | 901521-26 | | | | |
| UF5 | 74LS00 | | 901521-01 | | | | |
| UF6 | 74LS74 | | 901521-06 | | | | |
| UG2 | 74LS86 | | 901521-32 | | | | |
| UG3 | 9602 One Shot | | 901510-01 | | | | |
| UG4 | 7417 | | 901522-01 | | | | |
| UH4 | 311 OP AMP | | 901523-04 | | | | |
| UH5 | 592 | | 901523-08 | | | | |
| UH7 | 592 | | 901523-08 | | | | |
| Sub: | | | | | | | |
| TRANSISTORS | | | | CAPACITORS | | | |
| Q1 | 2SA673 | | | C1 | Electrolytic | 1μF, 25V | |
| Q2,3 | 2SC945 Sub: | | | C2 | Elect | 47μF, 16V | |
| | 2SC1815 | | | C3 | Ceramic | .1μF, 50V | |
| Q4-7 | 2SD467 Sub: | | | C4 | Electrolytic | 1μF, 25V | |
| | 2SC2120 | | | C5 | Elect | 47μF, 16V | |
| Q8-11 | 2SA733 Sub: | | | C6-11 | Ceramic | .1μF, 50V | |
| | 2SA1015 | | | C12 | Tantalum | 10μF, 25V | |
| | | | | C13,14 | Ceramic | .1μF, 50V | |
| | | | | C15 | Tantalum | .47μF, 16V | +/- 20% |
| | | | | C16 | Ceramic | 680pF, 50V | +/- 5% |
| | | | | C17-22 | Ceramic | .1μF, 50V | |
| | | | | C23 | Tantalum | 3.3μF, 25V | |
| | | | | C24 | Tantalum | .47μF, 16V | +/- 20% |
| | | | | C25 | Ceramic | .1μF, 50V | |
| | | | | C26 | Ceramic | 1000pF, 50V | |
| | | | | C27 | Ceramic | 680pF, 50V | +/- 5% |
| | | | | C28 | Ceramic | 330pF, 50V | +/- 5% |
| | | | | C29-32 | Ceramic | .1μF, 50V | |
| | | | | C33 | Ceramic | 47pF, 50V | |
| | | | | C34,35 | Ceramic | .1μF, 50V | |
| | | | | C36 | Electrolytic | 10μF, 16V | |
| | | | | C37-42 | Ceramic | .1μF, 50V | |
| | | | | C43 | Ceramic | .01μF, 50V | |
| | | | | C44-48 | Ceramic | .1μF, 50V | |
| | | | | C49 | Ceramic | 330pF, 50V | +/- 5% |
| | | | | C50 | Ceramic | 680pF, 50V | +/- 5% |
| | | | | C51 | Electrolytic | 6800μF, 25V | |
| | | | | C52 | Electrolytic | 10000μF, 16V | |
| | | | | C53-57 | Ceramic | .1μF, 50V | |
| | | | | C58,59 | Ceramic | .022μF, 50V | |
| | | | | C60,61 | Ceramic | .1μF, 50V | |
| | | | | C62 | Tantalum | 4.7μF, 25V | |
| | | | | C63 | Tantalum | 1μF, 35V | |
| | | | | C64 | Ceramic | .033μF, 25V | |
| | | | | C65 | Electrolytic | 220μF, 25V | |
| | | | | C66-80 | Ceramic | 47pF, 50V | |
| | | | | C81 | Ceramic | .1μF, 50V | |
| DIODES | | | | MISCELLANEOUS | | | |
| CR1 | 1.5 A, 50V, Bridge Rectifier | | | P1 | Header Assy | Molex # 5271-04A | |
| CR2 | 1N4002 Signal | | | P2 | Header Assy | 5049-04AG | |
| CR3 | 4 A, 50V, Bridge Rectifier | | | P3 | Rt Angle Cnct IEEE | C 903206-01 | |
| CR4 | 1N4002 Signal | | | P5 | Header Assy | Molex # 3094-03A | |
| CR5 | 1N5226B, 3.3V, 500mW, Zener Sub: | | | P6 | Header Assy | 3094-15A | |
| | HZ3C-2, 3.3V, 500mW, Zener Sub: | | | P7 | Header Assy | 3094-06A | |
| | HZ4A-1, 3.3V, 500mW, Zener Sub: | | | P8 | Header Assy | 3094-03A | |
| CR6-11 | 1N4148 Signal | | | L1 | Inductor 2.2μH | | |
| CR12 | 1N5131B, 5.1V, 500mW, Zener | | | L2-6 | Ferrite Bead | | |
| | HZ5C-2, 5.1V, 500mW, Zener | | | L7 | Inductor 100μH | | |
| CR13-16 | 1N4002 Signal | | | L8 | Inductor 22μH | | |
| CR17-19 | 1N4148 Signal | | | L9,10 | Inductor 100μH | | |
| | | | | L11 | Inductor 22μH | | |
| | | | | L12-29 | Ferrite Bead | | |
| | | | | VR1 | Voltage Regulator, 12V, 1.5A, LM340 | | |
| | | | | VR2 | Voltage Regulator, 5V, 3A, LM323 | | |
| | | | | Y1 | Crystal Module, 16 MHz | C 325566-01 | |
| | | | | | Shield Box | 4022048-01 | |
| | | | | | Shield Cap | 4022047-01 | |
| RESISTORS — All Values are in ohms- 1/4 W 5% unless noted otherwise. | | | | | | | |
| R1 | 2.2K | R10 | 22K | | | | |
| R2 | 22K | R11 | 1K | | | | |
| R3 | 47 | R12,13 | 9.1K, 1/4W, 1% | | | | |
| R4 | 220 | R14,15 | 2.2K | | | | |
| R5 | 330 | R16,17 | 220 | | | | |
| R6 | 1K | R18,19 | 150 | | | | |
| R7 | 22K | R20 | 330 | | | | |
| R8 | 91, 1/4W, 1% | R21-23 | 2K | | | | |
| R9 | 680 | R24 | 510 | | | | |

