REV.	ZONE	ECO #	REVISION	APPD	DATE
A		P855	INITIAL RELEASE (was SK-L170-00)	[illegible] K.PATEL	4/85 4/85

NISHA DRIVE SPECIFICATION

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TOLERANCES UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DECIMALS .X ± ___ .XX ± ___ .XXX ± ___ ANGLES XX.X ± ___ FRACTIONS ± ___ DIMENSIONS IN PARENTHESIS ARE IN MILLIMETERS.	DRAWN BY HAAHR/R.J.B. DATE 11/84 CHECKED BY [illegible] DATE [illegible] APPROVED BY K. PATEL DATE 4/85 RELEASED BY [illegible] DATE 4/85	apple computer inc. TITLE SPECIFICATION, NISHA DRIVE
MATERIAL:		SIZE A DRAWING NUMBER 062-0287-A
NEXT ASSY.	FINISH:	SCALE: ----- SHEET 1 OF 30

APPLICABLE DOCUMENTS

Engineering Specification:

The HDA components shall meet all requirements and specifications set **forth in the following** documents unless separately specified herein.

NISHA Assembly	678-5007
Head Disk Assembly	678-5006
Disk Specification	062-0236
Head Specification	062-0231
Spindle Motor Assembly	699-5034
P.C.B. Assembly, Motor Control	678-0102

CONTENTS

1.0 SCOPE

The NISHA Drive consists of the NISHA HDA Assembly and **one Electronic** Board Assembly. The scope of this specification **is to** define the NISHA Drive without controller.

2.0 CAPACITY

No. of Disks	1
Recording Surface	2
Per Drive	20.7MB(Formatted)
No. of Cylinders	610
Total No. of Tracks	1220
No. of Sector/Track	32
Bytes/Sector	532(Formatted)
Total No. of Blocks (Data)	38,964
Spare Blocks	76

3.0 TRANSFER RATE 7.5MHZ

4.0 ACCESS TIME

Track to Track	10 ms
Average	50 ms
Maximum	150 ms
Average Latency	10.9 ms

5.0 ROTATIONAL SPEED 2749 RPM

6.0 RECORDING DENSITY

Bits Per Inch	19,065 (MAX)
Flux Changes Per Inch	12,710 (MAX)
Tracks Per Inch	600

7.0 RELIABILITY

MTBF (Typical Usage)	15,000 Hours
Component Life	5 Years
Media Life	10,000 Starts/Stops

8.0 ERROR RATE

Soft Read Errors (9 retries minimum)	1 per 10^9 bits
Hard Read Errors	1 per 10^{12} bits
Seek Errors	1 per 10^4 seek

