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34XX Technical Service Manual

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Introduction 1

This manual provides the service technician with the information necessary to maintain and service the Qualstar 34XX Series Tape Drive at the modular repair level. In addition to schematic diagrams and parts illustrations, sections are included to provide the service technician with an understanding of drive operations at the printed circuit board assembly (PCBA) functional level.

Information regarding the installation and configuration of the tape drive, as well as the technical and interface specifications, is not within the scope of this manual. This information can be found in the 34XX Series User's Guide (500300), the 341X Product Specification (500240), the 340X Product Specification (500540) and in the SCSI-2 Interface Manual (500358).

Although Qualstar has made every effort to insure the accuracy of the information contained in this manual, no guarantee is expressed or implied that the manual is error-free, and Qualstar reserves the right to make changes at any time without prior notification.

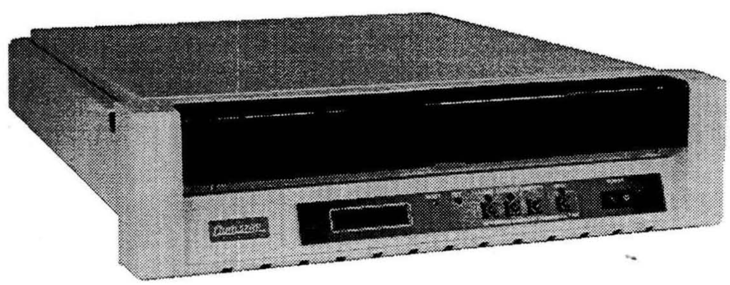


Figure 1-1 34XX Series Tape Drive

The Qualstar 34XX Series Tape Drive is a sophisticated, state-of-the-art computer peripheral, and should only be serviced by a competent service technician experienced with the operation and maintenance of tape drives, and only after reading and understanding the User's Guide and this technical service manual.

All of the operating instructions and maintenance procedures must be followed to prevent personal injury or damage to the equipment. In the interests of safety, there are two kinds of warnings in this document:

DANGER! **PERSONAL INJURY MAY RESULT IF YOU DO NOT FULLY COMPLY WITH THE HANDLING, OPERATING, OR SERVICE INSTRUCTIONS FOUND IN A *DANGER* PARAGRAPH.**

Caution! ***EQUIPMENT DAMAGE OR LOSS OF DATA may result if you do not fully comply with the handling, operating, or service instructions found in a Caution paragraph.***

In addition, useful information and tips may be found throughout the document in the following format:

Note: *SPECIAL ATTENTION to explanatory statements found in a Note paragraph will help you avoid mistakes and/or save time.*

General Description 2

The 34XX Series Tape Drive stores and retrieves data recorded in nine-track digital format on 1/2 inch wide magnetic tape. It contains its own data formatting electronics and was designed to be connected to a magnetic tape coupler using the Industry Standard Interface.

It can operate on 100, 110, 220, or 240 VAC, 50 or 60 Hz, and uses low power electronics and components wherever possible. The maximum power requirement of 225 watts occurs during tape repositioning.

Models are available at the speeds and densities shown in Table 2-1.

CONFIGURATION		SUPPORTED DENSITIES					SCSI OPTION
RACK MOUNT	DESKTOP	800 125 ips	1600 125 ips	3200 62.5 ips	6250 125 ips	6250 62.5 ips	
3402	3404		X	X			X
3410	3412	X	X	X	X		X
3413	3414		X			X	
3416	3418	X	X	X	X	X	X

Table 2-1 The 34XX Family

The drive has an auto-loading capability which locks the supply reel to the hub, threads, tensions, and brings the tape to load point (BOT) without operator assistance. It also has mid-reel load and automatic unloading capabilities.

The operator can communicate with the drive by pressing the switches and observing the indicators and LCD display on the front panel. Various operating configurations and options can be set either at the front panel or via the interface. The drive stores the last operating configuration and various maintenance parameters in non-volatile memory, and automatically restores these parameters each time it is switched on.

2.1 General Layout

The drive can be slide-mounted in a standard 19-inch EIA equipment rack requiring 5.25 inches of vertical space. A desktop enclosure option is also available. About 26 inches deep and weighing about sixty pounds, the drive consists of a base and a chassis which are hinged together at the rear. All of the tape handling components and some of the electrical components are mounted to the underside of the base, while the AC line components and the remaining electrical components are mounted to the chassis. The main power switch is located on the front panel.

The base is protected by a top cover, and a hinged door in the front of the drive allows the user to insert and remove tape reels. Both the cover and the door are interlocked and will stop tape motion whenever either is opened.

2.2 Base Assembly

The tape path area can be accessed for servicing and cleaning by first sliding the drive forward out of the mounting cabinet and then raising the top cover. The cover helps to keep the tape path area clean and also directs air flow during automatic tape threading at load time.

Lifting the cover provides access to the following subassemblies:

- Supply hub and take up reel
- EOT/BOT assembly
- Read/write head
- Read Preamplifier PCBA (341X only)
- Tape guides and rollers
- Tape-In-Path sensors
- Write ring sensor
- Tape cleaner

2.2.1 Supply Hub and Take Up Reel

A solenoid mechanism attached to the underside of the base locks and unlocks the supply hub automatically during the load and unload sequence. Should the solenoid or its circuitry fail, the user can manually lock and unlock the supply hub by opening the door and operating a lever while turning the hub by hand.

2.2.2 EOT/BOT Assembly

The EOT/BOT Assembly uses an infrared emitter/detector to sense the reflective tabs near the beginning and end of ANSI standard tapes. These sensors are continuously monitored by the tape control circuitry, and are used to generate the beginning of tape (BOT) and end of tape (EOT) interface signals (ILDP and IEOT).

2.2.3 Read/Write Head

The read/write head assembly ("head" for short) is a dual stack head which converts electrical impulses into magnetic information on the tape, and vice versa. Attached to the head is a full-width erase head which is on during write operations and off during read operations. The dual stack construction allows simultaneous reading and writing. The drive writes in the forward tape direction, and will read in both directions.

2.2.4 Read Preamplifier PCBA

A Read Preamplifier PCBA is connected to the rear of the read head and provides the first level of signal amplification while maintaining a high signal-to-noise ratio. Its analog output is sent to the Read Formatter PCBA for further processing and decoding.

2.2.5 Tape Guides and Reference Guides

Three tape guides and two reference guides direct the tape through the tape path, across the head, and into the reels. The tape guide nearest the supply hub is referred to as the *fixed guide*. It guides the tape into and out of the supply reel and helps establish an even tape pack.

Another tape guide, located next to the fixed guide, is mounted on a spring-loaded arm which forms part of tension sensor used to maintain a constant tape tension across the head. This tape guide is sometimes referred to as the *tension roller*.

A third tape guide, located near the take up reel, guides the tape into and out of the take up reel. It is part of a tachometer which is used to tell the tape control circuitry the position and velocity of the tape. This tape guide is sometimes referred to as the *tach roller*.

The reference guides are steel posts located on each side of the head. Their purpose is to establish the height of the tape relative to the head. The lower flanges on the reference guides are lightly spring-loaded to maintain the tape against the upper edge of the guides, known as the *reference edge*. The reference guides are shimmed to keep the tape path perpendicular relative to the head, thereby minimizing tape skew.

2.2.6 Tape-In-Path Sensors

Two Tape-In-Path sensors are mounted to the base, one between the fixed guide and the tension arm tape guide, the other between the tachometer and the take up reference guide. These infrared emitter/detectors sense the presence of tape and their outputs are used by the tape control circuitry to monitor the progress of load and unload operations.

2.2.7 Write Enable Ring Sensor

The Write Enable Ring Sensor is used to detect both the presence of a reel on the supply hub and the presence of a write enable ring on the supply reel. If a reel is in place, it will depress one of two reflective tabs which will then pass by the infrared emitter/detector with each revolution of the supply hub. If a write enable ring is installed, it will depress the second reflective tab which will then also be detected by the sensor, enabling the tape drive's write and erase circuitry. If the write enable ring is not installed, the write and erase circuitry is disabled.

2.2.8 Tape Cleaner

A sapphire blade tape cleaner mounted near the head cleans debris from the tape before it passes across the head.

2.3 Underside of Base

The base assembly is hinged at the rear and can be raised when needed to service the drive. The base can be held in the service position by engaging a positive locking mechanism located on the right side of the drive. Raising the base to the service position allows access to the drive's PCBAs, sensors, and motor components.

2.3.1 Reel Motors

The reel motors are attached to the underside of the base. Each winding of the three-phase, delta-wound motors is switched between +70 volts and ground to provide the driving force which turns the reels and moves the tape. By varying the drive signal to each reel motor independently, the tape control circuitry can control the speed, direction, and tension of the tape.

A tachometer and a tension sensor provide feedback to the tape control circuitry. A microprocessor on the Motion PCBA continuously monitors the outputs of these sensors and calculates drive signals to control the tape tension and velocity.

2.3.2 Blower Motor

The blower motor, sometimes referred to as the *fan*, is similar to the reel motors in design and control. During the load process, its speed is increased to provide additional airflow for directing the tape through the tape path. After the tape is loaded, the blower speed is reduced and provides cooling for the tape path area and the drive electronics.

2.3.3 Tension Sensor

The tension sensor provides the tape control circuitry with an indication of tape tension. The assembly consists of a tape guide and a slotted vane, or *shutter*, attached to the opposite end of a spring-loaded, pivoting arm. As the tape tension increases, the arm turns the vane, causing an infrared emitter/detector to generate pulses. These pulses are used together with pulses from the tachometer to vary the drive signals to the reel motors and thus maintain a constant tape tension across the head of ten ounces. A second emitter/detector on the sensor assembly provides the tape control circuits with an arm position reference signal by detecting a notch in the vane.

2.3.4 Tachometer

The tachometer assembly provides the tape control circuitry with an indication of tape position and direction. The assembly consists of a tape guide with a slotted disk attached to one end, and an infrared emitter/detector. As the tape moves, it turns the tape guide and the slotted disk, generating pulses which are monitored by the tape control circuitry.

Also attached to the underside of the base are the Shutter PCBA, the Tachometer PCBA, and three Hall PCBAs (one for each motor). The Shutter PCBA contains the sensing circuitry for the Tension Sensor Assembly, the Tachometer PCBA contains the sensing circuitry for the tachometer, and the Hall PCBAs contain three Hall sensors each, which sense the alternating magnetic fields as the rotor magnets pass by. A

Display PCBA, mounted behind the bezel assembly, contains the switch and display electronics.

2.4 Chassis Components

The bottom chassis is stamped aluminum with an aluminum back chassis attached to the rear. Removable covers attached to the back chassis provide access to the interface connectors on the PCBAs. The AC line fuse, AC power connector, and a small cooling fan are also located on the back chassis. Two AC voltage configuration switches are located under the rear top cover.

When the base is raised, the following major PCBAs are accessible:

- Write Executive PCBA
- Motion PCBA
- Read Formatter PCBA
- Power Supply PCBA
- SCSI Adapter PCBA (34XXS only)

Figure 2-1 illustrates the relationships of the major subassemblies to one another.

2.4.1 Write Executive (WREX) PCBA

The WREX PCBA is attached to the rear of the chassis. It is a two-layer PCBA containing a microprocessor and a digital signal processor. It provides the following functions:

- Decodes host commands and formats write data from the host
- Generates write parity
- Gates write and erase head source current
- Generates read parity and sends read data and drive status to the host
- Reads the front panel buttons and generates front panel display signals
- Gives high level commands to the Motion PCBA for tape motion
- Gives high level commands to the Read Formatter PCBA

2.4.2 Motion PCBA

The Motion PCBA is attached to the underside of the base. It is a two-layer PCBA containing a dedicated microcomputer and provides the following functions:

- Contains the power amplifiers for the reel motors and the blower motor
- Controls tape tension, motion and position by calculating motion control signals
- Switches write current through the write head windings

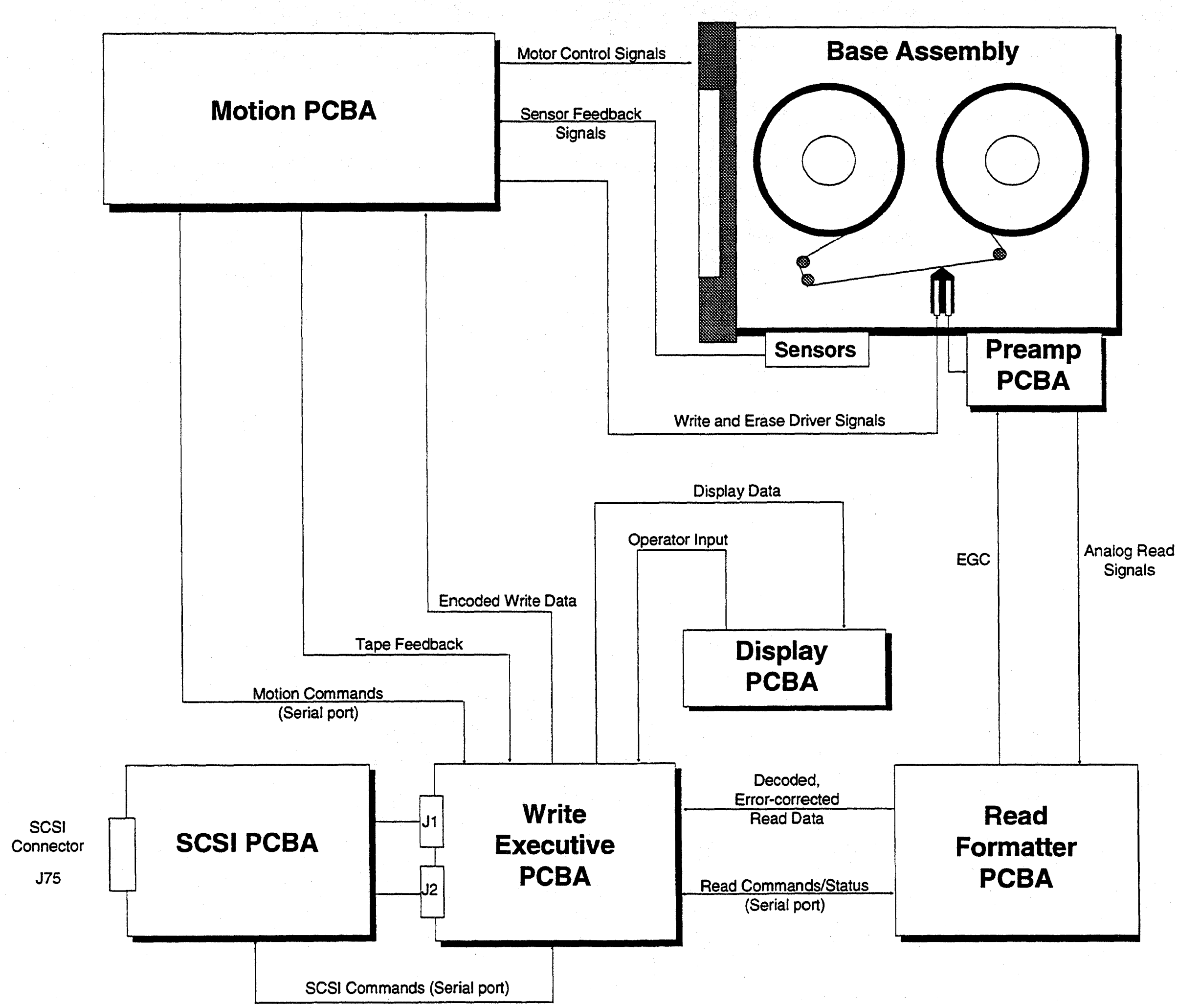


Figure 2-1 34XX Series General Block Diagram

- Controls cooling
- Passes display data from the WREX PCBA to the Display PCBA

2.4.3 Read Formatter PCBA

The Read Formatter PCBA is attached to the front part of the chassis and provides the following main functions:

- Recovers data from the tape and converts it into a format which the computer can use.
- Performs error detection and correction.

2.4.4 SCSI Adapter PCBA

The SCSI Adapter PCBA is located above the Write Executive PCBA on models 34XXS only. The SCSI Adapter PCBA is connected to the industry standard interface connectors at the rear of the Write Executive PCBA, and a variety of SCSI connector configurations at the rear panel are available.

2.4.5 Power Supply PCBA

The Power Supply PCBA is attached to the chassis alongside the Read Formatter and WREX PCBAs. It provides both regulated and unregulated DC voltages to the various PCBAs and sensors in the drive.

Data Formats 3

This chapter is included in the manual to provide the service technician with a basic understanding of the PE and GCR recording formats, and with enough information to understand the operation of the various write encoding and read recovery circuitry. DPE (3200 cpi) operation is identical to PE (1600 cpi) operation, except that the tape speed is reduced by exactly 50%, making the packing density on tape twice that of PE. The interface data transfer rate during DPE and PE operation are the same. NRZI operation is not discussed here.

Both PE and GCR data are recorded on nine tracks which are physically located on tape according to ANSI standards. A *track* is the actual path along tape that a particular bit stream follows, referenced by its physical position relative to the reference edge (the edge furthest from the base) of the tape. A *channel* (as seen by the host) refers to the path along tape that a particular bit follows as referenced by its logical position in the data byte. The relationship between tracks and channels is shown in Figure 3-1 on page 3-2.

The tracks are numbered consecutively, beginning at the reference edge with Track No. 1, and are assigned as follows:

ANSI Track	1	2	3	4	5	6	7	8	9
Channel	5	7	3	P	2	1	0	6	4

Bit P is the parity bit. Channel 0 is considered the most significant bit for ASCII tape formats.

The track width on tape is 0.043 inch minimum per track. The centerline distance between tracks is 0.055 inch nominal. The centerline of track 1 is 0.029 inch ±0.003 inch from the reference edge (nearest the labeled side of the tape reel).

In both PE and GCR recording, a *character* is a group of nine bits (0-7 and parity) written in parallel across the tape. The data is written by the recording head which polarizes the tape particles in one direction or another. A *flux reversal* (also called a flux transition) is a change in the alignment of magnetically polarized oxide particles on the surface of the tape.

3.1 Phase Encoded Data

3.1.1 Character Definition

PE (Phase Encoded) is the most widely used format for recording data on tape. Its density is 1600 characters per inch (cpi), or 63 characters per millimeter. Bit values are determined by the direction of a flux reversal on tape. A "one" data bit is defined as a flux reversal with the same polarity as the IBG, when reading in the forward direction. A "zero" data bit is defined as a flux reversal with the opposite polarity of the IBG, when reading in the forward direction.

3.1.2 Interphase Transitions

In PE, sequential bits of the same value must be separated by an additional flux reversal called an *interphase transition*. Refer to Figure 3-1. The interphase transition allows each bit to be represented by a flux reversal. If the interphase transitions were not present, two ones would be written with the same direction of magnetization and there would be no change on tape until the opposite bit value were written. This would be impossible to read. Because of the addition of interphase transitions, the recording efficiency of the PE format does not exceed 50%.

3.1.3 General PE Format

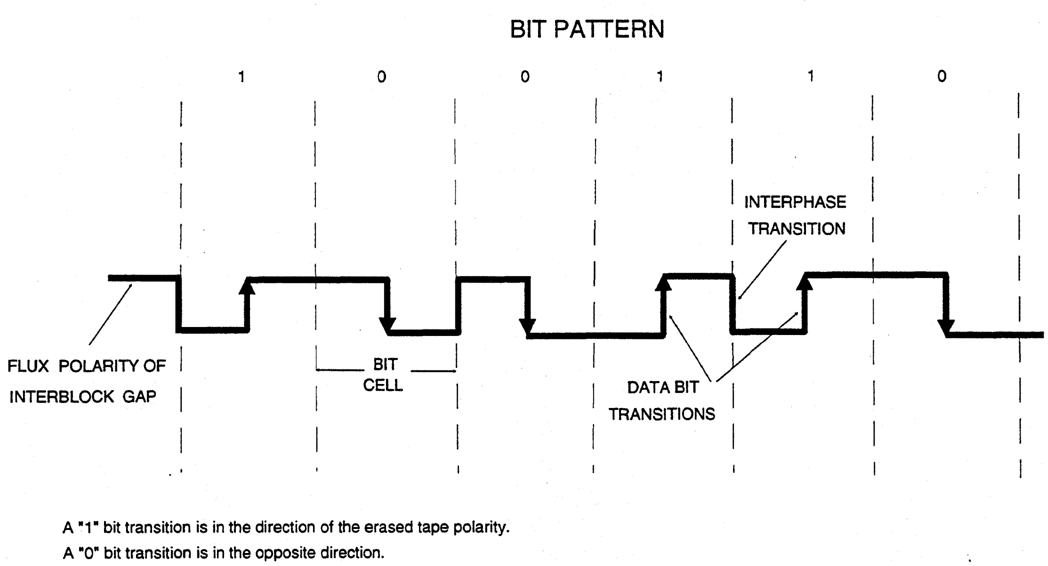


Figure 3-1 PE Data Bit Pattern

The general tape format for PE is shown in Figure 3-2 on page 3-3. The nominal character spacing, exclusive of interphase transitions, is 625 microinches. Data bits in a character cannot be displaced (skewed) more than 625 microinches from any other data bit in the same tape character, as measured perpendicular to the reference edge.

3.1.4 PE Block Layout

The data field of an ANSI-compatible block contains a minimum of 18 ASCII characters and a maximum of 2048 characters. Each data field is preceded by a *preamble*, consisting of 40 characters of all zeros in all tracks, followed by a *sync* byte, consisting

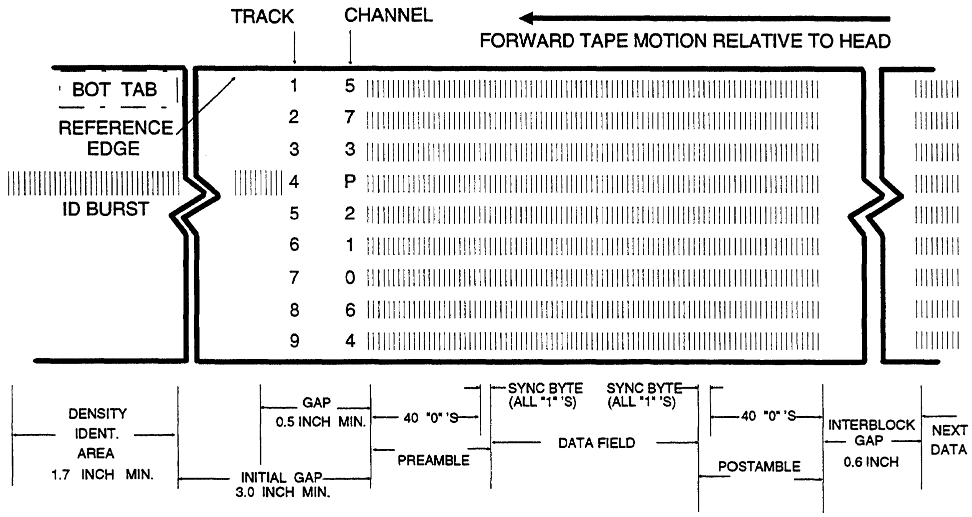


Figure 3-2 PE Data Format

of one character of all ones. Each data field is followed immediately by another sync byte, and then by a *postamble* consisting of 40 characters of all zeros.

The purpose of the preamble is to allow the read recovery circuits to recognize the block and to prepare for the coming data field. The purpose of the sync byte is to inform the read recovery circuits that the preamble is finished and that the next byte will be the first data byte. Notice that the postamble is a mirror image of the preamble. During reverse read operations, the postamble and its sync byte serve the same purpose as the preamble in forward read operations.

The PE format contains no error detection or correction characters.

3.1.5 PE IBG Length

The IBG (the erased portion of tape between blocks) length in PE is 0.6 inch nominal, 0.5 inch minimum, and 25 feet maximum.

3.1.6 PE ID Burst

PE tapes are identified by a recorded burst, known as the identification (ID) burst, in the area of the BOT marker. The ID burst consists of flux reversals on track 4 (channel P) only, while the remaining tracks are DC erased. The ID burst begins a minimum of 1.7 inches before the trailing edge of the BOT marker, and ends at least 0.5 inch before the first block.

An initial gap lies between the trailing edge of the BOT marker and the first recorded character. The length of this initial gap is three inches minimum and 25 feet maximum.

3.1.7 PE Filemark

A PE filemark consists of 64 to 256 flux reversals, recorded at 3200 flux reversals per inch in tracks 2, 5, and 8. Tracks 3, 6 and 9 are DC erased. Tracks 1, 4, and 7 may be erased, or they may be recorded the same as 2, 5 and 8 (as is the case with the Qualstar tape drives).

3.2 GCR Data

3.2.1 Character Definition

The *effective density* of GCR (Group Code Recording) is 6250 cpi. The *actual density* including overhead, is 9042 bytes per inch. The recording efficiency of GCR is 80%.

The bit values are determined like the NRZI recording method, with a flux reversal indicating a "one" and the absence of a flux reversal indicating a "zero". However, the data is coded in the formatter prior to being written so that no more than two consecutive zeros will ever occur on tape, regardless of the incoming data stream. The coding also provides self-clocking, error detection, and error correction abilities.

3.2.2 ID Burst

GCR tapes are identified by a GCR ID burst in the area of the BOT marker. This burst is in the PE frequency range on channel 1 (track 5), with the remaining tracks DC erased. The ID burst begins 1.7 inches (43.18 mm) minimum before the trailing edge of the BOT marker and continues past the trailing edge of the BOT marker.

3.2.3 ARA Burst

An Automatic Read Amplification (ARA) burst, consisting of an all ones pattern in all tracks, immediately follows the ID burst, and is separated from the ID burst by a gap of undefined length. Its purpose is to allow gains of the read amplifiers to be dynamically adjusted for all tracks. A special ARA ID burst character follows the ARA burst and is used to identify the ARA burst when reading in reverse to BOT.

3.2.4 GCR Filemark

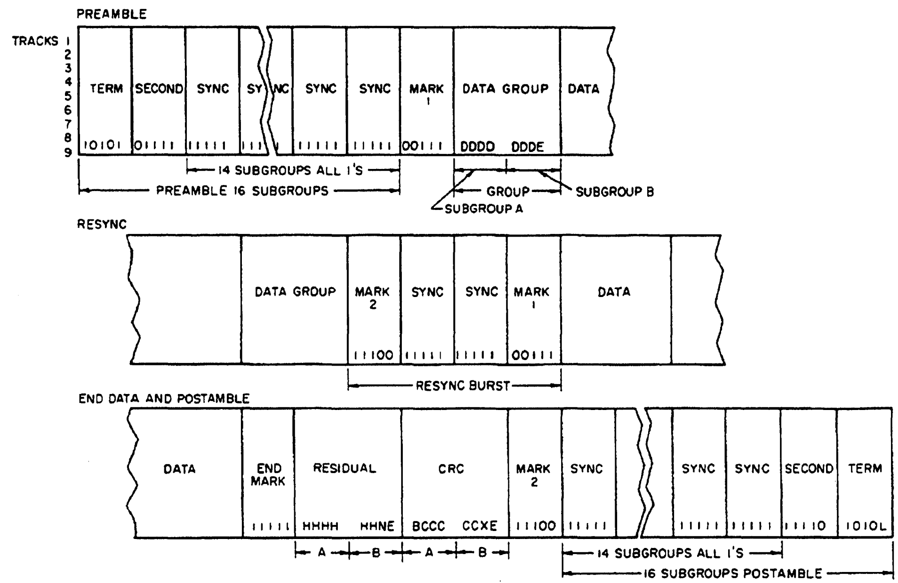
A filemark (also called tape mark) separates files and file labels on tape. It consists of 250 to 400 flux reversals, all ones in channels 7, 2, 6, 5, P, and 0, while channels 3, 1, and 4 are DC erased.

3.2.5 GCR Block Layout

The GCR tape format is shown in Figure 3-3.

3.2.5.1 Subgroups

There are two types of subgroups in the GCR format—a *control* subgroup, and a *data* subgroup. Each subgroup consists of five characters which are generated by the tape drive and which are transparent to the host. The control subgroups are used to identify various GCR format items on the tape and to allow the read circuitry to properly



Legend:

D: Data characters	C: CRC character
H: Pad or data character	N: Auxiliary CRC character
X: Residual character	L: Last character
E: ECC character	B: CRC or pad character

Figure 3-3 GCR Data Format

detect and track the data fields. Although the 3410/3412 tape drive records all control subgroups per ANSI specifications, not all of the control subgroups are required by the read recovery circuits.

- **Term Control Subgroup** - identifies the first or last subgroup of a block. The read recovery circuits ignore this subgroup.
- **Second Control Subgroup** - separates the Term subgroup from the Sync subgroups of each block. The read recovery circuits ignore this subgroup.
- **Sync Control Subgroups** - exist to allow the read circuitry (PLLs) to synchronize with and lock onto the incoming data stream. These are used by the PLL circuits on the Read Channel PCBAs.
- **Mark1 Control Subgroup** - alerts the read decoding circuitry that the following bytes belong to a data subgroup. This is similar in function to the sync byte in the PE format.
- **Data Subgroups** - contain the actual data from the host (or from the tape). Blocks are divided into Data Groups, the essential elements of group-code recording.
- **Mark2 Subgroup** - a mirror image of the Mark1 subgroup, has the same function as Mark1 in the reverse direction.

- **End Mark Control Subgroup** - used to indicate the end of a series of complete data groups, and the beginning of the Residual Group.

3.2.5.2 GCR Preamble

As in the PE format, each GCR data block is preceded by a preamble for synchronization purposes. However, a GCR preamble consists of a Term subgroup, followed by a Second subgroup, followed by fourteen Sync subgroups, rather than simply 40 characters of all zeros.

3.2.5.3 Data Groups

Following the preamble, an Mark1 subgroup indicates that data will follow. At other locations on tape, this subgroup is used to differentiate data groups from control subgroups.

The GCR formatting circuitry takes write data from the host and groups it into two different data subgroups as follows:

1. The GCR encoder accepts the first seven characters from the host.

2. The first four characters of this seven-character *data group* are encoded into a five-byte data subgroup such that no more than two zeros will be written consecutively on the tape. This is called Data Subgroup A.

3. The formatter then adds an error correction code (ECC) character to the end of the remaining three characters and encodes them into a second five-byte data subgroup as previously described. This subgroup is called Data Subgroup B.

4. Subgroups A and B are then recorded on the tape as a data group, and the process repeats until all the data from the host has been recorded.

5. After each 158 data groups (1106 bytes), a *Resync Burst* occurs to allow the read recovery circuits to resynchronize to the data stream within the data block. Each Resync Burst consists of a Mark2 subgroup, followed by two Sync subgroups, followed by one Mark1 subgroup.

3.2.5.4 Residual Data Group

A Residual Data Group contains either the extra data characters remaining after the division of blocks into Data Groups, or it contains padding characters to fill up the group. It also contains an ACRC character and an ECC character which are used for error detection.

3.2.5.5 GCR Check Characters

The GCR format contains three types of check characters:

- **ACRC** - An Auxiliary Cyclic Redundancy Check character is calculated by a polynomial and exclusive-OR operation on the data, including parity.

- **CRC** - A Cyclic Redundancy Check character is a repeating character calculated similarly to the ACRC character.

- **ECC** - An Error Check Character is generated by the Read/Formatter PCBA and added to the end of data subgroup B before the 4-to-5 encoding takes place.

A CRC Group follows the Residual Data Group and contains CRC characters, a residual character and an ECC character. This group is present at the end of each block and is used for error detection.

A Mark 2 group follows the CRC Group or Storage Groups and indicates that a Control Group (such as Sync) will follow. If a Mark 2 is at the end of the block, a postamble will follow.

3.2.5.6 GCR Postamble

The postamble is a mirror image of the preamble (with one exception) and is used as a preamble when reading in reverse.

The exception is the last byte of the postamble Term subgroup. It is like the LRC character in the NRZI format, and occurs when the write drivers are all returned to their default state. The direction of magnetism of this last character will always be the same as the direction of magnetism of the IBG.

3.2.6 GCR IBG Length

In addition to preambles and postambles, an IBG of 0.3 inch (0.28 inch minimum, 15 feet maximum) follows each block.

Motion and Power Supply PCBAS 4

This chapter describes the electronic components which comprise the motion and power supply circuitry of the 34XX Series tape drive. Enough detail is provided to enable a competent service technician to acquire a basic understanding of the interaction of the Motion and Power Supply PCBAs with the remainder of the drive.

Three-digit schematic references consist of the schematic page number, followed by a vertical edge reference letter and a horizontal edge reference number. An object located at reference 4C3 can be found on sheet 4 at the junction of vertical reference C and horizontal reference 30.

Descriptions of the following topics are included:

- Main motion control loop
- Motion PCBA (PN 500277-01-7, Schematic 500278)
- Power Supply PCBA (PN 500347-01-8, Schematic 500348)

4.1 Main Motion Control Loop

Tape motion control is accomplished by many components operating in a loop. The following paragraphs, along with Figure 4-2 on page 4-5, describe the major components in the loop and how they interact.

The five command lines from the host (IREV, IWRT, IFMK, IEDIT, and IERASE) are latched into the drive in a buffer by IGO on the Write Executive (WREX) PCBA. The output of this buffer is sampled by the WREX microprocessor which then decodes the command and generates the appropriate control signals to the rest of the drive. For tape motion control, the microprocessor sends motion commands (i.e., FWD, REV, REW) to the microprocessor on the Motion PCBA via an asynchronous communication line. A flip-flop, under microprocessor control, controls the IFBY signal back to the host.

The Motion microprocessor receives the motion command from the WREX microprocessor and translates it into a sequence of motor current control signals which contain both direction and magnitude information. These signals consists of a pair of 11-bit words sent on a synchronous communication line to each of the motor drive controllers (Signetics 5570 chips). At the same time, the microprocessor enables the appropriate controller to receive the current control signals.

Each 5570 chip converts its 11-bit word into three pairs of pulsewidth-modulated switching signals which turn on power switching transistors connected to the motor windings. The motors turn and move the tape, which in turn, moves the tachometer and the tension arm.

The tachometer and tension arm sensor generate pulses which are monitored by the Motion microprocessor. The Motion microprocessor recalculates the motor current control signals as necessary to maintain the required tape speed and tension. When the tape is up to speed, the Motion microprocessor sends the SPEEDOK signal to the WREX microprocessor.

4.2 Motion PCBA Description

The Motion PCBA contains the following circuits:

- Motion PCBA microcomputer
- Motor drive circuitry
- Dynamic feedback circuitry
- EOT/BOT circuitry
- On-board regulators

These circuits are described in the following paragraphs.

4.2.1 Motion PCBA Microcomputer

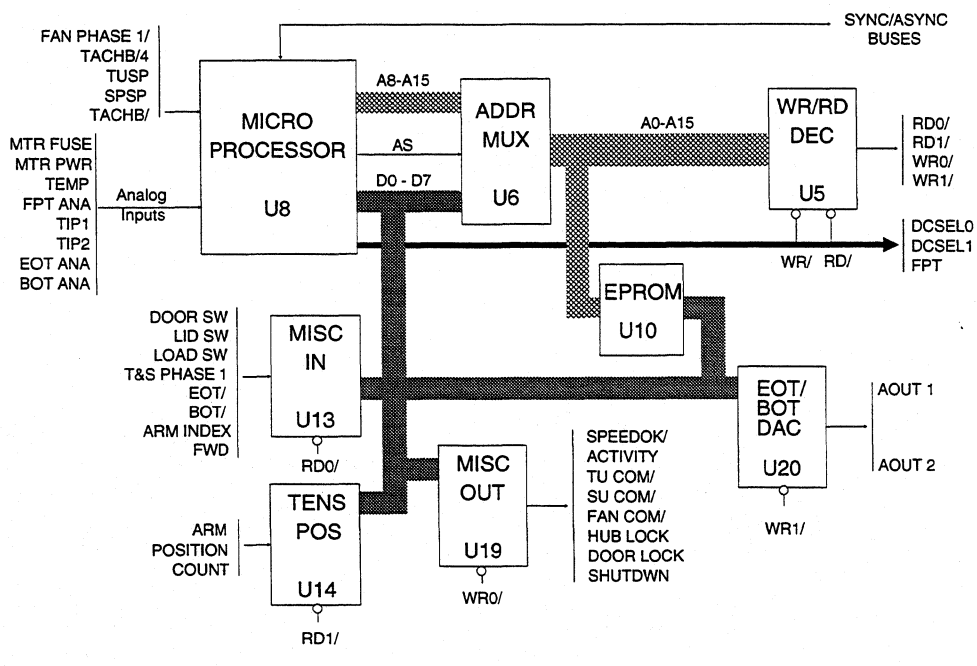


Figure 4-1 Motion Board Microcomputer Block Diagram

The Motion PCBA contains its own dedicated microcomputer consisting of a Motorola 68HC11 microprocessor (U8), a 32K EPROM (U10), an 8-bit data bus, and a 16-bit address bus. The Motion microprocessor communicates via a data and address bus, a synchronous serial bus, an asynchronous serial bus, an 8-input analog port, and various timer input and output lines. Connected to the data bus are two input and two output registers. Figure 4-1 on page 4-2 illustrates the major functional components of the Motion PCBA microcomputer.

4.2.1.1 On-Board Memory

The Motion PCBA microprocessor contains a 256 byte RAM which is used as a scratch pad memory.

4.2.1.2 Port A

Port A provides access to a number of timers inside the Motion microprocessor. TACH B, TACHB/4, SPSP, and TUSP are inputs to the timers and act as timer interrupts. DCSEL0, DCSEL1, and FPT are programmable outputs.

4.2.1.3 Ports B and C

16-bits of address information is carried on two ports. Port B carries the 8 most significant bits of the address, and Port C carries the 8 least significant bits. Port C also doubles as a bi-directional data bus. The microprocessor sets AS (Address Strobe) high when using Port C as an address bus, and low when using it as a data bus. When high, AS enables an 8-bit latch at U6 to convert the output of Port C into low order address bits.

4.2.1.4 Port D

Port D consists of a pair of asynchronous serial communication lines (RXD and TXD) and a fully synchronous, serial, bi-directional communication bus. RXD and TXD (receive data and transmit data lines) are always enabled, and are used to communicate with the WREX microprocessor at a rate of 125K baud.

MOSI (Master Out, Slave In) together with SCK (Serial Clock) provide a synchronous serial communication bus which is used to send information to the motor drive controllers.

4.2.1.5 Port E

The microprocessor has an internal, 8-bit A/D converter which it uses to measure analog signals from the write ring sensor (FPT ANA), the tape-in-path sensors (TIP1 and TIP2), and from the EOT/BOT sensor (EOT ANA and BOT ANA). These inputs to the A/D converter are at Port E. The other three inputs at Port E are connected to the +70 volt line, the load side of the +70 volt fuse, and to a temperature sensor, allowing the microprocessor to monitor the drive's internal temperature and the +70 volt motor supply on both sides of its fuse.

A precision voltage reference device fed by the +12 volt regulator provides an extremely accurate and stable +5.00 volt reference for the internal A/D converter.

4.2.1.6 Internal Interval Timer

The timing reference for the microprocessor is an 8 MHz crystal oscillator. The microprocessor divides the 8 MHz reference clock by 4, providing an internal 2 MHz clock and an external 2 MHz clock (ECLK). The microprocessor uses ECLK to synchronize various outside events with itself.

Inside the microprocessor, ECLK provides timing reference which enables the microprocessor to calculate the time intervals between various events (such as SPSP, or B/4). In this way, the microprocessor calculates reel speeds and tape speed, and provides timing windows during load and unload operations.

4.2.1.7 External Output Ports

In addition its own ports, the Motion microprocessor communicates with external circuitry by using two external output ports connected to its data bus. The microprocessor enables these ports using the signals WR0/ and WR1/ (WR = WRite), which are actually decoded address bus lines. If, for example, the microprocessor wanted to activate the hub lock solenoid, it would activate bit 4 of the data bus, place the appropriate address on the address bus, and then set the read/write control signal (R/W) low. Address decoder U5 decodes the address and activates WR0/. WRO/ is connected to the clock input of U19 and when low, latches the data bus at the input of U19 over to its output lines. The output signal HUB LOCK then goes high, causing the solenoid driver to draw current through the hub lock solenoid.

The process is similar when the Motion microprocessor wants to read information from various parts of the drive. To read the position of the tension arm, for example, the microprocessor first places the appropriate address on the address bus and then sets R/W high. Address decoder U5 activates output RD1/ (RD = ReaD), which, in turn latches the inputs of the tension arm counters into the tension position register at U14. The outputs of U14 are connected to the data bus which the microprocessor then reads.

4.2.2 Motor Drive Circuitry

The Motion PCBA contains switching circuitry and power amplifiers for the supply, take up, and blower motors. The three circuits are identical with the exception of the servo offset compensation network, which the blower motor does not use. The following paragraphs describe the operation of the servos.

4.2.2.1 DC Motor

The 34XX tape drives use three-phase brushless DC motors. The motors are commutated electronically, unlike brush-type motors which are commutated by mechanical brushes. The motor windings (stator) are fixed in place on the base and a cup containing several magnets (rotor) rotates around the windings. The motor shaft is connected to the rotor and to the supply hub, take up reel, or fan, depending upon the particular motor.

A Hall PCBA containing three Hall sensors is mounted on the base next to each rotor. The output of each Hall sensor switches whenever the polarity of the magnetic field they are in switches. The three Hall sensors sense the rotation angle of the rotor,

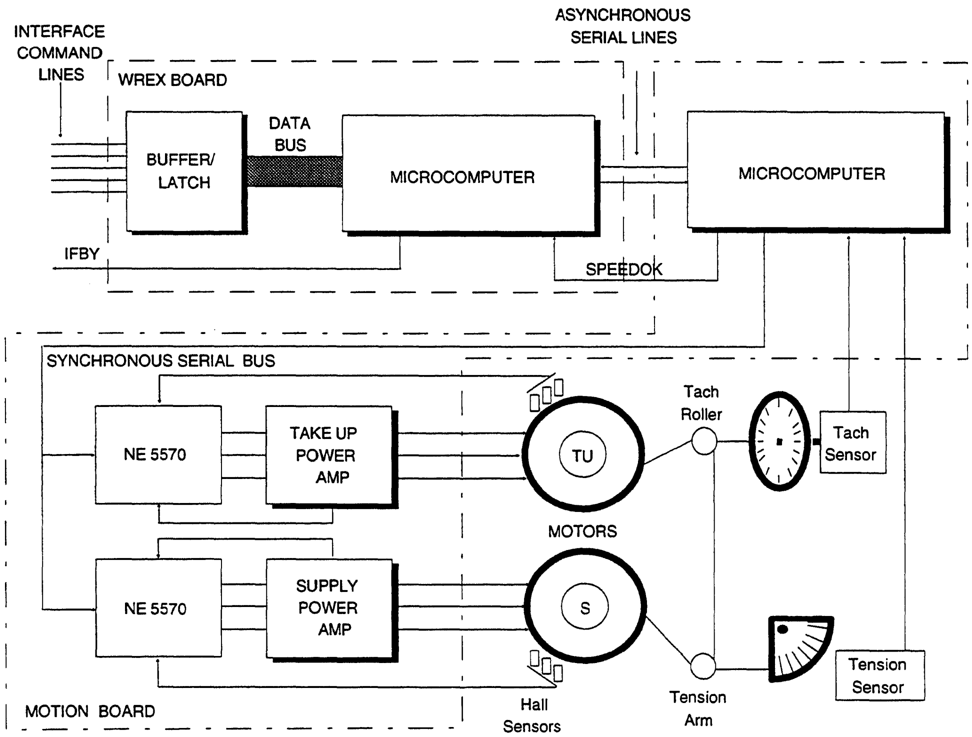


Figure 4-2 Motor Control Block Diagram

which the motor controller uses to determine which of the three motor phases to drive. The blower motor is identical to the supply and take up motors but is thinner since it requires less power.

4.2.2.2 Motor Controller

The NE5570 motor controller chip is a complex device which incorporates many functions. The chip consists of a data register, a nine-bit DAC, decoding logic, a sawtooth generator, a current sensing circuit, and a current sense comparator. The device controls the current in the motor, and commutates the motor so the appropriate motor phase is selected for any given motor shaft position.

The current control operates in the switch-mode, turning the power transistors on and off very rapidly. It relies on the inductance of the motor to smooth out the current so there is effectively constant current flowing through the windings. The current control looks at the voltage drop across the current sense resistors and adjusts the amount of time the power transistors are turned on.

It is important to understand that the current through the motor windings is nearly constant, even though the power transistors are turning on and off. When the transistors are off, the current in the winding flows through the catch diodes. Two amplifiers and a comparator inside the device perform the task of converting the voltages across the sense resistors to a signal which represents the current. These amplifiers control the on/off time of the power transistors to obtain the desired winding current.

As the rotor turns, the motor controller looks at the Hall sensor outputs and selects different motor phases to drive. There are six steps in the commutation cycle and four cycles per revolution, giving 24 commutations per revolution.

4.2.2.3 Main Drive Signal

All of the preceding takes place inside the NE5570 motor controllers and their supporting circuitry. The Motion microprocessor (68HC11) calculates the current required for each motor and sends this information to the motion controllers using a synchronous serial link. This link operates by encoding the command information into a serial stream of data using the MOSI line (Master Out/Slave In), and clocking each bit into the motor controllers one at a time using a serial clock signal (SCK).

MOSI and SCK are generated by hardware inside the 68HC11 microprocessor. Each motor controller is sent a new command exactly 250 times every second when tape is tensioned. When the tape is not tensioned, this rate varies depending upon the current conditions. Because MOSI and SCK go to all three motor controllers, the signals TU_COM/, SP_COM/ and FAN_COM/ are used to select which motor controller is being addressed.

The following commands are used to control the motors:

1. A *DIRECTION / CURRENT* command which contains a start bit, a direction bit, and 8 bits of torque (acceleration) information. This command automatically loads into a register;

2. A *RUN* command which causes the chip to process the DIRECTION/CURRENT information in the register (eventually turning the motor);

3. A *BRAKE* command which causes the motor to stop quickly by shorting the windings;

4. A *LOCK* command which will hold the stopped motor at fixed position with torque applied (detent);

5. A *DISABLE* command which removes all drive current from the motor.

4.2.2.4 Power Amplifier

The outputs of U70 are connected to the power amplifiers which in turn are connected to the stator windings in a push-pull configuration. Due to the delta-wound configuration, only two motor terminals are active at any given time. Current passes through the connected stator winding, causing the magnetic rotor to line up with one of that stator's poles, and turn the shaft. At the same time, the change in rotor position is detected by the Hall sensors and is fed back to U70. To make the rotor turn, the following (simplified) sequence occurs:

The switching logic in U70 sends a pulse to Q26 and Q31, momentarily switching them on. (The width of the pulse, and hence, the time current is actually applied to the winding, is a function of the command information from the microprocessor.)

Current flows from ground through a 0.1 ohm resistor (R110), through Q26 to motor terminal E5, through a one of the windings to terminal E4, and through Q31 to the +70 rail supply rail. The rotor begins to turn, and U70 turns Q26 and Q31 off. The magnetic field surrounding the rotor winding begins to collapse, generating a large potential which causes current to flow back into the power supply through R109 and diodes D13 and D14. U70 turns Q26 and Q31 on again, the process repeats, and the rotor moves away from one Hall detector and towards the next.

The signal from the next Hall sensor signal is fed back to U70 which in turn activates another transistor pair, for example, Q26 and Q27. Motor current flows now flows through Q26 to motor terminal E5, through a different winding to terminal E6, and through Q27 to the +70 volt supply. The rotor continues to turn and the next Hall sensor generates a signal which is also fed back to U70. In this manner, by controlling which transistor pair is turned on and by controlling the length of time the pair is turned on, U70 controls the current applied to the motor and hence its direction and torque.

4.2.2.5 Amplifier Stabilization

Due to internal tolerances within the motor controller chips, small unwanted offsets may appear at the outputs. To compensate for this, R109 and R110 (in the take up loop) are used to pass motor currents and develop proportional voltages which are used as motor current feedback signals by the motor controller. To attain a "zero out for zero in" condition, a voltage divider consisting of R259 and R260 is used to inject a known positive offset into the current loop large enough to insure the microprocessor can compensate for any internal offset the motor controller may have. During motion calibration, the Motion microprocessor measures this offset and subsequently compensates for it. This compensation is not used in the fan motor servo.

Each motor controller also contains a sawtooth generator, whose frequency is determined by a voltage (R138 and C88 for the take up loop). The sawtooth output is connected to the oscillator inputs of the other two motor controller chips to synchronize their operation and to guarantee that power amplifier switching in the three servos occurs simultaneously, thus minimizing any audible noise which may occur as a result of two or more motors beating together.

4.2.3 Dynamic Feedback

4.2.3.1 Tape Tension Feedback

A spring-loaded tension arm is used as a sensor to maintain a constant tape tension across the heads. The arm pivots at one end, and the tape passes around a roller which is attached to the other end. The arm is held against a stop by a spring which is anchored to the base. When the tape tension increases, the arm overcomes the spring tension and moves towards the head; when the tape tension decreases, the spring returns the arm towards the resting position.

Beneath the roller is a slotted disk which is called a shutter. When the arm moves, the shutter moves with it, and slots in outer edge of the disk move past an infrared sensor.

An infrared emitter/detector assembly, or sensor, is positioned such that the shutter passes between the emitter and the detector. When the shutter moves, the sensor detects the passing of the slots and generates the signals ARM A and ARM B. These signals are TTL levels and are *in quadrature*, or about 90 degrees out of phase with each other. ARM A will either lead or lag ARM B, depending upon the direction of arm movement. A second sensor detects a notch cut into the outside perimeter of the shutter and generates the signal ARM INDEX. ARM INDEX will transition each time the tension arm crosses the midpoint of its travel. When the spring tension is properly adjusted, ARM INDEX will occur at nominal tape tension.

ARM A, ARM B and ARM INDEX are fed to a shutter encoder interface on the Motion PCBA. This circuit consists of two up-down counters (U15 and U20) and some gating logic. Whenever the tension arm passes through the midpoint of its travel, ARM INDEX resets the counters to zero via U22-8. ARM A and ARM B are gated such that when the tension arm moves from the midpoint of its travel towards the head (i.e., the tape tension increases), the counters count up, and when the arm moves from the head towards the midpoint of its travel, the counters count down. U22-6 provides the pulses, while U22-11 tells the counters to count up or down, depending upon the direction of the tension arm and the consequent phase relationship between ARM B and ARM B.

The value of the counters at any given time represents the position of the tension arm relative to its midpoint, and hence the tape tension. This value is periodically polled by the microprocessor via U14. The greater the value, the further from midpoint the tension arm is. ARM INDEX tells the microprocessor, via U13, which side of mid-position the tension arm is at any given time.

4.2.3.2 Tape Speed Feedback

As the tape moves, it turns a roller which is attached to a slotted disk. An infrared emitter/sensor detects the slots in the disk and generates two signals, TACH A and TACH B. Like ARM A and ARM B, they are out of phase with each other and depending upon which direction the tach roller is turning, TACH A will either lead or lag TACH B. TACH A and B are fed to the Motion PCBA microprocessor's internal timer, which calculates the tape speed by measuring the time between consecutive pulses.

In addition, the states of TACH A and TACH B are compared in D-flop U3 to determine the direction of tape motion. The Q output (FWD) of U3 will be high when the tape is moving from the supply reel to the take up reel (i.e., forward), and will be low when the tape is moving in reverse. The microprocessor periodically samples the state of FWD via register U13.

4.2.3.3 Tape Position Feedback

The tape position is determined by incrementing or decrementing a counter when TACH B occurs, depending upon the direction of tape travel.

4.2.4 EOT/BOT Signal Conditioning

The Motion microprocessor can adjust the sensitivity of the EOT/BOT sensors by controlling the amount of current fed to the sensor emitters. This allows it to continually compensate for component aging. The microprocessor does this by first loading a value into register U20. The outputs of U20 are connected to two resistor networks which are configured as a pair of DACs. The outputs of these DACS (AOUT0 and AOUT1) are fed to amplifier U24 which fixes the current through the EOT and BOT infrared emitters.

When light is reflected from blank tape, the EOT and BOT sensors generate EOT ANA and BOT ANA. These analog signals are fed directly to Port E of the Motion microprocessor. If the signal amplitudes are incorrect, the microprocessor increases or decreases the emitter current as necessary, by loading new values into U20. This adjustment is automatic and occurs each time a new tape is loaded.

The EOT ANA and BOT ANA signals are also digitized by comparator U18, then sent to the Write Executive PCBA via line driver U2, where they become the interface signals IEOT and ILDP.

4.2.5 On-Board Regulators

The Motion PCBA contains its own +5 volt and a +12 volt power regulators. The +5 volt regulator (U26) is fed by the +12 volt regulator and provides Vcc for the Motion PCBA. The +12 volt regulator (U25) is fed by the +24 volt supply from the Power Supply PCBA and provides power for the sensor emitters and for various reference voltages on the Motion PCBA. These regulators are protected against overvoltage by VR3 and VR4.

A regulator consisting of Q19, Q21, VR2 and D11 is connected to the +70 volt supply lines, which are also connected to the motors. In the event of a power outage, the +24 volt supply from the Power supply board will drop out immediately, disabling the regulators on the Motion PCBA. In order to maintain power on the Motion PCBA long enough for the microprocessor to bring the reel motors to a controlled stop and to prevent tape damage, this circuit uses the energy stored in the motor to supply the +5 and +12 the Motion PCBA regulators as follows:

1. When the power fails, the +70 volt supply begins to drop and normally would be to low to allow any control of the motors, resulting in tape spillage. To prevent this, the microprocessor (which detects the power outage within one or two milliseconds) begins a motor stopping sequence which returns energy to the power supply.

2. The decelerating motors become generators, converting their stored kinetic energy into electrical energy which bolsters up the +70 volt supply and allows the motors to be stopped in a controlled manner.