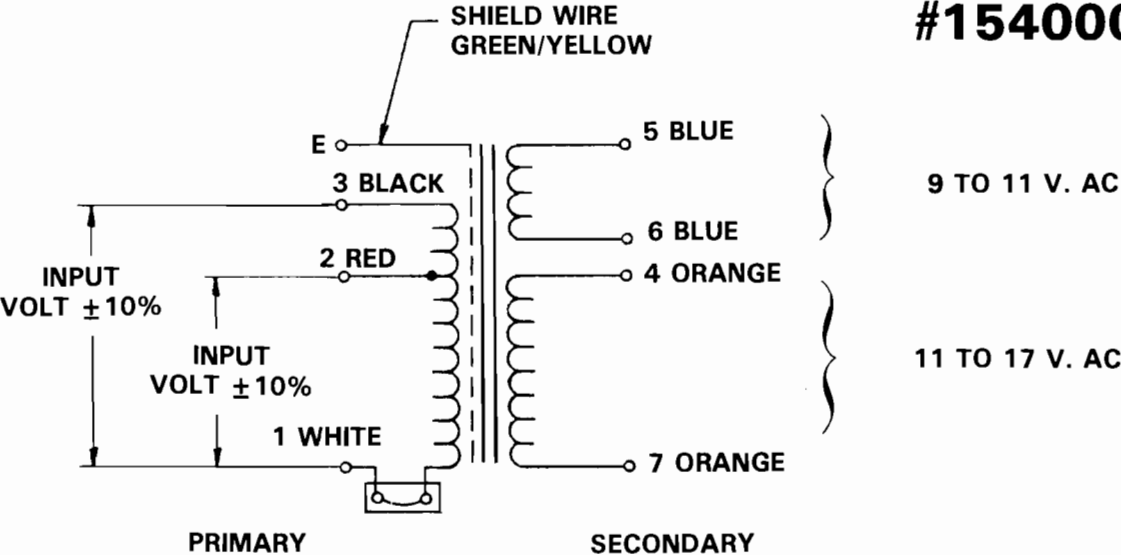
PCB ASSEMBLY #1540033 BOARD LAYOUT