3. When the +24 volt line from the Power Supply PCBA drops below +19 volts, D11 and Q21 conduct as determined by VR2, an 18 volt Zener diode. Q21 will then turn on and regulate the back EMF from the coasting motors to around +16 volts. This provides a current supply to the +5 and +12 volt regulators on the Motion PCBA long enough to bring the reel motors to a controlled and complete stop without stretching or otherwise damaging the tape.

4.2.6 Miscellaneous Microprocessor Functions

4.2.6.1 Temperature Control

Two cooling fans work together in the tape drive to keep the internal temperature comfortable for the tape and the electronics.

One fan is mounted on the back panel, and its job is to pull hot air out of the tape drive. Room temperature air enters through a grill in the front of the drive, and passes over the circuit boards before being exhausted out the rear. This fan always runs at the same speed.

The other fan is mounted internally in the casting. This fan is called "the blower" because it blows air across the heat sinks and other hot spots to keep those specific areas cool. The blower also provides air for threading the tape during loading. The blower is controlled by the Motion microprocessor, which constantly adjusts the blower speed in response to the heat load on the heat sinks. For example, shuttling tape, or constant starting and stopping of the tape will cause the heat sinks to get hotter. The Motion microprocessor can anticipate this and will increase the cooling by increasing the blower speed to prevent the heat sinks from heating up. This is why you may hear the blower speed up slightly if the drive is starting and stopping the tape often.

A temperature sensor near the center of the Motion PCBA tells the Motion microprocessor the drive's internal air temperature. If the temperature gets too high, the microprocessor speeds up the blower to inrease the cooling. If the temperature rises beyond a specific point, the Motion microprocessor will notify the Executive microprocessor that a "thermal emergency" exists. The Executive microprocessor responds by first finishing the current read or write operation and displaying a special message on the front panel. It then allows the Motion microprocessor to turn off the main power supply, thus eliminating most of the heat sources in the drive. The drive remains in this state until it cools down and the power is turned off.

A thermal emergency will not occur unless the cooling system is severely blocked or the drive is operated in an extremely warm environment. This mechanism is designed to protect both the tape and the tape drive.

If the cooling fan in the rear should fail, the drive will continue to function normally, but the blower speed will be increased to compensate for the loss of air flow. If, however, the *blower* fails, the situation is treated as a thermal emergency, and the following shutdown process occurs:

1. The Motion microprocessor sends a message to the WREX microprocessor (via the asynchronous serial bus) providing enough advance warning to allow an orderly completion of the current read or write operation.

2. The Motion microprocessor generates a shutdown signal at U19. This signal goes to the +5 volt regulator on the Power Supply PCBA and when high, will shut down the regulator.

3. The display backlighting will go out and an appropriate message will be displayed. The regulator will remain shut down until the power turned off and back on again.

4.2.6.2 File Protect

The Motion microprocessor detects the presence of a write protect ring in the supply reel by monitoring the output of the Write Ring sensor. The sensor output is connected to one of the microprocessor's analog inputs. When a write ring is not installed, the microprocessor generates the signal FPT. This signal is used by other circuitry to disable write and erase current, and to activate an interface line (IFPT) which tells the host that the drive is write protected.

4.2.6.3 SPEEDOK and ACTIVITY

Before reading or recording can begin, the tape must be up to speed. When the tape has reached operating speed and is properly positioned at the read/write head, the Motion microprocessor generates SPEEDOK at U19. SPEEDOK is sent to the Write Executive PCBA to tell where the WREX microprocessor uses it to determine when to start reading or writing.

When the Motion microprocessor begins to move the tape, it generates a signal called ACTIVITY at U19. This signal is set to the Display PCBA where it switches on the BUSY indicator on the Display PCBA. After the microprocessor has stopped the tape, it clears the ACTIVITY signal and the BUSY indicator is extinguished.

4.2.7 Motion PCBA Testpoints

The following paragraphs list the testpoints which are available on the Motion PCBA along with a brief description of the signals found on them.

ARMA, ARMB - These are digital signals which originate at the Tension Sensor. As long as the tension arm is moving through its arc of travel, these signals will alternate between high and low. ARMA and ARMB are *in quadrature*, or phase shifted with respect to each other, such that as the arm moves towards the head, ARMA will lead ARMB. ARMA and ARMB are used to determine the current position of the tension arm.

DS1 POWER - This is an LED which is between the +5v line and ground. If the +5 volt regulator is not operational, DS1 POWER will be off.

INDEX - INDEX is a DC level which goes high as the Tension Arm moves towards the head. The high transition is used to reset the tension up/down counters to zero when the tension arm is at its mid-position.

TACHA, TACHB - These are digital signals which originate at the Tachometer. As long as the tape is turning the tachometer roller, these signals will alternate between high and low. TACHA and TACHB are phase shifted with respect to each other, such that as the tape moves forward, TACHA leads TACHB. TACHA and TACHB are used to determine tape position and direction.

WR/ - This is a pulse which occurs when the microprocessor is in the bus write mode. In the write mode, the microprocessor data bus carries information to the various output ports. The term *write mode* as used here refers to read and write activity by the microprocessor and is not connected with reading or writing on the tape.

WRGND - This is a ground testpoint which should be used for ground reference when monitoring the write amplifier signals.

4.2.8 Motion PCBA Jumpers

W1, W2 - These jumpers are not used in the current revision of the Motion PCBA.

W3 - When installed, W3 applies a ground to the microprocessor reset pin which will reset the microprocessor. W3 is used during automated board testing only and is normally not installed.

W4 - W4 is used during automated PCBA testing only and is normally not installed.

4.3 Power Supply PCBA

The Power Supply PCBA is located on the right side of the chassis and supplies both regulated and unregulated power to the drive electronics. There are no adjustments on the PCBA. A functional drawing of the Power Supply PCBA is shown in Figure 4-3.

4.3.1 +70 Volt Unregulated Supply

The +70 volt supply consists of a pair of diodes (D7 and D7) connected as a full wave rectifier, and a filter network. The rectifier is fed by a dedicated, center-tapped secondary winding of the transformer. The +70 volts supplies the power to the reel and blower motor amplifiers on the Motion PCBA.

4.3.2 +5 Volt Switching Regulator

The majority of the circuitry on the Power Supply PCBA consists of the +5 volt switching regulator whose output is fed to all boards except the Motion PCBA. The +5 volt supply consists of a pair of diodes connected as a full wave rectifier, a filter network, a regulator IC, a current monitor, and a reference voltage source.

A dedicated, center-tapped secondary winding of the transformer provides +24 volts to rectifier diodes D4 and D5. The +24 volts is filtered and applied to a pair of power transistors (Q2 and Q3) which are connected in parallel with each other and feed inductor L1. A voltage divider network connected across the regulator output provides a reference voltage to regulator U4 which, in turn, controls the series regulator power transistors. The output of the divider network is determined by switch settings and is set up at the factory. No further adjustment is required.

Additional circuitry provides overcurrent protection for the regulator and overvoltage protection for the +5 volt circuitry in the drive. Overcurrent protection is done by sampling the current flow through the series power transistors; overvoltage protection is

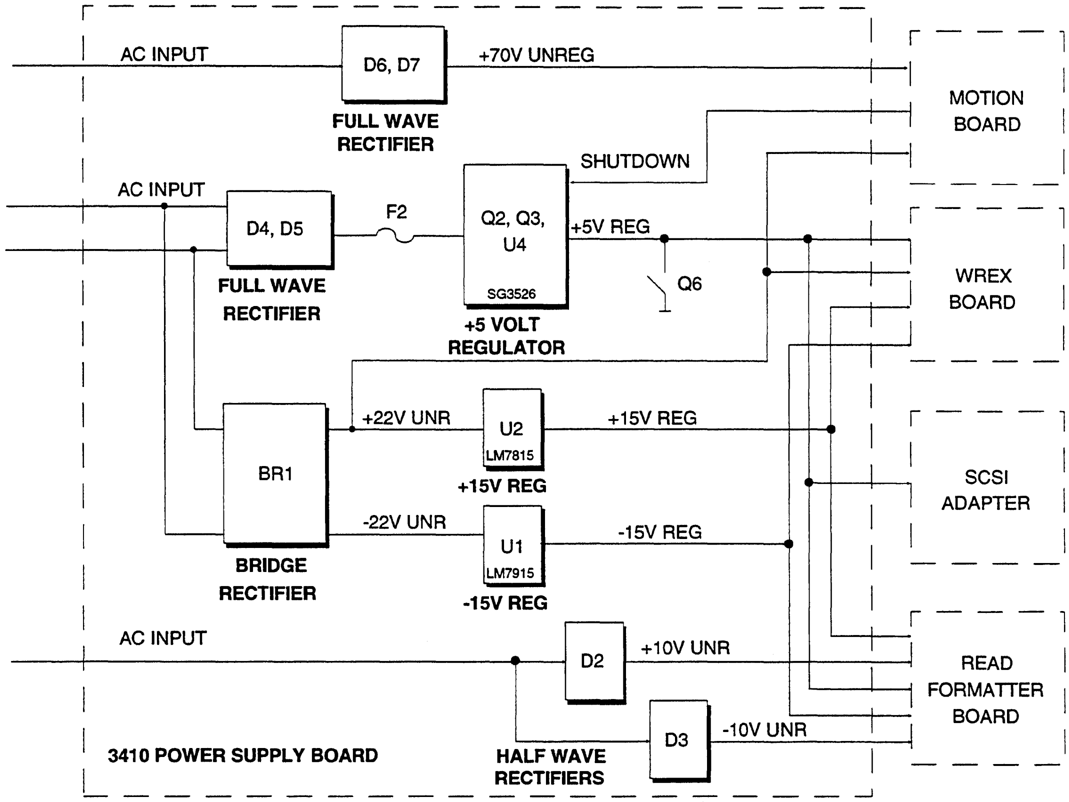


Figure 4-3 Power Supply Block Diagram

accomplished by using SCR Q6 to blow the 10 amp fuse (F2) if the output voltage rises too high.

In addition to the overcurrent and overvoltage protection, a SHUTDOWN signal to the regulator shuts down the +5 volt regulator by simulating an overcurrent condition. The SHUTDOWN input is activated by the Motion microprocessor when the internal drive temperature is too high.

4.3.3 22 Volt Unregulated Supply

A full wave bridge rectifier (BR1) supplies +22 volts to the Motion and Write Executive PCBAs. In addition, BR1 supplies a +15 volt regulator IC and a -15 volt regulator IC. The ±15 volts are used by the Read Formatter board, the Write/Executive PCBA, and the SCSI-2 Interface PCBA.

4.3.4 10 Volt Unregulated Supplies

A third winding from the transformer feeds a pair of half wave rectifiers (diodes D2 and D3), providing a filtered, unregulated ±10 volts to the Read Formatter PCBA.

Write/Executive PCBA 5

This chapter describes the Write/Executive (WREX) PCBA in enough detail to provide the service technician with a basic understanding of how it functions and interacts with the rest of the tape drive.

Three-digit schematic references consist of the schematic page number, followed by a vertical edge reference letter and a horizontal edge reference number. For example, an object located at reference 4C3 can be found on sheet 4 near the junction of vertical reference C and horizontal reference 3.

The WREX PCBA (PN 500367-01-0, Schematic 500368) has the following functions:

- Receive data and commands from the host.
- Process the commands and format the data into one of the four popular tape formats.
- Write the data on the tape.
- Control tape motion.
- Communicate with the other PCBAs and with the user and the host via the front panel and the interface.
- Oversee all operations and monitor internal tape drive conditions.

5.1 WREX Microcomputer

The main control unit on the WREX PCBA is a 68HC11 microcomputer (U43) consisting of a processor unit, an address and data bus, a 256K EPROM, an address decoder, and several input and output registers. This microcomputer oversees the operation of the entire drive by monitoring the interface and the front panel and communicating with the other microcomputers on the WREX, Motion, and Read Formatter PCBAs, and with the Display PCBA.

5.1.1 Microprocessor

The WREX microprocessor is a Motorola 68HC11 series running at 8MHz as determined by crystal Y1. External communications are organized into a series of five I/O ports, labeled PAX through PEX.

Port A provides access to a free-running timer inside the microprocessor. Only a portion of Port A on the WREX microprocessor is used. PA1 contains the LAST/ (Last Word) signal from the write formatter which notifies the WREX microprocessor that the last data byte is being processed. PA2 contains the DAVAIL (Data Available) signal from the read formatter; when DAVAIL is high, data is being read; DAVAIL going low tells the WREX microprocessor that the end of a block has been reached. TACHB, a signal derived from the tachometer, feeds PA7 and is used by the microprocessor to keep track of current tape position.

The 16-bit address bus is contained partly on Port B and partly on Port C. Port B is an output port for the eight most significant bits of the 16-bit address bus. The eight least significant bits of the address are multiplexed with data on the eight-bit, bi-directional data bus at Port C. To tell external circuitry whether address or data information is on the data bus, the microprocessor sets AS (Address Strobe) high when using the data bus to carry address information, and low when using the data bus to carry data. When high, AS enables an eight-bit latch at U18 to convert the data bus inputs into low order address bits.

Port C is a bi-directional eight-bit data bus and is the main artery of information flow throughout the WREX microcomputer. It is connected to a series of registers called input ports and output ports, and also to a 256K EPROM which holds the operating firmware.

Port D contains two asynchronous serial communication lines (RXD and TXD) and a fully synchronous, serial, bi-directional communication bus. RXD and TXD (receive data and transmit data lines) are always enabled, and are used to communicate with the microprocessors on the Motion and SCSI PCBAs at a rate of 125 KBaud. MISO, MOSI, SCK, and SSI lines form a bi-directional serial peripheral interface which communicates with the Write and Read Formatter digital signal processors (DSPs).

Port E consists of eight lines connected to an internal A/D converter with eight bits of resolution. The microprocessor uses it to measure analog signals representing various internal conditions and is described elsewhere in this section.

5.1.2 Address Decoding and Port Enabling

The microprocessor address bus (A0 through A15) is connected to a 256K EPROM at U19, and to address decoders U28 and U29. To read from and write to the various input and output registers, the microprocessor uses decoded addresses and a signal called R\W/. To read the contents of an input register, the microprocessor sets R\W/ high and places an address on the address bus. This address is decoded into one of several strobe lines (RD0/ through RD7/, which are not to be confused with read data signals from the tape) at U28. Each strobe is connected to an individual buffer device and when low, passes the inputs of the buffer to the outputs, which are connected to the data bus. Each time the microprocessor generates a strobe, it immediately thereafter reads the data bus and thereby monitors the various conditions.

To write information to an output register, the microprocessor sets R\W/ low and places an address on the address bus. This address is decoded into one of a different set of strobes (WR0/ through WR7/) at U29. Each of these strobes is connected to its own output register, and will latch the current state of the data bus into that register on the rising edge of the strobe.

5.2 Interface Line Drivers and Receivers

A series of exclusive or gates compares the drive address, set by the user via the front panel, with the current states of TAD0, TAD1 and FAD at U40. When the drive address matches the address on the interface lines, the drive will be selected and FSEL (formatter select) will go true. FSEL is used to enable IGO and ILOL at U10A and

U32B, and to gate the rewind and rewind/unload signals at U39. FSEL also enables line driver U6B which places IONL, IEARLY, IFPT, and IRWD on the interface lines.

If FSEL is true and if the drive is online and not rewinding, ONLSEL/ at U26A will go true. ONLSEL/ places the remaining drive status signals, along with IWSTR, IRSTR, and read signals IRP-IR7 on the interface lines via U6A, U7, U8 and U2B.

5.3 Host Command Processing

5.3.1 Command Bus

The interface lines IREV, IWRT, IWFM, IERASE, IEDIT, and IHISP, are controlled by the host and are presented to the drive on J1. Collectively, they are referred to as the *command bus*. The command bus is buffered by U2A, U3, and U5, and then latched into Command Register U17 by the GO signal. The WREX microprocessor reads the contents of the Command Register by setting RD0/ low.

5.3.2 IGO, IFBY, and IDBY

The host uses IGO to strobe the contents of the command bus into the drive. IGO is buffered by U3. If the drive is selected, the GO event will be latched into U10A at the rising edge of IGO, and GOL (GoLatch) will go high. GOL is fed to data bus input register U16 which is periodically sampled when the WREX microprocessor sets RD2/ low. After detecting a GO event, the WREX microprocessor can read the current state of the command bus by setting RD0/ low at U17.

The negative output of the Go Latch is connected to the preset input of the FBY flip-flop U9B, causing FBY to go true almost immediately after the rising edge of IGO. FBY is presented to the interface via line driver U2B if the drive is selected and online. The WREX microprocessor clears the FBY flip-flop by setting RD5/ low. In addition, it can set or reset the FBY flip-flop as required using its clock and D inputs via the WR0/ strobe and the D2 data bus line.

The host can extend the reinstruct window and keep the tape moving by holding IGO low. The WREX microprocessor monitors the state of IGO by periodically reading the contents of input register U16, to which GO is an input.

IDBY is under complete control of the WREX microprocessor, which latches the states of its data bus into status register U24 via WR1/. The DBY output is sent to line driver U6 and placed on the interface line IDBY if the drive is selected and online.

5.3.3 OnLine Status

The drive is online if ONL flip-flop U30A is set. The ONL flip-flop is controlled by the WREX microprocessor, which will set it when either ILOL goes true or when the ONLINE switch on the front panel is pressed. The WREX microprocessor can monitor the state of the ONL flip-flop by setting RD3/ low which reads the ONL signal onto the data bus at U14.

The Interface Load OnLine signal (ILOL) is buffered by U2A and then latched by U32B if the drive is selected (i.e., if FSEL is high). The output of the latch, LDONL, is sent to the WREX microprocessor via input register U16. The WREX microprocessor then sets ONL flip-flop U30A, placing the drive online. The microprocessor clears the LDONL latch by setting RD5/ low.

When the ONLINE switch is pressed, the event is latched by the ONLSW flip-flop U10B. The output of the ONLSW latch is sent to the WREX microprocessor via input register U16. The WREX microprocessor then sets ONL flip-flop U30A, placing the drive online. The microprocessor clears the ONLSW flip-flop via output register U23.

The ONLINE flip-flop at U30A is normally cleared by the microprocessor, but it can also be cleared if an interface rewind/unload signal is received while the drive is selected.

5.4 Tape Motion Control

While the microprocessor on the Motion PCBA controls the actual tape motion, it receives its instructions from the WREX microprocessor via a dedicated asynchronous communication port. The WREX microprocessor translates interface commands such as read, load, and rewind, into tape motion commands such as direction, speed, load, and unload and sends these commands to the Motion microprocessor using the dedicated, asynchronous communication lines. The Motion microprocessor then calculates the motor drive signals necessary to carry out the requested operation and monitors the tachometer and tension transducer signals to maintain correct tape speed and tension.

When the Motion microprocessor has completed the requested operation, it notifies the WREX microprocessor by sending a SPEEDOK signal to the WREX microprocessor via input register U15, indicating that either the tape is up to speed (at the start of a block) or that it has stopped (at the end of a block).

The WREX microprocessor keeps track of tape position by monitoring tach pulses (TACHB) in conjunction with TACHFWD.

5.5 Interboard Communications

The WREX microprocessor has a synchronous and an asynchronous serial communication port which it uses to communicate with other microprocessors in the tape drive:

- Write Digital Signal Processor (Write DSP), on the WREX PCBA (synchronous bus)
- Read Digital Signal Processor (Read DSP), on the Read Formatter PCBA (synchronous bus)
- Motion microprocessor, on the Motion PCBA (asynchronous bus)
- SCSI-2 microprocessor, on the SCSI-2 Interface PCBA (asynchronous bus)

5.5.1 Synchronous Serial Bus

To send information to the Write and Read DSPs, the WREX microprocessor uses the MOSI (Master Out/Slave In) signal, along with a synchronous clock signal (SCK). The SCK signal is or'ed with a sync pulse at U36B and sent to drivers U27A and B along with MOSI and FRAMESYNC. To gate the data to the Write DSP, the WREX microprocessor sets WRSEL/ low via output register U21, enabling U27B; to gate data to the Read DSP, it sets RDSEL/ low via U21, enabling U27A. WRSEL/ and RDSEL/ will never both be low simultaneously.

Data can be simultaneously received while it is being sent from the selected DSP.

5.5.2 Asynchronous Serial Bus

RXD and TXD constitute an asynchronous serial bus which the microprocessor uses to send and receive information to the Motion and to the SCSI-2 microprocessors. Gating logic consisting of U1, U11A and D, and U33C routes the TXD and RXD signals to and from the Motion PCBA and the SCSI-2 Interface PCBA. When MSEL (Motion Select) is high, communications are between the WREX and Motion microprocessors; when SSEL (SCSI Select) is high, communications are between the WREX and SCSI-2 microprocessors.

5.6 Extended Status Generation

The tape drive can send detailed status and error information using the Extended Status feature. Extended status consists of a series of bytes transmitted to the host over the read data lines (IRDP through IRD7). The WREX microprocessor latches the extended status information into output register U25 by setting WR3/ low. The WREX microprocessor then generates EXTSTAT/ and XRSTR/ at U21. EXTSTAT/ is used to place the contents of the register on the read data lines, and XRSTR is used as a read strobe for the extended status.

5.7 Front Panel Communications

The Display PCBA contains a two-line-by-16-character liquid crystal display (LCD), four pushbutton switches and five LED indicators. The WREX microprocessor controls the LCD and all indicators except for the BUSY indicator, which is controlled by the Motion microprocessor. A ribbon cable terminating at J27 connects the Front Panel to the Motion PCBA.

5.7.1 Front Panel Switches

The four pushbutton switches have their common contacts connected to +5 volts on the Display PCBA. LOADSW, ONLSW, DENSW, MENUSW are held at ground level by RN6 (1A4) when the switches are open. Pressing a switch closes its contacts, causing the signal to rise to +5 volts. These signals are sampled by the WREX microprocessor at U14 when RD3/ goes low (1A6). Switch contact debouncing is done in firmware. Additionally, the online switch (ONLSW) sets the ONLSWL flip-flop U10B (1A7) whenever it is pressed.

5.7.2 FPT Indicator

File protect status is controlled by the Motion microprocessor when it senses the presence of a write-enable ring. If a ring is in place, writing is enabled and FPT will be false. The WREX microprocessor can also file-protect the drive by setting RDONLY/

(Read Only) low. If the drive is in the NRZI mode, the drive will also become file protected. These three signals are or'ed at U26C (1B3).

The FPT indicator is driven by the FPT signal at U31B. If any of the signals FPT/, NRZI/, or RDONLY/ at U26 are low, FPT will be high. This will illuminate the FPT indicator and disable the write and erase current circuit.

5.7.3 ONLINE Indicator

If the ONL flip-flop at U30A is set, ONL will be high, illuminating the ONLINE indicator via driver U31A.

5.7.4 LDPOINT and MENU Indicators

The LDPOINT and MENU indicators are driven by U31E and U31F respectively and are under the direct control of the WREX microprocessor via output registers U23 and U24.

The front panel indicators are illuminated when their drive signals (LDPLED/, ONLLED/, FPTLED/, MENULED/) are low. The WREX microprocessor controls MENULED/ via U23 and WR4/, and controls LDPLED/ via U24 and WR1/. ONLLED/ is controlled by the ONL flip-flop, and FPTLED/ is controlled by the FPT signal from U26C.

5.7.5 Liquid Crystal Display Control

The front panel display is controlled by a high speed parallel interface consisting of eight data lines (DD0 thru DD7), Register Select (RS), and a strobe line (ESTB). The WREX microprocessor sets RS via U21 and WR5/ (1A6). It transfers the data to be displayed via U13 and WR6/ prior to pulsing ESTB at U9 (1A5). ESTB is set high whenever the WREX microprocessor pulses WR6/, and is reset low by the free running E-Clock (ECLK) signal from the microprocessor. A high pulse on the ESTB line latches the RS and data signals into the display.

The contrast of the liquid crystal display is controlled by the CONTRAST signal which is a DC voltage generated by two bits on from the WREX microprocessor at U22 and WR2/ and a network of four resistors (1C5).

W2 (1A4) is installed only while testing the display without the Motion PCBA connected to the cable at J27. After testing, W2 is removed.

The liquid crystal display contains an internal instruction register and an internal data register. The data register holds the characters to be displayed, while the instruction register controls the operation of the display itself. The WREX provides both instructions and data to the display using output registers U13 and U21. U13 transmits the eight-bit instruction or data byte, and the RS (Register Select) signal from output register U21 enables the appropriate display register. When RS is low, the instruction register is selected, and when RS is high, the data register is selected.

5.8 Write Data Formatting

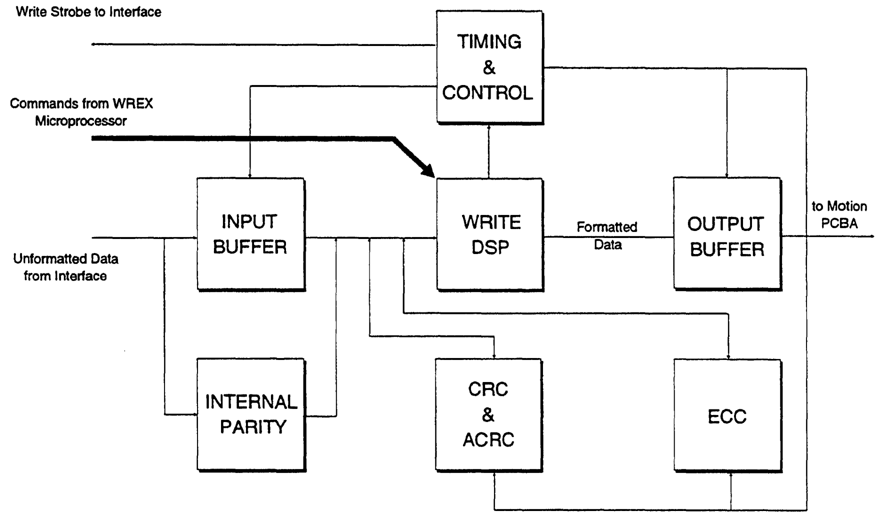


Figure 5-1 Write Formatter Block Diagram

5.8.1 Write DSP

The heart of the write formatting circuitry is a CMOS Digital Signal Processor (DSP) running at 36 MHz. The Write DSP is like a microprocessor in that it can address, read from and write to other devices, and perform a variety of instructions and calculations. Some of the features of the Write DSP are:

- 128K of program and data memory
- On-board timer
- 16-bit bi-directional data bus
- 16-bit address bus
- Synchronous serial port

The Write DSP is located at U71 and has the following tasks:

- Generates GCR mark, sync and resync fields and performs 4-to-5 group encoding
- Generates PE preamble, postamble, sync bytes, and data field
- Writes all ID bursts and filemarks and generates their associated gap times
- Supervises write timing functions

5.8.2 Synchronous Serial Bus

The Write DSP receives its instructions from the WREX microprocessor using a synchronous serial protocol consisting of the following three lines:

- **WRMOSI** - Write Master Out Slave In. This is the serial data output line from the WREX microprocessor (MOSI).
- **WRXCLK** - Write Clock. This is the clock signal which clocks the data on WRMOSI into (and WRMISO out of) the Write DSP. It is derived from CLOCK/ and the Serial Clock output (SCK) of the WREX microprocessor at U36B.
- **WFSYNC** - Write Frame Sync. This signal is derived from FRAMESYNC/ and the WREX microprocessor ECLK at U41. It consists of a pulse used to identify the first bit of an eight-bit word on WRMOSI.

MOSI, CLOCK/, and FRAMESYNC/ are also used to communicate with the read formatting circuitry. The WREX microprocessor gates these signals to the Write DSP by setting WRSEL/ (Write Select) low at U27B.

5.8.3 Commands to Write DSP

The WREX microprocessor sends the following types of commands to the Write DSP:

Select Commands - Select GCR, select PE, select DPE, select external parity, select internal parity.

Upon receipt of a Select Density command, the Write DSP calls in the appropriate instructions from the EPROMS in preparation for recording. It then generates control signals for density and parity selection (DENS0, DENS1, PSEL) at output register U66. These signals are used in the PLDs (proprietary Programmed Logic Devices) to control format timing.

Write ID Commands - Write GCR ID, write PE ID, write DPE ID, write ARA ID, and write ARA burst.

Upon receipt of a Write ID command, the Write DSP generates the appropriate pattern on the designated tracks and places it on the Write Bus until it receives a Stop command. In this way, the WREX microprocessor controls the length of all ID bursts, while the Write DSP controls the recorded pattern on the tape.

Write Commands - Write a block, write a filemark, write a maximum FRPI pattern.

Upon receipt of a Write Block command, the Write DSP will control the flow of data through the write formatter using a combination of direct enabling outputs and control signals derived from its data and address buses.

Stop Command - The Stop command will terminate the current operation immediately.

5.8.4 Write Formatter Firmware

The program for the Write DSP resides in two 64K EPROMS at U67 and U68.

5.9 General Write Data Flow

The flow of write data through the write formatter is through an input buffer, an input FIFO, onto a Write Bus, and out through an output buffer, an output FIFO, and a differential write signal generator. In the GCR mode, write data on the Write Bus is also routed through a Digital Signal Processor (the Write DSP) and through three auxiliary character generators for GCR encoding before going through the output buffer. The signal flow and associated terminology is described in more detail in the following paragraphs.

5.9.1 Write Timing Generators

The Write Timing PLD at U72 is used in conjunction with the Write DSP to generate timing signals which control the flow of write data through the WREX PCBA. The outputs of U72 are derived from WSTEN (Write Strobe Enable, which comes from the Write DSP), DENS0 and DENS1 (Density Select 0 and Density Select 1 from Write DSP output register U66), DCLK (a 9 MHz clock from the Write DSP and the 36 MHz oscillator input), and status signals from the input FIFOs. The outputs of U72 control the timing of the pedestal on the formatted write data waveforms at the output PLDS (U63, U64, and U65), the shifting of data into the input FIFOs (via ISTB), the shifting of data out of the input FIFOs (via ORDY), and the timing of IWSTR.

5.9.2 Input Buffers

Eight bits of buffered write data from the interface are clocked into a latch at U54 by XFRCK (Transfer Clock). XFRCK is generated by the Write Timing PLD at U72; it is derived from DCLK from the Write DSP and its frequency depends upon the recording density (DENS0 and DENS1). The outputs of the latch, WL0-7, together with a parity signal on WL8 and a Last Word signal on WL10, make up the Write Latch (WL) bus.

5.9.3 Last Word

The Last Word signal from the interface will set latch U50A. One output of this latch, LAST, is sent to an interrupt register in the WREX microprocessor and tells it that the last word from the interface has been received. LAST is also latched into U53 with the parity bit, and generates WL10 at the output.

5.9.4 Write Parity Generation

Whether internal or external write parity is used depends upon the Parity Select (PSEL) signal from the Write DSP. The input for this signal is a command from the WREX microprocessor via the serial bus, and ultimately originates from a front panel menu selection. If internal write parity is selected, PSEL will be low, and the parity generator at U44 will generate odd parity based upon the eight write data bits. If external write parity is selected, PSEL will be high, and the write parity line from the interface will be gated into the latch at U53. The write parity bit is carried on WL8 at the output of the latch.

5.9.5 Input FIFOs

The WL bus is applied to the input of three FIFOs (U55, U56, and U57), each of which can hold up to 16 four-bit words. Write data is shifted into U55 and U56, while the parity and last word bits are shifted into U57. WREN/ (Write Enable) enables each FIFO: When WREN/ is high, the FIFO inputs are disabled, and when WREN/ is low, the FIFO inputs are enabled. WREN/ is generated by the Write DSP at output register U66.

Data can be shifted into and out of the FIFOs independently and at different rates. When IR (Input Ready) is high, the FIFO is ready to receive data; data on the WL bus is then shifted into the FIFOs by ISTB (In Strobe) which is generated by U72 and derived from clock and density select signals. ISTB also shifts the parity and Last Word signal (WL8 and WL10) into FIFO U53.

When OR (Output Ready) is high, the first data bit is ready to be shifted out of the FIFO's output register. Data is then shifted out of the input FIFOs by FIFO Strobe flip-flop U48A. When the OR signals from all input FIFOs are high, U72 sets ORDY (Outputs Ready) high. FSTB, controlled by the Write DSP via an address decoder at U59, clocks U48A, producing a pulse which shifts a byte of data out of the FIFOs onto the DSP data bus (WB0-11).

To control the rate at which write data is fetched from the host, the Write DSP, together with clock signals, WSTEN (Write Strobe Enable) and U72, generates WSTR/ which eventually becomes IWSTR sent to the host.

5.9.6 ECC, CRC, ACRC Generators

GCR formatting incorporates special characters which are added into the write data from the host. These special characters aid in error detection and correction and contribute to other characteristics of the GCR block format itself. Exact details of GCR formatting are not a part of this circuit description.

Data strobed out of the input FIFOs and onto the Write Bus is stored in the Write DSP. The Write Bus is also connected to an ECC generator (U69), a CRC generator (U70), and an ACRC generator (U71). At times controlled by the Write DSP via address decoders U58 and U59 and by other PLDs, these generators will place ECC, CRC, and ACRC characters into the write data stream on the Write Bus.

5.9.7 Write DSP Formatting

During PE operations, the ECC, CRC and ACRC generators are not used. Data is taken directly from the input FIFOs to the Write DSP. After formatting, the Write DSP then places the formatted write data back on the Write Bus.

During GCR operations, the Write DSP takes groups of four bytes, encodes them into groups of five bytes, and places them back on the Write Bus.

5.9.8 Output Buffer and FIFO

The Write Bus is connected to the output buffer at U79. The write parity bit is buffered by a latch at U74A. Each assembled write data byte is clocked out of the buffer when W OUTR/ goes low. W OUTR/ (Write Out Register) is decoded from the Write DSP address bus at U58. The byte is shifted into output FIFOs U76, U77, and U78 by XFRSTB (Transfer Strobe) which is generated by W OUTR/ going high. Like the input FIFOs, the inputs are enabled when WREN/ goes low; unlike the input FIFOs, their outputs are always enabled.

The formatted write data is shifted out of the output FIFOs by strobe signals from three proprietary PLDs at U63, U64, and U65. These PLDs also convert the single-ended write data signals into complementary write signal pairs. The timing of each pair is such that a pedestal occurs on the leading edge of each byte to be recorded; this pedestal is used in the write power amplifiers to momentarily increase the write current and thus increase the magnetic saturation on the tape at the start of each flux reversal. The duration of the pedestal is controlled by clock signals generated by U72.

5.10 Write and Erase Current Control

5.10.1 Current Switching

Erase head current is switched on and off by the WREX microprocessor via output port U22. If the drive is not file protected, ERPWR/ going low turns Q5 on, which turns Q4 on, allowing current to flow through the erase head (ERASE+ and ERASE-). Write head center tap current is controlled by the WREX microprocessor in the same way. If the drive is not file protected, WRPWR/ going low turns Q6 on, which turns Q7 on, which applies -15 volts to the write head center-taps.

5.10.2 Write and Erase Current Monitor

The WREX microprocessor monitors erase and write current by looking at the signal WRISON/ (Write Is On) at input register U15. If either Q4 or Q7 is on, Q1 will turn on and WRISON/ will go true (low).

5.10.3 Write Current Control

The amount of write current flowing through the heads is variable and depends upon the recording density. The actual value is calculated by circuitry on the Read Formatter PCBA and is sent to the WREX PCBA via a signal called WRVOLTS. WRVOLTS is a DC level and is applied to amplifier U42 which drives power transistor Q2. If the drive is not file-protected, Q2 will apply a positive voltage from Q3 to the head coil switching transistors on the Motion PCBA.

The write current calculation is done at the factory during setup, but the user can tailor the drive to the tape currently in use via the front panel. When this option is selected, the drive will perform a write current calculation each time it writes from BOT in the GCR mode.

5.11 Miscellaneous Functions

5.11.1 Read Parity Generator

Read data from the Read Formatter comes into the WREX PCBA at connector J25 and is applied to interface line drivers U2B and U6. If the drive is online and selected, the line drivers are enabled. The read data is also applied to parity generator chip U12 which generates odd read parity. Its output will be high if an even number of inputs are high, and low if an odd number of inputs are high.

5.11.2 Read Strobe

The read strobe signal sent to the interface normally is generated by the Read Formatter PCBA (RSTR/) and comes in on the WREX board via J25. From J25, it goes to one leg of an OR gate. The other leg of the OR gate is XRSTR/ which is generated by the WREX microprocessor. XRSTR is used as the interface read strobe when the read lines contain extended status information.

5.11.3 MENU Enable

Jumper W1 (1A4) on the WREX PCBA has two positions: MENU ON and MENU OFF. The ON position enables full access to all menus (except the CE menu). The OFF position inhibits changes to the Drive Configuration menu, the SCSI Enable, Def. Config. and Def. SCSI Config. funtions. W1 has no effect on the ONLINE, LOAD, and DENSITY switches. The WREX microprocessor reads the position of W1 via input buffer U16.

5.11.4 Internal Conditions Monitor

The microprocessor chip uses its analog port to monitor various internal conditions. Each of the following signals is conditioned by a voltage divider and filter network before it is applied to Port E:

- **WRVOLTS** - a signal from the Read Formatter board used to determine the value of write current through the write heads (VWRITE)
- **VWRITE** - the write current signal generated on the WREX PCBA and dependent upon the value of WRVOLTS
- **RTHV** - a signal from the Read Formatter PCBA which represents the current read threshold
- **TERM** - a signal from the terminators indicating that termination voltage is present and within specification
- **MON6V** - a signal indicating that the ±6 volts to the Read Amplifier PCBAs are operational
- **±15V** - the output of the ±15 volt regulators on the Power PCBA
- **+22V** - the output of the +22 volt regulator on the Motion PCBA

5.11.5 Write Data Monitor

Input register U20 allows the WREX microprocessor to monitor the interface write data lines. This register is used during factory programming only and is not enabled during normal operations.

5.11.6 Last Word (ILWD)

ILWD from the host interface is or'ed with a signal from the WREX microprocessor called TLWD/ at U36A (1B3). This allows the WREX microprocessor to simulate a last word signal during internal diagnostic commands as well as when a write operation is aborted. LASTWORD is used to indicate the end of the data being recorded.

5.11.7 Hard Error (HER)

The interface signal IHER is activated by either the Read Formatter via HERA on J25 (1B1) or by the WREX microprocessor via HERB at U23 (1B6). The two signals are or'ed by U38D to form the IHER signal sent to the host.

5.11.8 WREX PCBA Testpoints

- **DBY** - Data Busy is controlled by the microprocessor. When the drive is selected and online, DBY is inverted to become IDBY.
- **FBY** - Formatter Busy is generated by IGO and is cleared by the microprocessor. When the drive is selected and online, FBY is inverted to become IFBY.
- **FSEL** - Formatter Select is high when the unit address set at the front panel matches the address sent by the host.
- **ONL** - Online is generated by the microprocessor, and is cleared by the microprocessor or by a rewind or unload operation. When the formatter is selected, ONL is inverted to become IONL.
- **RDY** - Ready is controlled by the microprocessor. When the formatter is selected, RDY is inverted to become IRDY.
- **RWD** - Rewinding is generated by either a rewind or an unload operation, and is cleared when the tape reaches load point (BOT) or by the microprocessor. When the drive is selected and online, this signal is inverted and becomes IRWD.

5.11.9 WREX PCBA Jumpers

- **W1** - When W1 is installed across pins 1 and 2, the ConfigurationMenu mode is enabled; the drive configuration can be changed and the Maintenance and CE modes can be entered. When W1 is installed across pins 2 and 3, or when W1 is missing, the Configuration Menu mode is disabled.
- **W2, 3, W4** - These jumpers are only used during factory testing and are normally not installed.

- **W5** - When installed, W5 applies a ground to the write formatter DSP reset pin which will reset it. W5 is only used during PCBA testing and is normally not installed.
- **W6** - When installed, W6 applies a ground to the microprocessor reset pin which will reset it. W6 is only used during PCBA testing and is normally not installed.

Read Formatter PCBA 6

This chapter gives an overview of the Read Formatter PCBA (and provides enough information to allow the service technician to recognize major circuit areas and to follow the general data flow through the PCBA. The Read Formatter PCBA is a multi-layer PCBA containing a Digital Signal Processor (DSP), many Programmed Logic Devices (PLDs), and several ROMs functioning as look-up tables for the GCR error correction circuitry. Due to the complexity of the PCBA and its many busses, much of the PCBA is not repairable without the use of extensive test equipment and detailed design knowledge. Therefore, the description of the Read Formatter PCBA is kept to a functional level.

Three-digit schematic references consist of the schematic page number, followed by a vertical edge reference letter and a horizontal edge reference number. An object located at reference 4C3 can be found on sheet 4 at the junction of vertical reference C and horizontal reference 3.

The purpose of the Read Formatter PCBA is to recover data from the tape, perform error correction and translate the data into a format usable by the host. Three different Read Formatter PCBAs may be found in 34XX tape drives:

- **PN 500377-01-5 (Schematic 500378)** - This PCBA was only used in 3410 and 3412 drives and was discontinued in October of 1992. This PCBA contains read recovery circuitry for all four densities (800, 1600, 3200 and 6250 cpi) and can be easily identified by the nine small Read Channel PCBAs which are plugged into the PCBA. It has been replaced by PN 500557-01-2.
- **PN 500497-01-5 (Schematic 500497)** - This PCBA is only used in the 3402/3404 drives. It contains read recovery circuitry for 1600 and 3200 cpi (PE) only, and does not have any Read Channel PCBAs.
- **PN 500557-01-2 (Schematic 500558)** - This PCBA replaces the 500377 PCBA and is used in all drives except the 3402 and 3404. The nine Read Channel PCBAs have been replaced by several VLSI (very large scale integration) chips.

The remainder of this chapter is divided into three sections, each dedicated to a functional description of the three different Read Channel PCBAs.

6.1 500377 Board

The following paragraphs describe the seven major blocks comprising the 500377 Read Formatter PCBA, and refer to Figure 6-1.

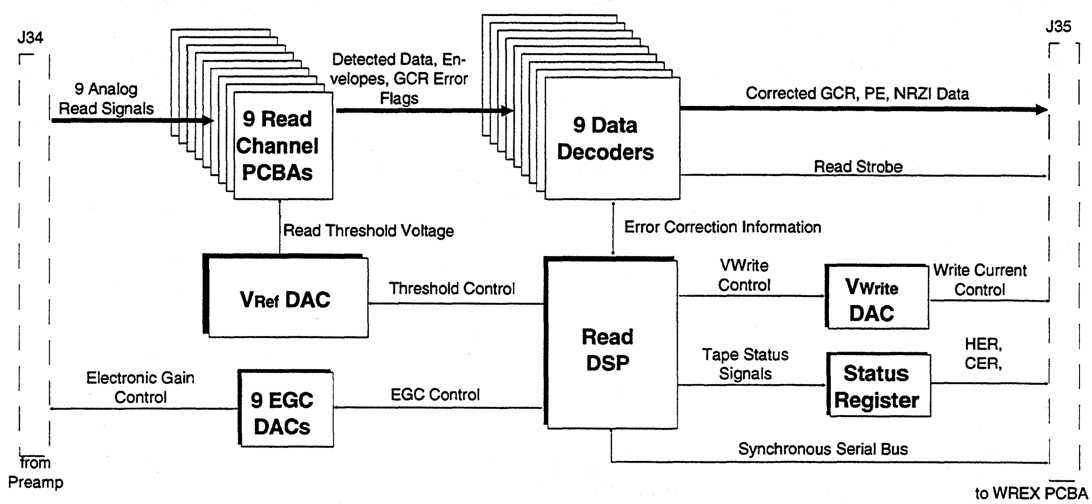


Figure 6-1 500377 Read Formatter Block Diagram

6.1.1 Read Channel PCBAs

Mounted on the Read Formatter PCBA are nine identical Read Channel PCBAs. These PCBAs receive raw analog read data from the Preamplifier PCBA and convert it into digital data for further processing by the read decoding circuitry. A series of read amplifiers, comparators, bandwidth selectors and an onboard phase lock oscillator provide digitized data outputs, read envelopes, and GCR error flags for each individual channel.

6.1.2 Read DSP

The heart of the Read Formatter PCBA is the Read Digital Signal Processor, (DSP) which runs at 36 MHz. The Read DSP is like a microprocessor in that it can address, read from and write to other devices, and perform a variety of instructions and calculations. Some of the features of the Read DSP are:

- 128K of program and data memory
- Onboard timer
- 16-bit bi-directional data bus
- 16-bit address bus

- Synchronous serial port.

The Read DSP has the following tasks:

- Detects PE preambles, postambles, and sync bytes
- Detects filemarks and ID bursts
- Detects single- and two-track errors in GCR, (single-track errors only in PE)
- Detects NRZI CRC and LRC errors
- Generates CER, HER, and FMK signals which eventually go to the host
- Generates timing and control signals which are used on the Read Formatter PCBA for data recovery and error detection/correction
- Communicates with the WREX microprocessor via the serial busses.

The WREX microprocessor sends the following types of commands to the Read DSP:

- **Select Commands** - Select GCR, DPE, PE,or NRZI densities.
- **Write Current and Read Gain Selection Commands** - These commands are used to set the initial gains of the read amplifiers and to establish the write currents according to the selected density. Some calibration commands are used only when the drive receives a read command while the tape is positioned at BOT.
- **Set Threshold Command -** These commands are used to select the appropriate read threshold depending upon the current activity (read-after-write, IBG traverse, normal read).
- **Set Read Mode Commands** - Read ID burst, Read Forward, Read Reverse, Space Forward, Space Reverse.
- **Set Error Reporting Commands** - These commands are used to set the CER reporting mode (report all CERs, report 2-track CERs only, or do not report CERs at all), and to set the HER line true.
- **Extended Status Commands** - These commands are used to transfer extended status information to the host.
- **Stop Command** - This command terminates the present command immediately.

The program for the Read DSP resides in a pair of EPROMs at U1 and U15. These EPROMS store a total of 8K by 16 bits of program memory.

6.1.3 Read Threshold DAC

The Read Threshold Generator consists of an eight-bit digital-to-analog converter (DAC) whose inputs are controlled by the Read DSP. The output of the DAC is a DC level which can be monitored at testpoint RDTHV. RDTHV is then routed to the peak detector amplifiers on each Read Channel PCBA.

6.1.4 Electronic Gain Control DAC

The gain of the analog read recovery circuits is controlled by the Electronic Gain Control (EGC) voltages applied individually to each read channel at the preamplifier stage. The circuitry which generates the EGC voltages consists of a discrete six-bit DAC, a DC amplifier, a demultiplexer and an output driver for each channel.

The DAC inputs are controlled by the Read DSP and consist of a separate value for each channel. Density inputs modify these values accordingly.

The output of the DC amplifier can be monitored at testpoint EGCMX (Electronic Gain Control Multiplexed) and will be a varying DC level. Each of the nine calculated values exists at a separate time, and each value is associated with a particular read channel.

6.1.5 Write Current Control

The Write Current Control circuitry of a discrete DAC and an analog amplifier. The DAC receives its inputs from the Read DSP; the output of the amplifier is a DC level and can be monitored at testpoint WRV. WRVOLTS is sent to the WREX PCBA where it becomes an input to the write current generator to modify the write current according to the recording density.

6.1.6 Status Register

The Read DSP is responsible for detecting hard errors, corrected errors, filemarks, and check characters (NRZI) and generates the appropriate interface signals (HER, CER, FMK, and CCG respectively). The Read DSP places these signals in a status register for later transmission to the host via the WREX PCBA.

6.1.7 On-Board Regulators

Not shown in the functional diagram of the Read Formatter PCBA are two on-board regulators which provide a regulated ±6 volts from the ±15 volt supplies. The ±6 volts is used in the read amplifiers on the Read Channel PCBAs.

The output of the two regulator ICs are and'ed together to produce a MON6V signal. As long as both regulators are operational, MON6V will be 0 volts. MON6V is monitored by the WREX microprocessor, which will show a message on the front panel if one or the other regulator fails.

6.1.8 Testpoints (500377-01)

AGND - Analog ground. This testpoint should be used as reference when monitoring the outputs of the ±6 volt on-board regulators on the Read Formatter PCBA.

ALGN - Align signal. This signal is generated by the Read DSP at U9. It is low during the GCR preamble, goes high 2/3 the way through the GCR preamble, and goes low again when Mark1 has been detected. It remains low during the data portion of the block. It is used by the Deskew FIFO and can be used as a scope trigger to look at data coming out of the Deskew FIFOs.

ALLRDY - All ready.

CCG/ - Check Character Gate/ will be low when the Read DSP detects the NRZI CRC and LRC characters.

CER - Correctable Error will be high whenever the Read DSP detects a single-track dropout during PE operation, or when it detects a single- or two-track dropout during GCR operation.

DAVAIL - Data Available is a signal which is goes high when the Read Formatter gets a Read command from the WREX PCBA and ENV/ is low.

EGCMX - Electronic Gain Control Multiplexed. This is a multiplexed DC signal which contains a separate EGC level for each read channel.

ESTB - E Strobe is a subgroup clock used to shift decoded GCR data into the Delay FIFOs.

FMK - Filemark will be high whenever the Read DSP detects a filemark in any density.

G1-G9 - These ground testpoint are located throughout the Read Formatter PCBA and should be used when monitoring signals on the Read Formatter PCBA.

HER - Hard Error will be high whenever the Read DSP detects one of the following conditions:

- A two-or-more track dropout has been detected during PE operation;
- A three-or-more track dropout has been detected during GCR operation;
- A CRC or ACRC error has been detected during GCR operation;
- A CRC or LRC error has been detected during NRZI operation.

MARK - This signal will be high when a Mark1 subgroup has been detected on all tracks. Mark1 is used to tell the Read DSP that GCR data is imminent.

RDCH - Read Channel. This signal is used by the Read DSP to read and process data.

RDGAT/ - Read Gate goes low when the Read Formatter receives a Read command from the WREX PCBA and ENV/ is low.

RDTHV - Read Threshold Voltage is a reference voltage for the nine Read Channel PCBAs. It is controlled by the Read DSP via DAC U10 (4B7), and is a DC level which varies according to the status of the current operation.

RSTR - Read Strobe. This signal eventually becomes the interface signal IRSTR. Its pulsewidth is determined by Counter U36 (2A3) and associated enabling circuitry.

SYNC - Sync will be high when a GCR Sync subgroup has been detected on all tracks.

WRV - This sets the write voltage for the Write Formatter.

9ENV/ - This is a composite signal of the nine read envelopes.

6.2 500497 Board

The following paragraphs describe the seven major blocks comprising the 500497 Read Formatter PCBA, and refer to Figure 6-2.

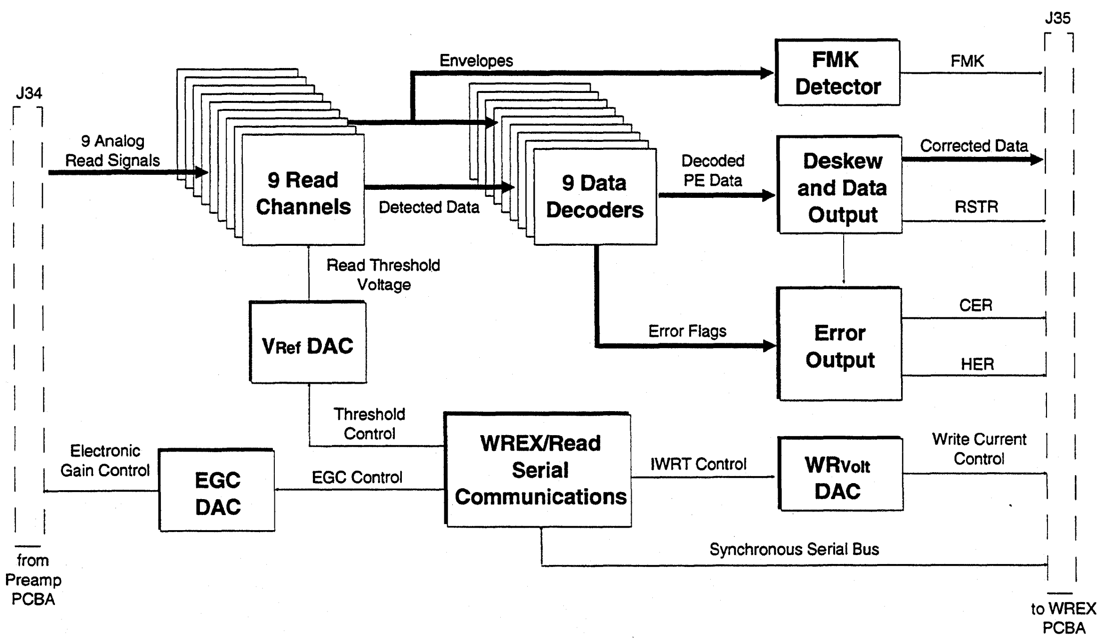


Figure 6-2 500497 Read Formatter Block Diagram

6.2.1 Read Channels

The read head signals are amplified by a nine-channel preamplifier located behind the head. The gain of each channel on the preamplifier is individually controlled by DC levels from nine EGC (electronic gain control) DAC's located on the Read Formatter PCBA. The operation of the EGC DAC is described in the following section.

The read signals from the Preamplifier PCBA are delivered to nine separate and identical analog read channels on the Read Formatter PCBA. Each channel compares the incoming analog data signal to a reference voltage (read threshold) to produce a qualified digital read signal. The read threshold voltage is under control of the WREX microprocessor via a synchronous serial bus. This allows WREX microprocessor to optimize the threshold voltage to the operation in progress (i.e., read/write, error recovery, density, etc.)

The output of each read analog channel to the read decoders consists of digitized read data not yet deskewed or decoded.

6.2.2 EGC DAC

The gains of each channel of the nine-channel Preamplifier PCBA are controlled by nine independent DC voltages. Each is generated by a dedicated four-bit DAC controlled by the WREX microprocessor via the synchronous serial bus.

6.2.3 Read Decoders

The digitized read data from each read analog channel is applied to a read decoder. A VCO (not shown in the diagram) is used to synchronize the decoding circuitry to the incoming data stream in typical PLL fashion. The PLL allows the decoders to track changes in tape speed and to compensate for data tapes which may not have been recorded at the correct speed. The PLL tracks the PE decode chip of channel 2. If channel 2 is out of commission, channel 6 is used.

The read decoders strip away the preambles, postambles, and sync bytes from the data blocks and perform read deskewing. They also perform single track error detection and correction.

6.2.4 WREX Serial Communication

Communications between the WREX microprocessor and the Read Formatter PCBA take place via a high-speed serial communications bus. The communication consists of sending an eight-bit address to the Formatter PCBA followed by an eight-bit command which gets clocked into the addressed register.

The WREX microprocessor sends the following types of commands:

- **Select Commands** - Selects 1600 or 3200 cpi operation.
- **Write Current and Read Gain Selection Commands** - These commands are used to set the value of the EGC DACs and to establish the correct write current.
- **Set Threshold Command -** These commands are used to select the appropriate read threshold depending upon the current activity (read-after-write, IBG traverse, normal read).
- **Set Read Mode Commands** - Read ID burst, Read Forward, Read Reverse, Space Forward, Space Reverse.

In addition to transferring information from the WREX microprocessor, the serial data bus is used to send error and ID burst information from the Formatter PCBA to the WREX PCBA.

6.2.5 On-Board Regulators

The power supply furnishes a regulated +5 volts, ±15 volts and an unregulated ±10 volts DC. The ±10 volts DC are regulated by a +6 volt regulator and a -6 volt regulator. These are the only on-board regulators, and they are used in the nine read analog channel amplifiers and differentiators.

6.2.6 VRef DAC

The VRef DAC is an eight-bit discrete digital to analog converter which provides a reference voltage to the nine read channels. This reference voltage is also referred to as the read threshold voltage, and is used to convert the analog read signals into digital read signals (detected data). The read threshold voltage is controlled by the WREX microprocessor via the synchronous serial bus.

6.2.7 Write Voltage DAC

This discrete six-bit DAC generates a write current control voltage between zero and five volts positive. Its output is sent to the WREX PCBA where it is used to control the write current through the head.

6.2.8 Testpoints (500497-01)

+6V and -6V - Regulated voltages to read channels.

AG1-AG6 - Ground references to ±6 volts.

+15V and -15V - Regulated voltages to read channels.

VCC - +5 volt power to integrated circuits.

ANA0-ANA7, ANAP - Analog signals for channel 0 through channel 7, and the parity channel.

ZCD0-ZCD7, ZCDP - Zero crossing detect for channel 0 through channel 7, and the parity channel.

RTHV - Read threshold voltage. This is the output of the eight-bit VRef DAC.

VCOCTL - VCO Control is a DC level that is generated by wrapping a PLL around either channel 6 or channel 2 decoder.

24XCLK - Output of the VCO, this 24X clock drives all nine decoders. The "window" signal of one of them drives a tracking oscillator which in turn generates the VCOCTL signal, closing the loop.

WDW2 - Window from channel 2 decoder. This window is used to control the PLL unless an error occurs in channel 2.

WDW6 - Window from channel 6 decoder. If an error occurs in channel 2, this signal is used to control the PLL.

WRVOLT - This DAC output is sent to the WREX PCBA to control the write current.

FDBY - Formatter Data Busy is a command from the WREX PCBA to the Formatter PCBA to look for activity.

DAVAIL - Data Available is the response from the Formatter PCBA to the WREX PCBA that activity has been found.

FMK - This signal indicates that the activity found was a filemark.

RSTR - Read strobe indicates the activity found was data. This signal also clocks the data to the WREX PCBA.

HER - Indicates a hard error was detected while processing data.

CER - Indicates an error was found while processing data and the data is corrected.

DETECT - Indicates sufficient envelope activity to respond to a WREX command.

SOUT/ - Shift Out (low) clocks data out of the deskewing circuits.

OSTB - Outstrobe shifts data out of the parity tree.

PDETL - Postamble Detect Latch indicates the postamble has been found.

XPDET/ - Auxiliary Postamble Detect (low) indicates the postamble has been found by the auxiliary detect circuit, which functions only if one channel has been "dead-tracked", then recovered.

SELZCD - Selected Zero Crossing Detect is the zero crossing signal from the channel that has been "dead-tracked".

6.2.9 Jumpers (500497-01)

Jumpers W1 and W2 are removed during factory test and must be installed for normal operation.

6.3 500557 Board

This section describes the major blocks comprising the 500557 Read Formatter PCBA, and refer to Figure 6-3.

6.3.1 Read Analog Channels

The read head signals are amplified by a nine-channel preamplifier located behind the head. The gain of each channel on the preamplifier is individually controlled by DC levels from nine EGC (electronic gain control) DAC's located on the Read Formatter PCBA. The operation of the EGC DACs is described in Section 6.3.2.

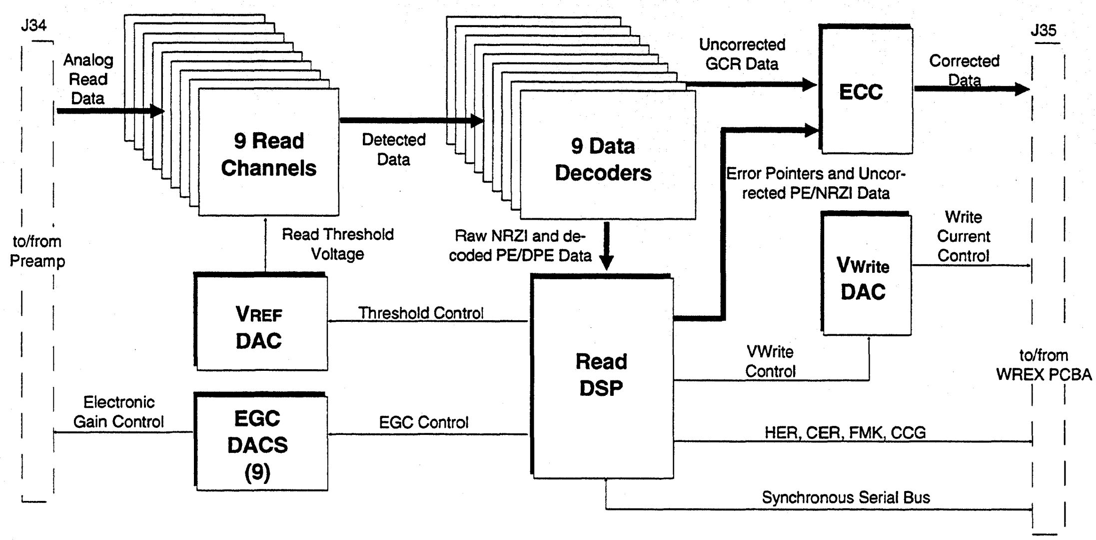


Figure 6-3 500557 Read Formatter Block Diagram

The read signals from the Preamplifier PCBA are delivered to nine separate and identical analog read channels on the Read Formatter PCBA. Each channel compares the incoming analog data signal to a reference voltage (read threshold) to produce a qualified digital read signal. The read threshold voltage is under control of the Read DSP, which in turn communicates with the WREX microprocessor via a synchronous serial bus. This allows WREX microprocessor to optimize the threshold voltage to the operation in progress (i.e., read/write, error recovery, density, etc.)

Three selectable bandwidths are used: A narrow one for NRZI data, a medium one for both PE densities and for low speed (62.5 ips) GCR, and a wide bandwidth for high speed (125 ips) GCR. The bandwidth switching (not shown in Figure 6-3) is controlled by the Read DSP.

The output of each read analog channel to the read decoders consists of digitized read data not yet deskewed or decoded.

6.3.2 EGC DAC

The gains of each channel of the nine-channel Preamplifier PCBA are controlled by nine independent DC voltages. Each is generated by a dedicated eight-bit DAC controlled by the Read DSP. In GCR, the value is determined by an EGC algorithm during the ARA burst at the beginning of tape. In PE, an initial default value is used which is dynamically optimized as the tape is read. This function can be turned off in the Drive Configuration menu. In NRZI, factory-set default values are used.

6.3.3 Read Decoders

The digitized read data from each read analog channel is applied to a read decoder along with a VCO (voltage controlled oscillator) signal. Each of the nine read decoders actually contains two separate VCOs which are used to synchronize the decoding circuitry to the incoming data stream in typical PLL fashion. One of the VCOs is used during PE, DPE, and low speed GCR operations, and the other is used during high speed GCR operations only. The PLL allows the decoders to track changes in tape speed and to compensate for data tapes which may not have been recorded at the correct speed.

In the GCR mode, the read decoders perform five-to-four GCR decoding and strip out all the special characters in the data block such as Mark 1, Mark 2, Sync, etc. Any illegal groups are also detected. In the PE modes, and together with the Read DSP, the read decoders strip away the preambles, postambles, and sync bytes from PE data blocks. The read decoders also perform read deskewing for all densities.

Decoded GCR data leaves the read decoders and goes directly to the error correction circuitry (ECC) where one and two track error detection and correction is performed. PE and NRZI data, on the other hand, is sent to the Read DSP which performs single-track error detection and correction for PE. There is no error correction in the NRZI mode.

6.3.4 Read DSP

The Read Digital Signal Processor (DSP) runs at 40 MHz and is the heart of the Read Formatter PCBA. It is like a microprocessor in that it can address other devices and read from and write to them, and can perform a variety of instructions and calculations. Some of the features of the Read DSP are:

- 128K of program and data memory
- Onboard timer
- 16-bit bi-directional data bus
- 16-bit address bus
- Synchronous serial port

It is the job of the Read DSP to control the data recovery and error correction processes and to provide write current control to the write head. The program for the Read DSP resides in a pair of EPROMs at U9 and U11. These EPROMs store a total of 64K by 16 bits of programming memory. However, the actual code that runs while the drive is reading resides in fast static RAM at U10 and U12.

The Read DSP generates timing and control signals which are used on the Read Formatter for the following tasks:

- Data recovery
- Interblock gap detection

- Error detection and HER/CER flag generation
- Error pointer generation for error correction circuits
- Threshold, EGC, write current, and bandwidth control
- Filemark and ID burst detection
- NRZI check character gate (CCG) generation
- NRZI CRC and LRC error detection and reporting
- PE single track error detection and correction

The Read DSP communicates with the WREX microprocessor via a serial communications port. Some of the commands which the WREX microprocessor sends to the Read DSP via this port are:

- **Read command switching** - Read forward/reverse, read ID burst, space forward/reverse.
- **Density and speed switching** - The Read DSP uses these commands to select the proper bandwidth, read threshold, and EGC values for the read recovery circuits.
- **Write current calibration** - A fixed write current is used for PE. A calibration algorithm is used when writing in GCR to ensure than an optimal read signal is achieved during read-after-write. This is done only once in front of the BOT tab if the drive were writing from BOT.
- **Automatic read amplifier adjustment** - During GCR operation, read calibration is done over a pre-written area of tape in front of the BOT tab, during which the gain of each read channel is adjusted. In the PE modes, the read gains are dynamically optimized while the tape is being read.
- **Extended status control** - These commands are used to transfer extended status information to the host.

6.3.5 ECC

Decoded GCR data leaves the decoding circuits and goes directly to the error correction circuitry (ECC), while PE data is sent first to the Read DSP. If a data error is detected, the Read DSP will compute an appropriate error pointer and send it to the ECC where the actual error correction takes place.

6.3.6 VWrite DAC

The current in the write head is controlled by an eight-bit DAC that is controlled by the Read DSP. The signal is sent to the WREX PCBA where it becomes an input to the write current generator to modify the write current according to the recording density. The value of VWRITE (write voltage) is factory-set in PE. In GCR, the value is determined dynamically prior to BOT by an algorithm similar to that used to determine the value of EGC, allowing the write current in GCR to be optimized to the tape currently mounted on the drive.

6.3.7 On-Board Regulators

Not shown in Figure 6-3 are two on-board regulators which provide regulated ±6 volts DC for the read analog circuits. They have their own raw supplies and are completely independent of the ±15 volt supplies, and of the +5 volt supply.

The outputs of the two regulators are combined to produce a voltage which is monitored by the WREX microprocessor. If the voltage is incorrect, a message will be displayed on the front panel.

6.3.8 Testpoints (500557-01)

DBY - Data Busy. Instruction to the Read Formatter PCBA to look for activity from the tape.

DAVIL - Data Available. Response to the WREX PCBA that activity has been found.

RSTR/ - Read Strobe (active low). If data is detected, this signal clocks it to the WREX PCBA.

FMK - Filemark. This informs the WREX PCBA that the activity found was a filemark.

CCG - Check Character Gate. This signal informs the WREX PCBA that the data byte currently being sent is either the CRC or LRC character. It is only valid during NRZI operations.

CER - Corrected Error. This signal informs the WREX PCBA that error correction has taken place. It is not used in NRZI.

HER - Hard Error. This signal informs the WREX PCBA that error correction has failed. Hard Error will be high whenever the Read DSP detects one of the following conditions:

- A two-or-more track dropout has been detected during PE operation;
- A three-or-more track dropout has been detected during GCR operation;
- A CRC or ACRC error has been detected during GCR operation;
- A CRC or LRC error has been detected during NRZI operation.

The following testpoints are related to DAC voltages:

DAC 12 - There are twelve DACS, eleven of which are used. This one is a spare.

VREF - This voltage is used by the nine read analog channels as the read threshold.

WRVOLTS - This voltage is sent to the WREX PCBA to establish write current.

EGC0-EGC7, EGCP - These are the electronic gain control voltages for read analog channels 0 through 7, and parity.

The following testpoints are input/output signals to the nine read decoders. There are nine sets of six, one set located within the silk-screened boundaries of each channel. The silk screen depicts an imaginary set of six, and the channel number of each set of six is determined by location.

ZXING - Zero Crossing. This is the output of the comparator driven by the differentiator within the read analog channel. The transitions indicate flux changes on the tape. In the absence of data on the tape, this signal will be noisy.

PHERR - Phase Detector Error, PLL. This variable duty factor signal provides error information to the analog section of the phase lock loop.

DDET - Data Detected. These are outputs from the read recovery circuits to the skew circuits. A high level indicates a one-bit, and a low level indicates a zero-bit.

ENV - Envelope. This is a high signal that straddles the entire block of data.

AMOKP and AMOKN - Amplitude Okay Positive and Negative. When these signals are low, the current transition of ZXING is valid.

The following are power supply testpoints:

+15V and **-15V** - ±15 volt supply to the read analog circuits.

+5V - Five volts for the digital circuits.

G1-G16 - These sixteen testpoints are all digital ground testpoints. They are the references for the +5 and ±15 volt supplies.

+6V and -6V - ±6 volts for the read amplifiers.

AG1-AG6 - These six analog ground testpoints are the reference for the ±6 volt supplies.

The remaining testpoints are used for engineering development and are not described.

6.3.9 Jumpers (500557-01)

The 500557-01 PCBA has the following jumpers (part number 684-0021-7):

- **RESET** - This is not really a jumper, but a pair of pins which, when shorted together, will reset the Read DSP. This pin pair is to be left open during normal operation.
- **CLK** - Present in Revision A boards only, this jumper is removed during factory test and must be installed for normal operation.

- **ROP** - When replacing the WREX or the Read Formatter PCBA (500557 only), you must check the revision of the WREX PCBA and then install/remove the Read Output Parity (ROP) jumper accordingly:

    a. If the WREX PCBA is revision G or later, you must install the ROP jumper on the Read Formatter PCBA or else read errors will result.

    b. If the WREX PCBA is revision A through F, you must remove the ROP jumper or else U28 on the Read Formatter PCBA will overheat and eventually fail, again causing read errors.

Miscellaneous Circuitry 7

This chapter describes miscellaneous electronic components of the 34XX Series Tape Drive in enough detail to provide the service technician with a basic understanding of how they interact with the remainder of the drive.

Three-digit schematic references consist of the schematic page number, followed by a vertical edge reference letter and a horizontal edge reference number. For example, an object located at reference 4C3 can be found on sheet 4 at the junction of vertical reference C and horizontal reference 3.

Descriptions of the following topics are included:

- Read Channel PCBAs (PN 500247-01-0, Schematic 500248)
- Read Preamplifier PCBA (PN 500237-01-4, Schematic 500238)
- Display PCBA (PN 500397-01-5, Schematic 500398)

7.1 Read Channel PCBAs

7.1.1 General Information

Nine identical Read Channel PCBAs are plugged into the 500377 Read Formatter PCBA, one for each read channel. The 500497 and 500557 Read Formatter PCBAs do not have Read Channel PCBAs.

Because the PCBAs are physically identical, they may be interchanged with one another for troubleshooting purposes. However, before returning the tape drive to normal operation, the Read Channel PCBAs should be returned to their original locations.

Each channel consists of a differential amplifier, an envelope generator, a zero-crossing detector, a pulse qualifier, and a variable frequency oscillator.

7.1.2 Differential Amplifiers

Differential read signals from the Read Preamplifier PCBA are fed into a pair or differential amplifiers at U10 and U11. The output of U10 feeds a pair of comparators, while the output of U11 feeds a peak detector. During PE and NRZI operations, C30 and C31 change the input bandwidth for both U10 and U11 while C32 and C33 change the differential gain of U11 only. This is done by analog switches U12A, B, C, and D. During GCR operation, C30, C31, C32, and C33 are switched out of the circuit.

7.1.3 Digitizer

The differential output of U10 is compared in comparator U8 to VREF. VREF is the read threshold voltage, which varies according to the current operation (i.e., read, write, of IBG). The value of VREF is common to all read channels and is automatically determined. Whenever the analog inputs to U8 go higher than the DC threshold voltage on pins 1 and 12, the outputs on pins 4 and 9 will be negative. These outputs, OKP/ and OKN/, will always be opposite in polarity to one another and are applied to the input of the envelope generator PLD U7.

7.1.4 Zero-Crossing Detector

Comparator U9 is a comparator connected as a zero-crossing detector. Whenever the level of the analog inputs, which are opposite in polarity, are equal, the outputs on pins 4 and 9 will change states.

7.1.5 Envelope Generator

The outputs of digitizer U8 go to a PLD configured as an envelope generator (U7). In the NRZI mode, U7 pin 5 will be high. This causes the PLD to generate a negative pulse at pin 9 for each flux transition on the tape. during NRZI, ENV/ is the data output of each Read Channel PCBA.

During PE and GCR, U7 acts as a true envelope detector, and the output on pin 9 will go low after four flux transitions on the tape have been detected. The ENV/ signal will go false if no data is present at the input for seven clock times from U5 pin 8.

In GCR and PE, AERR/ (amplitude error) will go low if no data is present at the input for six clock times. This output is used in the GCR error correction circuitry on the Read Formatter PCBA.

7.1.6 Pulse Qualifier

The PLD at U6 is configured as a pulse qualifier, and is not used during NRZI operations. Its inputs are the envelope signals and the digital signals from the zero-crossing detector. Each time its output (pin 18) goes low, flip-flop U4B pin 8 (DDET) goes high. DDET is a data detect signal and is the data output in PE and GCR to the Read Formatter PCBA.

The Phase Error output at pin 20 (PERR/) will go low if a phase error has been detected. This output is used in the GCR error detection circuitry on the Read Formatter PCBA.

7.1.7 Variable Frequency Oscillator

The remainder of the circuitry on the Read Channel PCBA is a variable frequency oscillator (VFO). The purpose of the VFO is to track the incoming data and to produce an error if excessive phase shifting should occur.

U2 is a dual voltage-controlled oscillator (VCO). Each part is enabled via the GCR/ and PE/ signals at the enable inputs (pins 6 and 11). The outputs on pins 7 and 10 (VCO1 and VCO2) are connected to PLD U3. This PLD is configured as a phase comparator. The frequency of VCO U2 is controlled by the voltage level on pins 1 and 2, and this signal is derived from the output of phase comparator U3 pin 8. The longer the duration of each positive pulse on pin 8, the more positive the control input is to the VCO. A more positive control input will lower the VCO frequency, and a more negative control input will raise its frequency.

7.1.8 Testpoints

Each Read Channel PCBA contains a row of ten testpoints, located at the top center of the PCBA. The testpoints are labeled J3, with pin 1 near U4 (towards the rear of the drive) and pin 10 near U8 (towards the front). These testpoints, identified on schematic 500248, reference 1B2, are listed in Table 7-1.

J3 pin-	SIGNAL	REMARKS
1	DDET	Data DETect: Digital data output
2	ENV/	ENVelope (inverted). GCR and PE: High during gaps, low during data. NRZI: Low for each flux transition on tape.
3	PERR/	Phase ERRor: Valid only during GCR, indicates a phase error when low.
4	OKN/	Digital read data at output of threshold comparator. Will be positive while analog input is more positive than VREF (read threshold voltage).
5	OKP/	Digital read data at output of threshold comparator. Will be negative while analog input is more negative than VREF (read threshold voltage).
6	AERR/	Amplitude ERRor: Valid only during GCR, indicates an amplitude error when low.
7	unassigned	—
8	ANALOG	Read differentiator output going to threshold comparator
9	unassigned	—
10	GROUND	This ground should be used as reference when monitoring signals on the PCBA.

Table 7-1 Read Channel Test Points

7.2 Read Preamplifier PCBA (500237-01)

7.2.1 General Information

The first stage of read signal amplification is located on the Read Preamplifier PCBA. To optimize the signal/noise ratio, the Read Preamplifier PCBA connects directly to the read head. The PCBA contains three triple differential amplifier devices and a pair of voltage regulators. The amplifier devices are powered by +5 volts and -6 volts, and each channel has its own amplifier circuit. The +5 volt and -6 volt regulators are supplied by 15 volt inputs to the PCBA.

7.2.2 Gain Control

The gain of each amplifier is individually controlled by FEGC 0-7,P (Filtered Electronic Gain Control, channels 0 through 7 and Parity). Each FEGC signal a DC level which is under control of the WREX microprocessor. During GCR operations, the WREX microprocessor recomputes the values on the nine FEGC lines using the ARA burst on the tape, each time a tape is loaded. Those values, which may be different for each channel and from one tape to another, are used until either another tape is loaded, or until the recording density is changed.

The FEGC values for NRZI and PE operations are determined during factory test and are used each time the machine operates in the NRZI or PE modes.

7.3 Display PCBA (500307-01)

The Display PCBA is perhaps the least complicated PCBA in the drive. It contains four pushbutton switches (LOAD, ONLINE, DENSITY, and MENU), five LED indicators (BUSY, LDP, ONL, FPT, and MENU), and a two-line, 16 character alphanumeric liquid crystal display unit. The indicators and the display unit are all controlled by the WREX microprocessor, which also periodically checks to see if any switch is depressed. There are no test points on the PCBA.

Preventive Maintenance 8

Preventive maintenance for the 34XX tape drive consists solely of keeping the head and tape path clean. The front panel display will indicate TIME2 CLEAN HEAD after a predetermined amount of tape has passed the head. This message is a reminder that the head and tape path components must be cleaned. The user can change the interval at which this message appears to suit individual environmental and operating conditions. Refer to the Menu chapter of the 34XX User's Guide (500300) for more information about this feature.

8.1 Purpose

As magnetic tape ages, the oxide particles on the coated side loosen and flake away from the tape. While most of these loose oxide particles will be caught by the tape cleaner as the tape passes through the tape path, some will be deposited on the head. If allowed to accumulate, the data reliability of the tape drive will be adversely affected, first appearing as recoverable data errors and progressing to hard errors during all attempts at data transfer. Because the tape cleaner removes the larger particles of dirt and dust, it must be periodically cleaned along with the oxide buildup on the head if maximum data reliability is to be achieved.

A buildup of oxide on the write head gaps acts like a keeper across a magnet and reduces the magnetic saturation of the flux reversals on the tape. A similar buildup on the read head gaps can cause a reduction in the induced signal from the tape. In severe cases, the buildup can actually lift the tape away from the head surface, further reducing signal strength.

In addition to the oxide deposits on the head, dirt, dust and oxide particles can accumulate on the tape guide surfaces and flanges. If allowed to accumulate, they can be transferred to the recording side of the tape when it packs onto the supply and take-up reels. In extreme situations, heavy accumulations on the guide surfaces can induce a skew effect resulting in data errors most noticeable when reading tapes generated on other drives.

8.2 Frequency

Several factors affect the frequency of cleaning:

- **Age and condition of the tape** - As previously stated, oxide particles tend to flake off older tapes more readily than off newer ones. The more that older tapes are used, the more frequently the tape path will have to be cleaned.

- **General cleanliness of the operating environment** - Tape drives which are operated in dusty, smokey, or high humidity environments, or in machine shops or heavy manufacturing areas will require more frequent cleaning than those which are operated in office environments or in computer rooms.

- **Tape handling and storage** - The use of tapes which are not properly handled and stored will require more frequent tape path cleaning. Tapes which are left on work benches will accumulate dust on the reel flanges which will eventually work its way into the tape path. Tape which has been partially unwound onto the floor or which has picked up fingerprints will transfer the dust and oil from the fingerprints to the tape cleaner and guides, necessitating more frequent cleaning.

  Exposing tapes to excessive heat (i.e., stored in automobiles on hot days, etc.) causes the binding material which holds the magnetic particles to the tape to migrate to the surface. When such tapes are run, this binding material (glue) is transferred to the tape cleaner and the head, resulting in stiction, tape motion problems and data errors. Tapes which have been exposed to high heat should be destroyed.

- **Amount of tape which has passed through the tape path** - Tape drives which run several thousand feet of tape through them each day will require more frequent cleaning than tape drives which are used only a few minutes a day. The 34XX tape drive features a head cleaning odometer which records how much tape has passed the heads. When a predetermined value is reached, the liquid crystal display indicates TIME2 CLEAN HEAD, reminding the user to clean the tape path. The reminder will appear each time the tape is unloaded until the user resets the odometer using the front panel controls.

Note: *The* TIME2 CLEAN HEAD *reminder should be considered an absolute maximum and assumes that the tape drive is operated in a clean office environment and that the tapes are handled properly. If the tape drive is operated in a dusty environment or if dirty, old, or mishandled tapes are used, the tape path must be cleaned more frequently, and the interval at which the reminder appears should be changed accordingly. Refer to the 34XX User's Guide instructions on changing the interval at which the head clean message appears.*

8.3 Tape Path Cleaning Procedure

Dirt shows up as dark brown or black smudges on the face of the head and is often difficult to see. A strong light and a small inspection mirror can be used to see the head more clearly. When cleaning the head and tape path, do not use abrasive materials, detergents, or general purpose cleaning solutions, as they can cause permanent damage to the head surface and roller bearings. Use only 91% isopropyl alcohol and non-abrasive applicators such as TexPads®.

1. Clean the entire surface of the head, including the erase head. Rub firmly until all deposits are removed.

2. Clean the tape cleaner blade.

3. Clean the surface of all rollers and guides. Clean the areas between the roller surfaces and their flanges. Be especially alert to deposits under the caps on the reference guides and make sure these areas are clean.

Subassembly Replacement 9

To replace these parts,	See Section:
General Access	9.2
SCSI PCBA	9.3
Read Formatter PCBA	9.4
Write Executive PCBA	9.5
Power Supply PCBA	9.6
Motion Control PCBA	9.7
Preamplifier PCBA	9.8
Display PCBA	9.9
Read/Write Head	9.10
Sensors	9.11
Tape Guide Subassemblies	9.12
Motor Rotors and Stators	9.13
Hall PCBAs	9.14

Table 9-1 Field Replaceable Subassemblies

DANGER! **HAZARDOUS VOLTAGES ARE PRESENT WHEN THE BASE IS IN THE SERVICE POSITION AND THE POWER IS ON. WHENEVER REMOVING PCBAS OR SUBASSEMBLIES FROM THE TAPE DRIVE, ALWAYS DISCONNECT THE MAIN POWER CONNECTOR FROM THE REAR OF THE UNIT.**

ESD Caution! ***Because many of the PCBAs contain static sensitive components which can be destroyed by a static discharge unnoticable to the technician, always observe proper ESD precautions and perform all work in an ESD-protected work environment.***

9.1 Before You Start...

You can remove most of the subassemblies and PCBAs inside the drive by simply raising the base to the service position. However, it may be easier in some cases to work on the drive when it is open and resting on its side, as is the case when replacing the Motion PCBA. The procedure for doing this is included in Section 9.7, *Motion PCBA Replacement*.

In most cases, subassembly reinstallation is the exact reverse of the removal procedure. Any special items you need to be aware of will be noted after the removal procedure.

Some of the mechanical subassemblies may require alignment after they are replaced. Anything you need to accomplish this will be mentioned before the removal instructions for that subassembly.

9.1.1 Required Tools

1. The following common tools are all that are required in the course of replacing most of the subassemblies and PCBAs in the tape drive:

    a. #2 Phillips screwdriver

    b. Flat blade screwdriver

    c. 1/4 inch nut driver

    d. 1/4 inch combination wrench

    e. Diagonal cutters (for cutting cable ties)

    f. Needle-nosed pliers

    g. 1/16 inch Allen driver

    h. 9/64 inch Allen driver

    i. 3/32-inch Allen driver

    j. 7/64 Allen driver

    k. 5/32 inch Allen wrench with a 90° bend

2. The following special purpose tools, while not absolutely required, are recommended:

    a. Cover switch override tool (Qualstar P/N 600144-01-8)

    b. Torque wrench with 1/4-inch socket, set to 5 inch-pounds (read/write head screws)

3. The following tools are required only for motor disassembly:

    a. 3/16 inch Allen socket (3/8 inch drive)

    b. Torque wrench, 0 to 200 inch-pounds (3/8 inch drive)

    c. 9/16 inch hex socket (3/8 inch drive)

    d. 3/32 inch hex socket (3/8 inch drive)

    e. 3/8 inch drive ratchet wrench or breaker bar, one foot long

9.1.2 Miscellaneous Parts

In addition to these tools, you may need a small quantity of cable ties to replace those cut during subassembly removal.

To facilitate assembly during manufacturing, most of the subassemblies are fastened to the base with self-tapping screws. These self-tapping screws can be identified by their brass color and if they are reinserted improperly, they will cut new threads in the hole and render the hole useless. Use care when reusing these self-tapping screws, or replace them with standard thread, 6-32 x 3/8 inch pan head screws (Qualstar part number 700-0606-9).

9.2 General Access

9.2.1 Removing the Top Cover

1. Unplug the AC power cord from the rear of the drive.
2. If the drive has side covers, remove them by removing the five Phillips screws in each one.
3. Lift the top cover and remove the two Phillips screws which fasten the hinged support arm to the top of the base.
4. Use the needle-nosed pliers to extract the hitch pin from each hinge pin at the rear of the cover.
5. Remove the hinge pins and lift off the top cover.

9.2.2 Removing the Rear Cover

1. Unplug the AC power cord from the rear of the drive.
2. Remove the two Phillips screws which hold the rear cover to the rear of the chassis.
3. Slide the rear cover back about 1/4 inch, then lift it up and off.

9.2.3 Accessing the Take Up Reel and Blower Fan

1. Unplug the AC power cord from the rear of the drive.
2. Remove the top cover as previously described.
3. Remove the seven Phillips screws which hold the blower cover to the base.
4. Remove the two Phillips screws which fasten the flat air baffle to the base between the read/write head and the tape cleaner.
5. Lift off the blower cover and air baffle assembly.

9.2.4 Locking the Base in the Service Position

DANGER! **THE HINGED SUPPORT BRACKET CONTAINS AN INTEGRAL SAFETY LATCH MECHANISM. FOR YOUR SAFETY, ALWAYS INSURE THIS SAFETY LATCH IS ENGAGED BEFORE WORKING WITH THE BASE IN THE SERVICE POSITION.**

The base is raised to the service position follows:

1. Using the 9/64 inch Allen driver, loosen the captive shipping screws which secure the base to the front of the main chassis. See Figure 9-1.

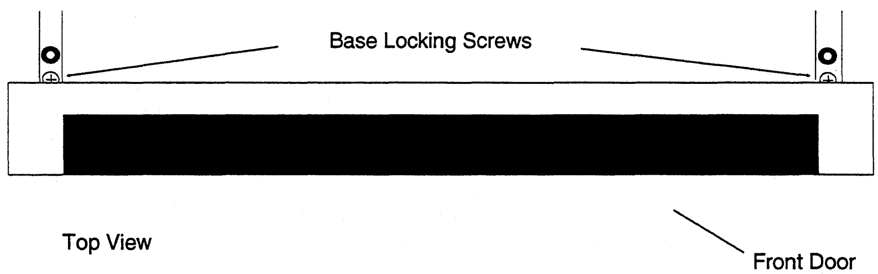


Figure 9-1 Top cover raised showing location of base locking screws

2. With both hands, lift the base to the full open position (about 50°).
3. Support the base with the left hand and pull the support hinge all the way forward with the right hand.
4. While holding the support hinge forward, lower the base to the service position.
5. Push the center of the hinge towards the rear of the tape drive to engage the safety latch.

9.3 SCSI PCBA Replacement

See Figure 9-2 for SCSI PCBA component identification.

9.3.1 Required Tools

#2 Phillips screwdriver
Flat blade screwdriver
1/4 inch end wrench
7/64 Allen driver

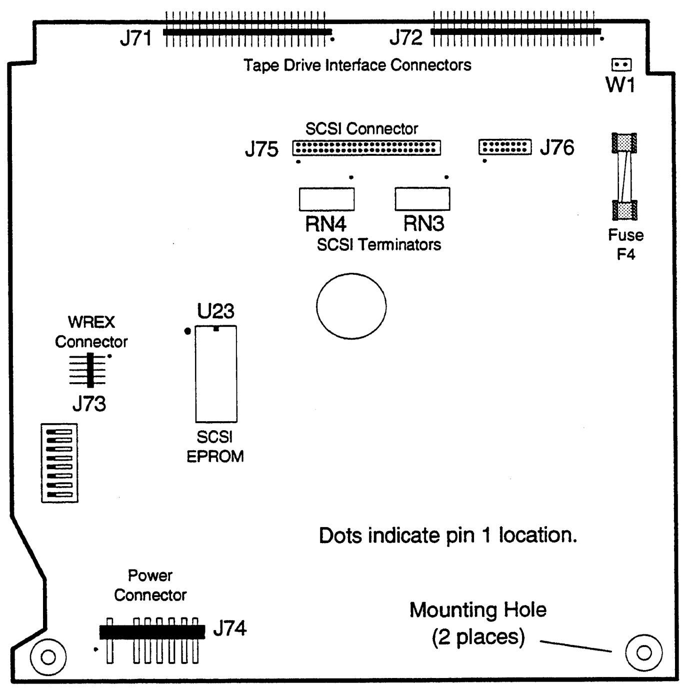


Figure 9-2 SCSI PCBA (500417)

9.3.2 SCSI PCBA Removal Procedure

1. Unplug the power cord from the tape drive.

2. Remove the rear cover as described in Section 9.2.2.

3. Differential SCSI drives:

   a. Locate the ribbon cable coming from the rear of the tape drive to the SCSI connector on the Differential Adapter PCBA and unplug it;

b. Remove the two Phillips screws which secure the SCSI connector plate to the rear of the drive;

c. Remove the SCSI connector plate and attached ribbon cable from the rear of the drive;

d. Remove the Differential Adapter PCBA by lifting it out of its card guides;

e. Remove both card guides from the SCSI PCBA using a 7/64 inch Allen driver.

4. Single-ended SCSI drives:

   a. Locate the ribbon cable coming from the rear of the tape drive to J75 SCSI connector on the SCSI PCBA and disconnect it from the SCSI PCBA by pulling the connector straight up. Do not pull on the ribbon cable;

   b. Remove the two Phillips screws which secure the SCSI connector plate to the rear of the drive;

   c. Remove the SCSI connector plate and attached ribbon cable from the rear of the drive.

5. Loosen the Tape Drive Interface cables J71 and J72 at the rear SCSI PCBA by pushing them to the rear of the drive as far as possible (about 1/8 inch). A flat blade screwdriver may help.

6. Lock the base in the service position following the procedure in Section 9.2.4.

7. Disconnect J74 power cable at the front of the SCSI PCBA.

8. Disconnect J73 WREX cable from the SCSI PCBA near the power transformer. (Early drive models will not have a cable connected to J73.)

9. Locate the one inch long plastic hex standoff from the inside of the right chassis wall near the front of the SCSI PCBA and remove it.

10. Remove the two 1/4 inch nuts which secure the front of the SCSI PCBA to the chassis.

11. Lift the SCSI PCBA up and forwards about an inch, then reach around and completely disconnect J71 and J72.

12. Lift the SCSI PCBA out the front of the drive.

9.3.3 SCSI PCBA Installation Procedure

1. Position the SCSI PCBA over the WREX PCBA and slide it to the rear, taking care that the fiber insulating sheet does not snag any components on the WREX PCBA, and that the two ribbon cables from the WREX PCBA are straight.

2. While the SCSI PCBA is still about one inch out, plug P1 and P2 ribbon connectors into the rear of the SCSI PCBA.

3. Slide the SCSI PCBA into the two slotted hex standoffs at the rear of the WREX PCBA, and lower the front over the two mounting studs at the front of the WREX PCBA.

Note: *It is essential that both slotted hex standoffs engage the rear of the SCSI PCBA. This can only be done by sliding the SCSI PCBA straight back and into both slots simultaneously. Do not procede until the PCBA is properly seated in the slots.*

4. Reinstall the two nuts at the front of the SCSI PCBA.

5. Reinstall the one inch plastic hex standoff on the inside of the right chassis wall.

6. Reconnect J73 WREX connector and J74 power connector.

7. Differential SCSI drives only: Reinstall the two card guides and the Differential Adapter PCBA.

8. Disengage the safety latch and lower the base to the operating position..

9. Feed the cable from the SCSI connector plate through the opening in the rear of the drive and connect it to J75 on the SCSI PCBA, or to the Differential Adapter PCBA.

10. Secure the SCSI connector plate to the rear panel using two Phillips screws.

11. Reinstall the rear cover.

9.3.4 Required Adjustments

None.

9.4 Read Formatter PCBA Replacement

The Read Formatter PCBA can be removed using the following procedure.

9.4.1 Required Tools and Parts

1/4 inch nut driver
#2 Phillips screwdriver

9.4.2 Read Formatter Removal Procedure

See Figure 9-3 for mounting hole locations.

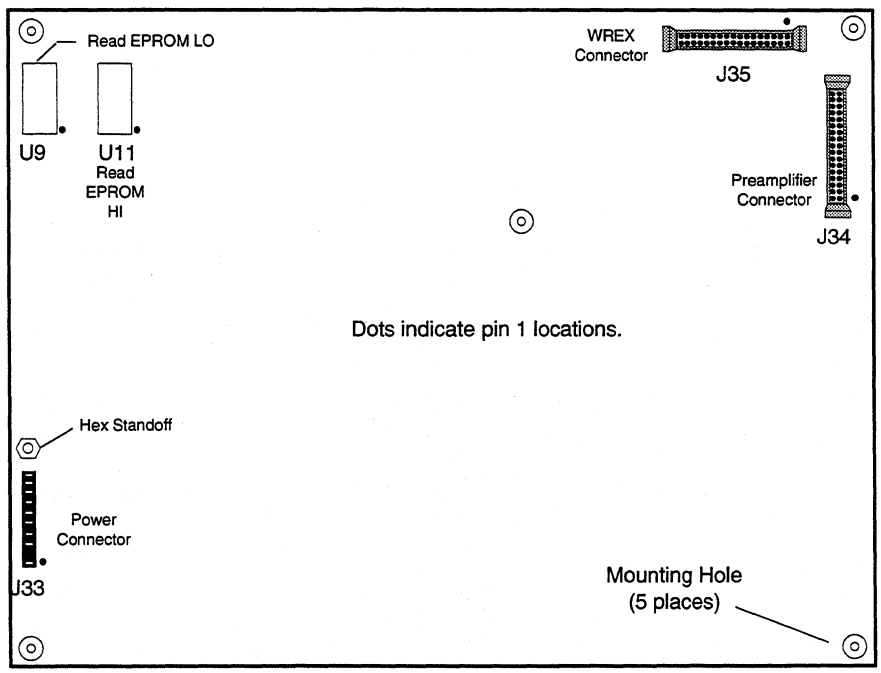


Figure 9-3 341X Read Formatter (500557)

1. Unplug the power cord from the rear of the drive.
2. Lock the base in the service position as described in Section 9.2.4.
3. Unplug ribbon connectors J34 and J35. If the drive contains a SCSI PCBA, you will have to remove the two nuts at the front of the SCSI PCBA and lift it up in order to unplug J35 from the rear of the Read Formatter PCBA.
4. Unplug J33 power connector.

5. 341X drives only: Remove the screw which secures the power cable tie mount to the standoff above the power connector.

6. SCSI drives only: Unplug J74 power connector from the front of the SCSI PCBA.

7. Remove the four 1/4 inch mounting nuts (one at each corner) and one Phillips screw (near the center of the PCBA).

8. If the Read Formatter has Read Channel PCBAs (early 3410/3412 only), remove the two Read Channel PCBA clamps (four screws) and lift the Read Formatter PCBA out of the chassis.

9. Lift the Read Formatter PCBA out of the chassis.

9.4.3 Read Formatter Installation Procedure

The procedure to install the Read Formatter PCBA is the reverse of the removal procedure.

9.4.4 Required Adjustments

No adjustments are required after replacing the Read Formatter PCBA. However, on all models other than the 3402/3404, you will need to perform the Board Change function in the Maintenance Service menu.

9.5 Write Executive PCBA Replacement

The Write Executive (WREX) PCBA can be removed for service using the following procedure.

9.5.1 Required Tools

1/4 inch nut driver
1/4 inch open end wrench

9.5.2 WREX PCBA Removal Procedure

See Figure 9-4 for mounting screw locations.

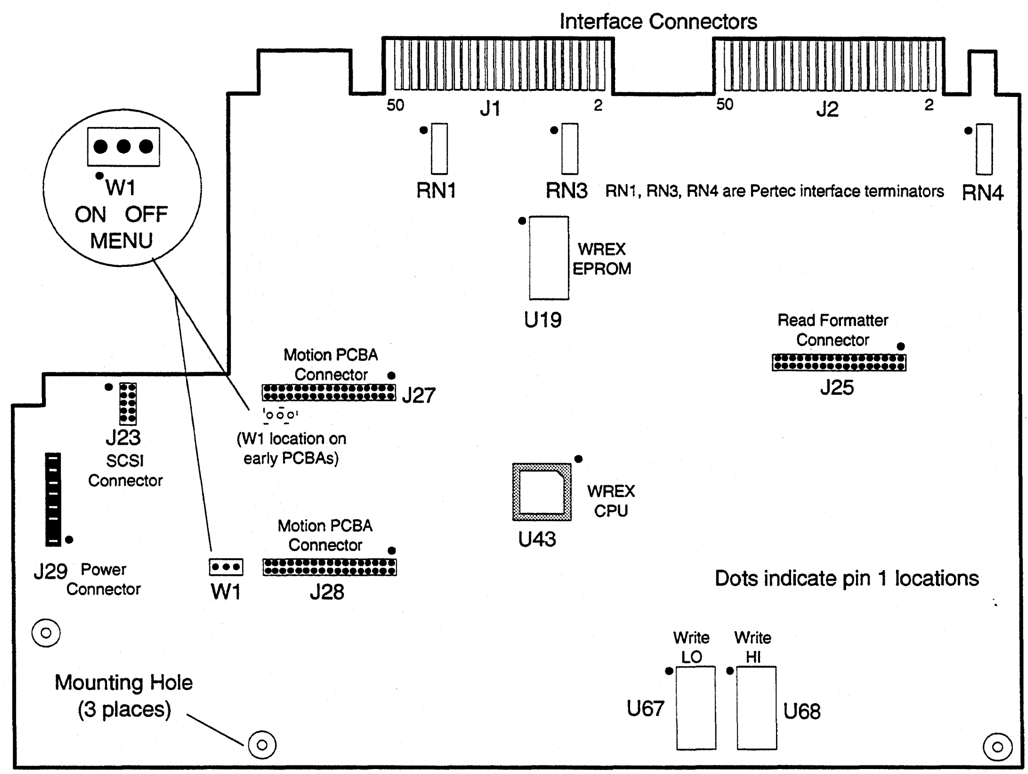


Figure 9-4 WREX PCBA (500367)

1. Unplug the power cord from the rear of the drive.
2. Lock the base in the service position following the procedure in Section 9.2.4.
3. SCSI drives only: Remove the SCSI PCBA following the procedure in Section 9.3.
4. Unplug J35 ribbon connector at the rear of the Read Formatter PCBA and J28 ribbon connector at the center of the WREX PCBA.

5. Unplug J29 power connector.
6. Locate and remove the two 1/4 inch hex standoffs at the forward corners of the WREX PCBA.
7. Using a 1/4 inch end wrench, remove the 1/4 inch nut just in front of J29 at the left edge of the WREX PCBA.
8. Lift the WREX PCBA up to clear the mounting studs, then slide it forward about half an inch and lift it out of the chassis.
9. Disconnect J27.

9.5.3 WREX PCBA Installation Procedure

Note: *Because the 68HC11 microprocessor on the WREX PCBA stores operating parameters, maintenance history, and drive configuration information, it must be transferred to the replacement PCBA whenever the WREX PCBA is replaced.*

The procedure to install the WREX PCBA is the reverse of the removal procedure. Use the following guidelines during the reinstallation.

1. SCSI drives only: Plug ribbon connectors J1 and J2 into the back of the WREX PCBA before installing the PCBA.
2. Hold the WREX PCBA over the Read Formatter PCBA and plug in ribbon connectors J27 and J28.
3. Make sure the ribbon cables from J27 and J28 fold neatly between the WREX PCBA and the power receptacle box at the rear of the drive.

9.5.4 Required Adjustments

If the 68HC11 microprocessor from the original PCBA is not transferred to the replacement PCBA, it will be necessary to perform the motion calibration procedure; otherwise, no adjustments are required after replacing the WREX PCBA.

Perform the Board Change function in the Maintenance Service menu.

9.6 Power Supply PCBA Replacement

The Power Supply PCBA is attached to the chassis and can easily be removed using the following procedure.

9.6.1 Required Tools

1/4 inch nut driver
Needle-nosed pliers

9.6.2 Power PCBA Removal Procedure

1. Unplug the power cord from the rear of the drive.
2. Lock the base in the service position following the procedure in Section 9.2.4.
3. Unplug the power connectors from the Power PCBA.
4. Unplug the eight slide-on connectors at the rear of the PCBA.
5. Remove the two nuts in the front of the PCBA and the two in the middle. Do not remove the two nuts at the rear.
6. Slide the PCBA forward about half an inch and lift it out of the chassis.

9.6.3 Power Supply PCBA Installation Procedure

The procedure to install the Power Supply PCBA is the reverse of the removal procedure.

Note: *After you have installed the Power Supply PCBA, route the two wires from the fan connectors between the second and third capacitors nearest the front of the drive and down along the edge of the board.*

9.6.4 Required Adjustments

No adjustments are required if the Power Supply PCBA is replaced.

9.7 Motion PCBA Replacement

9.7.1 General Information

The Motion PCBA is attached to the underside of the base assembly and can be removed while the base is in the service position. However, you may find it easier to first remove the drive from the system (if it is rack-mounted) and set on its side on a work bench (power switch down). The base support bracket can then be disconnected from the base and the unit opened wider for easier access. This lessens the possibility of dropping and loosing hardware on the lower PCBAs, and greatly facilitates removal and replacement of the Motion PCBA.

9.7.2 Required Tools and Parts

#2 Phillips screwdriver
Needle-nosed pliers
Small diagonal cutters
Two cable ties

9.7.3 Required Adjustments

If the Motion PCBA is repaired or replaced, the automatic motion calibration procedure must be performed before returning the drive to service. You will need a full 2400 foot reel of tape for this procedure.

9.7.4 Motion PCBA Removal Procedure

See Figure 9-5 for connector and mounting screw locations.

1. Unplug the power cord from the rear of the drive.

2. Gain access to the drive as follows (optional):

   a. Remove the drive from the system and place it on a suitable work surface with the power switch down;

   b. Loosen the two base clamp retaining screws and position the drive on its side with the power switch down;

   c. Open the drive fully and locate the ribbon cable which connects the Preamplifier to the Read Formatter PCBA;

   d. Disconnect P61 at the rear of the Power Supply PCBA;

   e. Unplug this cable from the Read Preamplifier PCBA to prevent damaging it during the next step;

   f. Remove the two Phillips screws which hold the hinged support arm to the underside of the base;

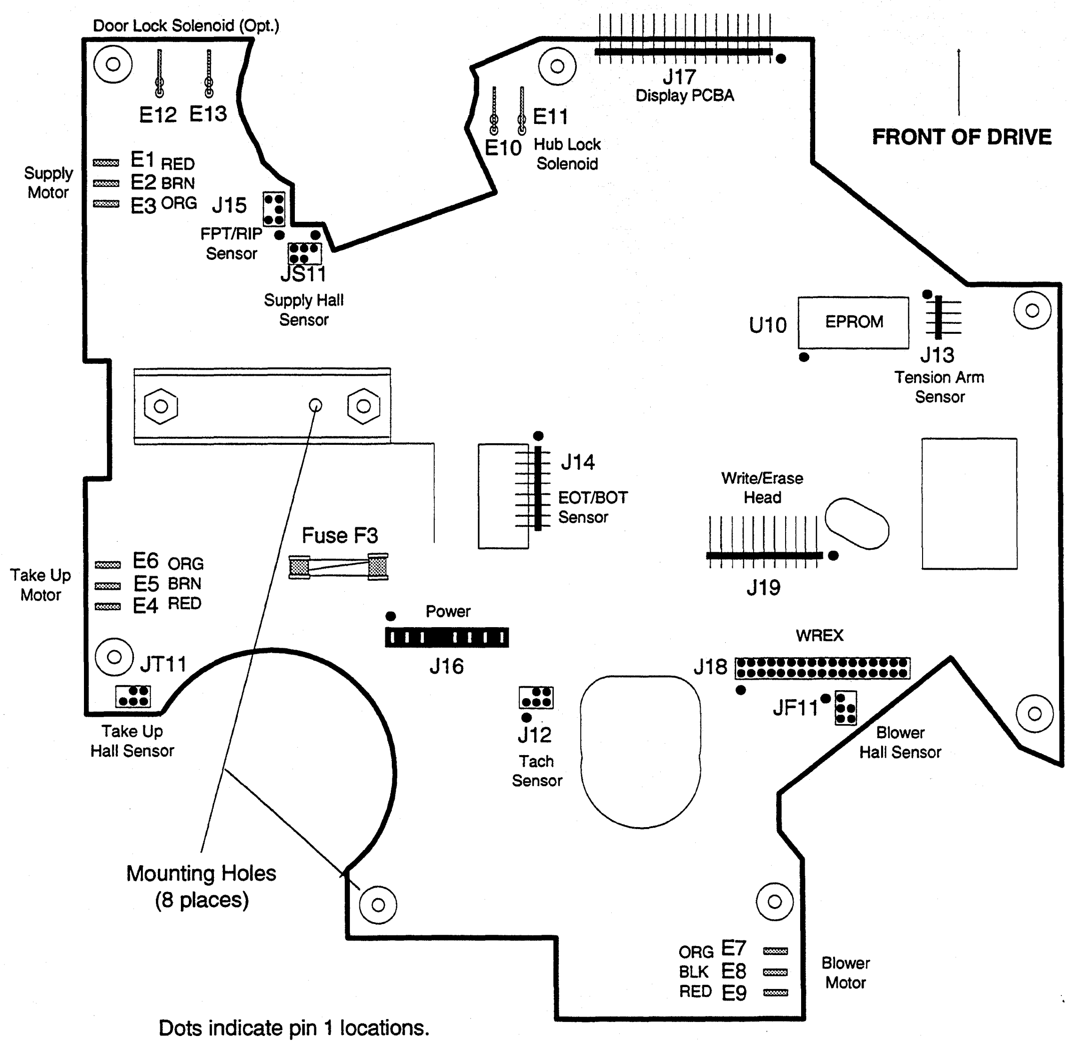


Figure 9-5 Motion PCBA (500277)

g. Move the hinged support arm away from the base and open the base to about a 90° angle. This will facilitate access to the various cables and screws.

3. Unplug or remove the following:

   a. Locate the red, brown (or black) and orange wires which are in the immediate vicinity of the supply, take up and blower motors (E1-E3, E4-E6, and E7-E9). Using a pair of needle-nosed pliers, carefully unplug them from the Motion PCBA. *Pull the connector, not the wire;*

b. Unplug E10 and E11 hub lock solenoid wires (near the supply motor);

c. Unplug E12 and E13 door lock solenoid wires (near the supply motor). These are only present on drives which have a door lock mechanism;

d. Locate the three short cable assemblies which connect the supply, take up and blower Hall sensors to the Motion PCBA (JS11, JT11, JF11) and remove them from both the Motion PCBA and the sensor boards. (These cable assemblies are identical and can be interchanged;)

e. Unplug J17 ribbon cable (near the hub lock solenoid);

f. Unplug J18 ribbon cable (near the blower motor);

g. Locate J12 cable assembly which connects the tachometer sensor PCBA to the Motion PCBA and remove it from both the sensor and the Motion PCBAs;

h. Unplug J13 cable assembly which connects the tension sensor PCBA to the Motion PCBA;

i. Unplug J19 write head cable (near the middle of the PCBA);

j. Unplug J14 ribbon cable (next to the large heat sink);

k. Unplug J15 RIP/FPT sensor cable (near the supply motor);

l. Cut the two cable ties which secure the power cable to the small heat sink at the rear of the PCBA;

m. Unplug J16 power connector (between the two heat sinks).