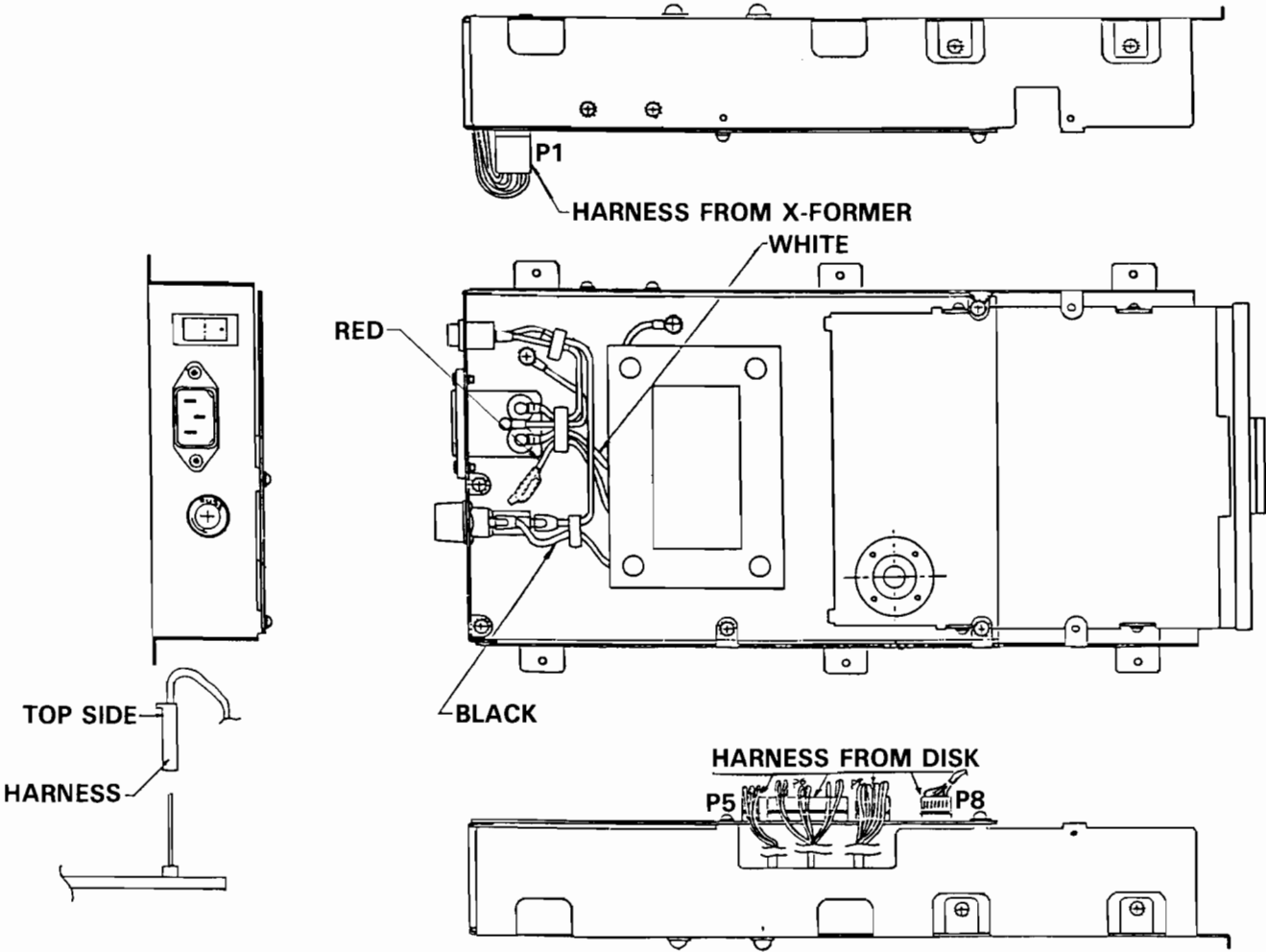
1540/41/2031 LP POWER SUPPLY ASSEMBLY PARTS LIST