4. Remove the seven Phillips screws from the perimeter of the Motion PCBA. Do not intermix these mounting screws with self-tapping screws used elsewhere on the base.

5. Loosen the Phillips screw which is in the middle of the large heat sink.

6. While supporting the PCBA with one hand so that it does not drop, remove the Phillips screw.

Caution! ***When moving the Motion PCBA away from the base, ensure that it does not damage the fragile tachometer disk.***

7. Carefully work the Motion PCBA past the various cables and the tachometer disk and remove the PCBA.

9.7.5 Motion PCBA Installation Procedure

The installation of the Motion PCBA is essentially the reverse of the removal procedure. It will be easier if you install the PCBA according to the following procedure.

1. Work the PCBA over the tachometer disk while guiding the write head cable through the square hole near the Preamplifier PCBA. Take care not to damage the fragile tachometer disk. If you bend it, you will have to replace it.
2. Reach through the small square hole near the large heat sink with a pair of needle-nose pliers and carefully pull J14 ribbon connector through the hole while positioning the PCBA against the base.
3. Position the PCBA against the base and check around the perimeter for any cables or wires which may be caught under the PCBA. Do not install any mounting screws yet.

Note: *The routing described in the next step is important!*

4. Locate the two wires from the hub lock solenoid, route them between the edge of the Motion PCBA and the plastic shield behind the board and then connect one of them to E10 and the other to E11;
5. Connect J17 ribbon cable to the Motion PCBA near the front of the drive. When correctly routed, the wires from the hub lock solenoid will be between J17 ribbon connector and the plastic shield.
6. Install the seven mounting screws around the perimeter of the PCBA, and the one in the large heat sink.
7. Plug in the remaining connectors in the following order:
   a. J19 from the Write head;
   b. J18 ribbon connector near the tachometer sensor;
   c. J12 cable assembly from the tachometer sensor;
   d. J13 from the tension sensor;
   e. J15 near the supply motor;
   f. Three sets of red, brown (or black), and orange motor wires, observing the color callouts printed on the PCBA;
   g. Cable assemblies (three) from the Hall sensors to JF11, JT11, and JS11 (the cables are interchangeable);

Caution! ***Install the cable assembly near the take up motor (JT11) such that it is between the motor rotor and the red, brown and orange motor wires. This prevents the wires from rubbing against the rotor.***

h. J16 power connector;

i. J61 power connector to the Power Supply PCBA;

j. Ribbon connector from the Read Preamplifier to the Read Formatter PCBA

8. Reattach the hinged support arm to the underside of the base.

9.7.6 Adjustments

1. After you have replaced the Motion PCBA, power up the drive and perform the Board Change function in the Maintenance Service menu.

2. Perform the motion calibration procedure described in the Adjustment section of this manual. You will need a full 2400 foot reel of tape.

9.8 Read Preamplifier PCBA Replacement

The Read Preamplifier PCBA is secured to the base from above with two self-tapping Phillips screws.

1. Unplug the power cord from the rear of the drive.

2. Raise the top cover and unplug J98 ribbon connector from the Preamplifier PCBA.

3. Remove the two Phillips screws which hold the Preamplifier to the base.

4. Lock the base in the service position following the procedure in Section 9.2.4.

5. Unplug J94 ribbon connector from the bottom of the Preamplifier PCBA.

6. Lift the PCBA out together with its mounting brackets from above.

No adjustments are required after replacing the Read Preamplifier PCBA.

9.9 Display PCBA Replacement

The front panel Display PCBA, operator switches, bezel, and door assembly are removed from the tape drive as a unit. After removing the bezel assembly, the Display PCBA and switch assembly can be removed. The power switch can be replaced separately, but the rest of the switches, and the display, are an integral part of the Display PCBA.

9.9.1 Required Tools and Replacement Parts

5/32 inch Allen wrench (90° bend)
Diagonal cutters
One cable tie

9.9.2 Required Adjustments

No adjustments are required if the Display PCBA is replaced.

9.9.3 Display PCBA Removal Procedure

DANGER! **REMOVE THE MAIN POWER CONNECTOR FROM THE REAR OF THE TAPE DRIVE BEFORE CONTINUING.**

1. Unplug the power cord from the rear of the drive.
2. Lock the base in the service position following the procedure in Section 9.2.4.
3. Disconnect the two wires from the front panel power switch and cut the cable tie which secures the power cable to the bezel assembly.
4. Unplug the ribbon cable from the Display PCBA.

Caution! ***To avoid dropping the bezel assembly, handle it by its ends only. Do not handle or transport it by holding the tape loading door alone.***

5. Using a 5/32 inch Allen wrench, remove the three Allen screws which secure the bezel assembly to the front of the base, then remove the bezel assembly.
6. Remove the two tie wraps which secure the wires to the door interlock switch, and unplug those wires from the Display PCBA.
7. Remove the six hex screws holding the Display PCBA mounting frame to the back of the bezel, and lift out the Display PCBA. The power switch can now be removed.

9.10 Read/Write Head Replacement

The 34XX tape drive uses a hard-faced read/write head which, under normal circumstances, will last many thousands of hours. The actual life of the head varies according to the amount of tape run through the drive, the abrasiveness of the tape used, and whether or not proper preventive maintenance has been performed, etc.

9.10.1 Required Tools

1/4-inch hex driver
3/32-inch Allen driver
Torque wrench with 1/4-inch socket, set to 5 inch-pounds

9.10.2 Required Adjustments and Special Tools

Whenever the head is replaced, it is necessary to check the read skew by using a special skew tape, a dual channel oscilloscope, and by following the procedures in Chapter 10.

9.10.3 Head Removal Procedure

1. Unplug the power cord from the rear of the drive and remove the head cover, if so equipped.

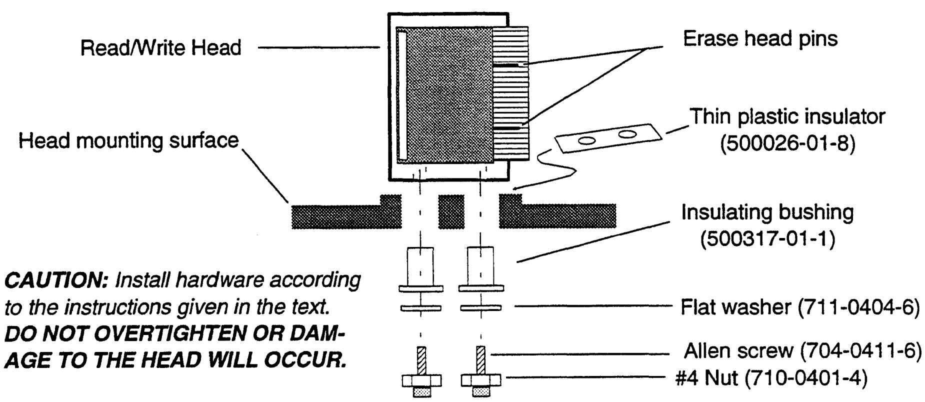
2. Unplug the erase, write, and read connectors from the rear of the head.

3. Raise and lock the base in the service position following the procedure in Section 9.2.4.

4. Remove the two head mounting screws (or nuts) through the cutout in the Motion PCBA.

5. Lift out the head, making sure not to lose the thin plastic insulator which fits between the head and the drive mounting surface.

9.10.4 Head Installation Procedure



CAUTION:** Install hardware according to the instructions given in the text.* ***DO NOT OVERTIGHTEN OR DAMAGE TO THE HEAD WILL OCCUR.

Figure 9-6 Head Installation Hardware

1. Using the hardware which came with the replacement head, install the nuts on the mounting screws finger-tight against the screw heads.

2. Wipe any debris from the underside of the head and from the drive mounting surface.

3. Insert the two screws into the mounting holes from the underside of the base.

4. While holding the two screws, place the thin plastic insulator over them and position the head over the mounting screws.

5. Turn the screws into the head, being careful not to drop them or to dislodge the thin plastic insulator in the process.

6. Tighten the mounting screws all the way into the head *finger-tight only*.

7. The tape wrap angle across the head is set by moving the head into the tape path and verifying that the tape bends slightly around the surface of the erase head. It may help to look for reflections on the tape to determine this. If the tape is not contacting the erase head, loosen the nuts slightly and rotate the head clockwise (as seen from the top) until it does as shown in Figure 9-7.

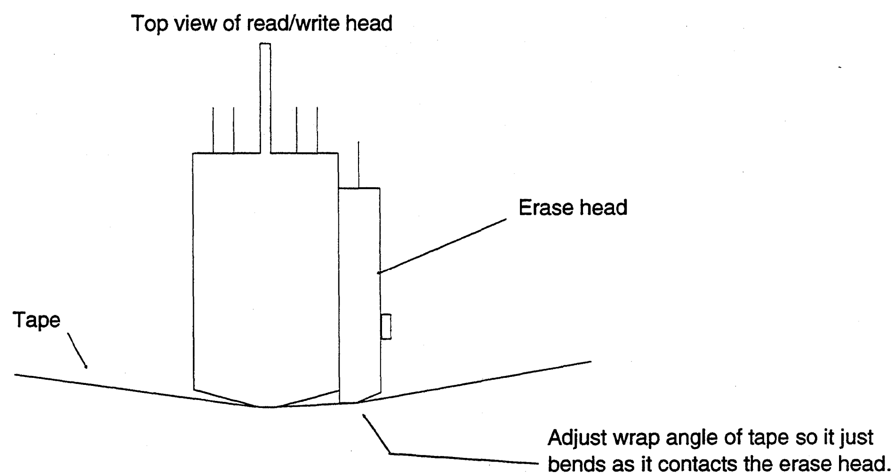


Figure 9-7 Tape/Erase head contact.

8. Tighten the nuts against the base to five inch-pounds to secure the head. ***DO NOT OVERTIGHTEN OR DAMAGE TO THE HEAD WILL OCCUR!***

9. Reattach the erase, write and read cables to the head. Note that the colored wires on the erase and write connectors go towards the base.

9.11 Sensor Assemblies

In general, all sensors are secured to the base using self-tapping Phillips screws. The sensors' positions are determined by their mounting holes and there is no physical alignment (the tension sensor is the one exception to this). It is necessary, however, to perform the Motion Calibrate procedure in the Service sub-menu of the Maintenance menu whenever any sensor is replaced. The procedure is described in Section 10.1 beginning on page 10-1. This procedure requires a full 2400 foot reel of tape.

9.11.1 Tachometer Sensor PCBA

The position of the PCBA is determined by its mounting holes and does not require alignment. Use care not to damage the slotted tachometer disk when replacing the sensor PCBA.

9.11.1.1 Required Tools

3/32 inch Allen driver
#2 Phillips screwdriver

9.11.1.2 Tachometer Sensor Removal Procedure

1. Unplug the power cord from the rear of the drive.
2. Lock the base in the service position following the procedure in Section 9.2.4.
3. Remove the tachometer slotted disk:
   a. Using a 3/32 inch Allen driver, remove the screw which secures the disk to the tachometer shaft and remove the outer clamp washer and spacer;
   b. DO NOT ATTEMPT TO SLIDE THE DISK OFF OF THE TACHOMETER SHAFT. Instead, push the tachometer shaft up through the disk and then slide the disk away from the sensor assembly. The inner clamp washer will probably drop into the drive.

Note: *If the disk is bent or kinked, it must be replaced.*

4. Remove the connector from the tachometer sensor PCBA, then remove the two Phillips screws which secure the sensor mounting bracket to the base.
5. Retrieve the inner clamp washer.

9.11.1.3 Tachometer Sensor Installation Procedure

The installation procedure is essentially the reverse of the removal procedure. When replacing the sensor PCBA, make sure that the thick plastic insulator between the Motion PCBA and the base does not get caught between the sensor mounting bracket and the base. Use Figure 11-2 on page 11-7 as a guide.

After replacing the sensor, perform the Motion Calibrate procedure described in Section 10.1.

9.11.2 Tension Sensor PCBA

The tension sensor PCBA is attached to the underside of the base by a mounting bracket and two Phillips screws. Use care not to damage the slotted tension shutter when replacing the tension sensor.

9.11.2.1 Required Tools

#2 Phillips Screwdriver
1/16 inch Allen driver

9.11.2.2 Required Adjustments

If the tension sensor assembly is replaced, it must be physically aligned as described in Section 10.4.2. This procedure requires an oscilloscope.

9.11.2.3 Tension Sensor Removal Procedure

1. Unplug the power cord from the rear of the drive.
2. Lock the base in the service position following the procedure in Section 9.2.4.
3. Before removing the tension sensor, move the power connecter cable out of the way of the bracket by removing the single Phillips screw and tie mount.
4. Unplug the connector from the sensor assembly and remove the two Phillips screws which secure it to the base.
5. Slide the sensor bracket towards the edge of the base and away from the shutter.

9.11.2.4 Tension Sensor Installation Procedure

The installation procedure is essentially the reverse of the removal procedure. Align the tension sensor as described in Section 10.4.2., and then perform the Motion Calibrate procedure described in Section 10.1.

9.11.3 EOT/BOT Sensor

The EOT/BOT Sensor assembly is attached to the top of the base by two Phillips screws.

9.11.3.1 Required Tools and Parts

#2 Phillips screwdriver
Diagonal cutters
One cable tie

9.11.3.2 Required Adjustments

The EOT/BOT sensor's position is defined by its mounting holes, and no physical alignment is possible; however, the Motion Calibrate procedure must be performed after the sensor is replaced. This requires a full 2400 foot reel of tape.

9.11.3.3 EOT/BOT Sensor Removal Procedure

Figure 9-8 illustrates how the EOT/BOT sensor is mounted to the base.

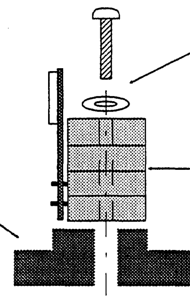


Figure 9-8 EOT/BOT Sensor Assembly Mounting

1. Unplug the AC power cord from the rear of the drive.
2. Lock the base in the service position following the procedure in Section 9.2.4.
3. Unplug P14 from the center of the Motion PCBA.
4. Lower the base and raise the top cover.
5. Remove the two Phillips screws which secure the interlock switch cover to the base and remove the switch cover.
6. Unplug the two TIP connectors from the EOT/BOT Sensor.
7. Cut the cable tie at the top corner of the EOT/BOT sensor.
8. Remove the sensor assembly (two Phillips screws on top of block).

9.11.3.4 EOT/BOT Sensor InstallationProcedure

The installation procedure is essentially the reverse of the removal procedure. After replacing the sensor, perform the Motion Calibrate procedure described in Section 10.1.

9.11.4 Supply Tape-In-Path Sensor

The Supply Tape-In-Path (TIP) sensor is mounted to the top of the base with two flat-head Phillips screws. The supply TIP sensor's position is defined by its mounting holes, and no physical alignment is possible; however, the Motion Calibrate procedure must be performed after the TIP sensor is replaced. This requires a full 2400 foot reel of tape.

9.11.4.1 Required Tools and Parts

#2 Phillips screwdriver
Diagonal cutters
Two cable ties

9.11.4.2 Supply TIP Sensor Removal Procedure

1. Unplug the AC power cord from the rear of the drive.

2. Remove the two Phillips screws which secure the interlock switch cover to the base and remove the switch cover.

3. Remove the two Phillips flathead screws which secure the TIP sensor to the base.

4. Remove the two Phillips screws which secure the interlock switch bracket to the base.

5. Cut the cable tie which secures the sensor cable to the interlock switch bracket tie mount.

6. Disconnect the two wires from the interlock switch.

7. Cut the cable tie which secures the sensor cable to the top corner of the EOT/BOT sensor.

8. Unplug the 8-pin connector from the EOT/BOT sensor and remove the TIP sensor and interlock wires as one subassembly.

9.11.4.3 Supply TIP Sensor Installation Procedure

1. Install the supply TIP sensor using two flathead screws.

2. Connect the two wires to the bottom lugs on the interlock switch.

3. Secure the interlock switch bracket to the base with the tie mount under the front screw. The tie mount should point towards the EOT/BOT sensor.

4. Connect the cable to the EOT/BOT sensor.

5. Secure the cable with one cable tie at the top corner of the EOT/BOT sensor and another at the switch bracket tie mount.

6. Reinstall the interlock switch cover.

7. Perform the Motion Calibration procedure as described in Section 10.1.

9.11.5 Take Up Tape-In-Path Sensor

The take up TIP sensor is mounted to the top of the base with two flathead Phillips screws. The take up TIP sensor's position is defined by its mounting holes, and no physical alignment is possible; however, the Motion Calibrate procedure must be performed after the TIP sensor is replaced. This requires a full 2400 foot reel of tape.

9.11.5.1 Required Tools and Parts

#2 Phillips screwdriver
Diagonal cutters
One cable tie

9.11.5.2 Take Up TIP Sensor Removal Procedure

1. Unplug the AC power cord from the rear of the drive.
2. Remove the two Phillips screws which secure the interlock switch cover to the base and remove the switch cover.
3. Remove the two Phillips flathead screws which secure the TIP sensor to the base.
4. Cut the cable tie which secures the sensor cable to the base.
5. Uplug the sensor cable from the EOT/BOT sensor and remove the TIP sensor.

9.11.5.3 Take Up TIP Sensor Installation Procedure

The replacement procedure is essentially the reverse of the removal procedure. After replacing the sensor, perform the Motion Calibration procedure as described in Section 10.1.

9.12 Tape Guide Subassemblies

Qualstar uses high quality, permanently lubricated guide bearings which will last the life of the tape drive. The only reasons for replacing the guides would be due to a noisy bearing or a physically damaged guide surface. This procedure can be used should it ever become necessary to replace a tape guide.

Note: *The heights of the tension, fixed and tachometer tape guides are critical and are set at the factory by shims. To insure compatibility with other components in the tape path, spare tension and fixed tape guides are provided as a matched set, and both the tension and the fixed guides must be replaced if one is defective. Either guide in the replacement set may be used in either position.*

Adjustments are not required after replacing tape guides.

9.12.1 Fixed Tape Guide

The fixed tape guide is a roller guide located between the supply reel and the supply TIP sensor. Its purpose is to guide the tape into the tape path in the forward direction and to guide the tape into the supply reel in the reverse direction.

9.12.1.1 Required Tools

7/64 inch Allen driver

9.12.1.2 Fixed Tape Guide Removal Procedure

1. Unplug the AC power connector from the rear of the drive.
2. Lock the base in the service position following the procedure in Section 9.2.4.

3. Remove the Allen screw from the bottom of the tape guide shaft. An access hole has been provided in the tension arm to facilitate removal of the tension tape guide without disturbing other components.

4. Lift out the tape guide from the top of the base taking care not to lose any of the shims. To avoid intermixing the shims from one guide to another, do not remove more than one tape guide at a time.

9.12.1.3 Fixed Tape Guide Installation Procedure

1. Install the tape guide and its shims into the base from the top.

2. Secure with an Allen screw in the bottom of the tape guide.

3. Replace the tension tape guide.

9.12.2 Tension Tape Guide

The tension tape guide is a roller guide located on a spring-loaded arm between the supply TIP sensor and the EOT/BOT sensor. It is part of the tension feedback loop.

9.12.2.1 Required Tools

7/64 inch Allen driver

9.12.2.2 Tension Tape Guide Removal Procedure

1. Unplug the AC power connector from the rear of the drive.

2. Lock the base in the service position following the procedure in Section 9.2.4.

3. Remove the Allen screw from the bottom of the tape guide shaft. An access hole has been provided in the tension arm to facilitate removal of the tension tape guide without disturbing other components.

4. Lift out the tape guide from the top of the base taking care not to lose any of the shims. To avoid intermixing the shims from one guide to another, do not remove more than one tape guide at a time.

9.12.2.3 Tension Tape Guide Installation Procedure

1. Install the tape guide and its shims into the base from the top.

2. Secure with an Allen screw in the bottom of the tape guide.

3. Replace the fixed tape guide.

9.12.3 Tachometer Tape Guide

The tachometer tape guide bearings are bonded to the base with bearing mount adhesive. The only reason for replacing the tachometer tape guide is if the guide face is scratched or otherwise damaged.

9.12.3.1 Required Tools

3/32 inch Allen driver

9.12.3.2 Tachometer Tape Guide Removal Procedure

1. Unplug the AC power connector from the rear of the drive.
2. Lock the base in the service position following the procedure in Section 9.2.4.
3. Use a 3/32 inch Allen driver to remove the screw in the bottom of the tachometer shaft.
4. Remove the outer clamp washer and spacer.
5. ***Do not attempt to slide the disk off of the tachometer shaft***. Instead, push the tachometer shaft up through the disk and then slide the disk away from the sensor assembly. The inner clamp washer will drop into the drive.
6. Retrieve the inner clamp washer and lower the base.
7. Lift out the tape guide from the top of the base taking care not to lose any of the shims.

9.12.3.3 Tachometer Tape Guide Installation Procedure

1. See Figure 11-2 on page 11-7 for a detailed drawing of the tachometer tape guide components.
2. Install the tape guide and its shims into the base from the top.
3. Lock the base in the service position following the procedure in Section 9.2.4.
4. Install the inner clamp washer, slotted disk, outer clamp washer and spacer and secure with the Allen screw in the bottom of the tape guide.

9.13 Motor Rotor and Stator Disassembly

9.13.1 General Information

This section describes how to disassemble and reassemble the motor and how to replace the motor stator. The procedure is the same for all three motors. Chapter 11 describes in detail how to replace the motor bearings.

Figure 9-9 shows the general assembly of each of the three motors. The motors are basically the same, each consisting of a stator and a rotor held together by a hollow, internally-threaded shaft bolt. On one end of each shaft bolt is a rotating magnetic assembly (the rotor) and on the other end is either a supply hub, a take up reel, or a blower fan, depending upon the particular motor.

Each motor can be disassembled by locking the base in the service position and removing the Allen screw from the end of its hollow shaft screw. The rotor can then be removed, exposing the stator winding assembly and the motor's Hall transistor PCBA. The supply hub assembly, the take up reel, and the blower fan can be removed by

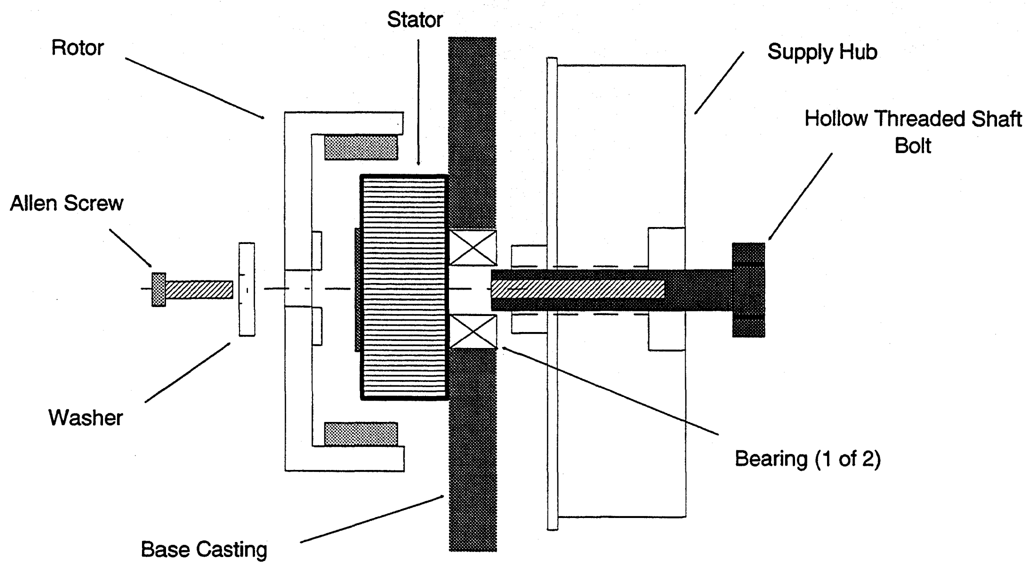


Figure 9-9 Typical Motor Assembly

withdrawing the hollow shaft bolt. Mechanical alignment is not required when replacing these items.

9.13.2 Required Tools

3/16 inch Allen socket (3/8 inch drive)
Torque wrench, 0 to 200 inch-pounds (3/8 inch drive)
9/16 inch hex socket (3/8 inch drive)
3/32 inch hex socket (3/8 inch drive)
3/8 inch drive ratchet wrench or breaker bar, one foot long
Medium-hold thread adhesive (Loctite 242 or equivalent)

9.13.3 Required Adjustments

After replacing any part of the reel motor assemblies, perform the motion calibration procedure. No adjustment is required after servicing the blower motor.

9.13.4 Rotor Removal Procedure

1. Remove the Allen screw and the spacer from the hollow shaft bolt. These parts are factory-torqued to 180 inch-pounds.

2. Briskly pull the rotor straight away from the base. Note that the magnetic rotor will tend to stick to the internal stator pole pieces.

3. The hollow shaft screw and the supply hub (take up reel, blower fan) may now be removed from the drive.

9.13.5 Rotor Installation

1. Slide the hollow shaft screw (and the supply hub, take up reel, or blower fan) all the way into the base.
2. Fit the rotor over the stator windings.
3. Before installing the Allen screw, verify that the rotor is fully seated and that the threaded end of the hollow shaft screw is flush with the outer surface of the rotor.
4. Place the Allen screw into the countersunk side of the spacer and thread it into the motor shaft. Tighten it just enough to remove all slack from the motor assembly.
5. Verify that the rotor turns freely and does not scrape against the stator windings.
6. Torque the assembly to 180 inch-pounds.

9.13.6 Motor Stator Removal Procedure

The stators are attached to the underside of the base with self-tapping screws. In the unlikely event a stator fails, the motor must first be disassembled to allow access to the stator.

1. Remove the rotor following the procedure in Section 9.13.4.
2. Remove the three Phillips screws which hold the stator winding assembly to the base (the blower stator is held by two screws).
3. Lift the stator away from the base.
4. Disconnect the stator connector from the Motion PCBA.

9.13.7 Motor Stator Installation

When reinstalling a stator, replace the self-tapping screws with 6-32x1/2 inch pan head screws, and apply one drop of medium-hold thread adhesive (i.e., Loctite 242 or equivalent) to the end of each screw before installing. Do not overtighten the stator mounting screws.

9.14 Hall PCBAs

An integral part of each motor is its Hall PCBA. These PCBAs are mounted to the underside of the base with self-tapping Phillips screws. The locations of the Hall PCBAs are determined by their mounting screws and require no adjustment.

1. Disconnect the power cord from the rear of the drive.
2. Lock the base in the service position following the procedure in Section 9.2.4.

3. Remove the motor stator as described in Section 9.13.6.
4. Remove the Phillips screws which hold the Hall PCBA to the base.
5. Disconnect the cable from the Hall PCBA.

When installing the Hall PCBAs, replace the self-tapping screws with 6-32x3/8 inch pan head screws.

Checks and Adjustments 10

10.1 Motion Calibrate Function

10.1.1 General Information

The **MOTION CALIBRATE** function is used to test the motion system, calibrate the motors, and to calibrate the BOT, EOT, TIP and FPT sensors. The calibration is fully automatic, eliminating the need for manual adjustments. Motion Calibrate performs the following functions:

- Checks the blower motor for correct power consumption;
- Checks the Tape-In-Path (TIP) sensors and establishes thresholds for tape detection;
- Checks and calibrates the Reel-In-Place sensor and the two reflective tabs on the supply hub;
- Checks the temperature sensor and the +70 volt power supply;
- Checks and calibrates the BOT/EOT sensors;
- Determines the offsets of the motor driver circuits (used in motor control);
- Determines the back-EMF of the motors;
- Loads a tape to check the loading sequence.

10.1.2 When Required

The Motion Calibrate function must be performed whenever the WREX microprocessor (U43), Motion PCBA, or any sensor or reel motor is replaced.

10.1.3 Required Equipment

You will need a full 2400 foot reel of tape for this procedure.

10.1.4 Procedure

The test is begun with no tape on the supply hub. Perform the following steps to run the test:

1. Remove any tape from the tape drive.
2. Enter the menu mode and select the Maintenance menu.
3. Select the Service sub-menu in the Maintenance menu.
4. Select **MOTION CALIBRATE**.

5. Press ENTER and carefully read the instructions on the display. It is vital that you fully comply with all instructions.
6. If there is a reel of tape in the drive, remove it.
7. After reading the messages, press LOAD to start the automatic calibration procedure. Do not open the top cover or the door until the display asks for the insertion of a tape.
8. A series of messages will appear which describe the activities being performed. If a problem is detected, the function will terminate and a message will be displayed describing the problem.
9. After about 40 seconds, the drive will ask for a 10.5 inch reel of tape with a write enable ring. Insert a full 10.5 inch reel (2400 feet), close the door, and press LOAD to continue the calibration. Do not use a valuable tape for this procedure.
10. The drive will load the tape, and if successful, will display **CALIBRATION COMPLETED**.
    a. If the function completed successfully, the calibration information will be stored in the WREX microprocessor (U43).
    b. If an error is detected, an appropriate message will be displayed. Note the message and repeat the procedure. The drive must complete the calibration procedure successfully for the drive to operate. If the failure persists, the drive requires service. Possible error messages are listed in the Error Code chapter of the 34XX User's Guide (PN 500300).
11. Press EXIT until the MENU indicator extinguishes.

10.2 Read Skew Measurement

10.2.1 General Information

To understand this procedure, you need to know the difference between azimuth and skew. *Azimuth* refers to the horizontal distance between the top and bottom tracks on the head. When the azimuth is zero, 1 will be directly above track 9. Azimuth errors are usually caused by minor imperfections in the machining of the base, and can be reduced by adjusting the angle between the head and the base.

Skew is the time displacement of all the individual read gaps with respect to the tape plane and to each other. It is a function of minor errors in the assembly of the head. While skew is affected by azimuth, it is not adjustable. Skew is measured after first adjusting the azimuth.

On early models, azimuth was adjusted at the factory by shimming the tape guides to move the the way the tape tracked across the head. Because the shim selection process required special tools, azimuth on these models cannot be adjusted in the field.

When the skew does not meet specifications, you can try using a different head. This may or may not give low enough skew to allow the drive to read 800 cpi tapes.

Later models incorporate an azimuth adjustment screw which tilts the head mounting plate with respect to the tape path. These tape drives can be easily identified by a metal plate which covers the read/write head area.

Because the shimming or azimuth adjustment does not change with time, you only need to check skew if you replace the head. Skew is measured while reading a 200 cpi Master Head Alignment tape (skew tape). To facilitate the skew measurement, a special Skew Measure function found in the Maintenance Service sub-menu allows you to control the tape motion by using the front panel switches. This function is not available on early models.

If the drive has a 500557 Read/Formatter PCBA, with version 1.08 or later Read DSP firmware and version 2.13 or later WREX CPU firmware, you can use the measurement procedure described in Section 10.2.3. Use the measurement procedure described in Section 10.2.4 for all other models. Skew measurement of 340X models requires an oscilloscope to observe the time difference between the read signals from the earliest and latest tracks on the read head.

Note: *Use the Display Firmware function in the Maintenance menu to check both the PCBA part number and the firmware version number.*

10.2.2 When Required

Only after replacing the read/write head.

10.2.3 Measurement Procedure #1

Note: *Use this measurement procedure only if your tape drive has a 500557 Read/Formatter PCBA with a Read HI/LO EPROM version 1.08 or higher. For all other tape drive configurations, use Measurement Procedure #2.*

10.2.3.1 Special Tools

Master Head Alignment tape, 200 cpi, Qualstar PN 646-0010-9

10.2.3.2 Procedure

1. Load a Pericomp 200 cpi master head alignment tape.

2. Enter the Skew measure function in the Maintenance Service sub-menu. This function displays the information shown in Figure 10-1 on page 10-4.

3. Select SKEW MEASURE (not to be confused with Skew CHECK) from the Maintenance Service sub-menu. When the tape is not moving, display line two identifies which button to press to move the tape.

4. Press the “forward” button and let the tape go all the way to EOT.

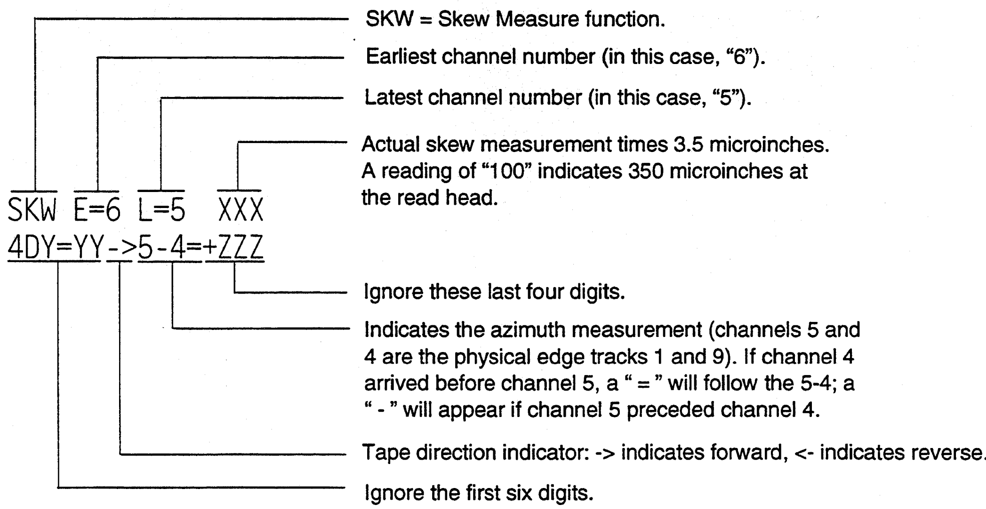


Figure 10-1 Skew Measure Front Panel Display

5. Press the "reverse" button and let the tape return to BOT. This causes the tape to center properly on the supply reel for the drive being measured.

6. Press the forward button and allow several seconds for data to be acquired, then slowly turn the azimuth adjust screw counter-clockwise until the *azimuth* reading (**ZZZ** in display line two) stops changing. Each half turn will change the azimuth reading by about 100.

7. While observing the azimuth reading, slowly turn the azimuth adjust screw clockwise to bring the reading as close to zero as possible.

8. Record the *skew* reading (**XXX** in display line one).

9. Press the reverse button, let the tape run for several seconds and record the *skew* reading.

10. Unload the skew tape, turn the drive off and look at the values you recorded.

    a. If both readings were less than 40, the drive will read 800 cpi.

    b. If both readings were between 40 and 80, the drive will not read 800 cpi reliably, but will read and write 1600, 3200 3125, and 6250 cpi reliably.

    c. If either reading is greater than 80, change the head and repeat the entire procedure.

10.2.4 Measurement Procedure #2

Note: *Use this measurement procedure only if your tape drive does **not** have a 500557 Read/Formatter PCBA with a Read HI/LO EPROM version 1.08 or higher.*

10.2.4.1 Special Tools

Master Head Alignment tape, Qualstar PN 646-0004-2
Dual channel oscilloscope

10.2.4.2 Procedure

1. Load the skew tape.
2. Raise the base to the service position.
3. Connect the scope probes to the Read Formatter PCBA as follows:
   a. **Early 3410/3412 (500377 PCBA)** - Connect channel one scope probe to test connector J3 pin 8 on Read Channel 5 PCBA, channel two scope probe to J3 pin 8 on Read Channel 4 PCBA and the ground reference clips to J3 pin 10. Test connector J3 is located at the top of each Read Channel PCBA. Refer to Figure 10-2 on page 10-6 for the test point locations.
   b. **All 3402/3404 drives (500497 PCBA)** - Connect channel one scope probe to ANA5 and channel two scope probe to ANA4. There are nine "ANA" test points, one for each read channel. The nine read channels are located along the right hand portion of the PCBA and each channel is labeled. Referring to Figure 10-3 on page 10-6, ANA5 is shown just in front of U110. For probe grounds, use the nearest "AG#" test point to the right of the ANA test points.
   c. **Drives with 500557 PCBA and Read HI/LO EPROM version 1.07 or lower** - Referring to Figure 10-4 on page 10-7, connect the scope probes to the test points shown for channel 5 and 4. There are nine analog test points, one for each read channel. They are numbered "A0", "A5", "A6", etc. in a column about three inches from the right edge of the PCBA. For probe grounds, use the nearest "AG#" test point to the right of the "A#" test points.
4. Set the scope to trigger internally on channel 1, AC coupling, and set the time base to two microseconds per division.
5. Set the vertical sensitivity on both channels to 0.5 volts per division and adjust the vertical positioning for each channel to align the ground reference levels to the center graticule. Once this is done, set the vertical coupling to AC and do not move the vertical positioning.
6. Select the SKEW CHECK (not Skew MEASURE) function in the Maintenance Service sub-menu. The drive will configure itself for low speed and will

disable write, erase, and rewind operations, and the front panel switches will assume new functions (see Figure 10-5 on page 10-7):

a. Pressing DENSITY moves the tape forward. The tape will stop at EOT;

b. Pressing LOAD moves the tape reverse. The tape will stop at BOT;

c. Pressing ONLINE stops tape motion;

d. Pressing MENU exits the Skew Check function and unloads the tape. Once the Exit operation has begun, it cannot be stopped.

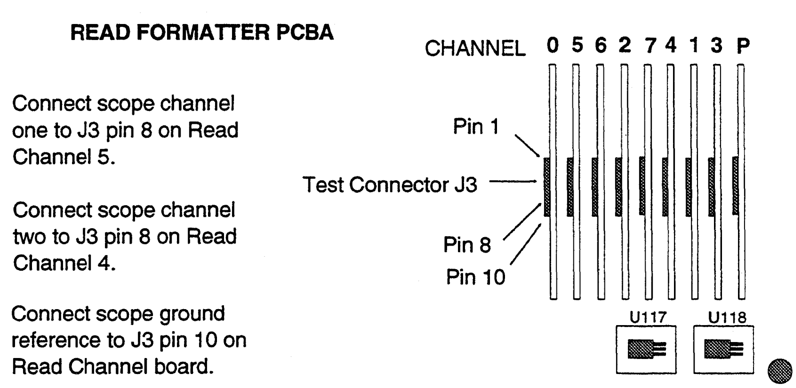


Figure 10-2 Skew Testpoints (500377 PCBA)

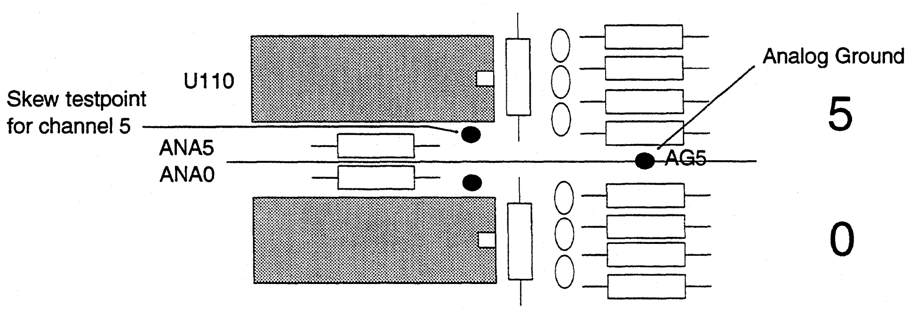


Figure 10-3 Skew Testpoints (500497 PCBA)

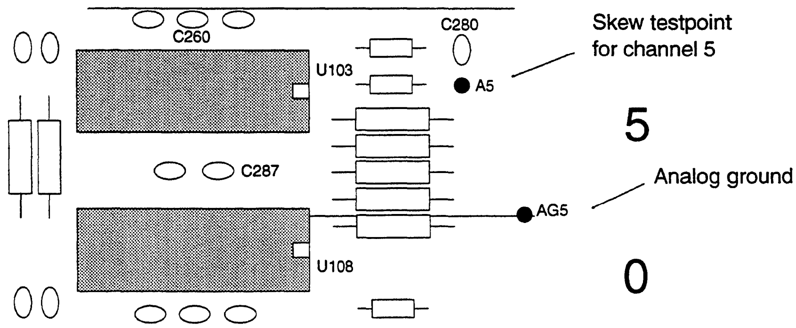


Figure 10-4 Skew Testpoints (500557 PCBA)

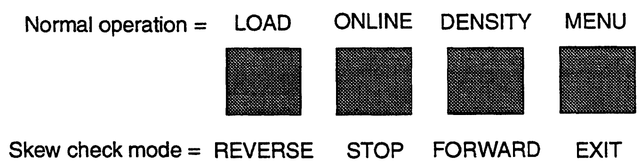


Figure 10-5 Front Panel Switches in the Skew Check Function

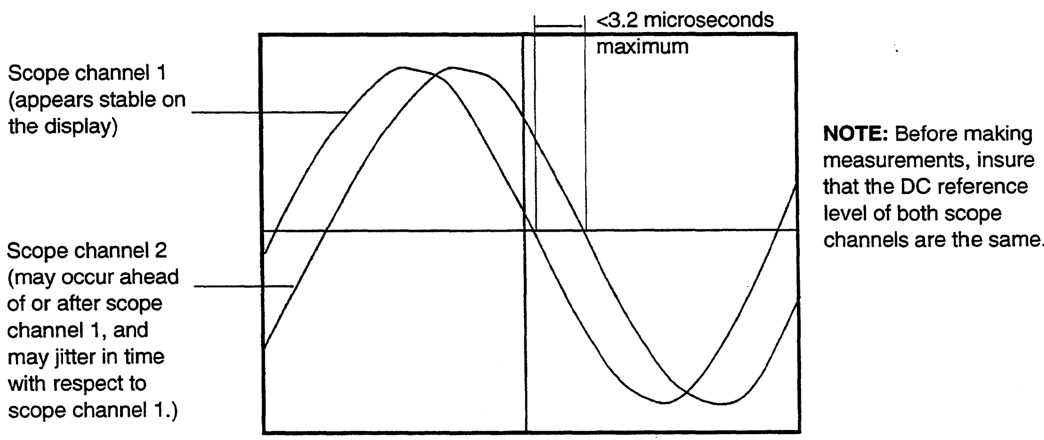


Figure 10-6 Skew Waveforms

ANSI TRACK	CHANNEL
1	5
2	7
3	3
4	P
5	2
6	1
7	0
8	6
9	4

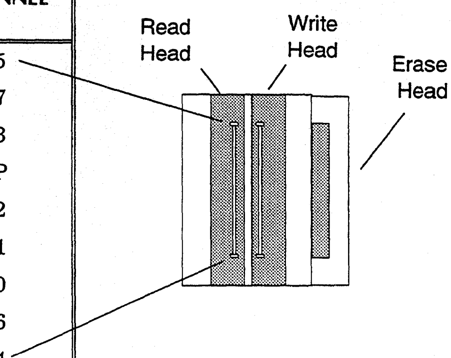


Figure 10-7 Track layout as seen from face of head

7. Move the tape forward and adjust the scope for a stable display like that shown in Figure 10-6 on page 10-7. If the tape reaches EOT, run it back to BOT by pressing the LOAD switch.

8. In the forward direction, measure the maximum time in microseconds from the point where channel one waveform crosses the zero graticule to where channel two waveform crosses the zero graticule.

9. If the total time displacement exceeds 3.0 microseconds in the forward tape direction, the tape drive must be returned to the factory for corrective action.

10. When the check is complete, press the MENU switch to exit the Skew Check function.

11. Remove the scope probes and the skew tape from the drive, and return the drive to its operating configuration.

10.2.5 Azimuth Adjustment Procedure

If the head mounting plate on your drive is adjustable, you can adjust the azimuth. Otherwise, you must either replace the head or return the drive to the factory for repair. To see if your tape drive contains an adjustable head mounting plate, raise the top cover and look at the head area. If the head area is covered by a metal plate, you can adjust the azimuth.

To adjust the azimuth (and thereby optimize the skew):

1. Remove the head cover plate and locate the adjustable skew plate. You will find it between the read/write head and the tape cleaner. See Figure 10-8.

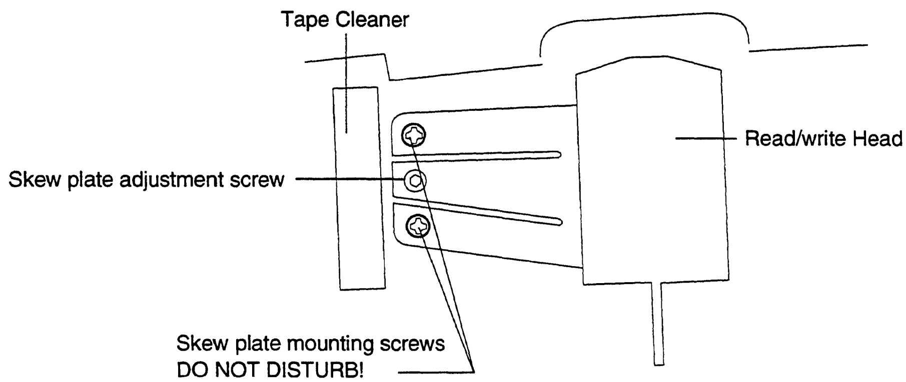


Figure 10-8 Adjustable Skew Plate

2. Set up the drive to measure the skew as described earlier in this section. Check both in forward and reverse.

3. While the skew tape is moving, use a 3/32 inch Allen wrench and turn the skew plate adjustment screw until the front panel or oscilloscope indicates the skew is within specification in both the forward and reverse directions. Failure to meet specification in both directions indicates tape path problems. Refer to Section 10.3 to check the tape path.

10.3 Tape Path Check

The tape path is determined by the height of the tape guides (tachometer, tension, and fixed) with respect to the reference guides on either side of the read/write head. The heights of the guides is set at the factory using shims and special measuring devices which do not readily lend themselves for field use. Therefore, a tape drive should be returned to the factory for tape path alignment if any problems in this area are found.

The following procedure can be used to check for tracking problems in the field. No special tools are required, but a strong light and an inspection mirror will help detect tape-to-flange contact.

1. Load a good quality, 2400 foot reel of tape (one without obvious signs of wear or edge damage).

2. Press LOAD and after the tape has stopped at BOT, enable the Skew Check function in the Maintenance Service sub-menu. The front panel switches then operate as follows:

   a. Pressing DENSITY moves tape forward at 62.5 ips. The tape will stop at EOT;

b. Pressing ONLINE stops tape motion;

c. Pressing LOAD moves tape reverse at 62.5 ips. The tape will stop at BOT;

d. Pressing MENU unloads the tape at 62.5 ips and exits the Skew Check function.

3. Raise the top cover and override the cover interlock using the cover interlock override tool (600144-01-8).

DANGER! **KEEP HANDS AWAY FROM THE MOVING REELS.**

4. Using the front panel switches, move the tape forward and reverse while observing the tape where is enters and exits each tape guide roller. The tape must enter and exit the guide roller without touching either the upper or lower roller flange. Ideally, the tape will ride in the center of the guide roller.

5. Check the tape path across the other tape guides.

6. Check to see that the tape does not touch the upper or lower supply or take up reel flanges at the point where it just enters the reel.

10.4 Factory Adjustments

The following paragraphs describe adjustments which are performed in the factory after the tape drive is assembled. Because all spare parts are tested and adjusted in the factory prior to shipment, you do not need to adjust them when replacing them.

10.4.1 Tape Tension Spring Anchor Adjustment

10.4.1.1 Purpose

The position of the tension spring anchor is set at the factory to obtain the proper tape tension.

10.4.1.2 When Required

Adjustment of the tension spring anchor is not required during the normal life of the tape drive. If the tension spring or its anchor tab has been accidentally moved or damaged, use this procedure to re-establish correct tape tension.

10.4.1.3 Special Tools

Precision weight, Qualstar PN 600131-02.

10.4.1.4 Procedure

1. Open the drive to the service position.

2. Lift the top cover and place the tool on top of the tension guide assembly. The pin in the tool fits into the hollow guide shaft.

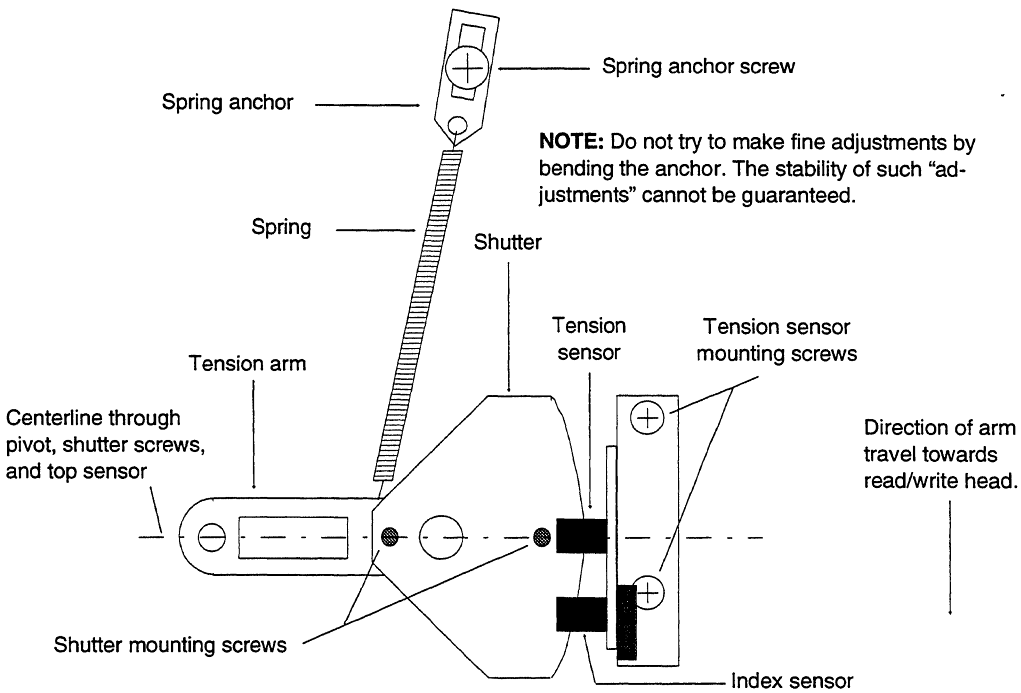


Figure 10-9 Tension Arm Adjustment Components

3. The weight of the tool will move the tension guide towards the head. If the tension is correct, the tension guide will rest in the exact middle of its travel.
4. The adjustment is correct when a straight line through the tension arm pivot and both shutter screws bisects the top sensor, as shown in Figure 10-9 on page 10-11.
5. If it does not, loosen the screw which secures the tension spring anchor, and move the spring anchor until the tension arm and shutter line up with the center of the tension (top) sensor, with the tool in place, as shown in Figure 10-9.
6. Tighten the tension spring anchor screw.
7. When the adjustment is correct, remove the tool and return the drive to its operating configuration.

10.4.2 Tension Sensor Position Adjustment

10.4.2.1 Purpose

The purpose of the adjustment is to insure that the slots in the shutter fully engage the sensor's field of view, and that the edge of the shutter does not rub against the sensors.

10.4.2.2 When Required

This adjustment should be performed only if the position of the tension sensor assembly has been changed.

10.4.2.3 Special Tools

Oscilloscope

10.4.2.4 Procedure

1. Loosen the two Phillips screws which secure the tension sensor assembly to the base, rotate the sensor and mounting bracket all the way clockwise, and retighten the screws (see Figure 10-9).

2. Monitor the INDEX test point below J13 on the Motion PCBA with one channel of the oscilloscope.

3. Set the oscilloscope to 2 volts per division, 1 millisecond per division, and auto-trigger.

4. Apply power to the drive. The Index test point should be high.

5. Move the tension arm all the way down, against the spring pressure, with your finger. The Index test point should be low.

   a. If it is not, either move the shutter towards the sensor assembly (use a 1/16 inch Allen driver for the mounting screws) or rotate the sensor assembly slightly counter-clockwise towards the shutter. See Figure 10-9.

   b. Tighten the sensor assembly mounting screws, verify that the shutter does not rub the sensor, and recheck the Index test point as previously described.

6. While holding the tension arm all the way down, flex the sensor assembly away from the shutter while observing the oscilloscope.

7. The Index test point should remain low while flexing the sensor assembly. If it ever goes high, rotate the tension sensor assembly counter-clockwise slightly as previously described.

10.4.3 +5 Volt Adjustment

10.4.3.1 Purpose

The +5 volt regulator has provisions to allow adjustment during manufacturing to compensate for component variations on the PCBA.

10.4.3.2 When Required

The +5 volt regulator adjustment is preset during PCBA production and does not require further adjustment. Once preset, the regulator automatically compensates for variations in supply and load currents. Spare Power PCBAs are shipped with the +5 volt regulator pre-adjusted.

The adjustment is done by setting four DIP switches, allowing for sixteen degrees of adjustment. Adjustment is required only if components in the +5 volt regulator have been replaced or if the switches have been inadvertently moved.

10.4.3.3 Special Tools

A digital voltmeter.

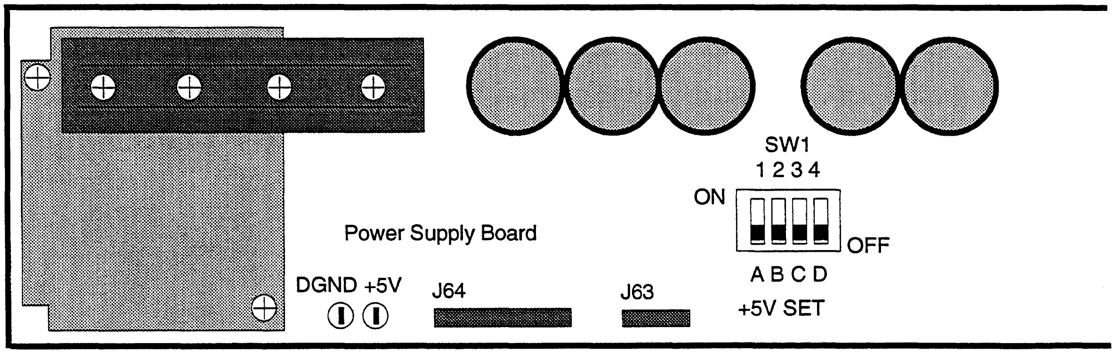


Figure 10-10 +5 Volt Regulator Adjustment Location

10.4.3.4 Procedure

Refer to Figure 10-10 for test point and switch locations.

1. Apply power and load a tape.
2. Using the DVM, measure the voltage between the VCC and G9 test points on the WREX PCBA.
3. Set the switches in S1 to obtain a reading as close to +5.00 volts as possible.

   Setting a switch on increases the voltage, and setting a switch off decreases the voltage. The switch nearest the front of the drive has the greatest effect, and will provide a 1% adjustment. The second switch provides a 0.5% adjustment, the third switch provides a 0.25% adjustment, and the switch nearest the rear of the drive provides a 0.125% adjustment.

Bearing Replacement 11

The bearings used in the Qualstar tape drives are high quality and are designed to last the life of the tape drive. This chapter describes the correct procedures for replacing motor and guide bearings in the remote possibility that one should fail.

The following subassemblies are mounted in bearings:

- Supply motor and take up motor
- Blower motor
- Tachometer tape guide
- Tension arm pivot shaft
- Tape guide assemblies (fixed and tension)

To replace these parts,	See Section:
Motor Bearings	11.4
Tachometer Bearings	11.5
Tension Arm Bearings	11.5

Table 11-1 Field Replaceable Subassemblies

11.1 When To Replace a Bearing

A bearing set should be replaced when:

- The motor or tape guide feels rough when turned by hand;
- Clicking, whirring or buzzing noises are heard during tape motion, most obvious during rewind operations;

11.2 Special Tools

The following special tools are required to properly replace bearings:

- Small scraper, such as an X-Acto knife, for cleaning bearing bores
- Flat tip nailset and plastic or soft metal hammer to tap out old bearings
- Loctite Primer Type T adhesive primer
- Loctite 609 Bearing Mount adhesive

11.3 Bearing Replacement Procedures Common to All Assemblies

This section contains important information common to all assemblies which should be read and understood before attempting to replace any bearing assembly. The following sections provide information which is unique to each individual assembly.

The following guidelines must be adhered to when replacing bearings:

- Always use bearings supplied by Qualstar. While other bearings may fit, Qualstar cannot guarantee their reliability.
- Each motor and guide shaft is supported by two roller bearings. Because it is difficult to determine which bearing of a pair is defective, always replace both bearings.
- Only use new bearings. Never reuse a bearing which has been removed from a drive.
- Do not use bearings which have been dropped onto a hard surface such as a surface plate or a concrete floor. The impact will damage the bearing's inner surfaces and lead to premature failure.
- Roller bearings must be properly installed with the correct axial preload. To accomplish this, the machined surface which contacts the bearing outer diameter must be clean and smooth enough to allow a new bearing to slip easily into and out of the bores in the casting. Check that these conditions are met and correct if necessary.

Caution! ***When tapping out old bearings, tap them out evenly all around and do not allow them to cock in the bore. The steel bearing housings are much harder than the aluminum base casting and may damage the bore if incorrectly removed.***

If the bore is nicked or gouged, the fit of the bearing may be too loose or too tight. If the fit is too loose, then the bearing may seat off-center and cause excessive runout. If the fit is too tight, the friction between the bearing and the bore will not overcome the force applied by the preload spring, causing incorrect bearing preload and early failure. When the bore surface has been properly prepared, a new bearing will just slide in and out of the bore under the force of the preload spring.

- Always clean the bores and the outer diameter of the new bearings with adhesive primer.
- Do not allow any adhesive primer to seep into the bearing.
- Always allow five minutes for adhesive primer to dry before applying bearing mount adhesive.
- Always apply a thin coat of bearing mount adhesive to the inside of the bores in the casting rather than to the outer diameter of the bearing.

Caution! ***Never force new bearings into position. Find and eliminate the cause of any binding before seating bearings.***

DANGER! **HAZARDOUS VOLTAGES ARE PRESENT WHEN THE BASE IS IN THE SERVICE POSITION AND THE POWER IS ON. WHENEVER REMOVING PCBAS OR SUBASSEMBLIES FROM THE TAPE DRIVE, ALWAYS DISCONNECT THE MAIN POWER CONNECTOR FROM THE REAR OF THE UNIT.**

THE HINGED SUPPORT BRACKET CONTAINS AN INTEGRAL SAFETY LATCH MECHANISM. ALWAYS INSURE THE SAFETY LATCH IS ENGAGED BEFORE WORKING WITH THE BASE IN THE SERVICE POSITION.

11.4 Motor Bearings

Each motor is supported by two roller bearings which are set into the base assembly with retaining compound (Loctite 609 or equivalent). These bearings are permanently lubricated and do not require servicing or adjustment. Should a bearing fail, the drive should be returned to the factory for servicing. However, the bearings can be replaced in the field if adequate care is taken.

The bearings are seated against internal circlips which are installed in grooves inside each boss. Correct bearing preload is determined by a spring-loaded spacer between the bearings' inner races.

Because the bearings are set into the base casting with adhesive, they must be carefully tapped out. When replacing a motor bearing, always use a retaining compound and carefully seat the bearings into the boss against the circlips.

11.4.1 Motor Bearing Removal Procedure

This procedure describes how to remove the supply reel motor bearings. The procedure is the same for the take up and blower bearings. For additional clearance, the drive may be opened and positioned on its side as described in Section 9.7, *Motion PCBA Replacement*. If for some reason the take up or blower motor needs to be disassembled, the top cover and blower air duct cover must also be removed as described in Chapter 9.

1. Remove the appropriate motor rotor as described in Section 9.13.

2. If replacing the blower or the take up motor bearings, remove the top cover and the blower air duct cover (blower motor only).

3. Remove the supply hub (take up reel/blower fan) from the top of the base.

4. Insert a nailset through the rear bearing and using a plastic or soft metal hammer, tap at several locations around the inner race of the front bearing until the bearing is dislodged.

Caution! ***Do not allow the bearings to cock in the bore. The steel bearing housings are much harder than the aluminum base casting and may damage the inside diameter of the bored hole.***

5. Insert the nailset through the front bearing journal and tap out the rear bearing, taking care not to cock it in the bore of the casting.
6. Remove the four Belleville springs and the shaft spacer from the bore and inspect them. If they are damaged, replace them.
7. Clean the bores and new bearings as described in Section 11.3.

Note: *When the bore surface has been properly prepared, a new bearing will slide in and out of the bore with slight resistance only.*

11.4.2 Motor Reassembly

To replace motor bearings and reassemble the motor, follow the steps in Figure 11-1.

11.4.3 Checks and Adjustments

The motor should turn freely by hand with no clicking, scraping, or roughness. The rotor and hub/fan should not wobble.

11.5 Tachometer Bearings

The tachometer tape guide is supported by two roller bearings which are secured to the base with bearing mount adhesive (Loctite RC 609 or equivalent). The correct bearing preload is determined by a spring-loaded spacer between the bearings' outer races and a fixed-length spacer between the inner races.

The following instructions pertain specifically to the tachometers, but because the tension arm pivot shaft bearings are installed in a similar manner, these instructions and Figure 11-2 may be used as a guide when replacing the tension arm pivot shaft bearings.

11.5.1 Adjustments

After replacing the tachometer bearings, perform the Motion Calibration procedure in the Maintenance menu as described in the Menu chapter of the 34XX User's Guide.

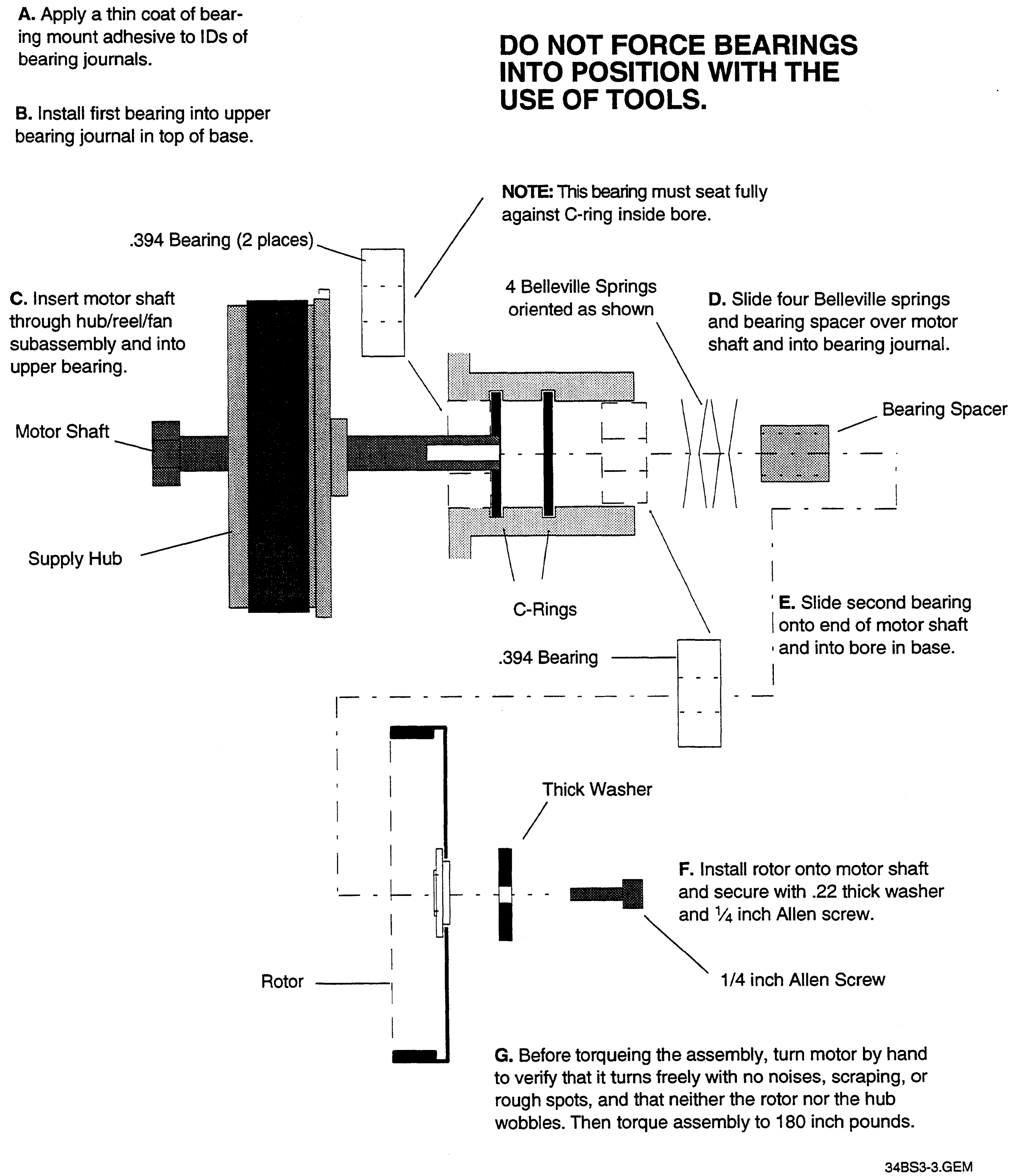


Figure 11-1 Motor Bearing Replacement Instructions

11.5.2 Tachometer Bearing Removal

1. Raise the base to the service position and engage the safety latch.

2. Remove the Allen screw from the bottom of the tachometer shaft and remove the two tachometer disk clamps and the tachometer disk.

3. Remove the tachometer shaft from the top side of the base.

4. Insert a flat-tipped nailset through the upper bearing, carefully tap out the lower bearing and discard it.

Caution! ***Do not allow the bearings to cock in the bearing journals. The steel bearing housings are much harder than the aluminum base casting and may damage the inside diameter of the bored hole.***

5. When the bearing comes out, an internal spring and one or both of the internal spacers may fall out and roll out of sight. Retrieve the spring and two spacers and discard them.

6. Insert the nailset through the lower bearing journal, carefully tap out the upper bearing and discard it.

11.5.3 Tachometer Bearing Installation

The instructions for installing the tachometer bearings and reinstalling the tachometer assembly are given in Figure 11-2 on page 11-7.

Before installing new bearings, insure all adhesive residue has been removed from the bearing journals. Clean the bearing journals and the bearing ODs with adhesive primer and allow five minutes for the primer to dry. Failure to clean the mounting surfaces may result in improper bearing seating and early bearing failure.

When installing the front bearing, use finger pressure only to insert it squarely into the bore until it is flush with the outside surface of the base casting. The final position of the rear bearing will be determined by the preload spring pressure.

Note: *If the parts have been correctly assembled, the upper bearing flange will be flush with the base boss and the lower bearing will protrude slightly due to the inner spacers.*

11.6 Tape Guide Bearings

The tape guide bearings for both the tension roller and the fixed roller are fixed permanently inside the tape guide subssemblies with bearing mount adhesive. If a bearing in one of these subassemblies goes bad, the entire subassembly must be replaced. Identical subassemblies are used for both the tension roller and the fixed roller. Instructions for removing, reinstalling and adjusting the tape guide subassemblies are given in Chapter 9.

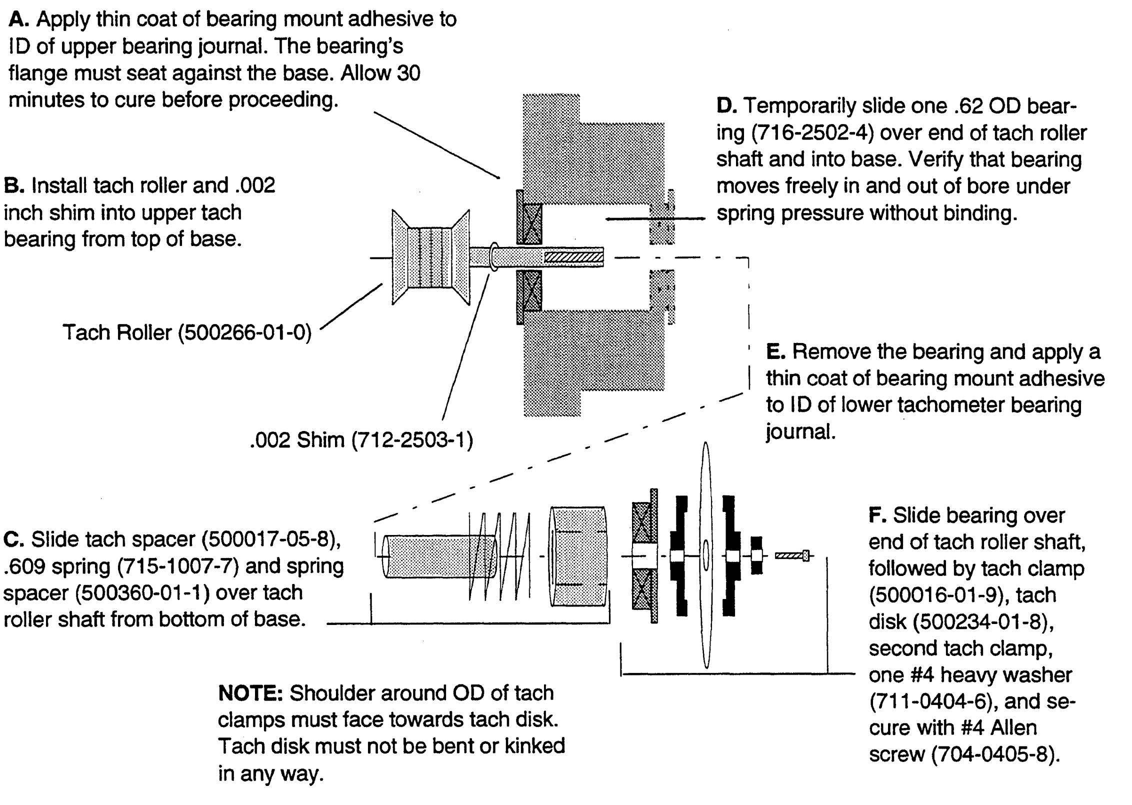


Figure 11-2 Tachometer Bearing Installation

11.7 Tension Arm Pivot Shaft Bearings

The techniques used to remove and replace the tachometer bearings can be used to remove and replace the tension arm pivot shaft bearings.

11.8 Fixed Tape Guide Roller Bearings

The bearings in the fixed tape guide are mounted to the roller with bearing mount adhesive. If one of these bearings needs to be replaced, the entire tape guide subassembly must be replaced. The procedure for replacing tape guides is given in Chapter 9.

Troubleshooting 12

This chapter describes basic troubleshooting procedures for the 34XX tape drives. Refer to previous chapters for information regarding the theory of operation, subassembly replacement, and adjustments.

SYMPTOM	POSSIBLE CAUSES
Unable to load tape	1. No signal from shutter sensor; 2. No signal from tachometer sensor; 3. Defective Motion PCBA; 4. Bad tachometer preload; 5. Bad phase in motor; 6. Hub not locking; check hub, solenoid, and mount bracket; 7. Shutter arm sticking; 8. Improper air flow in tape path; 9. Defective or misadjusted index sensor.
Load Fault 35	Defective TIP 2 sensor.
Motion Fault 62 (no tip detected while tape was tensioned)	1. Defective TIP 1 or TIP 2 sensor; 2. Tape came out of tape path; 3. EOT or BOT not detected.
Position Errors	1. Defective Read Formatter PCBA; 2. Defective shutter arm.
TIP 1 or TIP 2 failure	1. Defective sensors. (Note that emitters are wired in series); 2. EOT/BOT assembly is defective; 3. Short on the Motion PCBA; 4. Defective cabling or connectors.
Shutter does not ride in center	1. Defective or misadjusted index sensor; 2. Defective Motion PCBA; 3. Tape tension spring misadjusted; 4. Shutter arm binding.
Bad phase in motor.	1. Hall PCBA defective or shorted to chassis; 2. Open or short in motor stator; 3. Defective Motion PCBA.
Noisy motor or blower	1. Bad motor bearings; 2. Bad motor phase; 3. Bad Hall PCBA.
Motion COM failure	1. Defective Motion PCBA; 2. Loose or misconnected cable.

Table 12-1 Tape Handling and Motor Problems

SYMPTOM	POSSIBLE CAUSES
Write-V D/A failure	1. Defective WREX PCBA; 2. Defective Read Formatter PCBA.
Continuous error (HER or CER)	1. Defective Read Formatter PDCBA; 2. Defective Read Channel PCBA(s); 3. Defective or dirty read/write head; 4. Defective head cable or cable connector; 5. If able to read, defective WREX PCBA; 6. Read or Write cable misconnected; 7. Defective Read Preamplifier; 8. Media problems.
Compatibility problems	1. Tape path incorrect; 2. Skew out of tolerance; 3. Speed difference between tape drives; 4. Erase head connector or wires reversed.
ID verification failure	1. Read or Write cable not connected; 2. If able to read, defective WREX PCBA; 3. Defective Read Formatter PCBA.
Write errors during GCR only.	1. Dirty or defective read/write head; 2. If able to read, defective WREX PCBA.
Read COM failure	1. Defective Read Formatter PCBA; 2. Loose or misconnected cable; 3. Defective crystal on Read Formatter PCBA.

Table 12-2 Read/Write Problems

SYMPTOM	POSSIBLE CAUSES
"Check 15 Volt" error. NOTE: If 15 volt regulator is defective, also check BR1 for shorts.	1. Defective ± 15 volt regulator; 2. Read formatter PCBA shorts out 15 volt supply; 3. WREX PCBA shorts out 15 volt supply; 4. BR1 is shorted; 5. Bad 15 volt sensing circuit on WREX PCBA; 6. Write cable reversed.
"Check 6 Volt" error.	1. Defective ± 6 volt regulator; 2. Power cable not connected; 3. Cable between J35 and J25 miswired or not connected.
"Check 22 Volt" error.	1. Low line voltage; 2. Wrong AC Configuration Switch settings.
No display.	1. Defective Display PCBA; 2. Miswired or defective display cable; 3. Defective WREX PCBA; 4. +5 volts missing; 5. Fuse F2 on Power Supply PCBA blown; 6 Defective Power Supply PCBA.
Fan does not start. CAUTION: If fan does not spin, power supply filter capacitors will remain charged after power is turned off.	1. If DS1 is not on, one of the Hall PCBAs could be shorted to the chassis; 2. Defective Motion PCBA; 3. Misconnected cable.
Fails BEMF during calibration; motors stay on continuously.	One or more Hall PCBAs shorted or defective.

Table 12-3 Miscellaneous Problems

12.1 Problem Isolation Techniques

12.1.1 Maintain the Original Failure Conditions

Until the problem has been confirmed, it is important to maintain the original failure conditions.

- Avoid the temptation to open the cover and "have a look" before confirming a problem, as this will immediately change the temperature in the tape path.
- Avoid disturbing the interface cables, moving the drive in and out on its rack, or raising the base to the service position, as this could mask a borderline connector problem.
- Problems which only occur upon first power up in the morning are usually difficult to verify after the drive has been powered up for any length of time.
- Hair dryers and cooling sprays often mask the original problem or creates a new one, and is discouraged.

12.1.2 Try Another Drive

The first thing to do when the tape drive is suspected is to verify that the tape drive, rather than some other system component, is defective.

- Disconnect the interface cable from the rear of the suspected drive and connect it to a known good drive.
- Avoid moving the tape drive to another system, as intermittent problems often disappear temporarily when the drive is disturbed.

12.1.3 Try Another Tape

Use name brand tapes in good condition. The tape does not have to be new, but it should be one which has been certified by the manufacturer for operation at 6250 cpi. Reconditioned tape may result in reduced data reliability. Because Qualstar has no control over the production of tape, it cannot recommend one brand over another.

12.1.4 Check the Interface Cables and Termination

- Verify that the interface cables are not longer than twenty feet, measured from the controller connector to the connectors on the last drive on the cable. Longer cables may result in reduced data reliability.
- Verify that the tape drive cable terminators are installed in the tape drive and in the tape coupler board in the system. If there is more than one tape drive on the interface, only the coupler and the drive at the physical end of the cable should have terminators.
- Verify that there is no unused cable stub after the last pair of connectors.

- The interface cable should be either twisted pair ribbon or round cable. Refer to the Product Specification (Qualstar document 500240 or 500540) for the correct cable type.
- Visually inspect the cable connectors for cracks, breaks, and damaged or bent pins. Replace any cable with damaged connectors.
- If the solder connections are external to the connector, check them for poor solder connections.

12.1.5 Check the AC Line Voltage

Refer to the User's guide for line voltage requirements, and verify that the AC Configuration switches at the rear of the drive are set correctly. When in doubt, measure the line voltage at the receptacle to which the drive is connected. The Diagnostic submenu in the Maintenance menu contains an AC voltage monitor function which graphically displays the AC line voltage. See the 34XX User's Guide for further information.

12.2 Test Methods

12.2.1 Front Panel Diagnostic Testing

Use the built-in diagnostic features of the tape drive as a first means of checking the tape drive. They allow the majority of the drive's electronics to be tested without opening the base, moving cables, or otherwise disturbing the tape drive or its environment. The offline diagnostics will verify the data paths used for reading and writing within the tape drive (i.e., interboard and read/write head connections) but cannot check the data paths between the PCBA interface connectors and the line drivers and receivers. The offline diagnostics are described in detail in the User's Guide (Qualstar document 500300.)

12.2.2 Online Diagnostic Testing

If the tape drive passes the front panel diagnostic tests, test the drive on the system using system-level software diagnostics. Usually the system manufacturer or the supplier of the tape coupler has provided tape drive utilities which you can use to effect simple data transfers under controlled conditions.

System-level diagnostics also allow you to test the tape drive without disturbing the interface cables, the tape drive, or its environment. Use these diagnostics to perform simple tape I/O operations at first, then to simulate more complex system operations.

12.2.3 Offline Testing Using an Exerciser

If online diagnostics are not available, or if system usage prevents their use, you may use external test equipment. This may be in the form of a portable PC, or a dedicated offline tape formatter exerciser. Whenever possible, avoid moving the tape drive or otherwise disturbing the normal operating environment. Disconnect the tape drive interface cables and connect the external test equipment without moving, opening, or otherwise disturbing the tape drive.

For basic go/no-go testing, a Wilson TFX-500 Tape Formatter exerciser may be used to read and write tapes and to check basic data functionality, compatibility, and tape handling.

More information about the Wilson TFX-500 can be obtained from:

Wilson Laboratories, Inc.
2237 North Batavia Street, Orange, CA 92665
Telephone (714) 998-1980

12.2.4 Online Testing

If system diagnostics and offline exercisers are unavailable, try reproducing the problem using an application other than the one in which the failure occurs. Try using other types of applications or utilities which access the tape drive, such as backup and restore routines, file copy, and file translation programs.

12.3 Problems Catagorized According to Frequency of Occurrence

12.3.1 Solid, Recurring Problems

These are problems which can be reproduced at will under specified circumstances.

a. If related to specific locations on the media, try another tape;

b. If related to specific system-level commands, check for an application or system design/integration problem;

c. If related to hardware, verify the problem is caused by the tape drive;

d. If related to the environment, check for proper operating ambient temperature and humidity level. See if any externally-induced vibration is present during the failure mode. Environmental specifications are given in the Product Specifications.

12.3.2 Intermittent Problems

These are problems which occur randomly and which cannot be reproduced at will. The time interval between failures can vary from as little as a few seconds, to several weeks or months.

a. **Several seconds between failures** - Check for electrical noise on the power cable; inadequate grounding;

b. **Several minutes between failures** - Check for direct static discharge to tape drive or other system component; media problems; adjustment settings; noisy power lines, or power sags which exceed the operating specification of the tape drive; environmental conditions which produce condensation within the tape drive or which exceed media specifications; other concurrent activity in local area;

c. **Several hours, weeks, or months between failures** - Usually related to external power conditions such as low line voltage due to seasonal changes and the use of air conditioners and fans; check for weather-related ambient temperature or humidity conditions which may cause the specifications of the media or the tape drive to be exceeded.

12.3.3 Problem Condition Worsens over Time

a. **Preventive Maintenance** - An error rate which steadily increases over a period of weeks or months usually indicates inadequate preventive maintenance (i.e., dirt embedded on the read/write head or on other tape path components). Careful inspection using a strong light and magnifying glass may reveal a previously undetected oxide buildup on the head; if so, the oxide must then be removed;

b. **Head Wear** - Another common cause of a steady decline in data reliability is a worn head. Although the Qualstar tape drive uses a premium hard-faced head for maximum longevity, the use of substandard or abrasive tapes can accelerate head wear. Problems in this area generally first appear as incompatibility between tape drives.

c. **Tape Path** - Problems affecting tape handling which worsen over time may be due to worn motor or tape guide bearings. Tape guide bearings can wear out prematurely if cleaning solution is allowed to seep into the bearing when the tape guide is being cleaned.

With the power off and the tape removed from the drive, manually turn each hub and feel for unevenness and rough spots while listening for clicking or other noises. A good bearing will turn smoothly, quietly, and with no detectable roughness.

d. **Tape Wear** - Tapes wear out first near the BOT marker. You can verify that the problem is caused by worn tape near the BOT marker by carefully removing the marker strip and applying a new one several feet down tape in the direction of the EOT marker. Take care not to damage the tape or contaminate it with fingerprints or dust.

12.3.4 Problem Suddenly Occurs

Problems which suddenly occur usually can be related to some specific event, although that event may be difficult to track down. Look for things which didn't exist before the failure was noticed.

- **System change** - Tape controller replaced; software update; new application; new operator; new operating hours; new brand or type of tape;

- **Environment change** - Drive moved, interface cable disconnected and reconnected; new equipment moved into area (fans, fluorescent lamps, motors); load change on electrical line; carpeting installed or cleaned, opening way for static-related problems; heavy equipment (such as printing presses, motor generators, large air conditioners, foundry machinery, etc) installed on same building service feed;

- **After PM was performed** - Tape path component damaged or knocked out of alignment; head scratched or left dirty;

- **After drive was "repaired"** - Cable not fully seated; cable flexed causing questionable contact between cable header and ribbon; cable insulation pinched enough to expose wires; wrong or unauthorized part used to effect repairs; required adjustments not performed correctly, or not performed at all; ESD precautions not observed, which resulted in a weakening of a component on a PCBA, leading to a delayed failure; hardware left on PCBAs.

12.3.5 Temperature Sensitive Problems

These problems occur at a particular temperature or within a particular range of temperatures.

a. The operating temperature specification of the tape drive has been exceeded;

b. The temperature specification of the media has been exceeded;

c. The tape drive does not have adequate ventilation.

Illustrated Parts List 13

The following pages illustrate various views of the 34XX Series Tape Drive. Some field-replaceable parts may not be illustrated.

Following the illustrations is a table which lists these parts numerically by Qualstar part number. When ordering parts, be sure to give the complete part number.

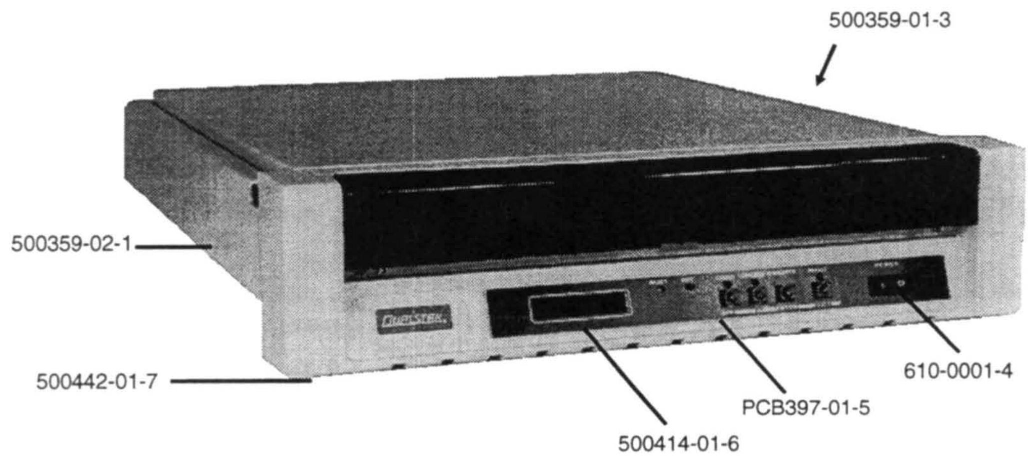


Figure 13-1 34XX Tape Drive

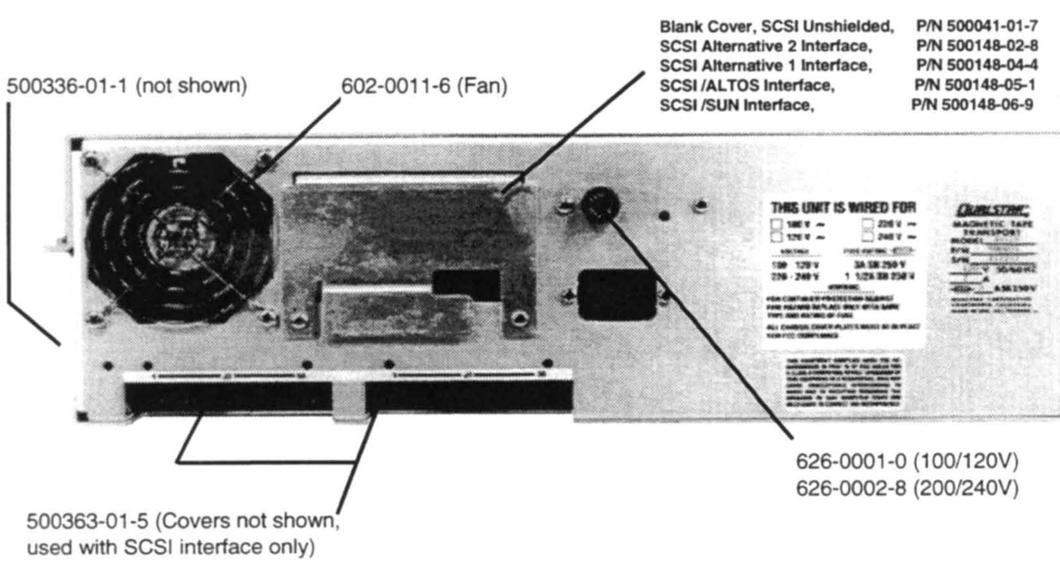


Figure 13-2 34XX Tape Drive, Rear View

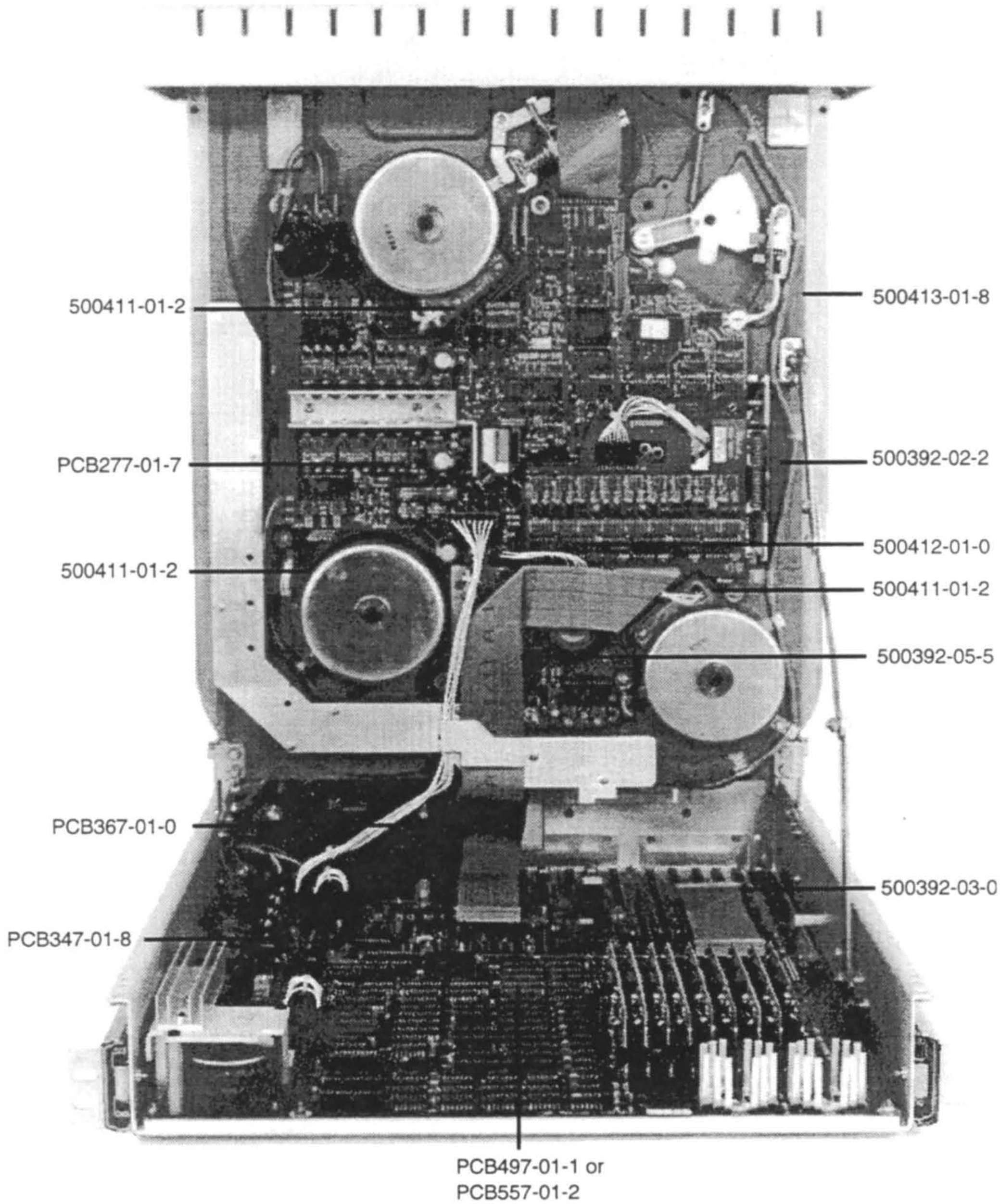


Figure 13-3 3410/3412 Internal Component Locations

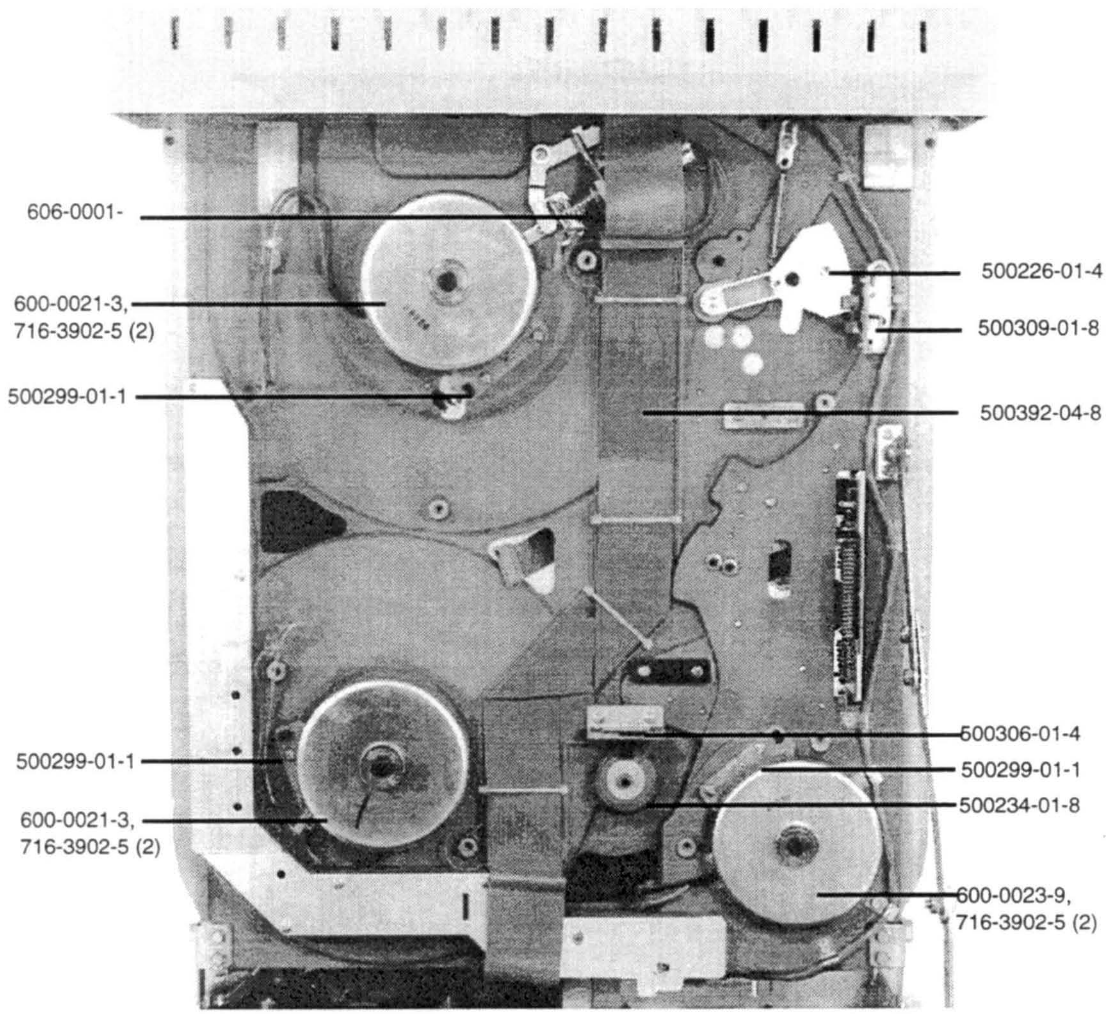


Figure 13-4 Underside of Base with Motion PCBA removed

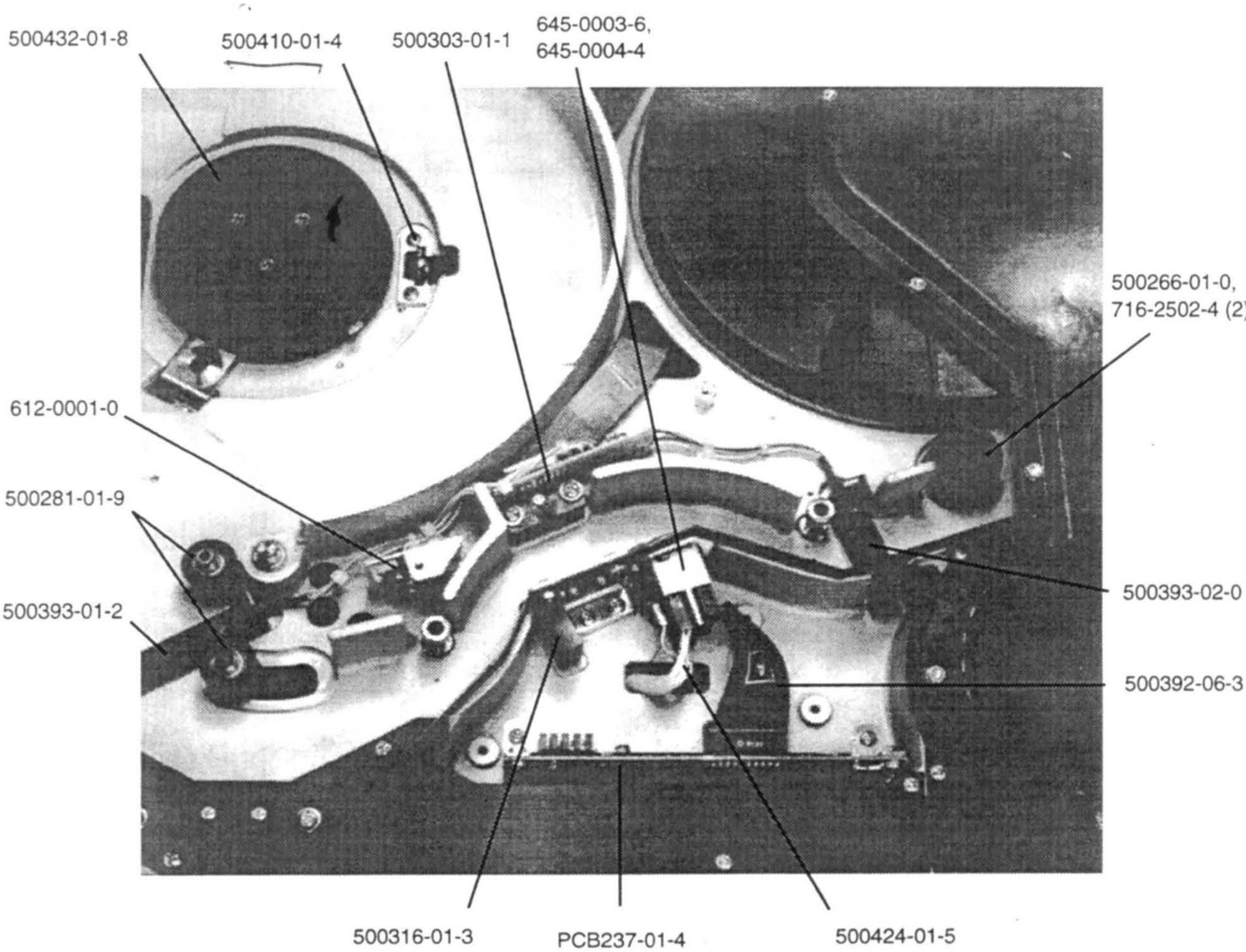


Figure 13-5 34XXTape Path Component Locations

ORDER NO.	FIELD REPLACEABLE UNIT	QUANTITY (IF MORE THAN ONE)	REMARKS
500226-01-4	Shutter		
500234-01-8	Tach Disk		
500266-01-0	Tach Roller		
500280-01-1	Shim	as required	Skew shim
500281-01-9	Tape Guide Assembly	2	Fixed/Tension Roller
500299-01-1	Hall Switch Assembly	3	
500303-01-1	EOT/BOT Assembly		
500306-01-4	Tach Assembly		Tach sensor
500309-01-8	Shutter Assembly		Shutter sensor
500316-01-3	Tape Cleaner Assembly		
500334-01-6	Hold Down Screw	2	Base lock screws
500336-01-1	Slide Assembly Set		Rack mount units only
500359-01-3	Side Plate, Right Side		Desk top units only
500359-02-1	Side Plate, Left Side		Desk top units only
500363-01-5	Interface Cover	2	
500392-02-2	Cable Assembly		Preamp/Read PCBAs
500392-03-0	Cable Assembly		WREX/Read PCBAs
500392-04-8	Cable Assembly		WREX/Motion/Display
500392-05-5	Cable Assembly		WREX/Motion PCBAs
500392-06-3	Cable Assembly		Head/Preamp PCBA
500392-07-1	Cable Assembly	2	Pertec/SCSI
500392-08-9	Cable Assembly		WREX/SCSI PCBAs
500393-01-2	TIP-1 Assembly		
500393-02-0	TIP-2 Assembly		
500410-01-4	FPT/RIP Assembly		
500411-01-2	Hall Cable Assembly	3	
500412-01-0	Tach Cable Assembly		
500413-01-8	Shutter Cable Assembly		
500414-01-6	Liquid Crystal Display Assembly		

34XX Field Replaceable Unit Parts List

ORDER NO.	FIELD REPLACEABLE UNIT	QUANTITY (IF MORE THAN ONE)	REMARKS
500424-01-5	Write Head Cable Assembly		
500426-01-0	Nut Plate	2	
500432-01-8	Supply Hub Assembly		
500442-01-7	Bezel Assembly		
600-0021-3	Reel Motor	2	Supply & Take Up
600-0023-9	Blower Motor		
604-0011-6	Fan, 30 CFM 24 volt		
606-0001-2	Solenoid, Hub Lock		
606-0002-0	Solenoid, Door Lock		Optional
610-0001-4	Power Switch		Front Panel Power
612-0001-0	Snap Switch	2	Interlock switches
626-0001-0	Fuse F1, 100-120 volt drives		3 amp 3AG Slo-Blo, 250v
626-0002-8	Fuse F1, 220-240 volt drives		1.5 amp, 3AG Slo-Blo, 250v
626-0010-1	Fuse F2, Power Supply PCBA		10 amp, 32 V
626-0013-5	Fuse F3, Motion PCBA		6 amp, 32V, 3AG
626-0014-3	Fuse F4, SCSI-2 PCBA		1.0 amp, 3AG
630-0014-5	Transformer		
645-0003-6	Head, 9-track GCR		341X only
645-0004-4	Head, 9-track PE		340X only
684-0021-7	Option Jumper		All PCBAs
716-2502-4	Bearing, .250 ID	2	
716-3902-5	Bearing, .394 ID	4	
PCB237-01-4	Read Preamplifier PCBA		
PCB247-01-0	Read Channel PCBA		NOTE 1
PCB277-01-7	Motion PCBA		NOTE 2
PCB347-01-8	Power Supply PCBA		
PCB367-01-0	Write/ExecutivePCBA		NOTE 2
PCB377-01-5	Read Formatter PCBA		341X prior to 11/92
PCB397-01-5	Display PCBA		
PCB417-01-9	SCSI-2 PCBA		34XXS, 34XXSD
PCB467-01-4	SCSI-2 Differential PCBA		34XXSD
PCB497-01-1	PE Read Formatter PCBA		340X only
PCB557-01-2	Read Formatter PCBA		341X only

NOTE 1: 341X with 500377 Read Formatter PCBA only. All nine channel cards must be same revision.
NOTE 2: Specify drive model and serial number when ordering this part.

34XX Field Replaceable Unit Parts List
(continued)

PCBA Drawings and Schematics — Appendix A.

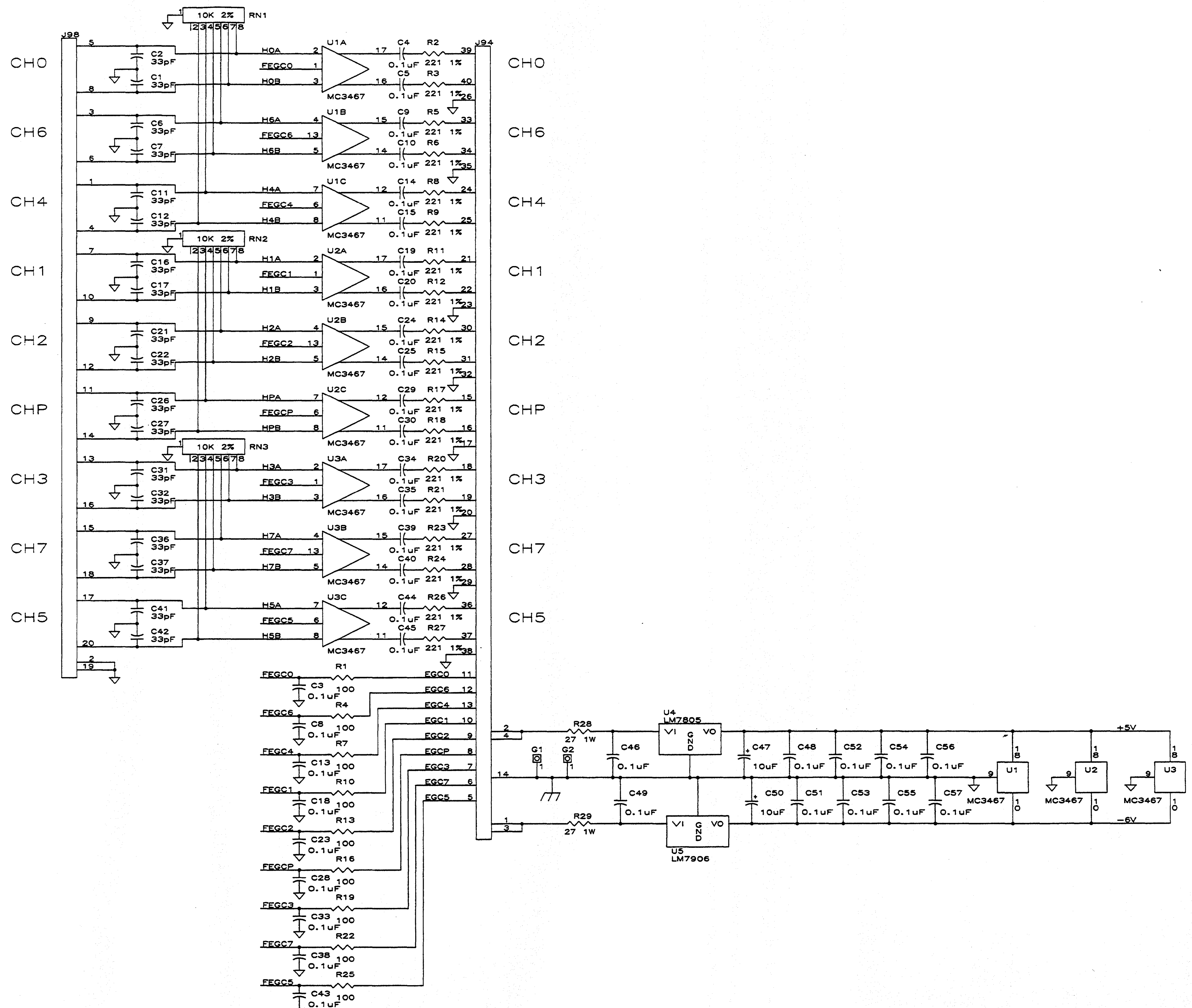
This appendix contains the following schematics and assembly drawings:

DRAWING NUMBER	TITLE
500237	Preamplifier PCBA
500238	Schematic Diagram, Preamplifier
500277	Motion PCBA
500278	Schematic Diagram, Motion
500347	Power Supply PCBA
500348	Schematic Diagram, Power Supply
500367	Write Executive PCBA
500368	Schematic Diagram, Write Executive
500397	Display PCBA
500398	Schematic Diagram, Display
500417	SCSI Interface PCBA
500418	Schematic Diagram, SCSI Interface
500452	System Interconnect Diagram — Model 34XX
500467	SCSI Differential PCBA
500468	Schematic Diagram, SCSI Differential
500497	Read Formatter PCBA (3402)
500498	Schematic Diagram, Read Formatter (3402)
500557	Read Formatter PCBA (341X)
500558	Schematic Diagram, Read Formatter (341X)

Table A-1 Schematics and Locational Diagrams

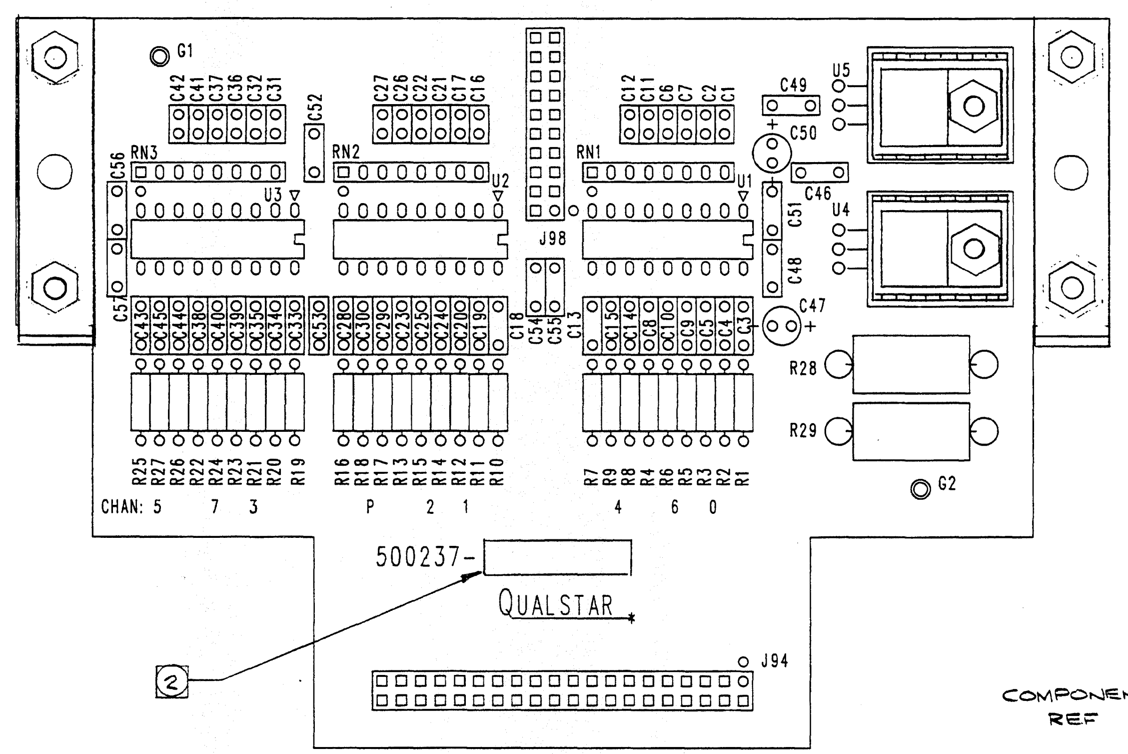
Note: *When replacing components on PCBAs, always use genuine Qualstar parts. Many of the discrete parts used on Qualstar products are screened to meet Qualstar specifications; generic parts purchased "off the shelf" which do not meet Qualstar specifications may not work reliably in a given application.*

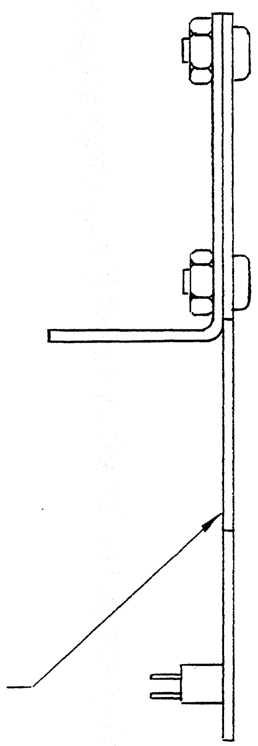
LTR	CHANGES	DATE
A1	INITIAL RELEASE	12/20/88
B1	CHG OUT.CONN. & OUTLINE	11/22/89
B2	REVISED PER EN-143	09/06/90
C1	REVISED PER EN-230	01/21/91



QUALSTAR CORPORATION		
TITLE PREAMP - MODEL 3410		
SIZE D	NUMBER 500238	REV. C1
DATE SEPT 21, 1989	SHEET 1 OF 1	

LTR	DESCRIPTION	DWN	CHK	DATE	APVD
B1	PRODUCTION RELEASE	JT		1/5/90	BG
B2	EN 143	JT		9/1/90	BG
C	EN 230	JET	TRAN.	1/22/91	TRAN.