| | |
|----------------------------|----------------|
| FUSE HOLDER | 903614-01 |
| ROCKER SWITCH | 904509-01 |
| POWER CNNCT FILTER | 903467-03 sub: |
| | 325552-01 |
| FUSE, SLOW BLO, 250V, 1.0A | 903556-16 |
| POWER TRANSFORMER | 1540009-02 |

2031 LOW PROFILE POWER SUPPLY #1540002-01

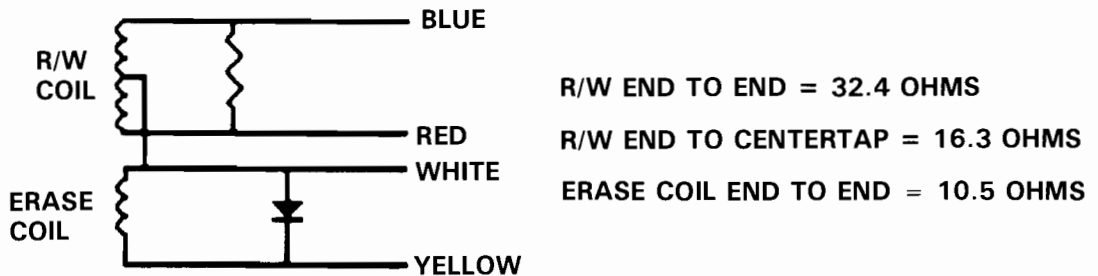
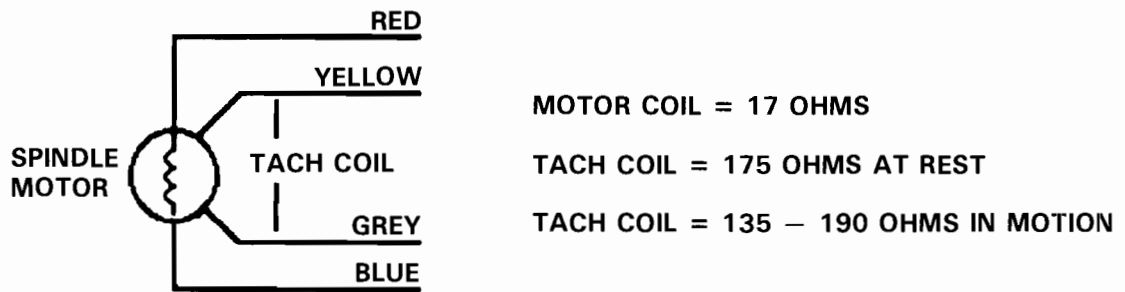
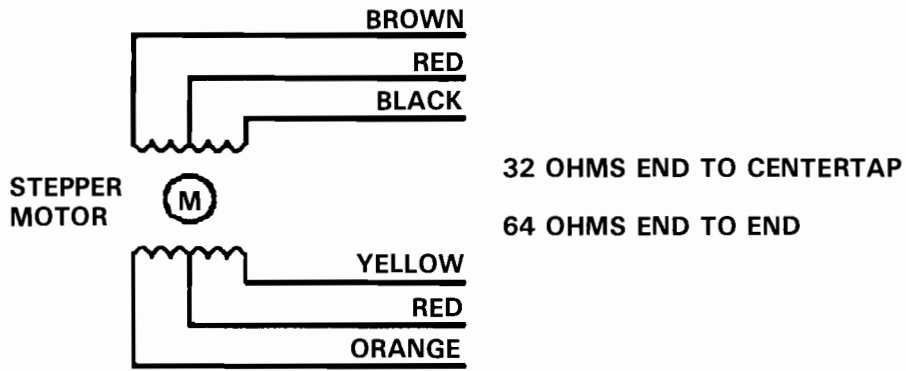