COMPONENT SIDE
REF

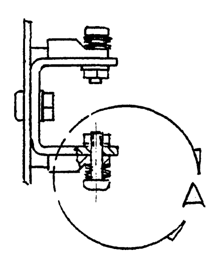
MATERIAL	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DEBURR AND BREAK ALL SHARP EDGES AND CORNERS .01R OR CHAMFER DIM AND TOL PER ANSI Y14.5 TOLERANCES: .XX +/- .XXX +/- ANGULAR +/- DO NOT SCALE DRAWING	SIGNATURE	DATE	QUALSTAR
		DWN J. TOMAZIN	1/6/90	READ PREAMPLIER PCBA
FINISH		CHK		
		APVD BG	1/7/90	SIZE D / PRODUCT CODE / DWG NUMBER 500237 / REV C
		APVD		SCALE 2/1 / SHEET 1 OF 1

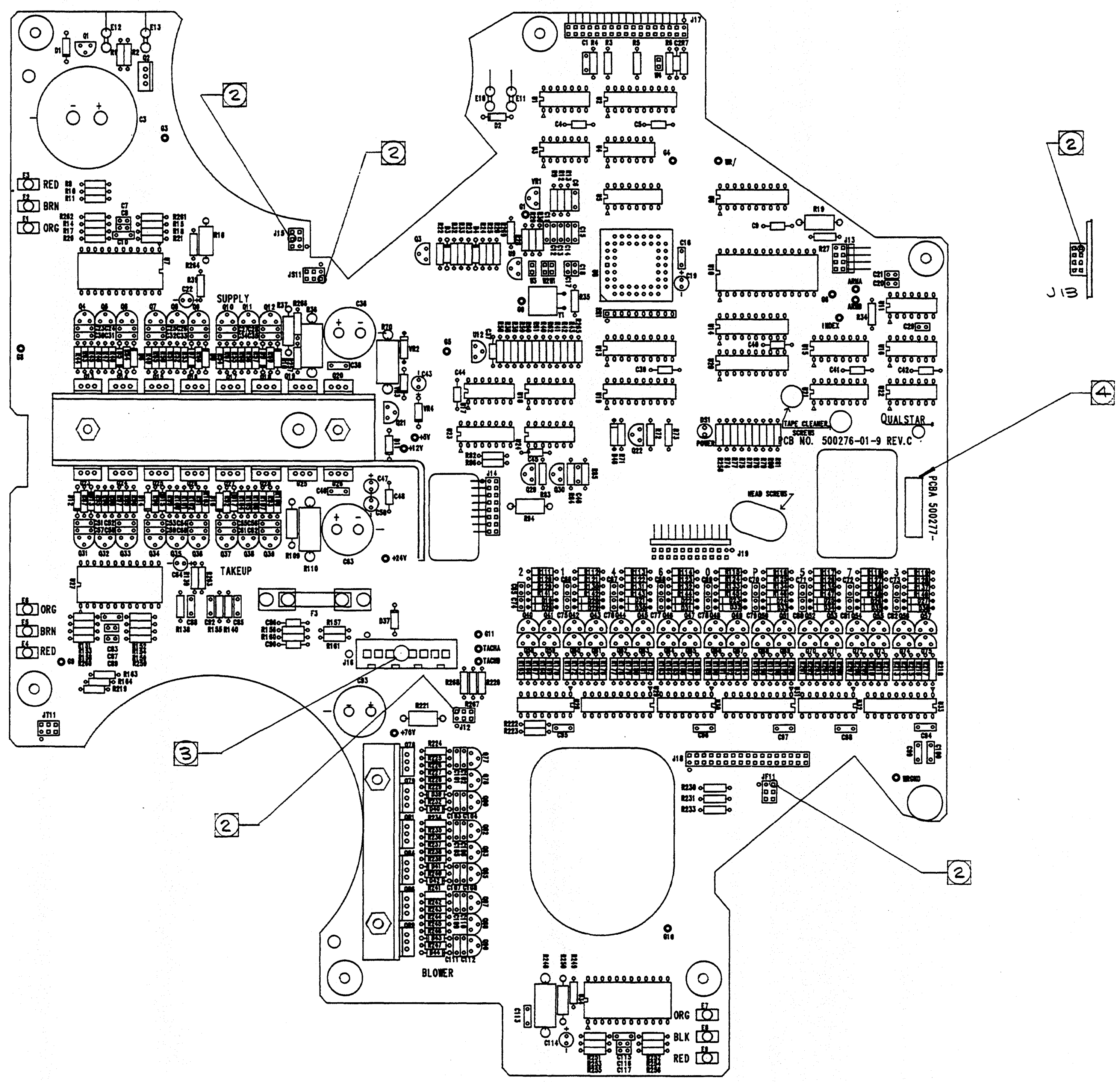
2 MARK ASSY P/N AND REVISION LETTER IN BLACK INK.

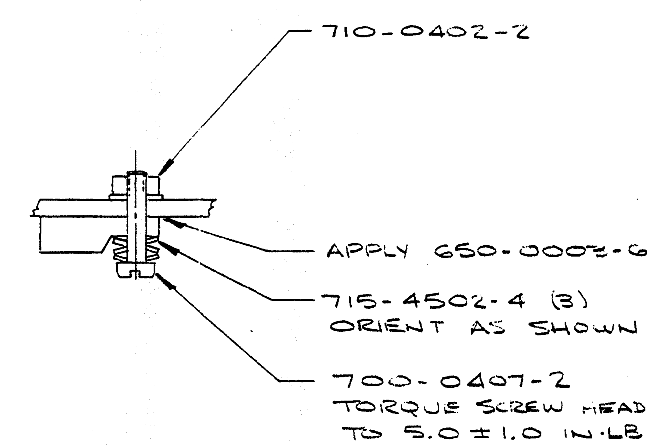
1. SEE LM FOR ASSY P/N

NOTES: UNLESS OTHERWISE SPECIFIED

LTR	DESCRIPTION	DWN	CHK	DATE	APVD
A	PRODUCTION RELEASE	JT	BG	1/4/90	BG
B1A	ADDED NOTE 2	JT	RN	1/10/90	RN
B1B	ADDED HEAT SINK COMPOUND 650-0003-6; CHANGED VIEW OF HEAT SINK	J.T.	BG	1/25/90	RN
B3	EN 081	J.T.	BG	3/28/90	BG
B4	EN 131	JT	BG	9/7/90	BG
C	EN 226		R.A.	1/15/91	R.A.







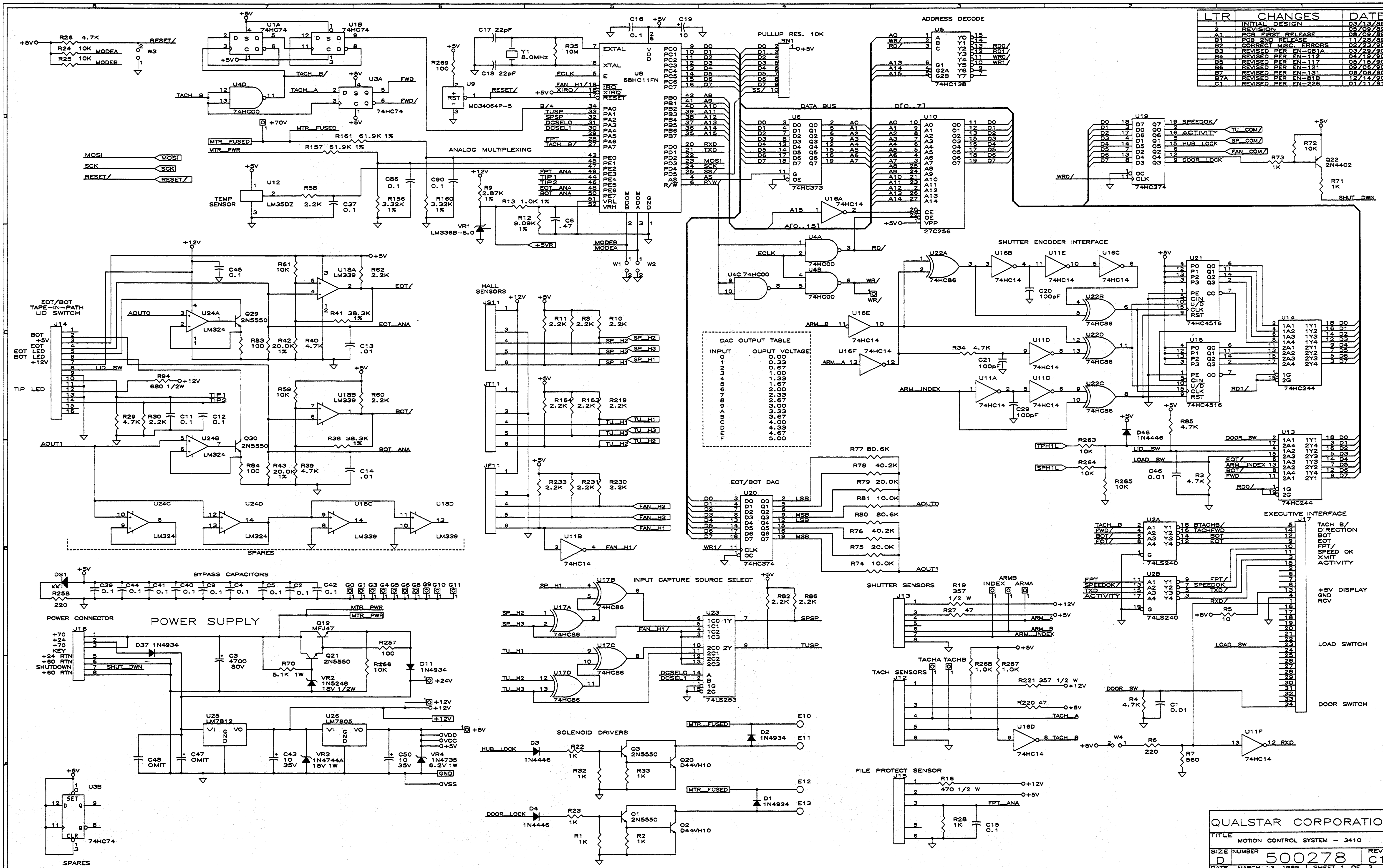
VIEW A

TYP 22 PL

4. IDENTIFY WITH ASSY PART NUMBER AND REVISION LETTER IN BLACK INK.
3. REMOVE PIN 4 BEFORE INSTALLING HEADER.
2. CLIP INDICATED PIN OFF AS CLOSE TO CONNECTOR BODY AS POSSIBLE.
1. SEE LM FOR ASSY P/N.

NOTES: UNLESS OTHERWISE SPECIFIED

MATERIAL	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	SIGNATURE	DATE	QUALSTAR
	DEBURR AND BREAK ALL SHARP EDGES AND CORNERS .01R OR CHAMFER	DWN J.T.	1/4/90	MOTION PCBA
FINISH	DIM AND TOL PER ANSI Y14.5	CHK		
	TOLERANCES: .XX +/- .XXX +/- ANGULAR +/-	APVD BG		SIZE D · PRODUCT CODE · DWG NUMBER 500277 · REV C
	DO NOT SCALE DRAWING	APVD		SCALE FULL · SHEET 1 OF 1



LTR	CHANGES	DATE
1	INITIAL DESIGN	03/13/89
2	REVISION	05/09/89
A1	PCB FIRST RELEASE	08/09/89
B1	PCB 2ND RELEASE	11/28/89
B2	CORRECT MISC. ERRORS	02/23/90
B3	REVISED PER EN-081A	03/29/90
B4	REVISED PER EN-112	04/19/90
B5	REVISED PER EN-117	05/15/90
B6	REVISED PER EN-121	09/06/90
B7	REVISED PER EN-131	09/06/90
B7A	REVISED PER EN-81B	12/14/90
C1	REVISED PER EN-226	01/11/91

DAC OUTPUT TABLE

INPUT	OUPUT VOLTAGE
0	0.00
1	0.33
2	0.67
3	1.00
4	1.33
5	1.67
6	2.00
7	2.33
8	2.67
9	3.00
A	3.33
B	3.67
C	4.00
D	4.33
E	4.67
F	5.00

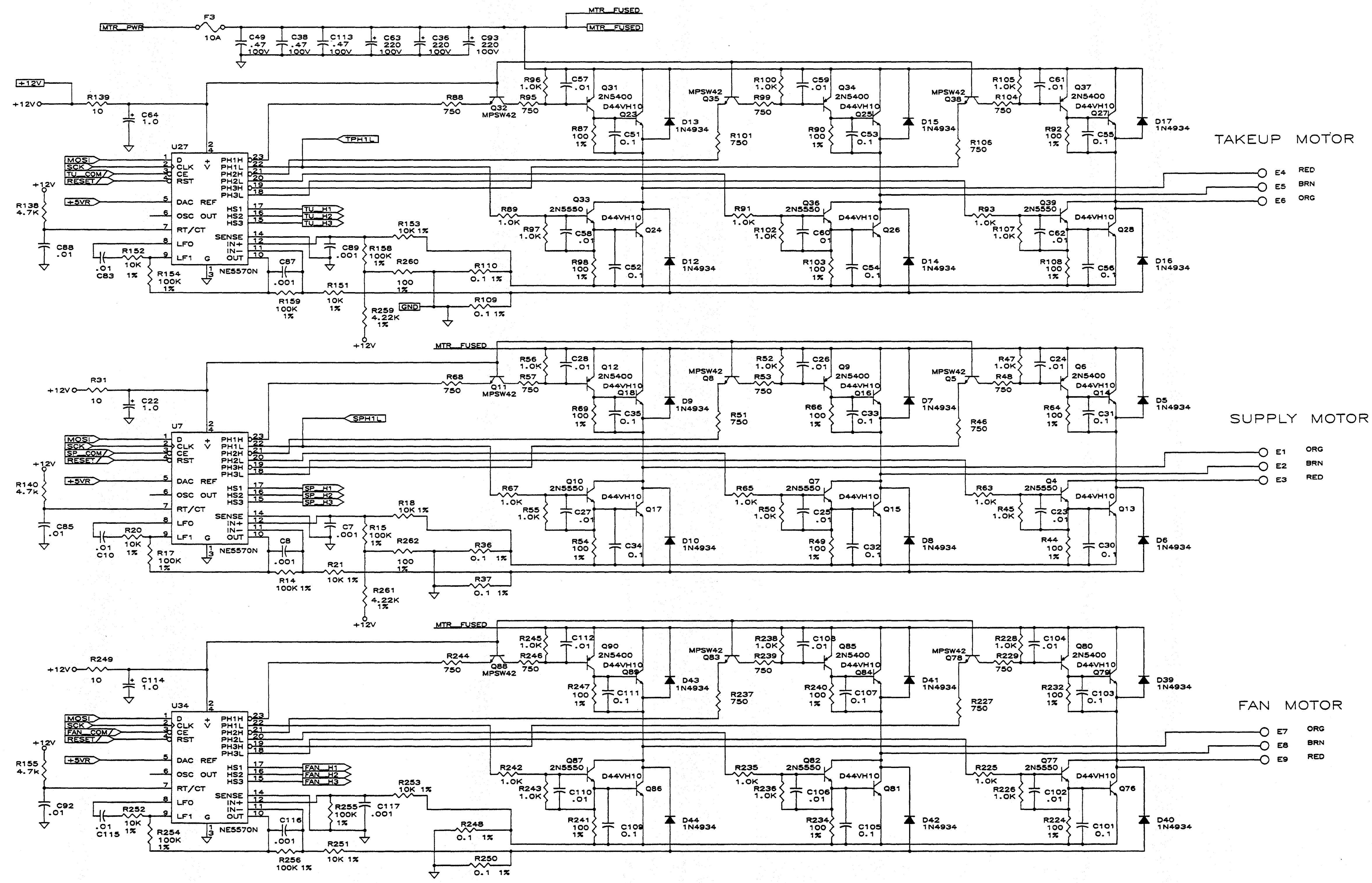
QUALSTAR CORPORATION

TITLE: MOTION CONTROL SYSTEM - 3410

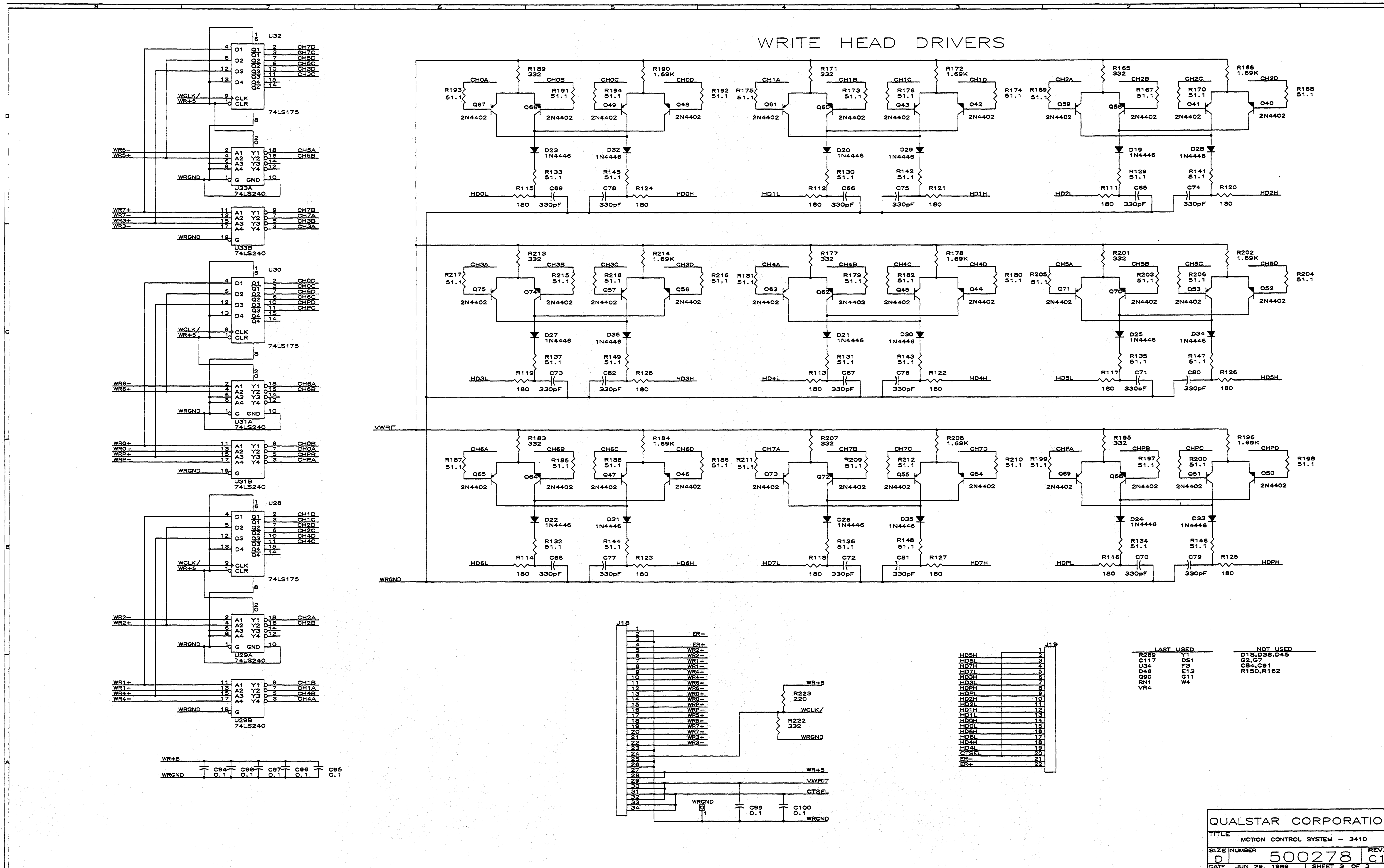
SIZE	NUMBER	REV.
D	500278	C1

DATE MARCH 13, 1989 | SHEET 1 OF 3

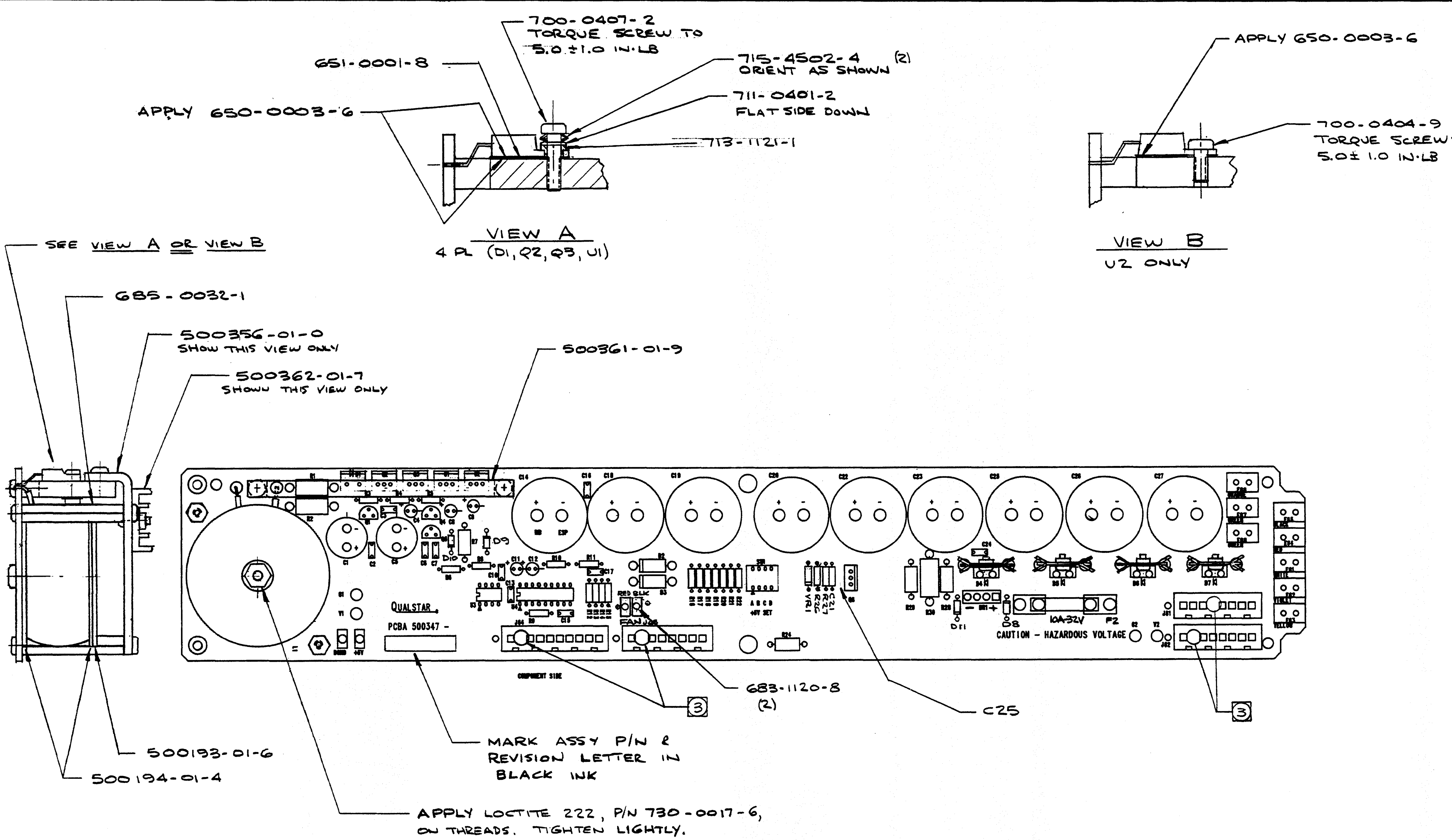
MOTOR DRIVER CIRCUITRY



QUALSTAR CORPORATION			
TITLE MOTION CONTROL SYSTEM – 3410			
SIZE D	NUMBER 500278		REV. C1
DATE MARCH 13, 1989	SHEET 2 OF 3		


WRITE HEAD DRIVERS
LAST USED
R269 Y1
C117 DS1
U34 F3
D46 E13
Q90 G11
RN1 W4
VR4
NOT USED
D18,D38,D45
G2,G7
C84,C91
R150,R162
QUALSTAR CORPORATION
TITLE MOTION CONTROL SYSTEM - 3410
SIZE D
NUMBER 500278
REV. C1
DATE JUN 29, 1989
SHEET 3 OF 3

LTR	DESCRIPTION	DWN	CHK	DATE	APVD
B1	PRODUCTION RELEASE	YET		5 JAN 90	B
B2	EN 104	YET		23 APR 90	B
B3	711-0401-2 WAS 711-0407-2	BS		12/26/90	B
C	EN 225	YET		1/10/91	B
C1	EN 322	YET		5/28/91	B
C2	EN 363	YET		8/22/91	B
D	EN 386	YET		9/24/91	B



3 REMOVE INDICATED PINS BEFORE INSTALLING HEADERS.

2. THIS BOARD IS MADE WITH 4 OZ COPPER.

1. SEE LM FOR ASSY P/N. & REV

NOTES: UNLESS OTHERWISE SPECIFIED

MATERIAL	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DEBURR AND BREAK ALL SHARP EDGES AND CORNERS .01R OR CHAMFER DIM AND TOL PER ANSI Y14.5 TOLERANCES: .XX +/- .XXX +/- ANGULAR +/- DO NOT SCALE DRAWING	SIGNATURE	DATE
FINISH		DWN YET	5 JAN 90
		CHK	
		APVD BS	1/7/90
		APVD	

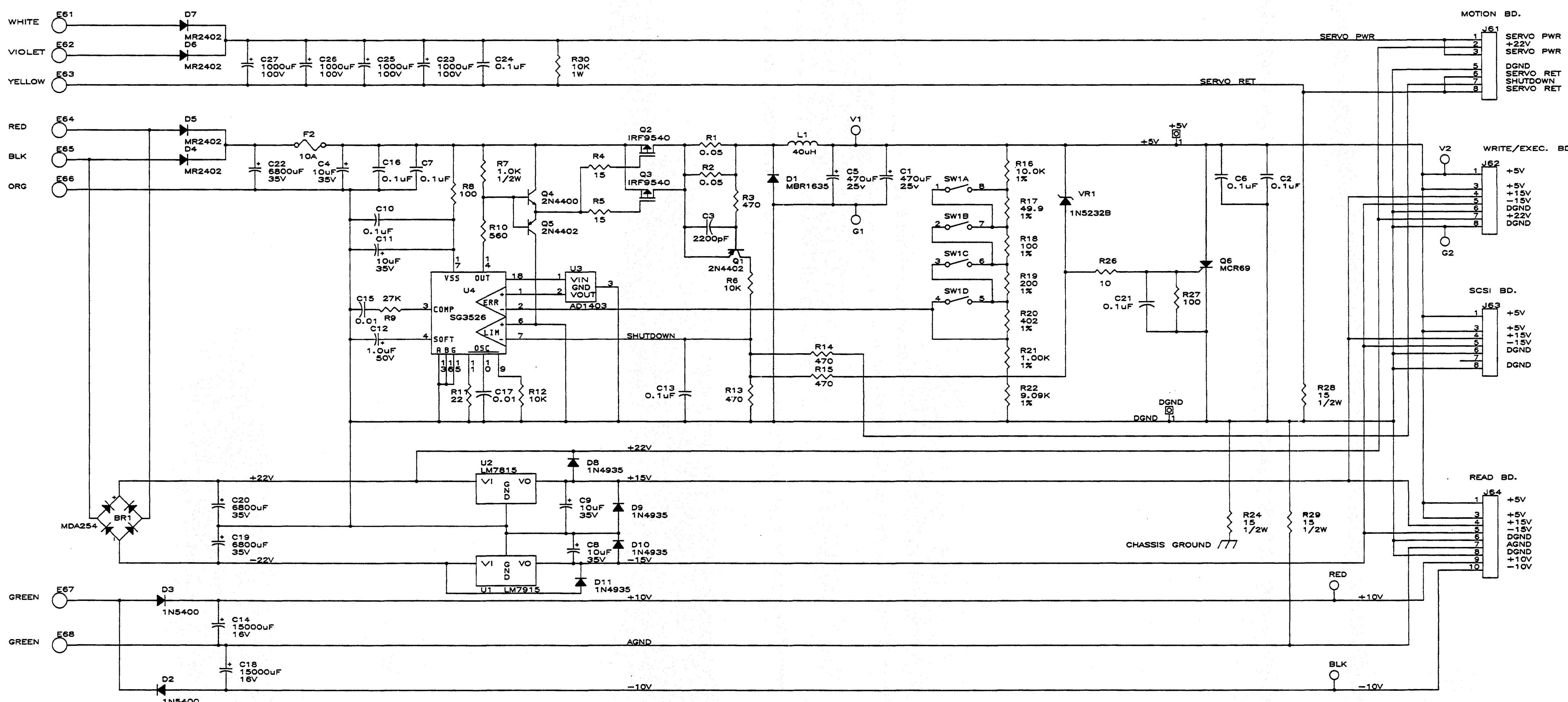
QUALSTAR

POWER SUPPLY PCBA

SIZE	PRODUCT CODE	DWG NUMBER	REV
D		500347	D

SCALE FULL | SHEET 1 OF 1

LTR	CHANGES	DATE
A1	INITIAL PCB RELEASE	08/07/89
B1	REVISED AND REDRAWN	11/27/89
B2	REVISED PER ECN-085	03/27/90
B2A	REVISED PER ECN-085A	04/20/90
B3	REVISED PER ECN-172	11/01/90
C1	EN 225 (NO CHANGE)	01/10/91
C2	EN 322	05/23/91
D1	EN 386	09/20/91

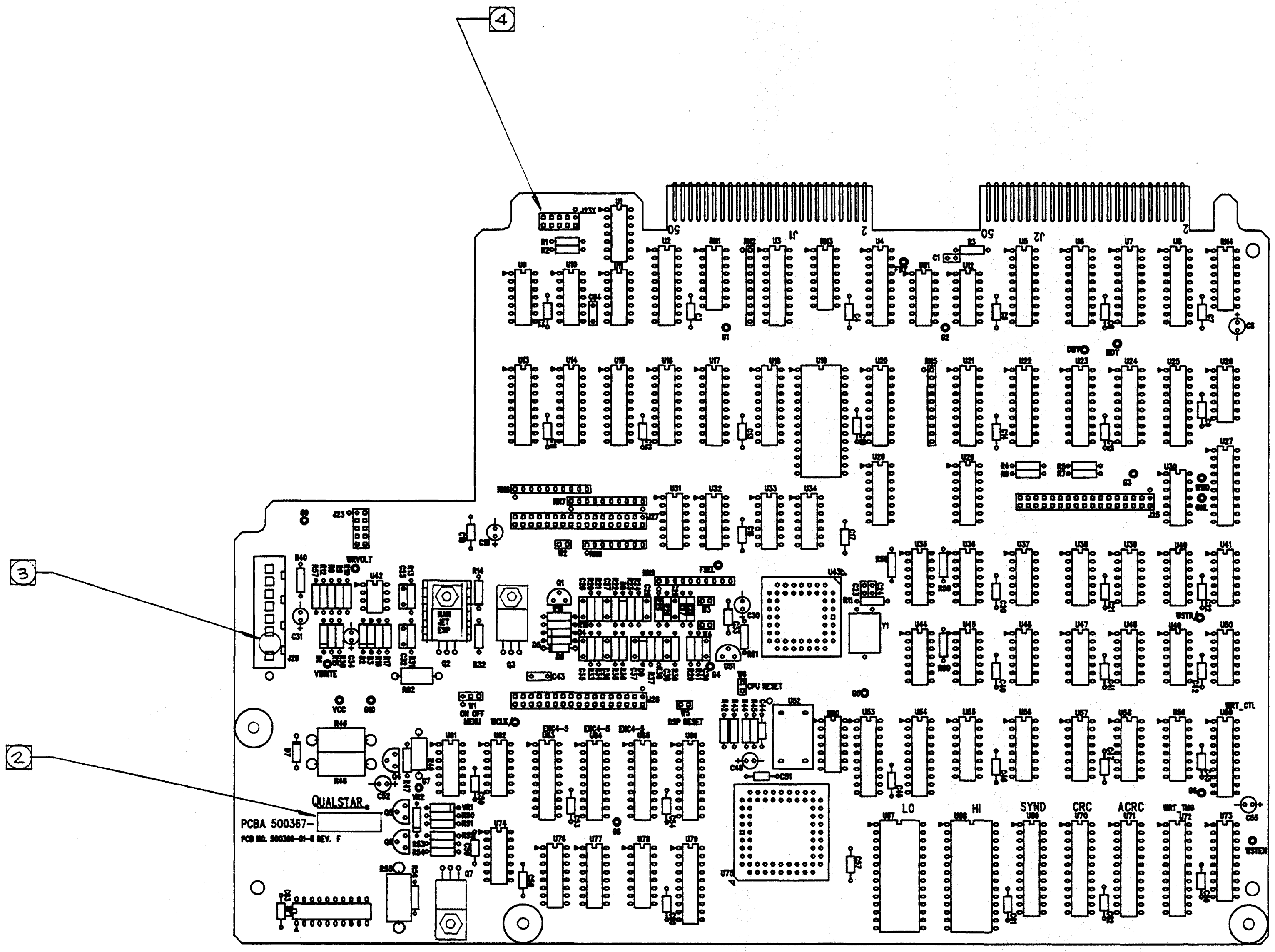


NOT USED

R23 R25

QUALSTAR CORPORATION		
TITLE SCHEMATIC: MODEL 3410 POWER SUPPLY BOARD		
SIZE D	NUMBER 500348	REV. D1
DATE JULY 31, 1989	SHEET 1 OF 1	

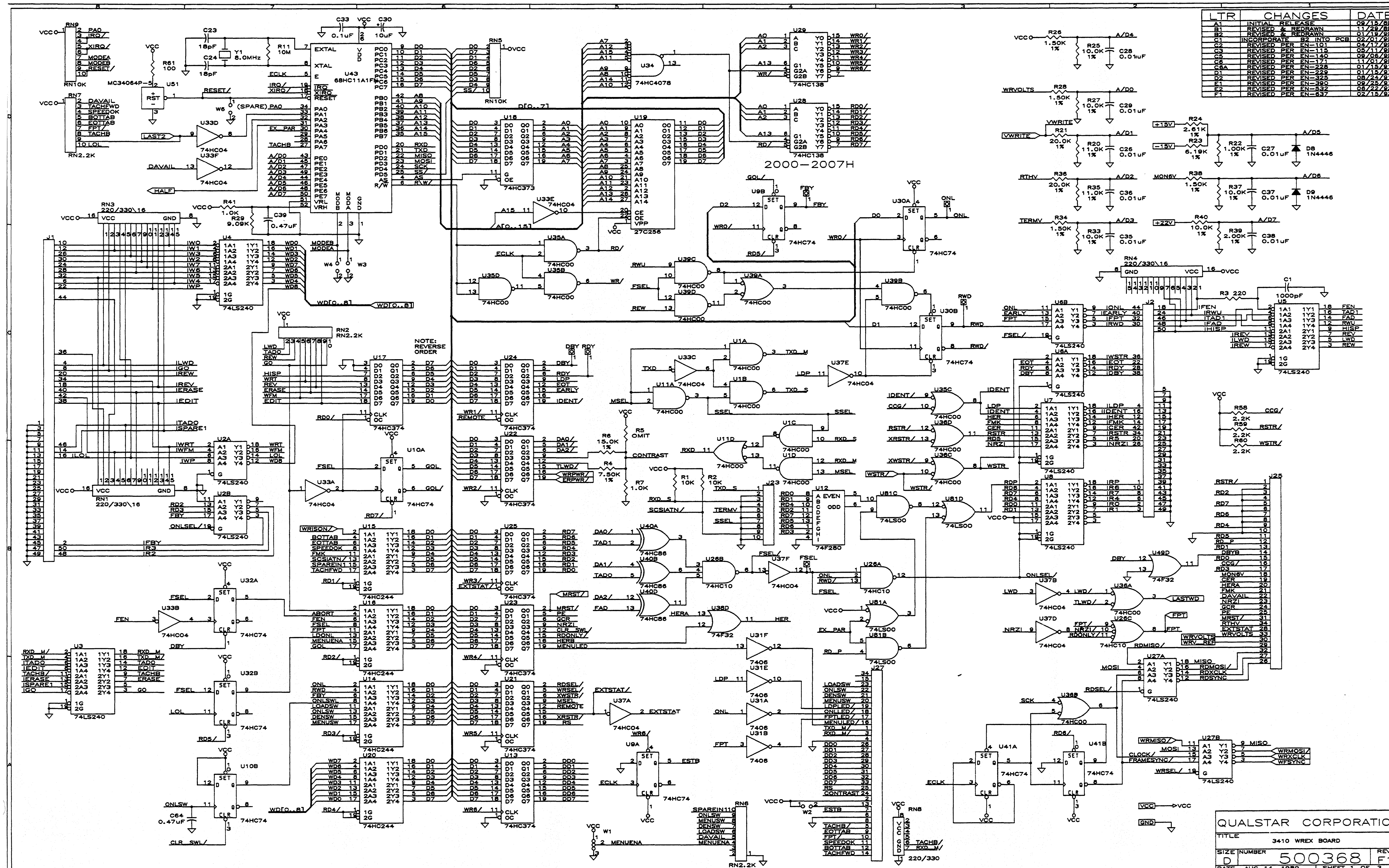
LTR	DESCRIPTION	DWN	CHK	DATE	APVD
B1	PRODUCTION RELEASE	JT	BG	1/4/90	BG
C1	REVISED U60, C55	RN	BG	2/2/90	RN
C2	EN 198	JT	RN	12/20/90	BG
D	EN 229	JT	RN	1/17/91	BG
E	EN 390	JT	RN	9/27/91	RN
E1	EN 532	JT	BG	7/23/92	BG
F	EN 637	YET	RAH.	2/22/92	RGA.



4. CONNECTOR PADS ARE FOR TEST ONLY. DO NOT INSTALL ANY CONNECTOR IN THIS LOCATION.
3. REMOVE PIN 2 BEFORE INSTALLING HEADER
2. MARK ASSY P/N AND REVISION LETTER IN BLACK INK.
1. SEE LM FOR ASSY PART NUMBER AND REVISION LETTER.

NOTES: UNLESS OTHERWISE SPECIFIED

MATERIAL	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DEBURR AND BREAK ALL SHARP EDGES AND CORNERS .01R OR CHAMFER DIM AND TOL PER ANSI Y14.5 TOLERANCES: .XX +/- .XXX +/- ANGULAR +/- DO NOT SCALE DRAWING		SIGNATURE	DATE	QUALSTAR
		DWN	JT	1/4/90	WRITE/EXECUTIVE PCBA
		CHK			
FINISH		APVD	BG		SIZE D · PRODUCT CODE · DWG NUMBER 500367 · REV F
		APVD			SCALE 1/1 · SHEET 1 OF 1



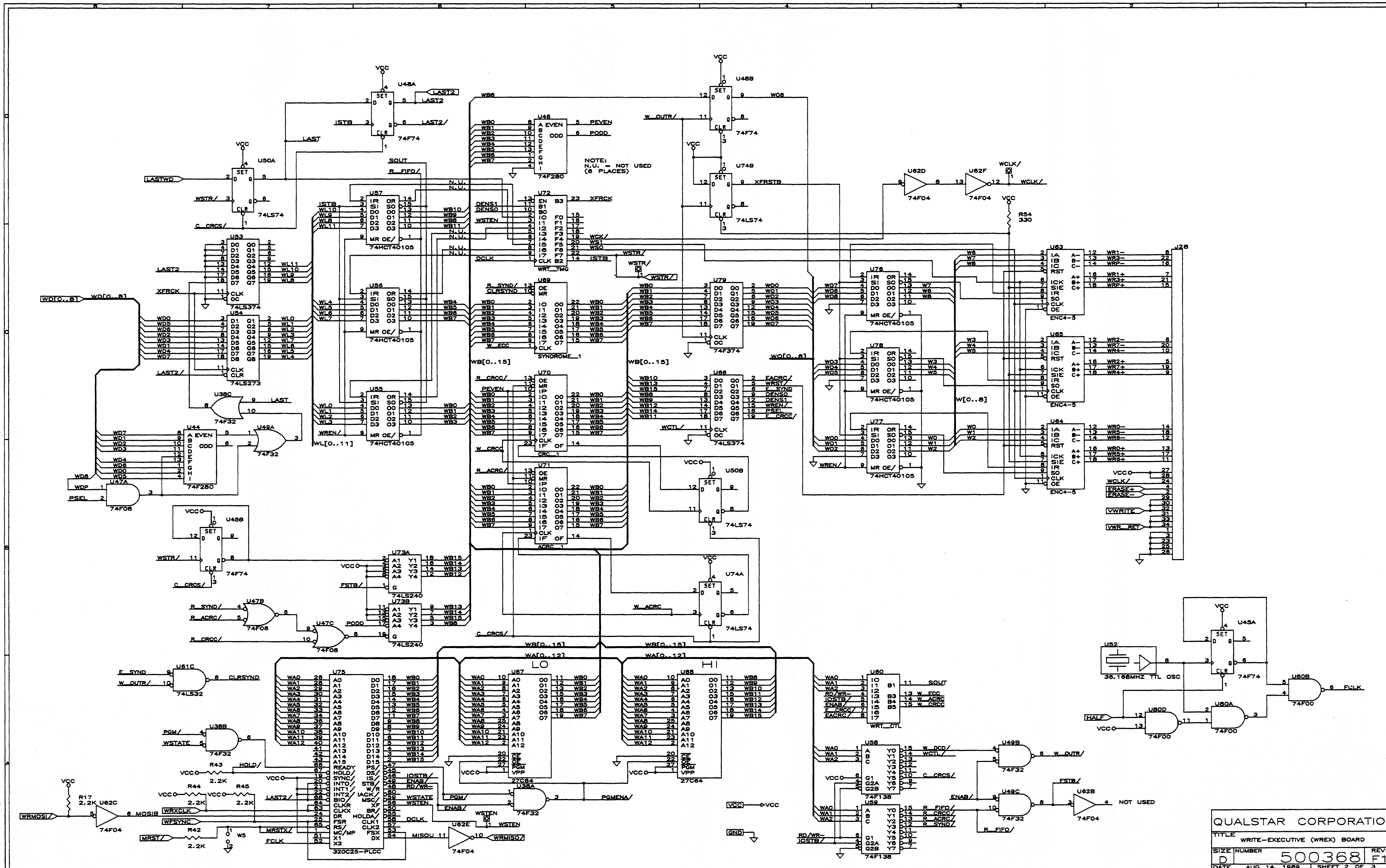
LTR	CHANGES	DATE
A1	INITIAL RELEASE	09/15/89
B1	REVISED & REDRAWN	11/29/89
B2	REVISED & REDRAWN	01/19/90
C1	INCORPORATE B2 INTO PCB	02/01/90
C2	REVISED PER EN-101	04/17/90
C3	REVISED PER EN-115	05/11/90
C5	REVISED PER EN-140	09/06/90
C6	REVISED PER EN-171	11/01/90
C6A	REVISED PER EN-228	01/15/91
D1	REVISED PER EN-229	01/15/91
D2	REVISED PER EN-325	08/24/91
E1	REVISED PER EN-390	09/25/91
E2	REVISED PER EN-532	06/22/92
F1	REVISED PER EN-637	02/15/93

QUALSTAR CORPORATION

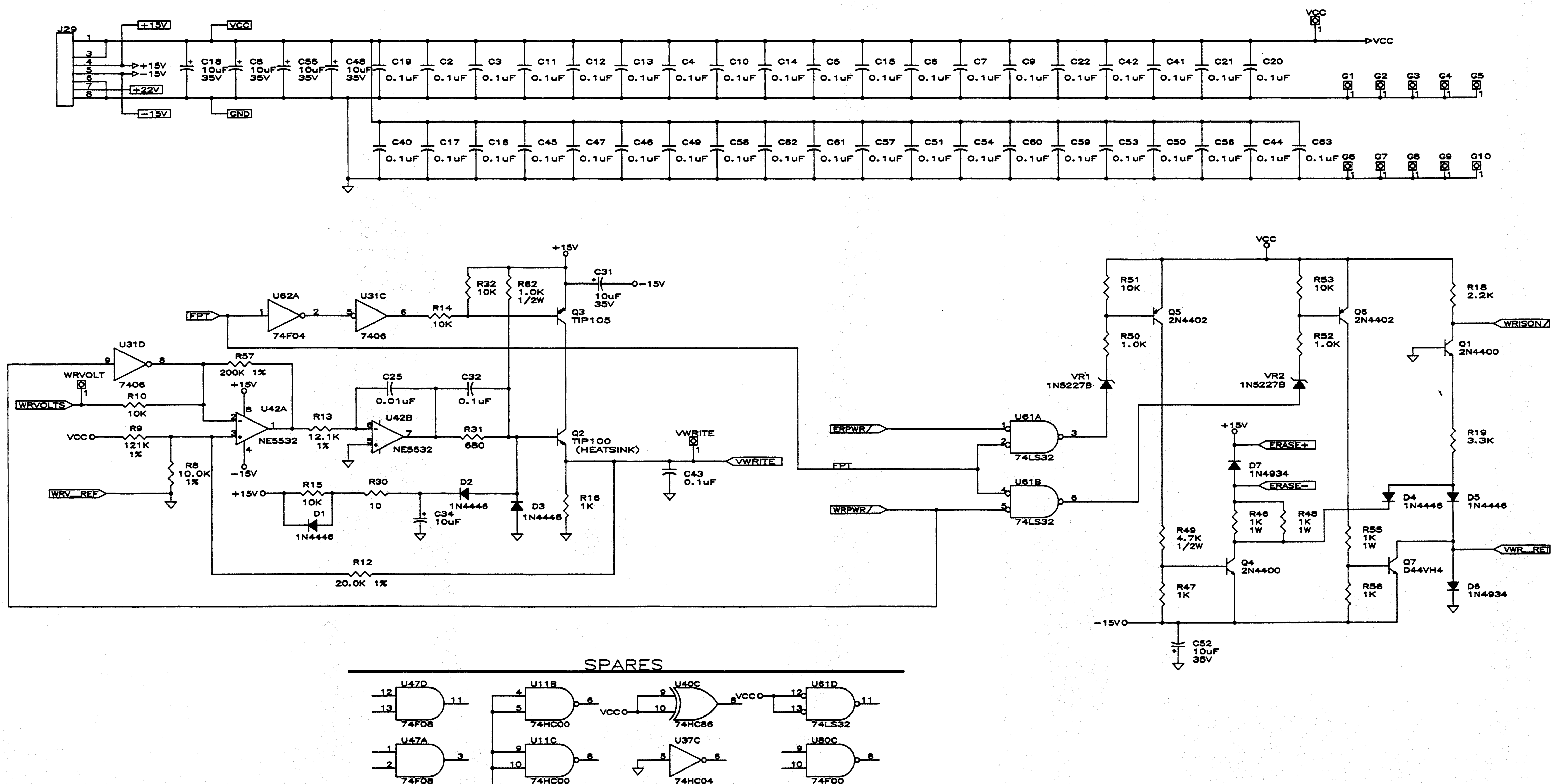
TITLE 3410 WREX BOARD

SIZE D | NUMBER 500368 | REV. F1

DATE AUG 14, 1989 | SHEET 1 OF 3



QUALSTAR CORPORATION
TITLE WRITE-EXECUTIVE (WREX) BOARD
SIZE D
NUMBER 500368
REV. F1
DATE AUG 14, 1989
SHEET 2 OF 3
NOTE: N.U. = NOT USED (6 PLACES)
U48A 74F74
U50A 74LS74
U53 74LS374
U54 74LS273
U38C 74F32
U44 74F280
U49A 74F32
U47A 74F08
U45B 74F74
U57 74HCT40105
U56 74HCT40105
U55 74HCT40105
U46 74F280
U72 WRT_TMG
U69 SYNDROME_1
U70 CRC_1
U71 ACRC_1
U73A 74LS240
U73B 74LS240
U47B 74F08
U47C 74F08
U48B 74F74
U74B 74LS74
U79 74F374
U66 74LS374
U50B 74LS74
U74A 74LS74
U76 74HCT40105
U78 74HCT40105
U77 74HCT40105
U63 ENC4-5
U65 ENC4-5
U64 ENC4-5
U62D 74F04
U62F 74F04
R54 330
J28
U61C 74LS32
U38B 74F32
U75 320C25-PLCC
U67 27C64
U68 27C64
LO
HI
U38A 74F32
PGMENA/
U62E 74F04
U62C 74F04
R17 2.2K
R43 2.2K
R44 2.2K
R45 2.2K
R42 2.2K
W5
U60 WRT_CTL
U58 74F138
U59 74F138
U49B 74F32
U49C 74F32
U62B 74F04
NOT USED
U52 36.168MHZ TTL OSC
U45A 74F74
U80B 74F00
U80D 74F00
U80A 74F00
FCLK



LAST USED

C64
D9
Q7
R62
RN9
U81
W6
Y1
VR2

NOT USED

SP1
C63
W2,W3,W4
J23X

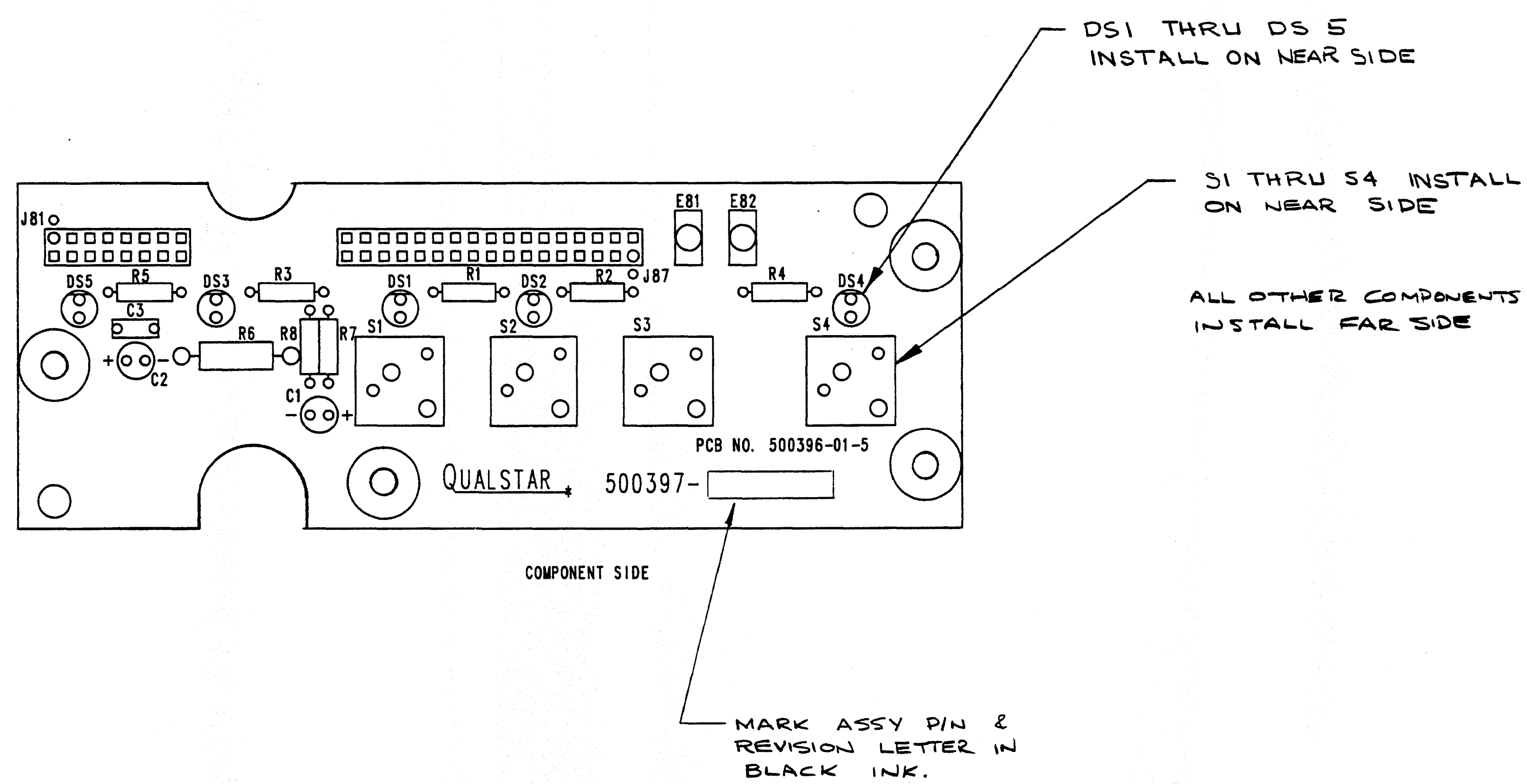
QUALSTAR CORPORATION

TITLE 3410 WREX BOARD

SIZE D | NUMBER 500368 | REV. F1

DATE AUG 14, 1989 | SHEET 3 OF 3

LTR	DESCRIPTION	DWN	CHK	DATE	APVD
A1	PRODUCTION RELEASE	JET	B	5 JAN 90	BS
A2	REVISED COMP INSTALL NOTES	JET	B	18 JUN 90	BS

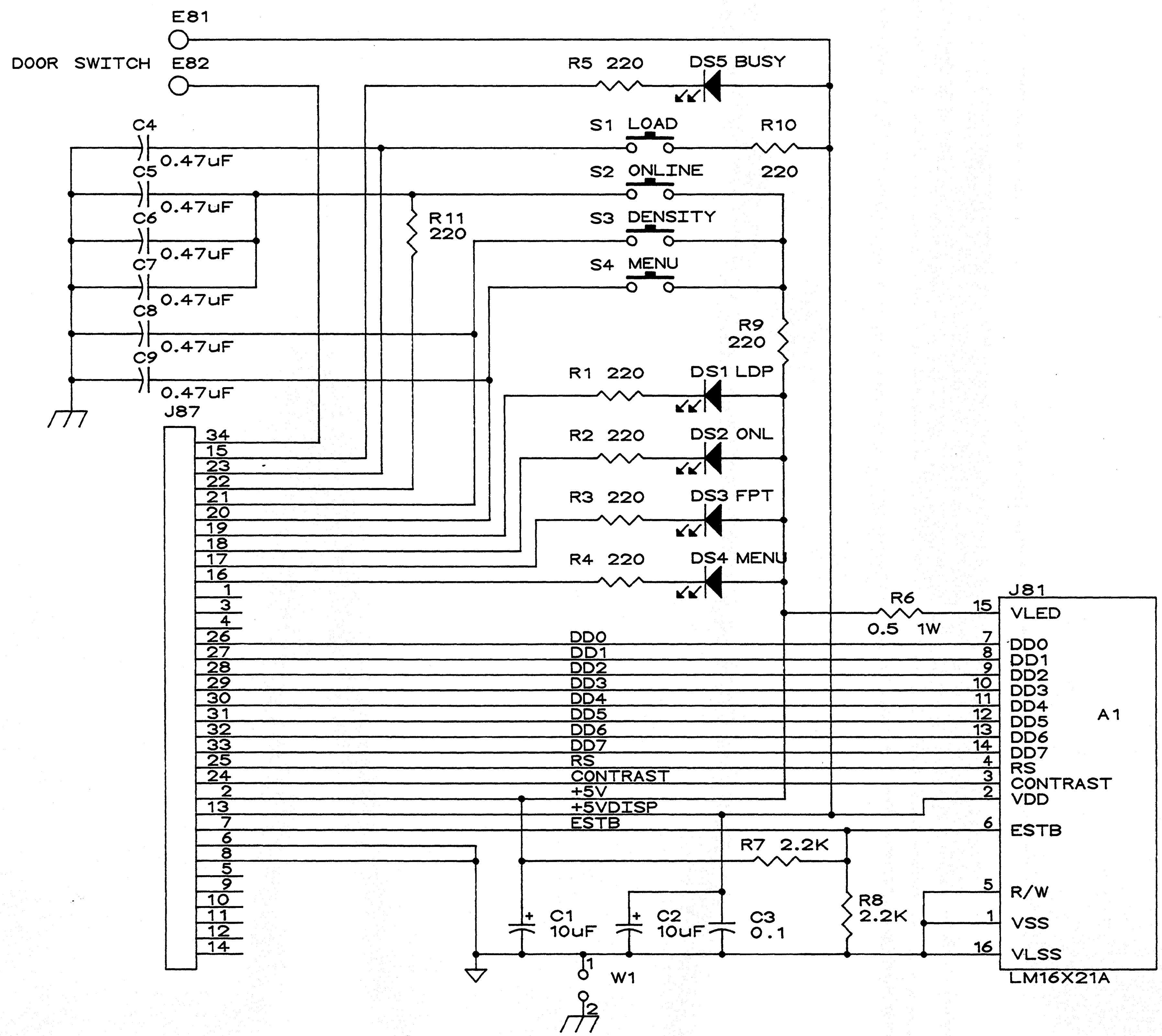


COMPONENT SIDE

1. SEE LM FOR ASSY P/N.

NOTES: UNLESS OTHERWISE SPECIFIED

MATERIAL	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES, DEBURR AND BREAK ALL SHARP EDGES AND CORNERS .01R OR CHAMFER. DIM AND TOL PER ANSI Y14.5 TOLERANCES: .XX +/- .XXX +/- ANGULAR +/- DO NOT SCALE DRAWING	SIGNATURE	DATE	QUALSTAR
FINISH		DWN JET	5 Jan 90	DISPLAY PCBA
		CHK		SIZE D / PRODUCT CODE / DWG NUMBER 500397 / REV A2
		APVD BS	1/7/90	SCALE 2/1 / SHEET 1 OF 1
		APVD		



LTR	CHANGES	DATE
A1	INITIAL PCB RELEASE	09/30/89
B1	REVISED PER EN-648	03/08/93

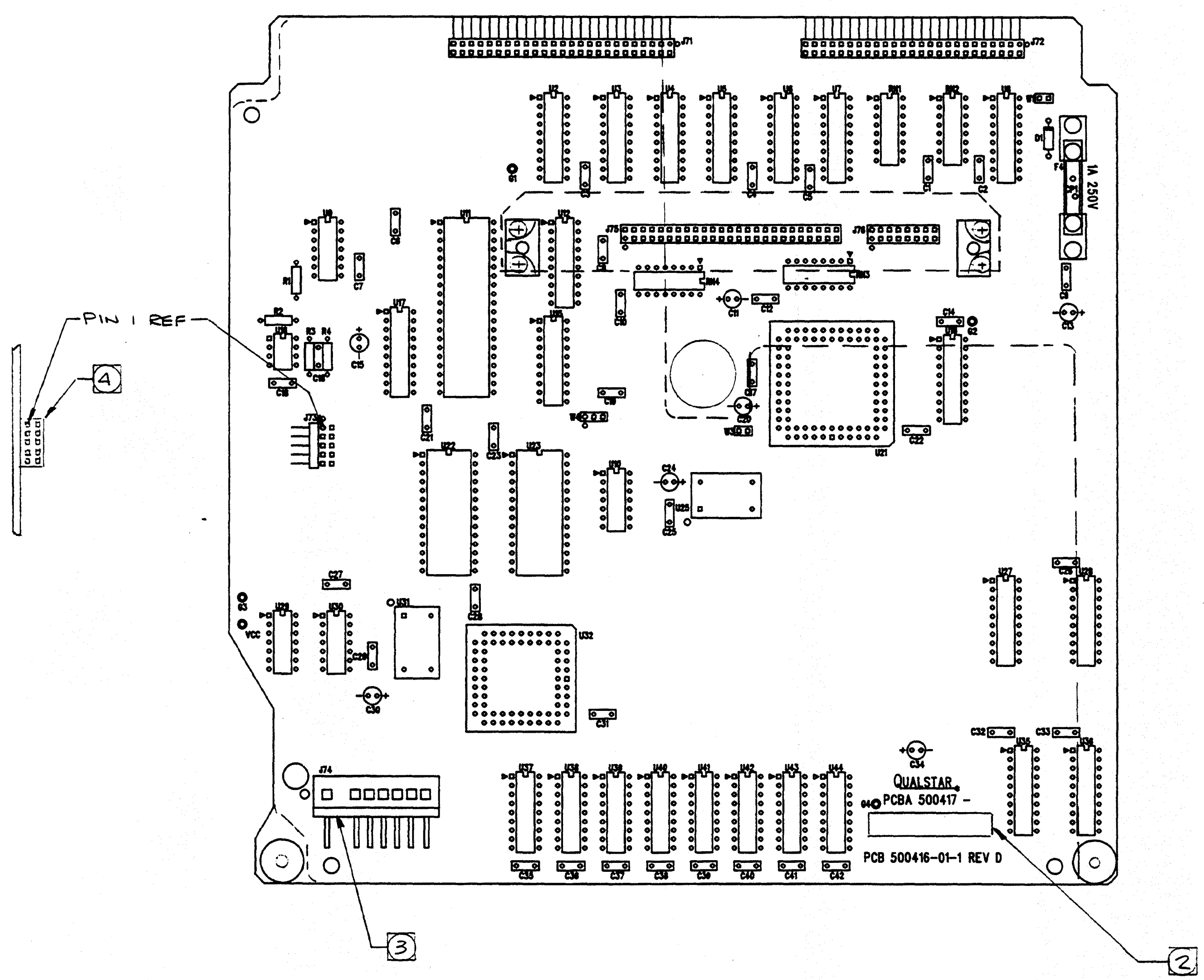
QUALSTAR CORPORATION

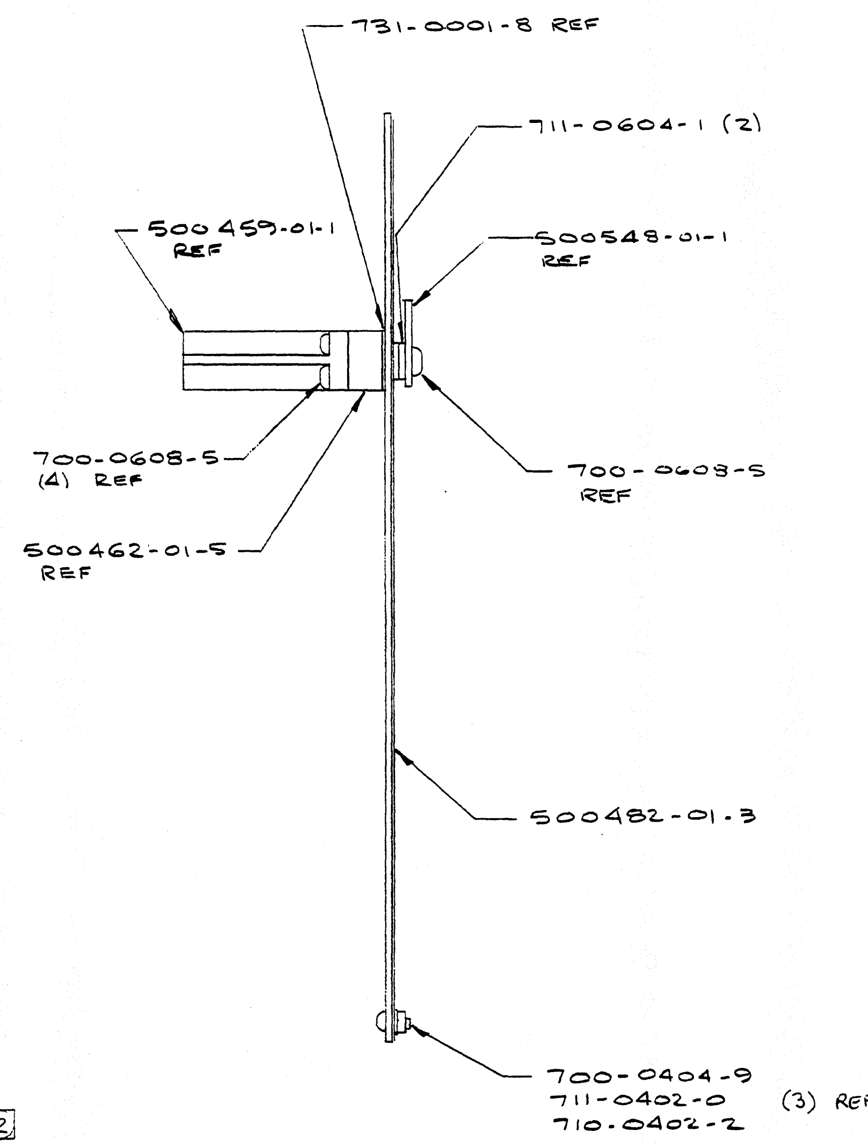
TITLE MODEL 3410 FRONT PANEL

SIZE B | NUMBER 500398 | REV. B1

DATE JUNE 09, 1989 | SHEET 1 OF 1

LTR	DESCRIPTION	DWN	CHK	DATE	APVD
B	PRODUCTION RELEASE	JT	BG	3/5/90	BG
B1	EN 198	JT		12/20/90	BG
C	EN 220	JT	S.Z.	1/4/90	BG
C1	EN 498	JT	RN	4/28/92	BG
D	EN 692	JET	RGN.	7/14/93	RGN.





4 CLIP OFF PIN 2 ON J73 FLUSH WITH INSULATOR.

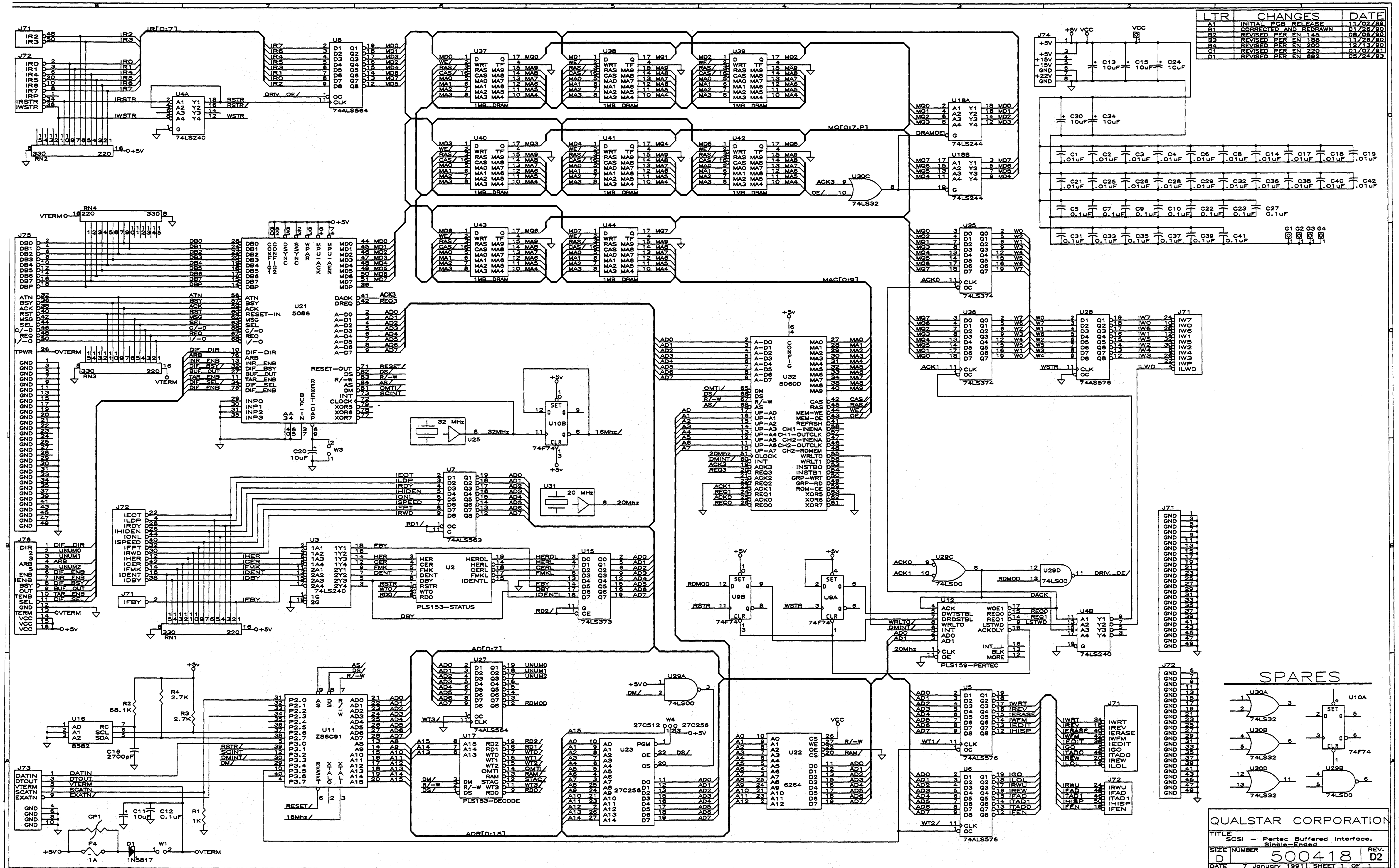
3 REMOVE PIN BEFORE INSTALLING HEADER.

2 MARK ASSY P/N AND REVISION LETTER IN BLACK INK.

1. SEE LM FOR ASSY P/N AND REVISION LETTER.

NOTES: UNLESS OTHERWISE SPECIFIED

MATERIAL	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	SIGNATURE	DATE	QUALSTAR
	DEBURR AND BREAK ALL SHARP EDGES AND CORNERS .01R OR CHAMFER	DWN J. TOMAZIN	3/5/90	SCSI PCBA
	DIM AND TOL PER ANSI Y14.5	CHK RGN.	7/14/93	
FINISH	TOLERANCES: .XX +/- .XXX +/- ANGULAR +/-	APVD RGN.	7/14/93	SIZE D · PRODUCT CODE · DWG NUMBER 500417 · REV D
	DO NOT SCALE DRAWING	APVD		SCALE FULL · SHEET 1 OF 1



LTR	CHANGES	DATE
A1	INITIAL PCB RELEASE	11/02/89
B1	CORRECTED AND REDRAWN	01/26/90
B2	REVISED PER EN 145	08/06/90
B3	REVISED PER EN 188	11/26/90
B4	REVISED PER EN 200	12/13/90
C1	REVISED PER EN 220	01/07/91
D1	REVISED PER EN 692	05/24/93

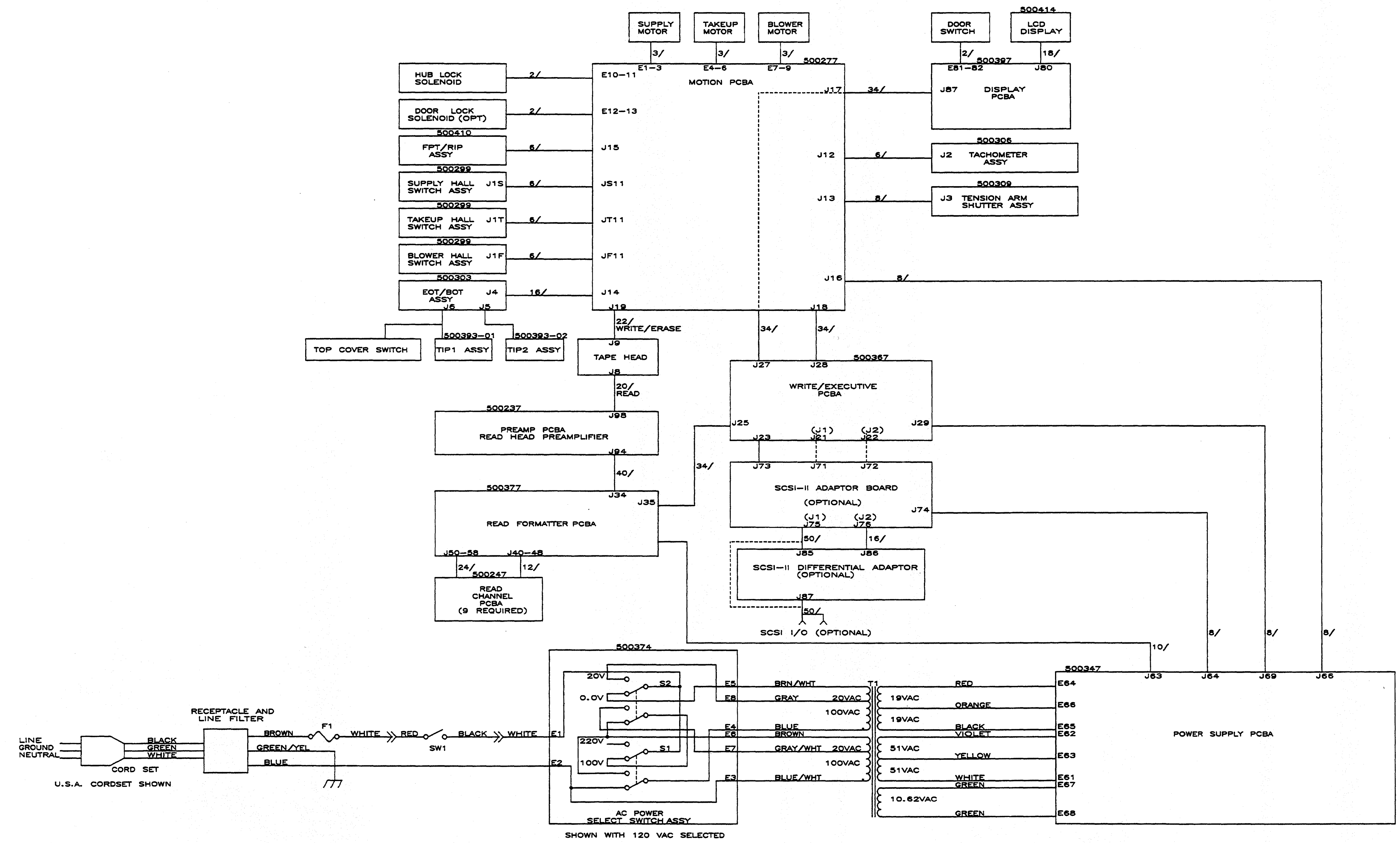
QUALSTAR CORPORATION

TITLE SCSI – Pertec Buffered Interface, Single-Ended

SIZE D | NUMBER 500418 | REV. D2

DATE 7 January 1991 | SHEET 1 OF 1

LTR	CHANGES	DATE
A1	INITIAL RELEASE	07/21/90



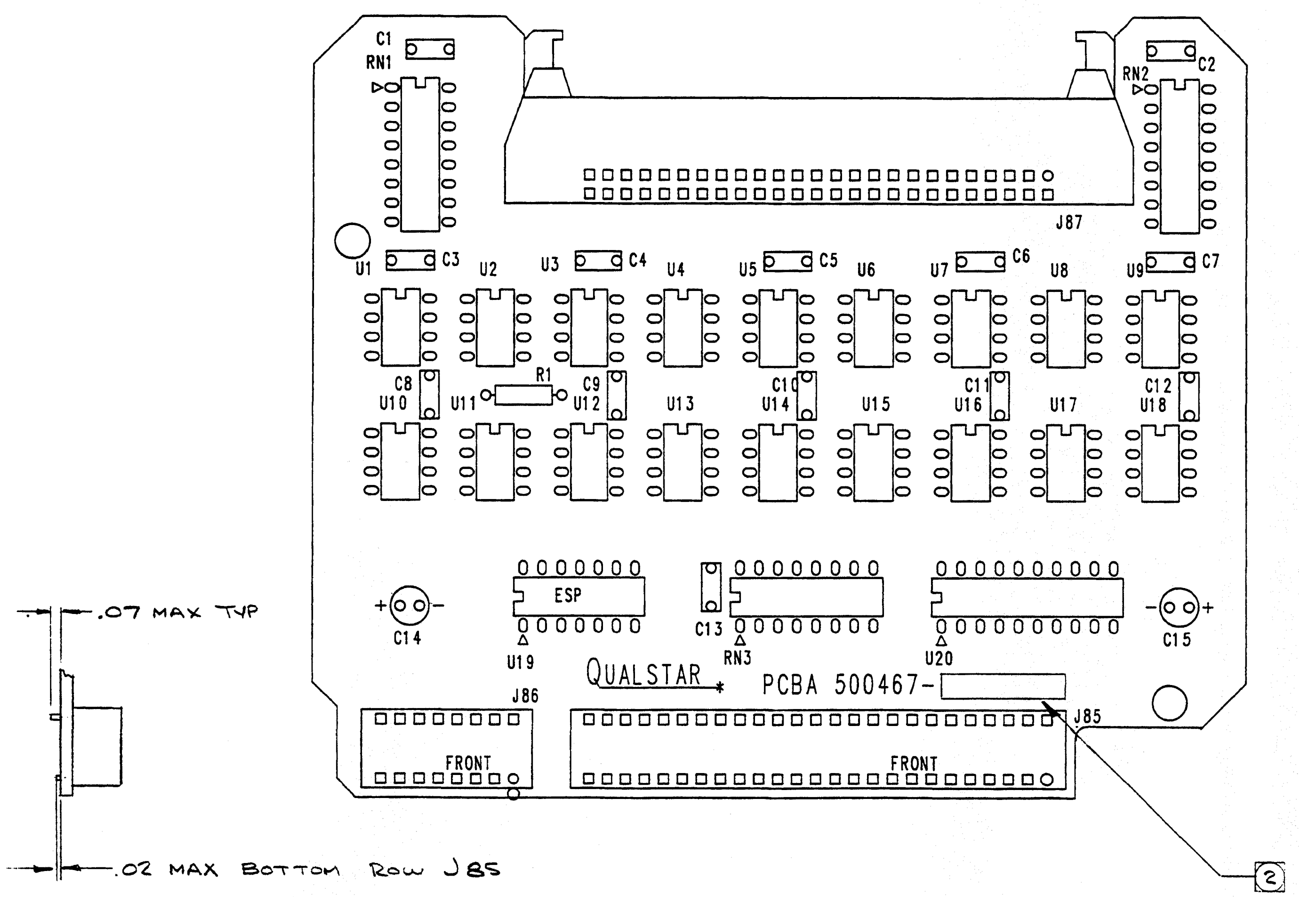
QUALSTAR CORPORATION

TITLE INTERCONNECT DIAGRAM – MODEL 3410/3412

SIZE	NUMBER	REV.
D	500452	A1

DATE JAN 11, 1990 | SHEET 1 OF 1

LTR	DESCRIPTION	DWN	CHK	DATE	APVD
A	PRODUCTION RELEASE	YET	D	20 MAR 90	BA
A1	ADDED VIEW SHOWING MAX LEAD PROTRUSION AFTER ASSY	YET	B	26 APR 90	BA

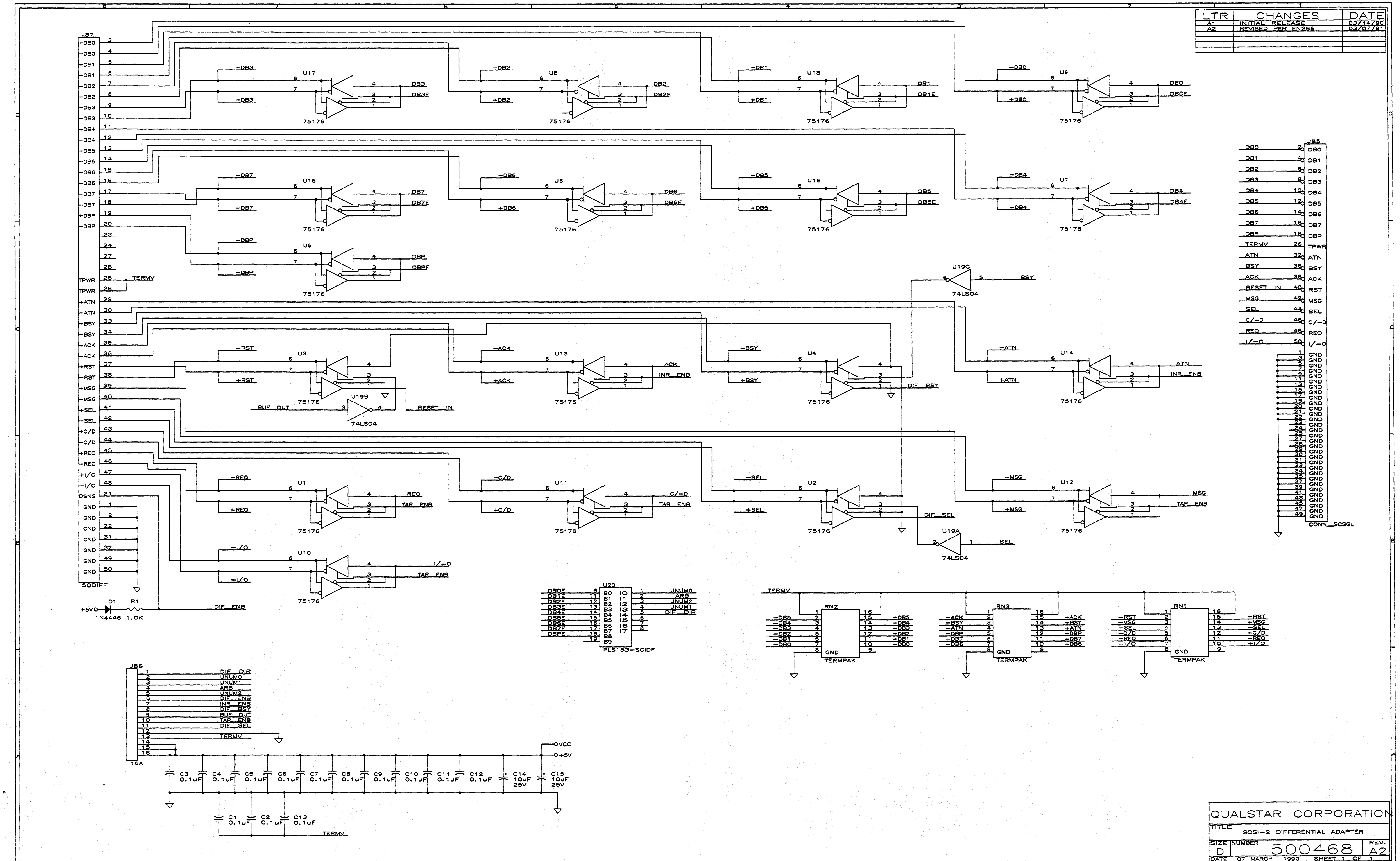


2 MARK ASSY NUMBER & REVISION LETTER IN BLACK INK.

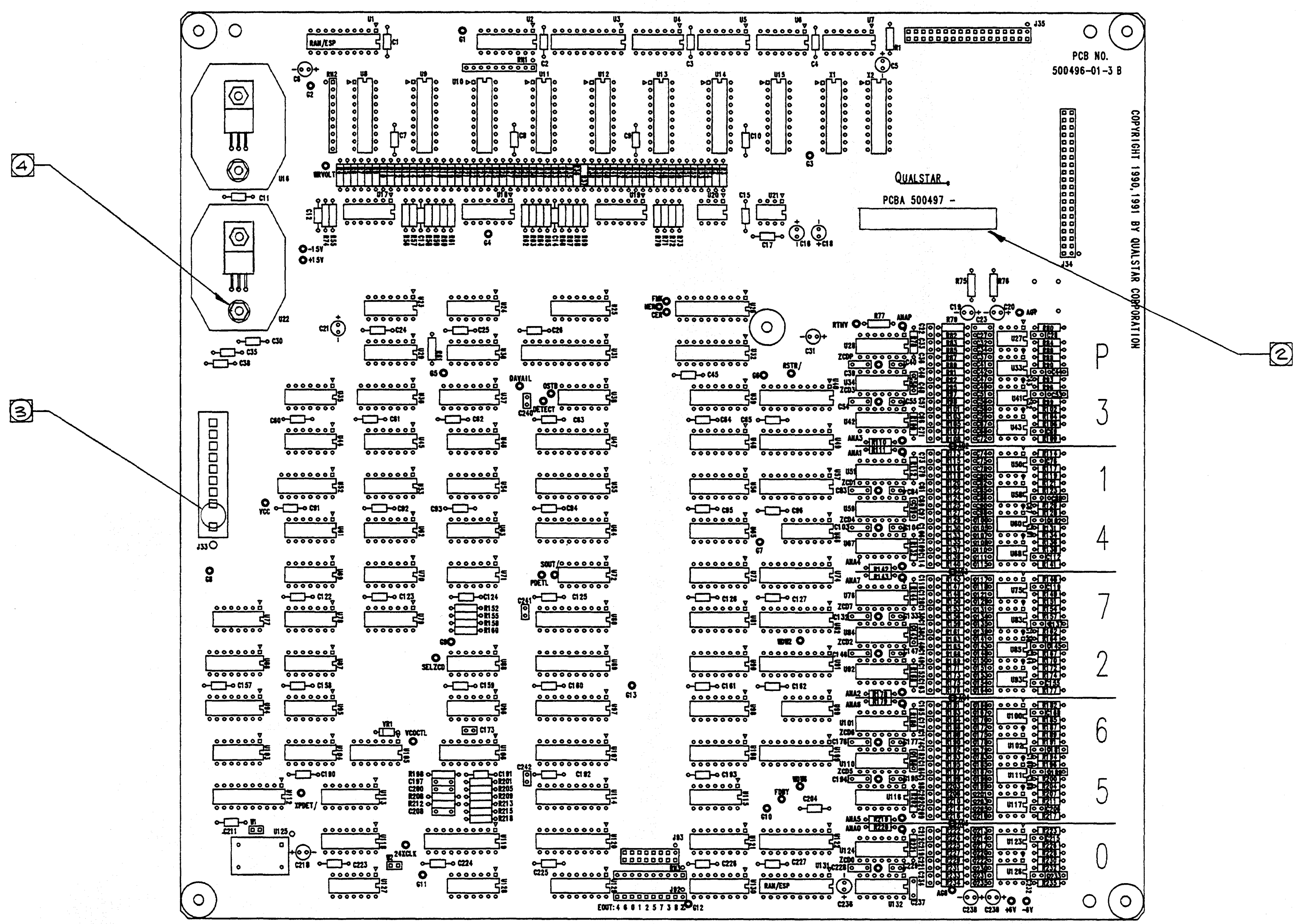
1. SEE -M FOR ASSY NUMBER.

NOTES: UNLESS OTHERWISE SPECIFIED

MATERIAL	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DEBURR AND BREAK ALL SHARP EDGES AND CORNERS .01R OR CHAMFER DIM AND TOL PER ANSI Y14.5 TOLERANCES: .XX +/- .XXX +/- ANGULAR +/- DO NOT SCALE DRAWING	SIGNATURE	DATE	QUALSTAR
FINISH		DWN YE Tomayin	16 MAR 90	SCSI-2 DIFFERENTIAL ADAPTOR
		CHK R.A. Nelson	3/16/90	
		APVD BA	3/16/90	SIZE D · PRODUCT CODE · DWG NUMBER 500467 · REV A1
		APVD		SCALE 2/1 · SHEET 1 OF 1


LTR CHANGES DATE
A1 INITIAL RELEASE 03/14/90
A2 REVISED PER EN265 03/07/91
J87
50DIFF
J85
CONN_SCSGL
J86
16A
U17 U8 U18 U9 U15 U6 U16 U7 U5 U3 U13 U4 U14 U1 U11 U2 U12 U10
75176
U19A U19B U19C
74LS04
U20
PLS153-SCIDF
RN1 RN2 RN3
TERMPAK
D1 1N4446
R1 1.0K
+5V
DIF_ENB
TERMV
C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 0.1uF
C14 10uF 25V
C15 10uF 25V
C1 C2 C13 0.1uF
VCC
QUALSTAR CORPORATION
TITLE SCSI-2 DIFFERENTIAL ADAPTER
SIZE D
NUMBER 500468
REV. A2
DATE 07 MARCH 1990
SHEET 1 OF 1

LTR	DESCRIPTION	DWN	CHK	DATE	APVD
B1	PROD. RELEASE ERN 024	✓ET	R.a.n.	2/22/91	R.C.L.



4 INSTALL HEX NUTS WITH WASHER NEARSIDE AS SHOWN.

3 REMOVE PIN 2 BEFORE INSTALLING HEADER.

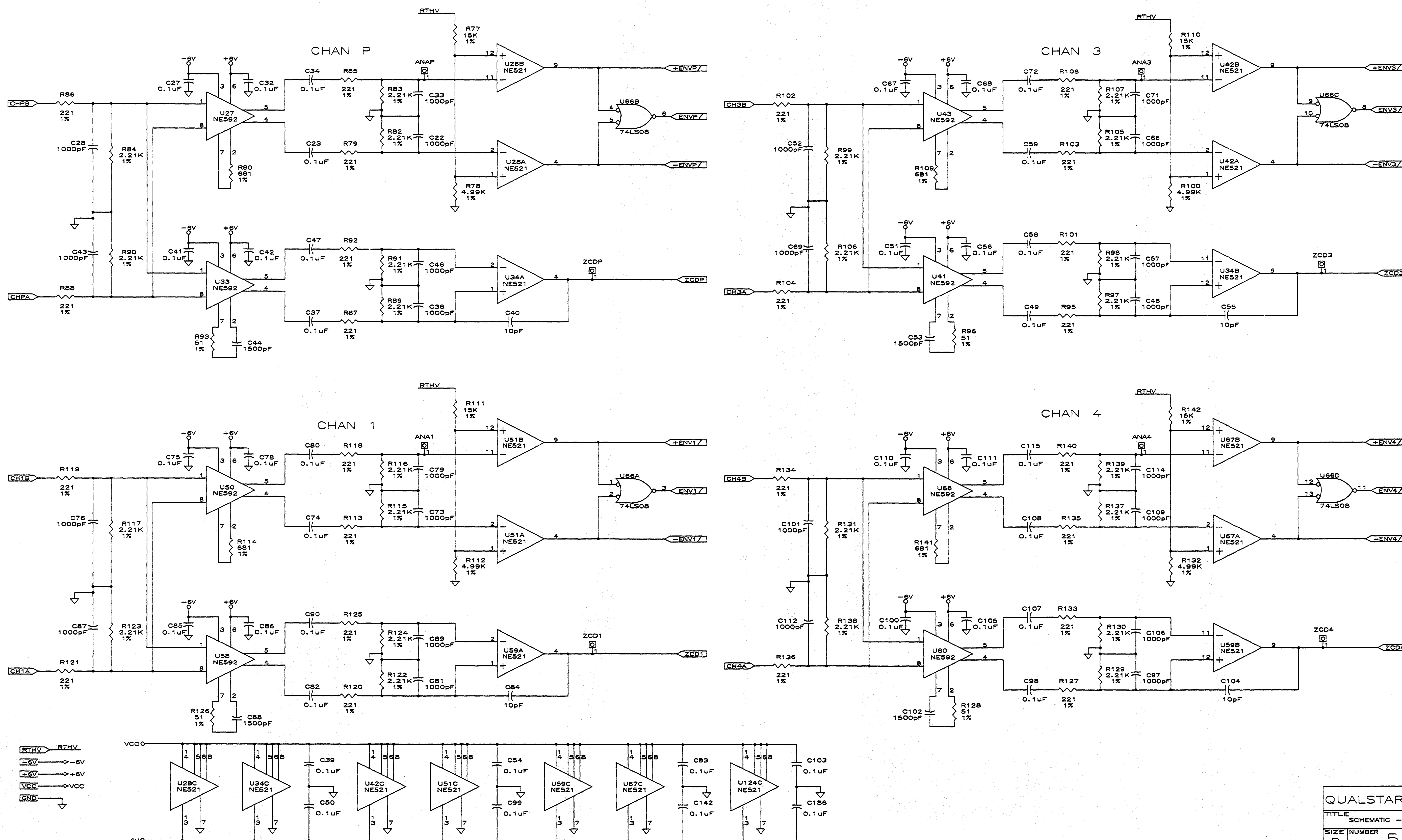
2 MARK ASSY # AND REVISION LETTER IN BLACK INK.

1. SEE LM FOR ASSY PART NUMBER AND REVISION LETTER.

NOTES: UNLESS OTHERWISE SPECIFIED

MATERIAL	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	SIGNATURE	DATE	QUALSTAR*
	DEBURR AND BREAK ALL SHARP EDGES AND CORNERS .01R OR CHAMFER	DWN ✓E Tomazin	2/22/91	340X PE READ FRMTR PCBA
FINISH	DIM AND TOL PER ANSI Y14.5	CHK		
	TOLERANCES: .XX +/- .XXX +/- ANGULAR +/-	APVD		SIZE D · PRODUCT CODE · DWG NUMBER 500497 · REV B1
	DO NOT SCALE DRAWING	APVD		SCALE 1/1 · SHEET 1 OF 1

LTR	CHANGES	DATE
A1	INITIAL RELEASE	10/04/90
B1	PROD. RELEASE ERN 024	02/14/91

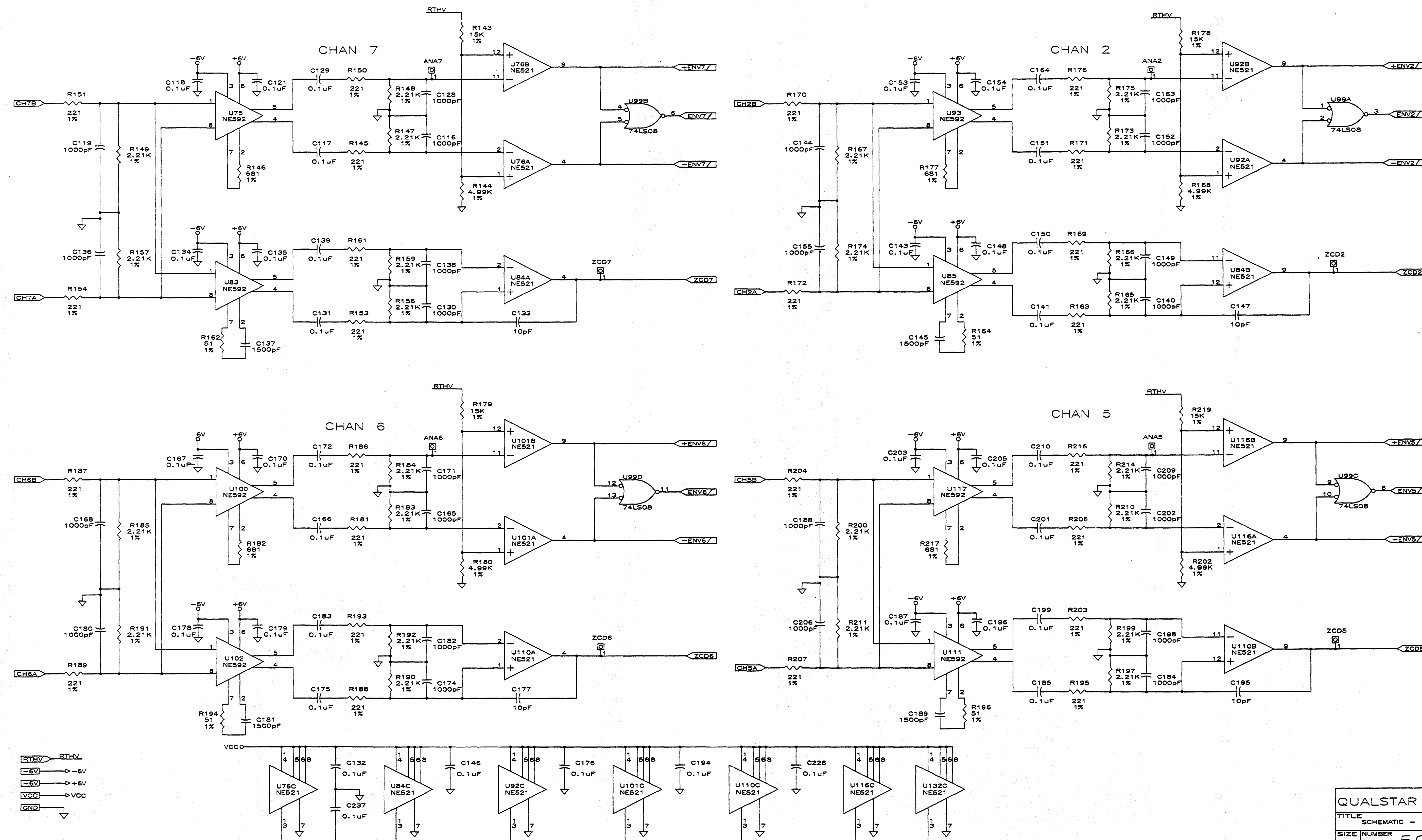


QUALSTAR CORPORATION

TITLE SCHEMATIC – 340X READ FORMATTER

SIZE	NUMBER	REV.
D	500498	B1

DATE AUG. 16, 1990 SHEET 1 OF 7

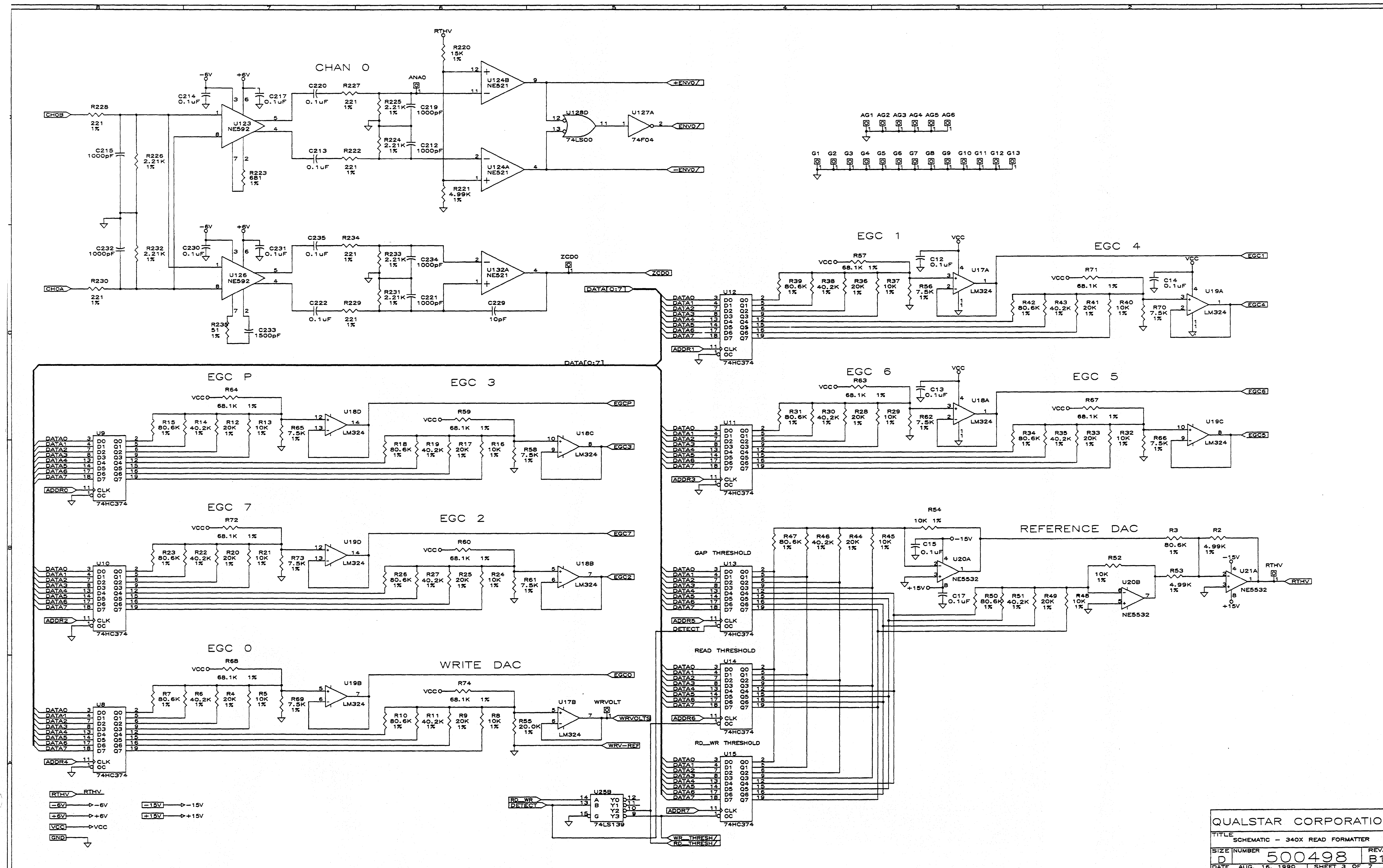


QUALSTAR CORPORATION

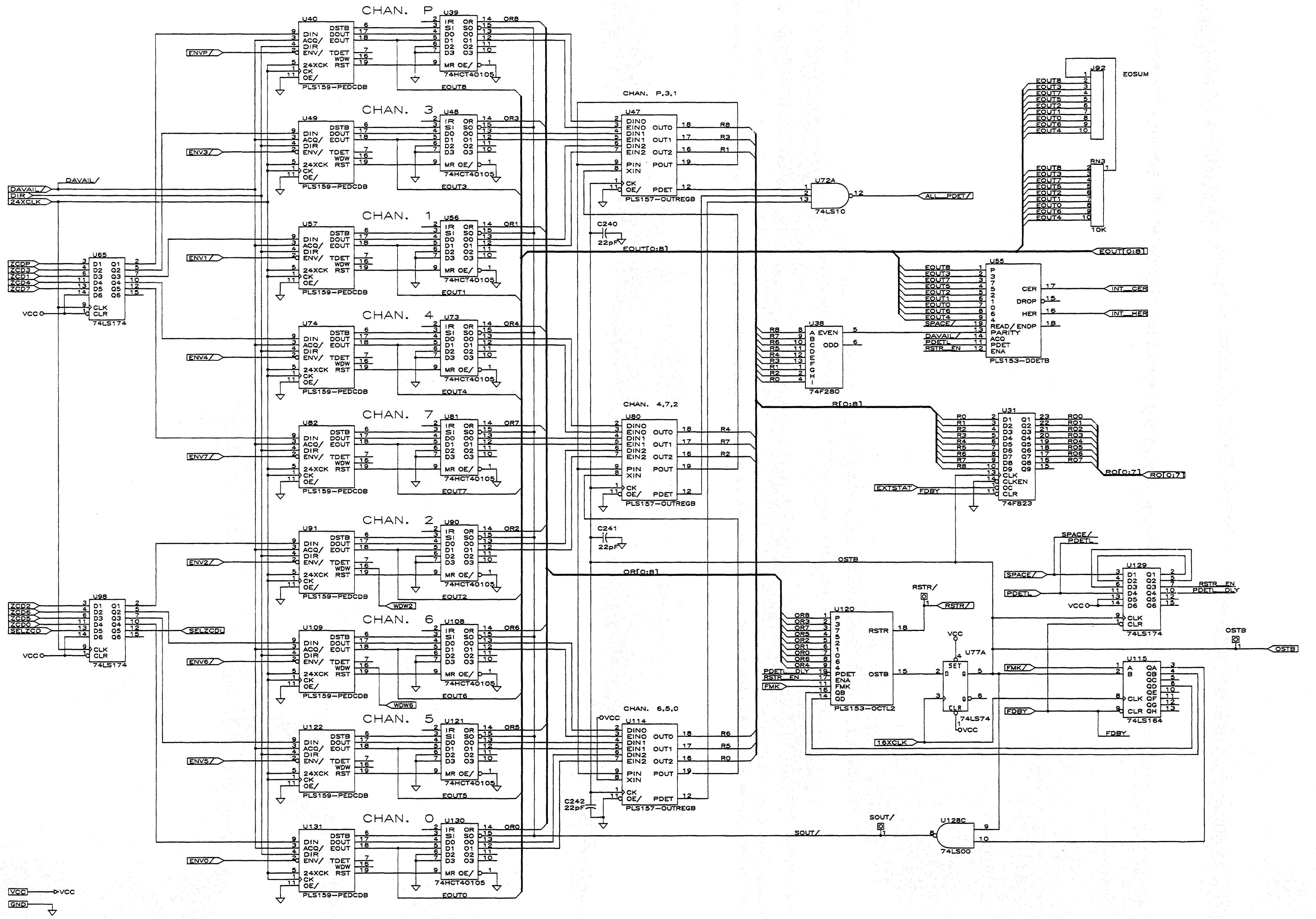
TITLE SCHEMATIC – 340X READ FORMATTER

SIZE	NUMBER	REV.
D	500498	B1

DATE AUG. 16, 1990 | SHEET 2 OF 7



CHAN 0
EGC 1
EGC 4
EGC 6
EGC 5
EGC P
EGC 3
EGC 7
EGC 2
EGC 0
WRITE DAC
REFERENCE DAC
GAP THRESHOLD
READ THRESHOLD
RD_WR THRESHOLD
QUALSTAR CORPORATION
TITLE SCHEMATIC - 340X READ FORMATTER
SIZE D
NUMBER 500498
REV. B1
DATE AUG. 16, 1990
SHEET 3 OF 7