TRANSFORMER



ASSEMBLY DRAWING

RESISTANCE CHECKS LOW PROFILE – ALPS DRIVE



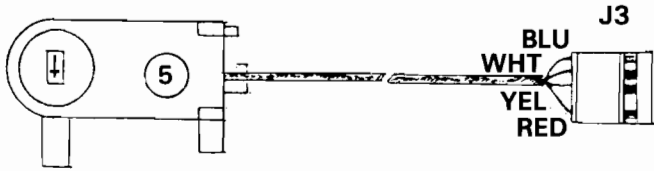
PARTS LIST

32551901 Alps Drive (Black)

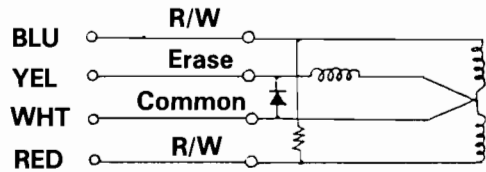
32551902 Alps Drive (Brown)

- | | |
|--|---|
| ① 31410001 ALP DOOR/HUB ASSEMBLY 1-Door Assy w/Spring 2-Hub/Collet Assy 3-Arm Support Assy | ⑦ 31410701 ALP MOTOR CONTROL PCB ASSEMBLY 1-Motor Control PCB 2-Harness Assy |
| ② 31410101 ALP LEFT DISK GUIDE ASSEMBLY 1-Diskette Guide 2-LED Assy w/Harness 3-Write Protect Assy | ⑧ 31410801 ALP TENSION PULLEY ASSEMBLY 1-Pulley Wheel w/Spring 2-Plastic Housing |
| ③ 31410201 ALP RIGHT DISK GUIDE | ⑨ 31410901 ALP HOUSING/SPINDLE ASSEMBLY 1-Housing Base 2-Spindle Assy 3-L/R Guide Shafts |
| ④ 31410301 ALP FRONT BEZEL (Black) 31410302 ALP FRONT BEZEL (Brown) | 31411001 ALP DRIVE BELT |
| ⑤ 31410401 ALP R/W HEAD ASSEMBLY 1-R/W Head 2-Load Arm w/Pad 3-Metal Band 31410501 ALP STEPPER MOTOR ASSEMBLY 1-Stepper Motor w/Harness 2-Stepper Pulley | ⑩ 31411101 ALP EJECT ASSEMBLY 1-Eject Plate 2-Eject Spring 31411201 ALP HARDWARE 1-Assorted Screws 2-Zero Stop Tab 31417401 UNIV Replacement Load Pad |
| ⑥ 31410601 ALP D.C. MOTOR | |

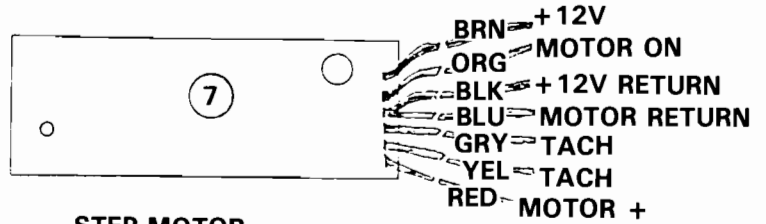
ALPS DRIVE ASSEMBLIES 1540/1541/2031 LP



READ/WRITE HEAD ASSEMBLY



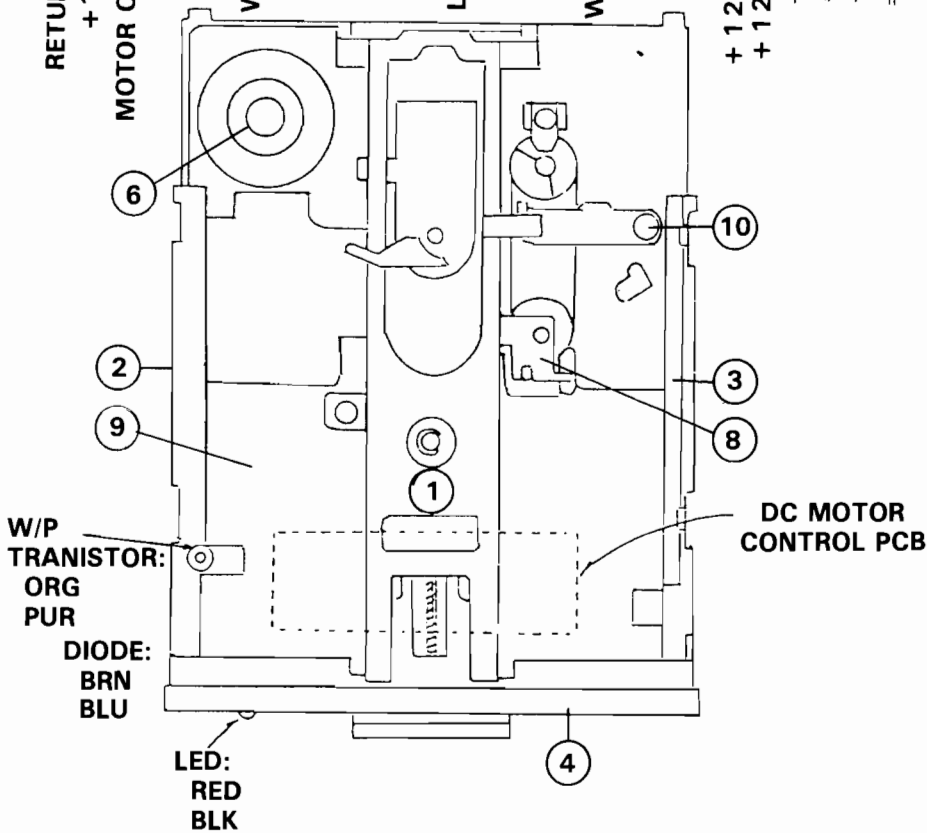
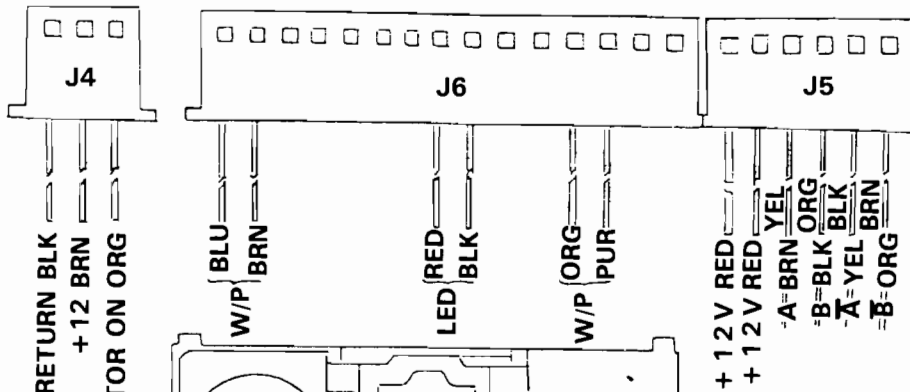
MOTOR CONTROL P.C.B.