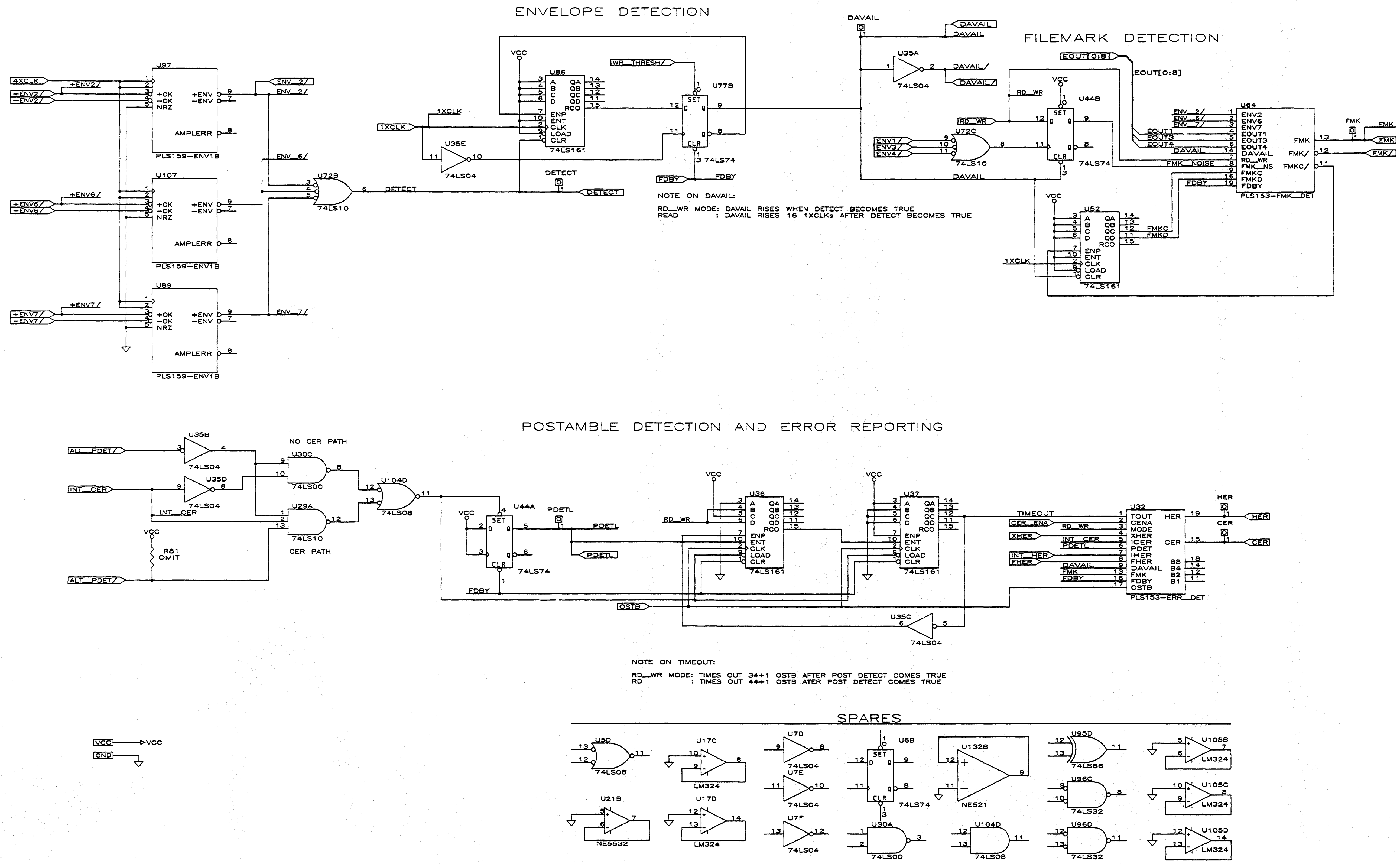


QUALSTAR CORPORATION

TITLE SCHEMATIC – 340X READ FORMATTER

SIZE	NUMBER	REV.
D	500498	B1

DATE AUG. 16, 1990 SHEET 4 OF 7

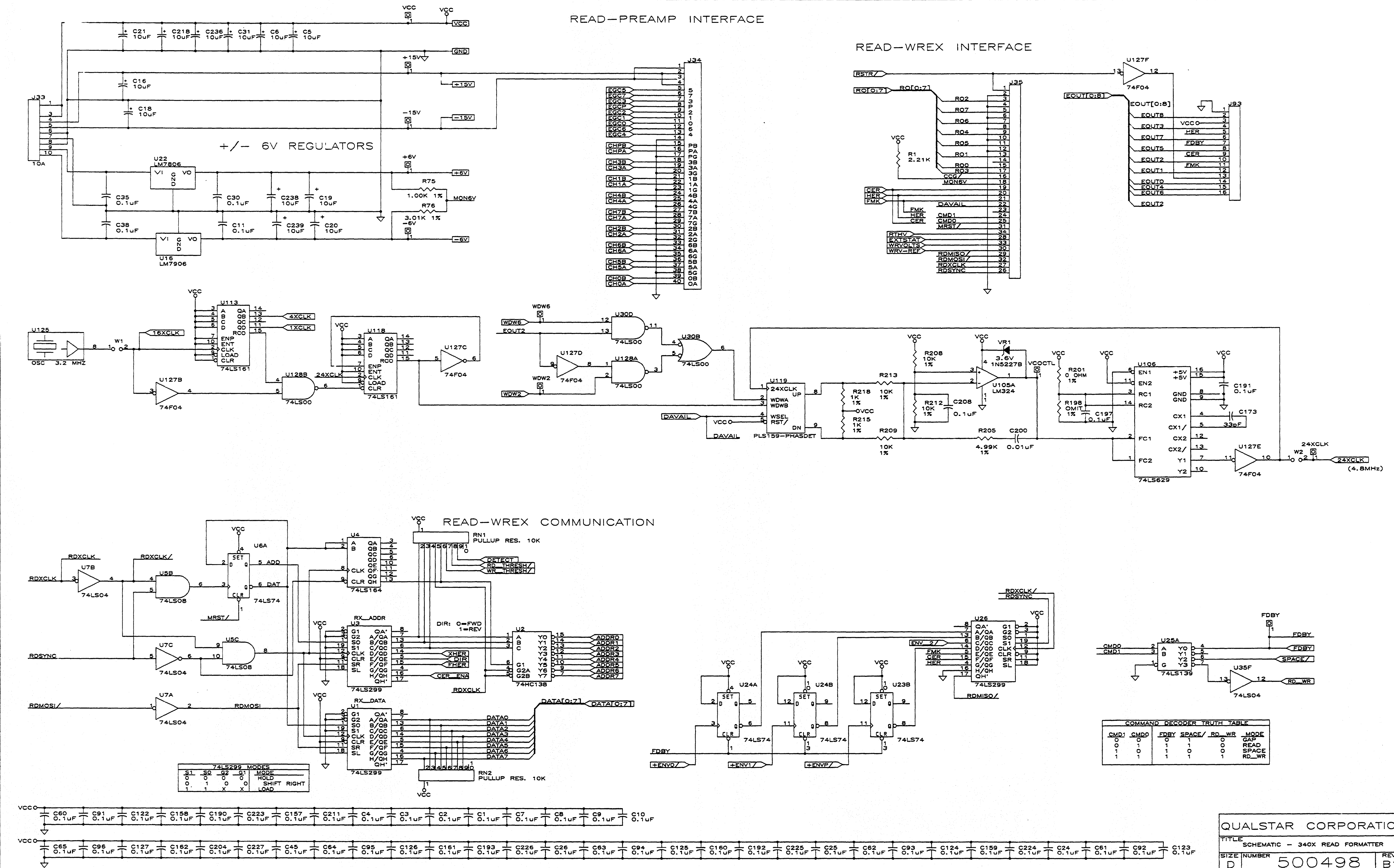


QUALSTAR CORPORATION

TITLE SCHEMATIC – 340X READ FORMATTER

SIZE D | NUMBER 500498 | REV. B1

DATE AUG. 16, 1990 | SHEET 5 OF 7



74LS299 MODES

S1	S0	G2	G1	MODE
0	0	0	0	HOLD
0	1	0	0	SHIFT RIGHT
1	1	X	X	LOAD

COMMAND DECODER TRUTH TABLE

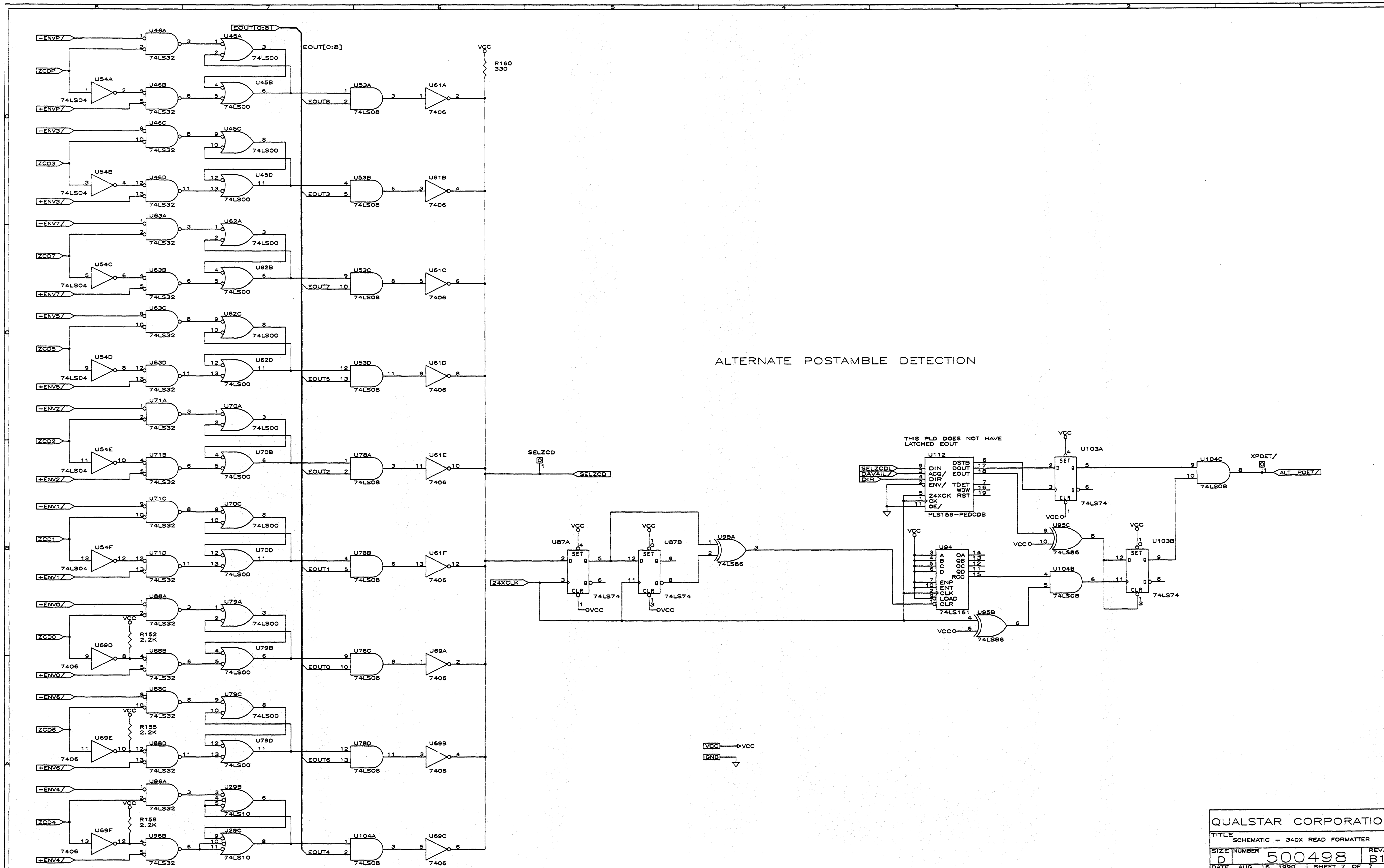
CMD1	CMD0	FDBY	SPACE/	RD_WR	MODE
0	0	0	1	0	GAP
0	1	1	1	0	READ
1	0	1	0	0	SPACE
1	1	1	1	1	RD_WR

QUALSTAR CORPORATION

TITLE SCHEMATIC - 340X READ FORMATTER

SIZE D NUMBER 500498 REV. B1

DATE AUG. 16, 1990 SHEET 6 OF 7



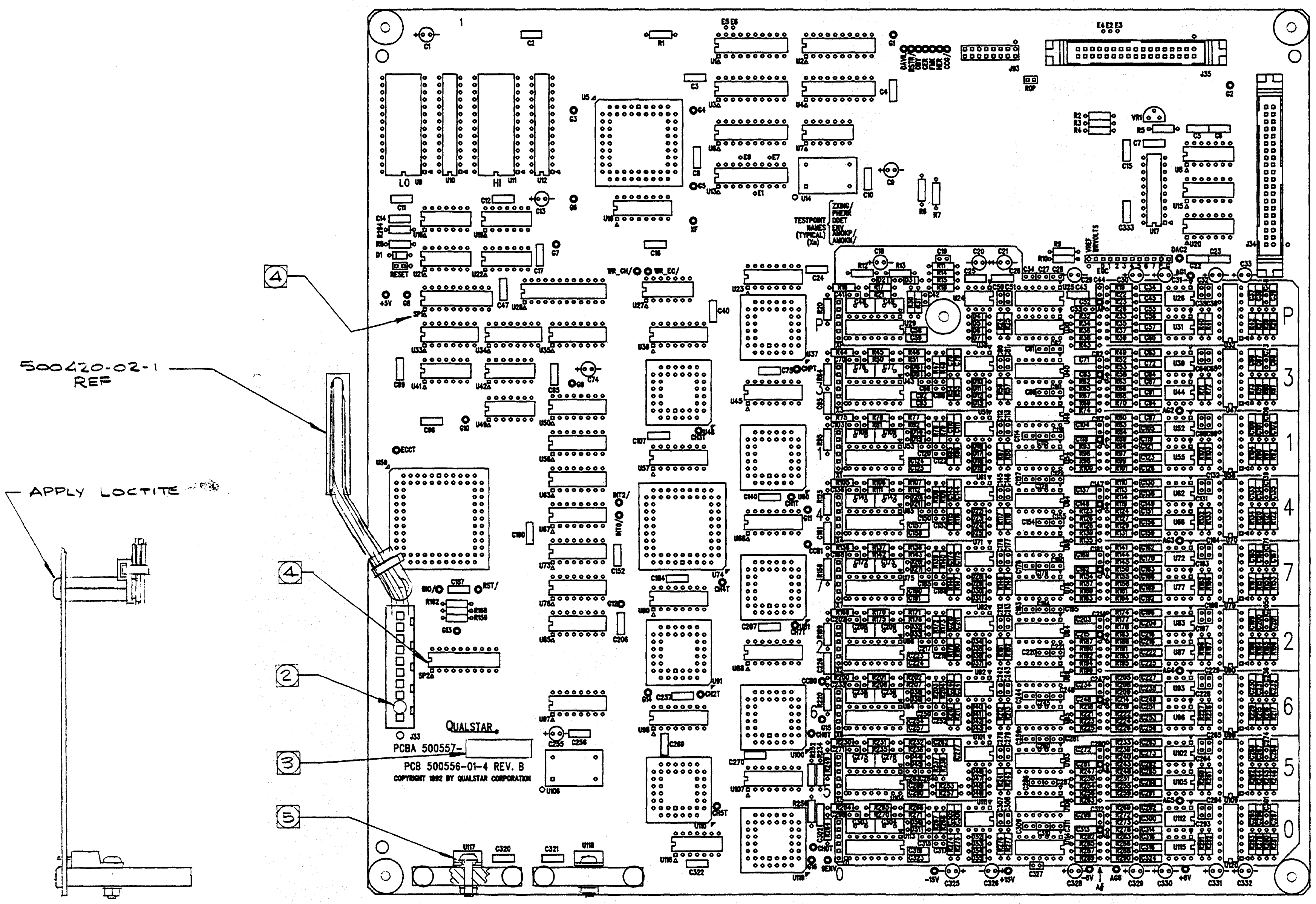
QUALSTAR CORPORATION

TITLE SCHEMATIC – 340X READ FORMATTER

SIZE D | NUMBER 500498 | REV. B1

DATE AUG. 16, 1990 | SHEET 7 OF 7

LTR	DESCRIPTION	DWN	CHK	DATE	APVD
A	INITIAL RELEASE	JT	RN	1/31/92	RN
A1	CLARIFY J34/35 ORIENTATION	JT		2/27/92	BM
B	EN 490 PRODUCTION RELEASE	JT	[illegible]	4/29/92	BM



5 ADD MICA WASHER (650-0001-8), NYLON BUSHING (713-1121-1) AND HEAT TRANSFER COMPOUND (650-0003-6) FOR U117 ONLY.

4 NO SOLDER PERMITTED IN SP1 & SP2 HOLE PATTERN. MASK OFF.

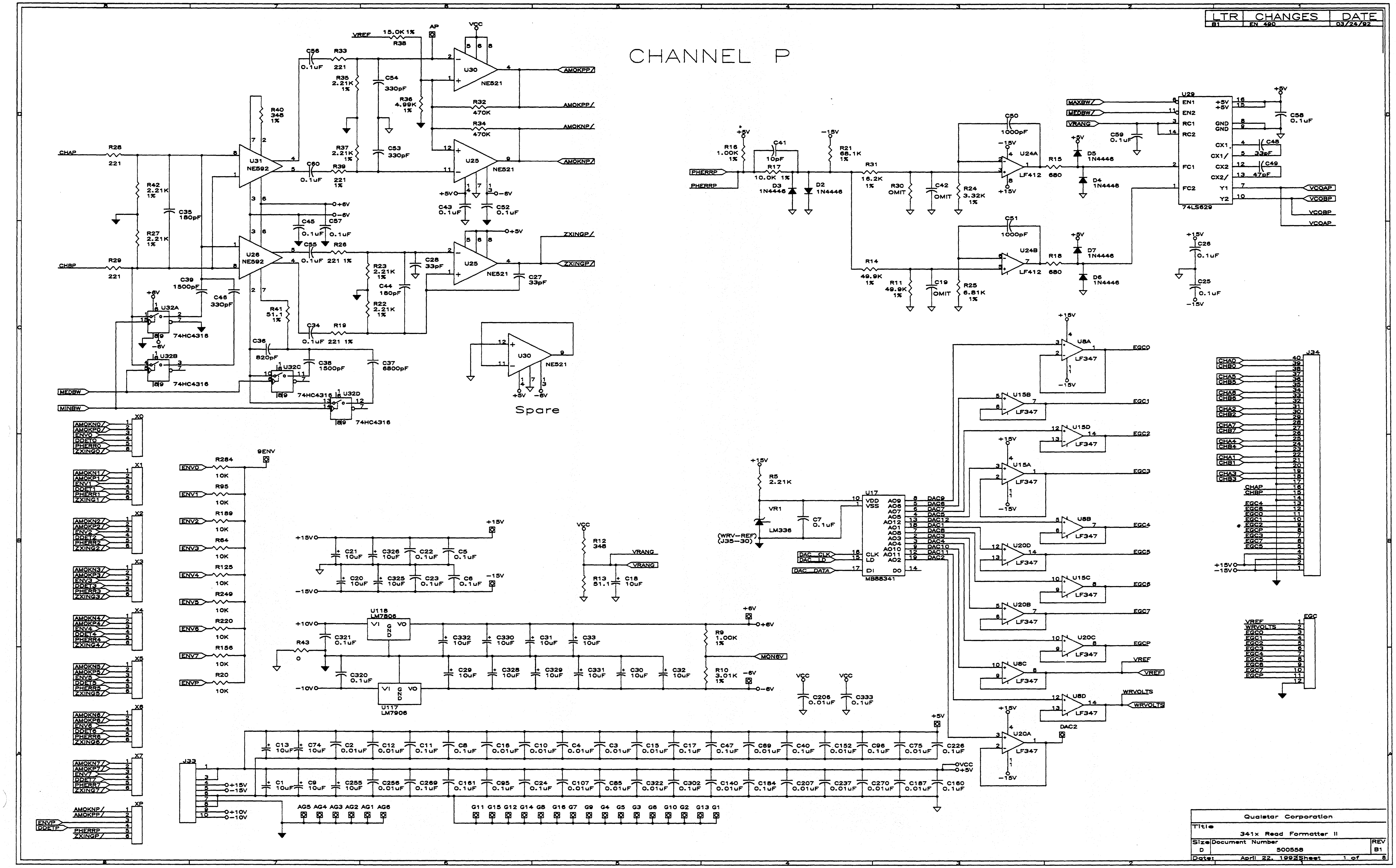
3 MARK ASSY P/N AND REVISION LETTER LETTER IN BLACK INK.

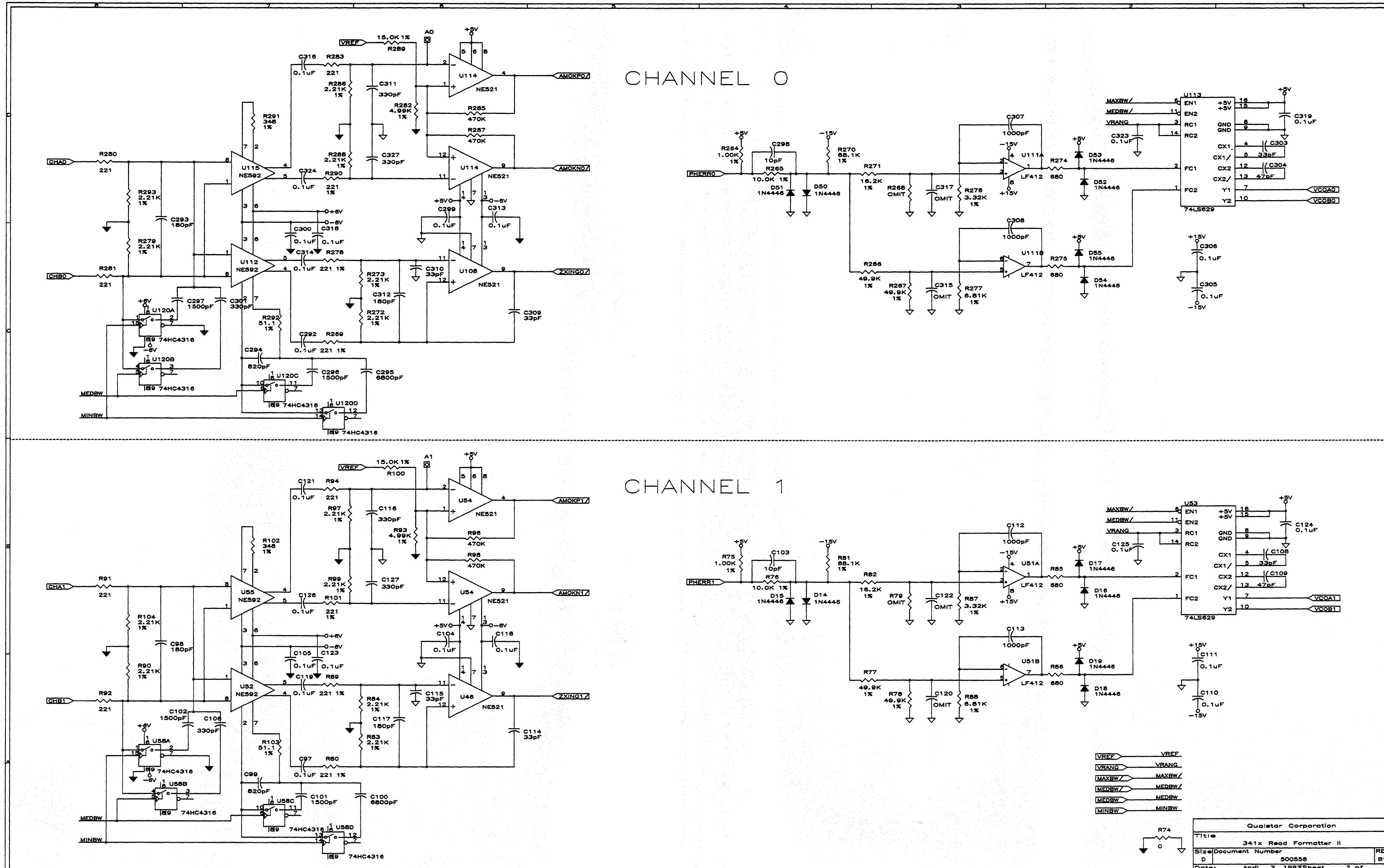
2 REMOVE PIN 2 BEFORE INSTALLING HEADER.

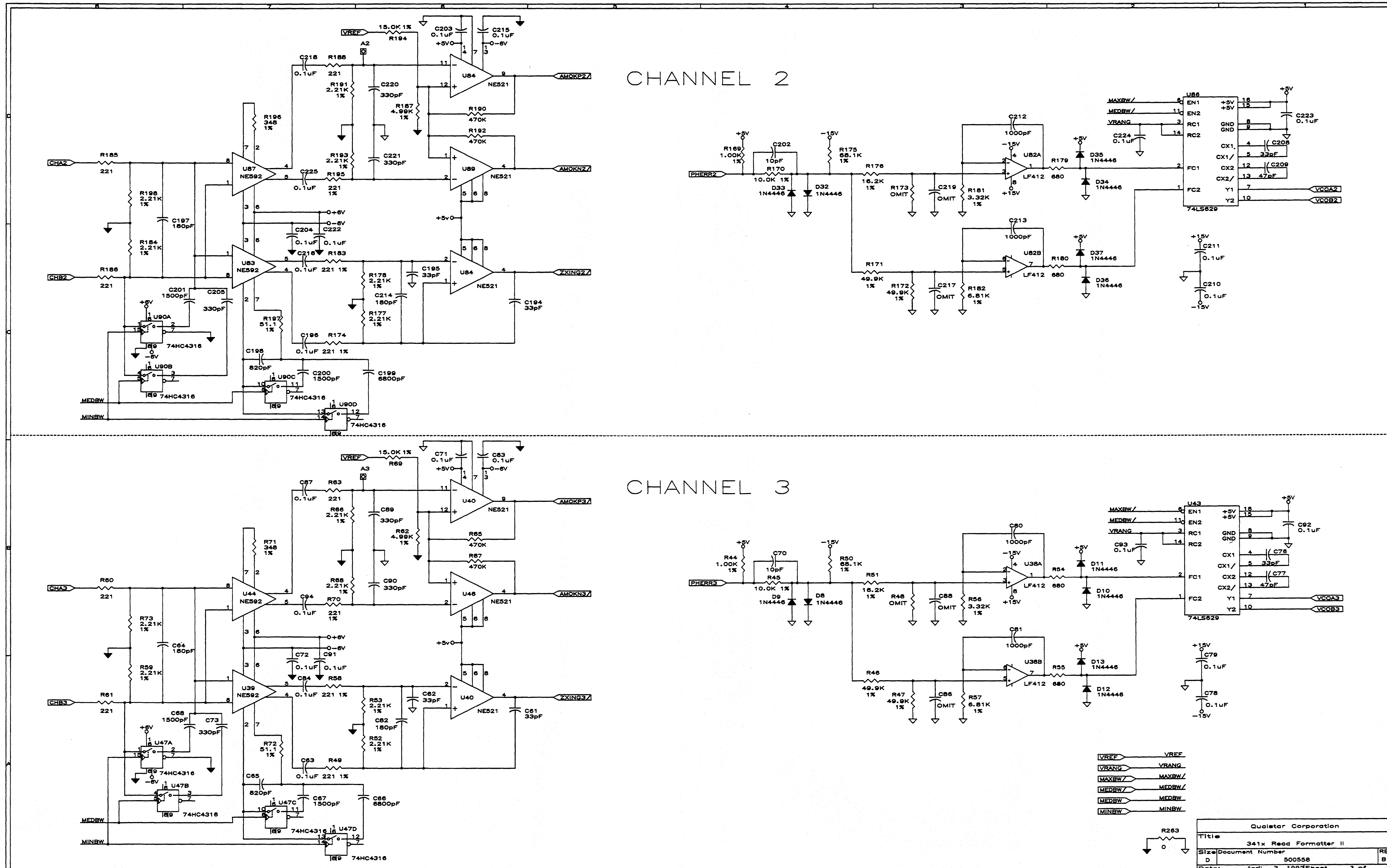
1. SEE LM FOR ASSY P/N.

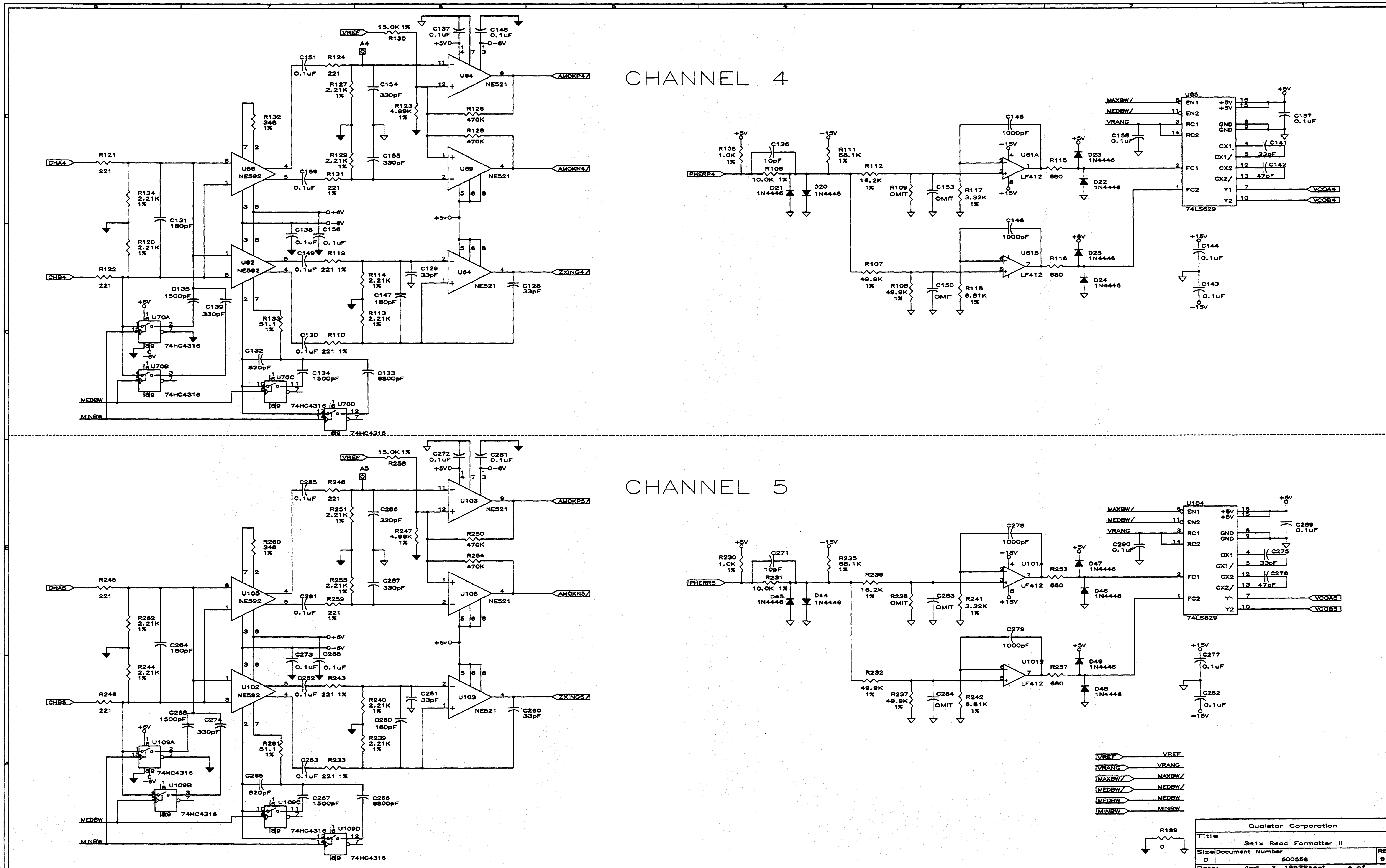
NOTES: UNLESS OTHERWISE SPECIFIED

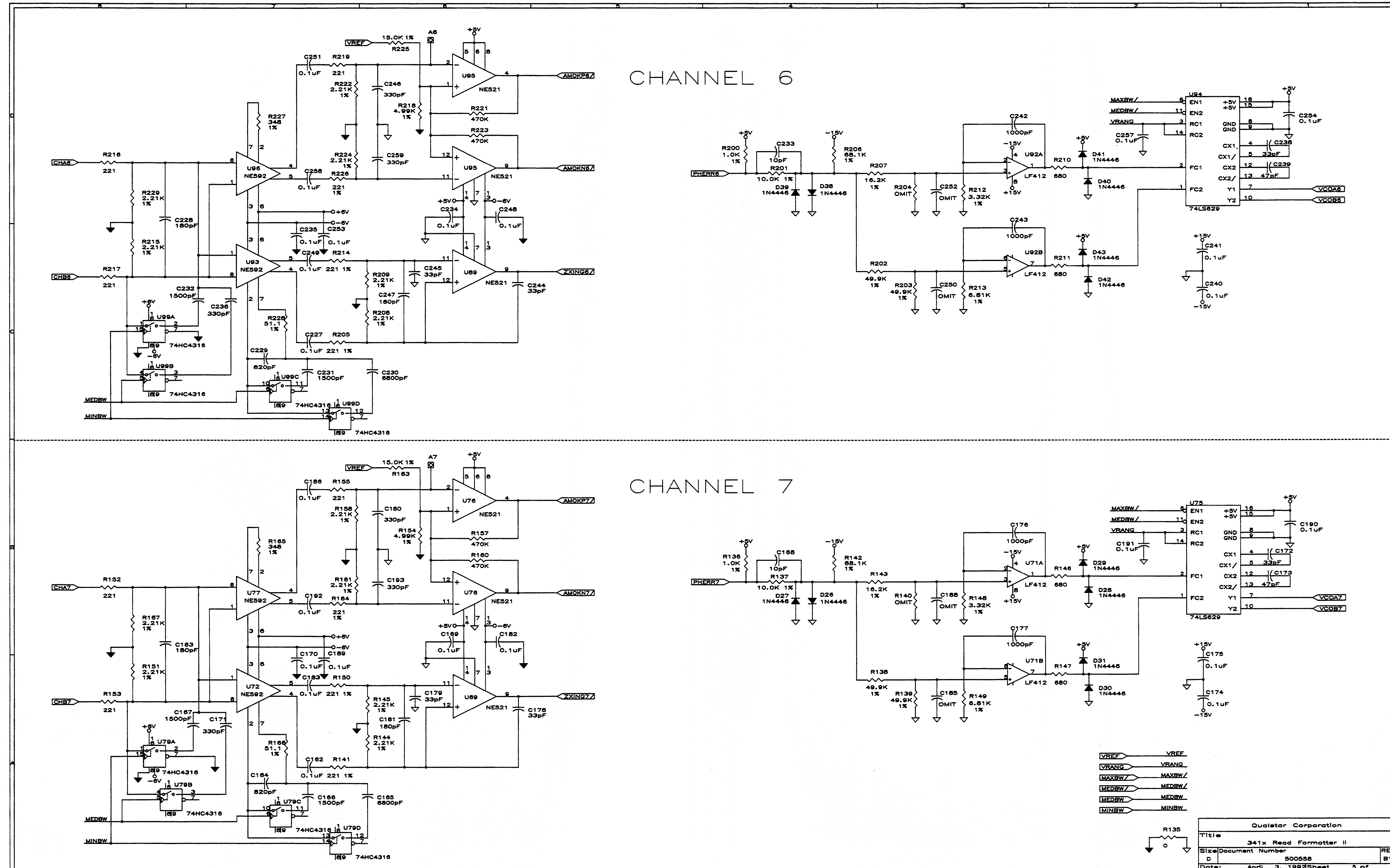
MATERIAL	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	SIGNATURE	DATE	QUALSTAR
	DEBURR AND BREAK ALL SHARP EDGES AND CORNERS .01R OR CHAMFER	DWN JE Tonazzi	4/29/92	READ FORMATTER PCBA
FINISH	DIM AND TOL PER ANSI Y14.5	CHK		
	TOLERANCES: .XX +/- .XXX +/- ANGULAR +/-	APVD		SIZE D · PRODUCT CODE · DWG NUMBER 500557 · REV B
	DO NOT SCALE DRAWING	APVD		SCALE /1 · SHEET 1 OF 1

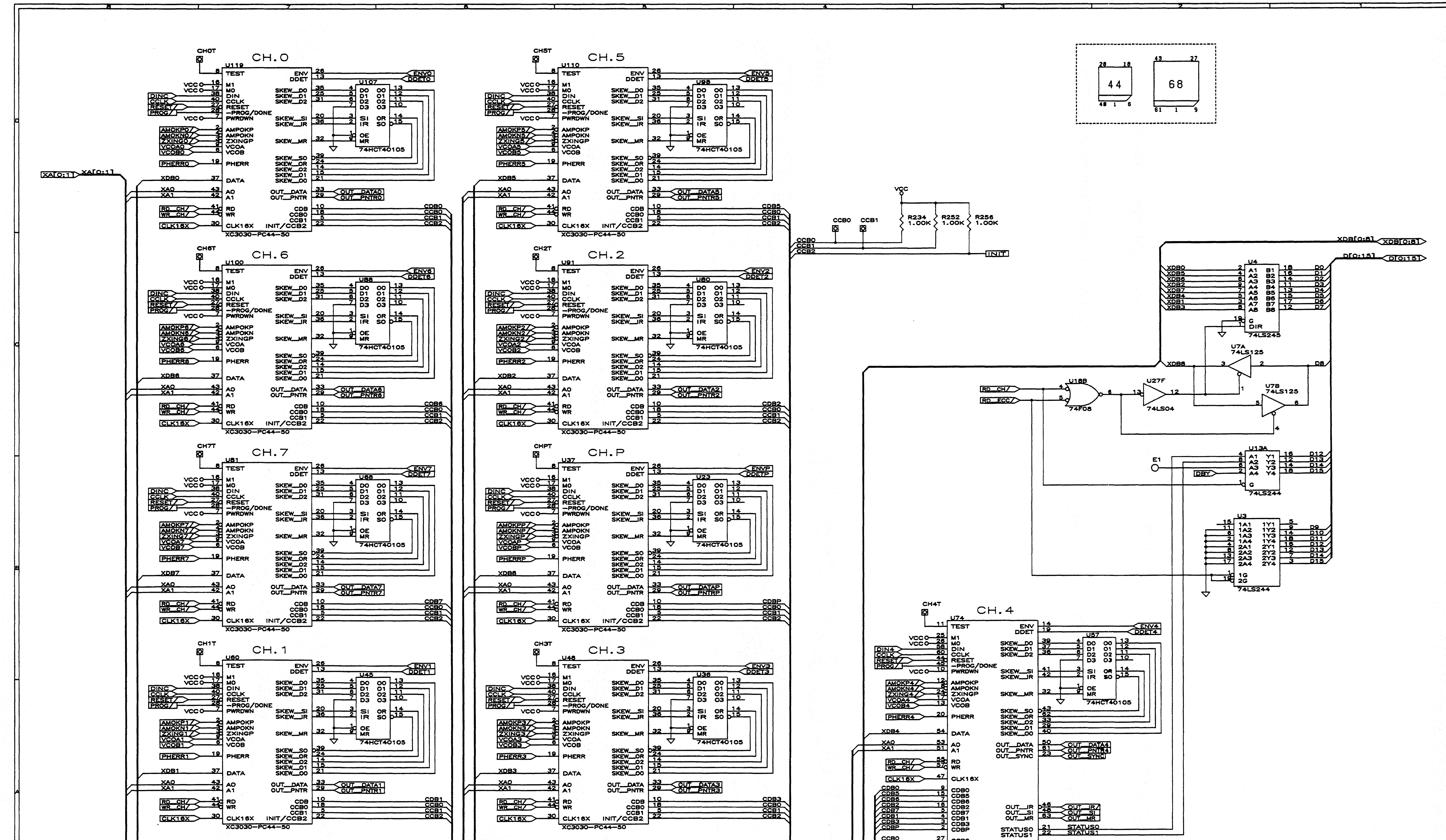

LTR CHANGES DATE
B1 EN 490 03/24/92
CHANNEL P
Spare
Qualstar Corporation
Title
341x Read Formatter II
Size Document Number REV
D 500558 B1
Date: April 22, 1992 Sheet 1 of 8


CHANNEL 0
CHANNEL 1
Qualstar Corporation
Title
341x Read Formatter II
Size D
Document Number 500558
REV B1
Date: April 3, 1992
Sheet 2 of 8

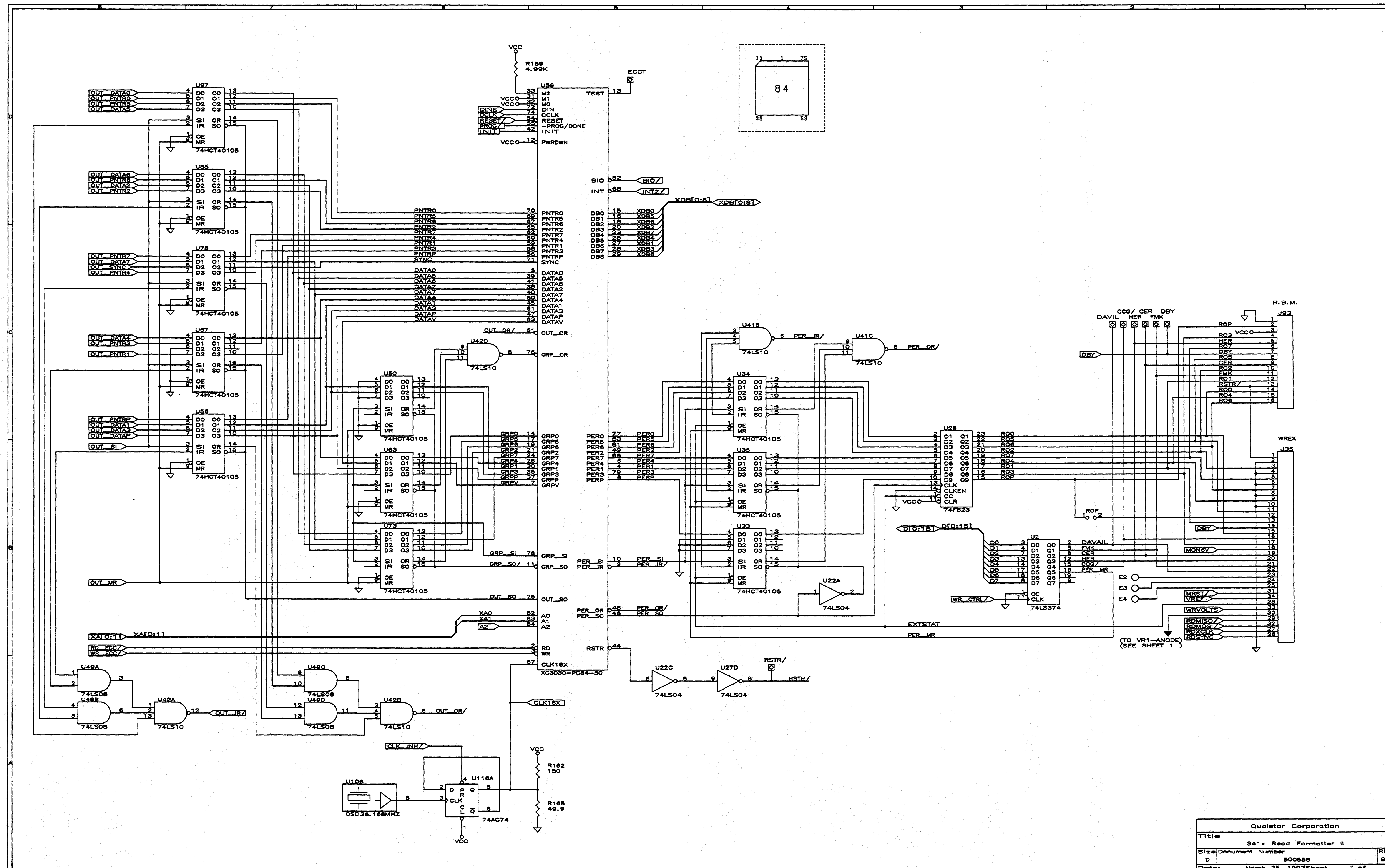

CHANNEL 2
CHANNEL 3
CHA2
CHB2
CHA3
CHB3
PHERR2
PHERR3
AMOKP2/
AMOKN2/
ZXING2/
AMOKP3/
AMOKN3/
ZXING3/
VCOA2
VCOB2
VCOA3
VCOB3
VREF
VRANG
MAXBW/
MEDBW/
MEDBW
MINBW
NE592
NE521
LF412
74LS629
74HC4316
Qualstar Corporation
Title
341x Read Formatter II
Size D
Document Number 500558
REV B1
Date: April 3, 1992
Sheet 3 of 8

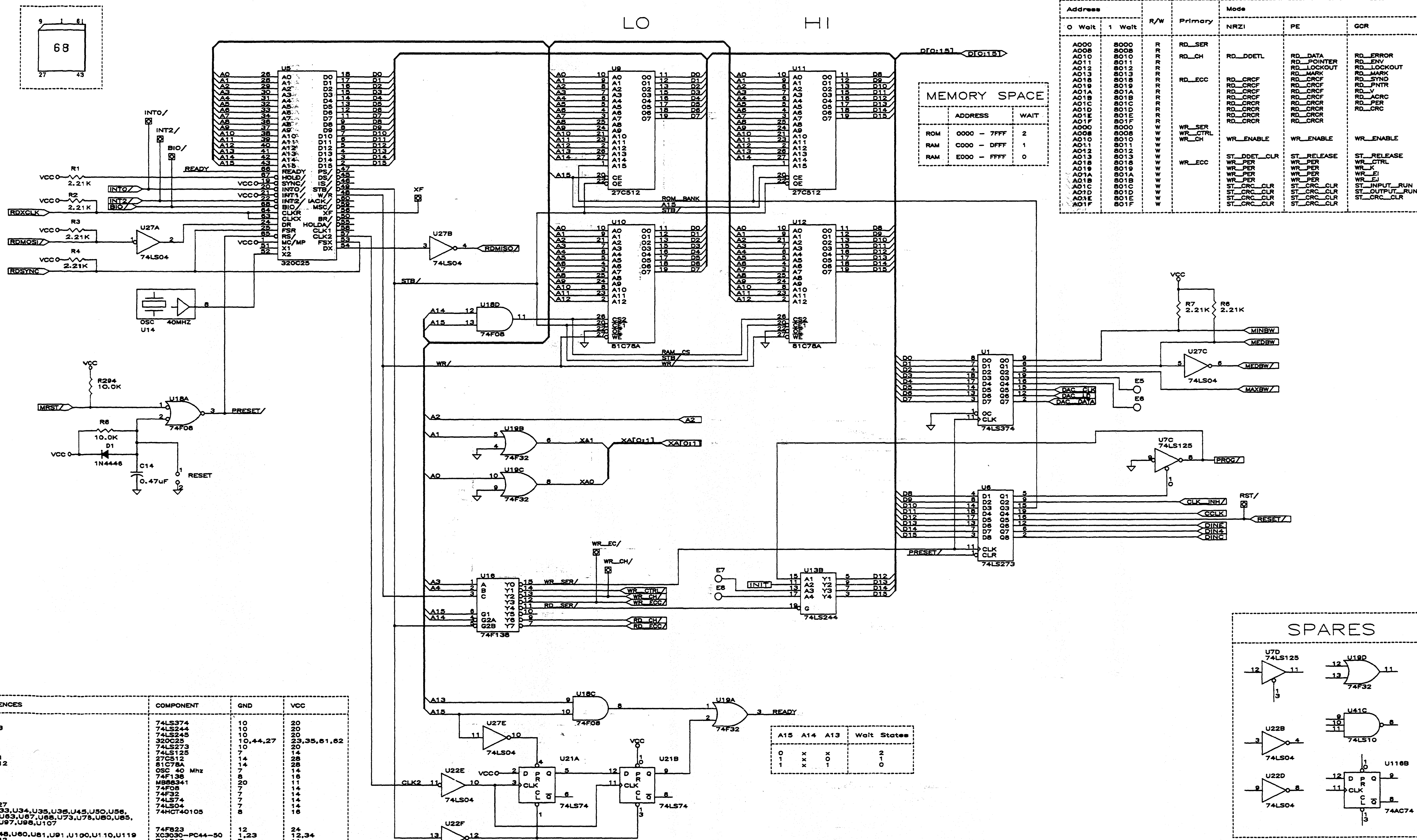

CHANNEL 4
CHANNEL 5
CHA4
CHB4
CHA5
CHB5
VREF
AMOKP4/
AMOKN4/
ZXING4/
AMOKP5/
AMOKN5/
ZXING5/
PHERR4
PHERR5
VCOA4
VCOB4
VCOA5
VCOB5
MAXBW/
MEDBW/
VRANG
MEDBW
MINBW
U64 NE521
U69 NE521
U66 NE592
U62 NE592
U70A 74HC4316
U70B 74HC4316
U70C 74HC4316
U70D 74HC4316
U61A LF412
U61B LF412
U65 74LS629
U103 NE521
U106 NE521
U105 NE592
U102 NE592
U109A 74HC4316
U109B 74HC4316
U109C 74HC4316
U109D 74HC4316
U101A LF412
U101B LF412
U104 74LS629
Qualstar Corporation
Title
341x Read Formatter II
Size D
Document Number 500558
REV B1
Date: April 3, 1992
Sheet 4 of 8


CHANNEL 6
CHANNEL 7
Qualstar Corporation
Title
341x Read Formatter II
Size D
Document Number 500558
REV B1
Date: April 3, 1992
Sheet 5 of 8



Qualstar Corporation		
Title 341X Read Formatter II		
Size D	Document Number 500558	REV B1
Date: March 23, 1992	Sheet 6 of 8	


Qualstar Corporation
Title
341x Read Formatter II
Size D
Document Number 500558
REV B1
Date: March 25, 1992
Sheet 7 of 8



I/O SPACE

Address 0 Wait	Address 1 Wait	R/W	Primary	Mode NRZI	Mode PE	Mode GCR
A000	8000	R	RD_SER			
A008	8008	R				
A010	8010	R	RD_CH	RD_DDETL	RD_DATA	RD_ERROR
A011	8011	R			RD_POINTER	RD_ENV
A012	8012	R			RD_LOCKOUT	RD_LOCKOUT
A013	8013	R			RD_MARK	RD_MARK
A018	8018	R	RD_ECC	RD_CRCF	RD_CRCF	RD_SYND
A019	8019	R		RD_CRCF	RD_CRCF	RD_PNTR
A01A	801A	R		RD_CRCF	RD_CRCF	RD_V
A01B	801B	R		RD_CRCF	RD_CRCF	RD_ACRC
A01C	801C	R		RD_CRCR	RD_CRCR	RD_PER
A01D	801D	R		RD_CRCR	RD_CRCR	RD_CRC
A01E	801E	R		RD_CRCR	RD_CRCR	
A01F	801F	R		RD_CRCR	RD_CRCR	
A000	8000	W	WR_SER			
A008	8008	W	WR_CTRL			
A010	8010	W	WR_CH	WR_ENABLE	WR_ENABLE	WR_ENABLE
A011	8011	W				
A012	8012	W				
A013	8013	W		ST_DDET_CLR	ST_RELEASE	ST_RELEASE
A018	8018	W	WR_ECC	WR_PER	WR_PER	WR_CTRL
A019	8019	W		WR_PER	WR_PER	WR_K
A01A	801A	W		WR_PER	WR_PER	WR_EI
A01B	801B	W		WR_PER	WR_PER	WR_EJ
A01C	801C	W		ST_CRC_CLR	ST_CRC_CLR	ST_INPUT_RUN
A01D	801D	W		ST_CRC_CLR	ST_CRC_CLR	ST_OUTPUT_RUN
A01E	801E	W		ST_CRC_CLR	ST_CRC_CLR	ST_CRC_CLR
A01F	801F	W		ST_CRC_CLR	ST_CRC_CLR	

MEMORY SPACE

	ADDRESS	WAIT
ROM	0000 – 7FFF	2
RAM	C000 – DFFF	1
RAM	E000 – FFFF	0

A15	A14	A13	Wait States
0	x	x	2
1	x	0	1
1	x	1	0

REFERENCES	COMPONENT	GND	VCC
U1,U2	74LS374	10	20
U3,U13	74LS244	10	20
U4	74LS245	10	20
U5	320C25	10,44,27	23,35,61,62
U6	74LS273	10	20
U7	74LS125	7	14
U9,U11	27C512	14	28
U10,U12	81C78A	14	28
U14	OSC 40 Mhz	7	14
U16	74F138	8	16
U17	MB88341	20	11
U18	74F08	7	14
U19	74F32	7	14
U21	74LS74	7	14
U22,U27	74LS04	7	14
U23,U33,U34,U35,U36,U45,U50,U56, U57,U63,U67,U68,U73,U78,U80,U85, U88,U97,U98,U107	74HCT40105	8	16
U28	74F823	12	24
U37,U48,U60,U81,U91,U100,U110,U119	XC3030–PC44–50	1,23	12,34
U41,U42	74LS10	7	14
U49	74LS08	7	14
U59	XC3030–PC84–50	1,43	22,64
U74	XC3030–PC68–50	1,35	18,52
U106	OSC 36.168 Mhz	7	14
U116	74AC74	7	14

Qualstar Corporation		
Title: 341x Read Formatter II		
Size: D	Document Number: 500558	REV: B1
Date: March 24, 1992	Sheet 8 of 8	