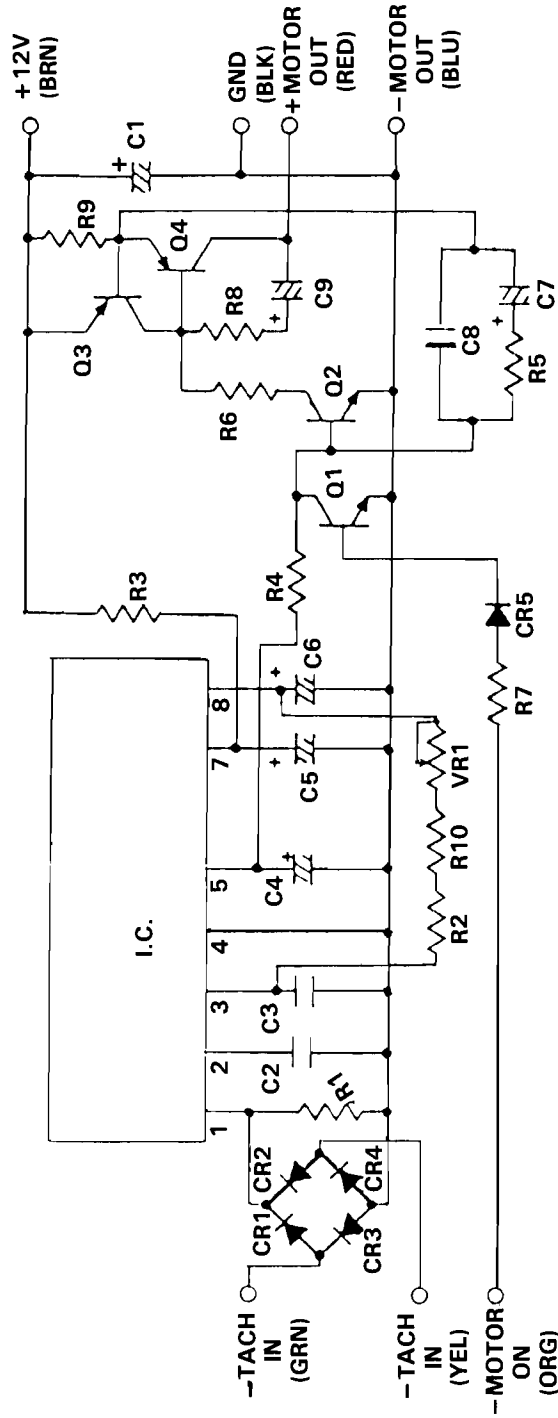
DC MOTOR CONTROL PCB

FUNCTION

STEP MOTOR



ALPS MOTOR CONTROL BOARD SCHEMATIC



| SYMBOL | DESCRIPTION |
|-------------|--|
| I.C. | Sony CX-065B |
| Q1 | Transistor 2SC2785 |
| Q2 | Transistor 2SC2785 |
| Q3 | Transistor 2SA1175 |
| Q4 | Transistor B703-Q36E |
| CR1,2,3,4,5 | Diode 1N4148 |
| R1,7 | Resistor, 1k Ω , 1/4W |
| R2 | Resistor, 68k Ω , 1/4W |
| R3 | Resistor, 220 Ω , 1/4W |
| R4 | Resistor, 3.3k Ω , 1/4W |
| R5 | Resistor, 2.7k Ω , 1/4W |
| R6 | Resistor, 820 Ω , 1/4W |
| R8 | Resistor, 150 Ω , 1/4W |
| R9 | Resistor, 0.68 Ω , 2W |
| R10 | Resistor, 5.1k μ , 1/8W |
| VR1 | Variable Resistor, 20k Ω |
| C1,5,6 | Capacitor, Electrolytic, 10 μ F, 35V |
| C2 | Capacitor, 0.0047 μ F, 50V |
| C3 | Capacitor, 0.033 μ F, 50V |
| C4,9 | Capacitor, Tantalum, 0.47 μ F, 35V |
| C7 | Capacitor, Tantalum, 2.2 μ F, 16V |
| C8 | Capacitor, 0.068 μ F, 50V |

(Fold In)

| | | | |
|--|--------|-------|----------|
| | | | CITY: |
| | | STATE | |
| | | ZIP | |
| | | | STREET: |
| | | | COMPANY: |
| | | | NAME: |
| | PHONE: | | |
| | DATE: | | |

PLACE
STAMP
HERE

COMMODORE BUSINESS MACHINES
C-2654
West Chester, PA 19380

Service Documentation

Fold and Tape

DO NOT STAPLE

Fold and Tape