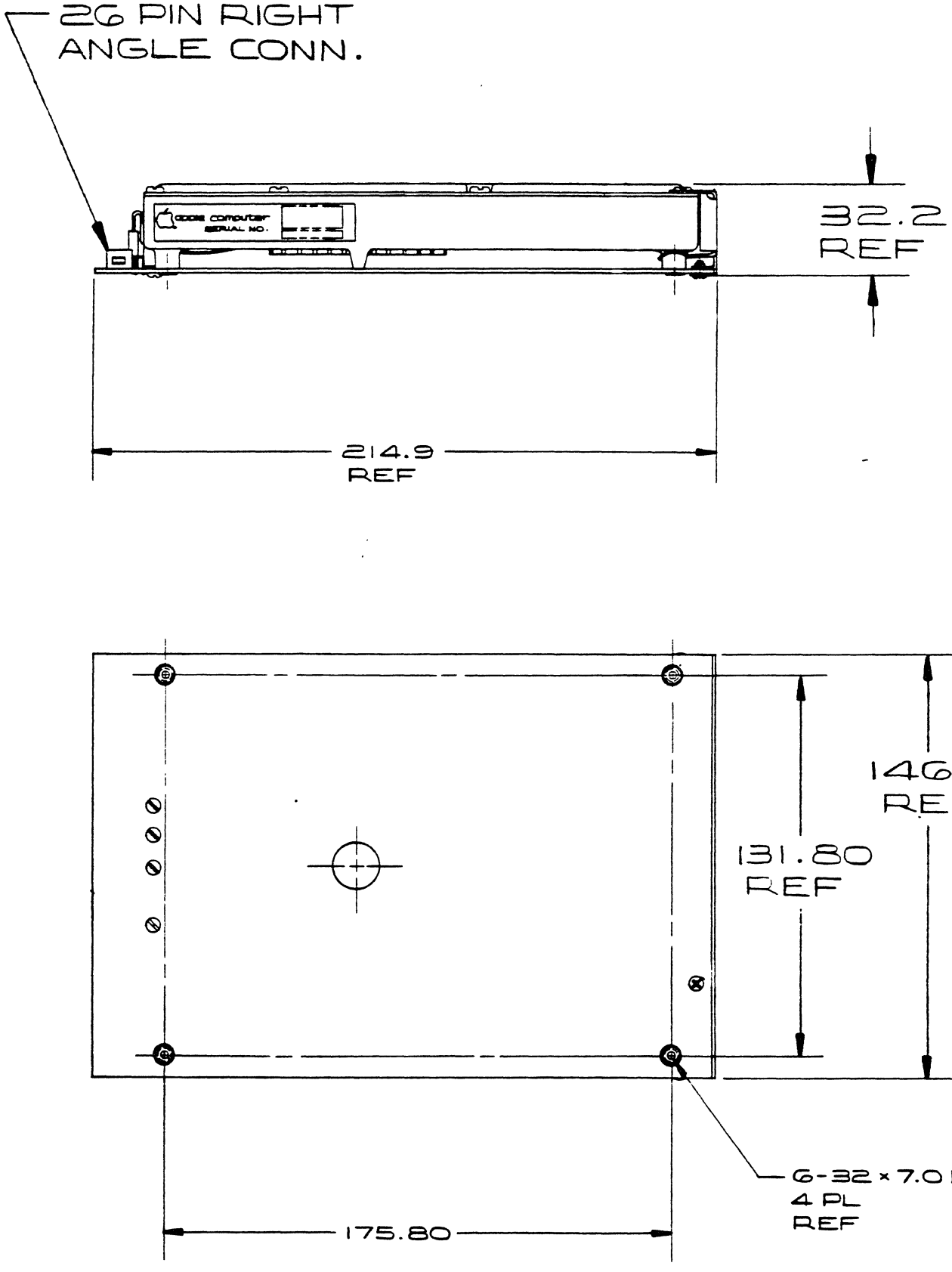
9.0 POWER REQUIREMENT

+5V DC 5%	620 ma
-12.5V DC 5%	180 ma
+12.5V DC 5%	470 ma (on Track)
	670 ma (Average Seek-R/W)
	1200 ma (Start for 5 Sec)
Standby Power	11.2 Watts
Typical Power	13.7 Watts

10.0 ENVIRONMENTAL

Ambient Temperature	
Operating	10^0C to 60^0C
Shipping	-40^0C to 70^0C
Storage	-40^0C to 70^0C
Maximum Temperature Gradient	
Operating	10^0C per hour
Non-operating	Below that causing Condensation
Relative Humidity (Non-Condensing)	
Relative Humidity	20% to 80%
Stray Magnetic Field (1 inch from casting)	20 Gauss(Max)
Attitude	10,000 Feet
Shock and Vibration	
Shock (Operating)	0.5G, 11 msec,half sine
Shock (shipping)	50G, 11msec,half sine
Vibration (Operational)	0.5g peak; 20-200Hz
Vibration(Non-operational)	2g peak; 20-200Hz

11.0 MOUNTING AND PHYSICAL CONFIGRUATION See Figure 1



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12.0 NISHA INTERFACE

12.1 GENERAL DESCRIPTION:

PIN	SIGNAL NAME	I/O	FUNCTION
1	INDEX	O	THIS SIGNAL INDICATES THE BEGINNING OF SERVO SECTOR AND END OF DATA SECTOR 31. ONE PER REVOLUTION (2749RPM +-1.5%).
3	SECTOR	O	THIS SIGNAL INDICATES THE BEGINNING OF DATA SECTORS. TOTAL DATA SECTORS IS 32 STARTING FROM SECTOR 0 TO 31. EACH SECTOR HAS 620+-16 BYTES OR 661+-17 US.
5	RWCLK	O	READ/WRITE CLOCK IS THE SIGNAL TO SYNCHRONIZE THE DRIVE READ/WRITE DATA. CLOCK FREQUENCY IS 7 5 MHZ +-40%. WITH 50+-10% DUTY CYCLE.
7	/RDATA	O	NRZ READ DATA FROM DRIVE IS SYNCHRONIZED TO THE RISING EDGE OF THE READ/WRITE CLOCK (RWCLK) READ DATA CAN CHANGE AT A MIN. OF 40NS AND AT A MAX OF 90NS FROM THE RISING EDGE OF THE RWCLK.
9	WDATA	I	NRZ WRITE DATA FROM CONTROLLER IS SYCHRONIZED TO THE RISING EDGE OF THE RWCLK. WRITE DATA CAN CHANGE AT A MIN. OF 40NS AND AT A MAX. OF 90NS FROM THE RISING EDGE OF THE RWCLK.

11	/WTGT	1	WRITE GATE FROM CONTROLLER, WHICH INDICATES THAT WRITE DATA IS SHIFTING FROM CONTROLLER TO DRIVE.
12	HS0	1	HEAD SELECT 0 INDICATES THE SELECTION OF HEAD 0. HEAD SWITCHING RECOVERY TIME IS 1 US.
13	RDGT	1	READ GATE FROM CONTROLLER, WHICH MUST BE TURNED ON AT GLITCH FREE DATA SYNCHRONIZATION AREA. READ DATA WILL BE AVAILABLE AFTER VCO IS LOCKED ON THE DATA SYNCHRONIZATION BYTES(00). VCO LOCK ON TIME IS 12 BYTES MAXIMUM.
14	HS1	1	HEAD SELECT 1, A RESERVED PIN FOR FUTURE ADDITION OF READ WRITE HEADS.
15	SO	1	SERVO SERIAL DATA OUT IS AN OUTPUT SIGNAL THAT SHIFTS SERVO STATUS FROM DRIVE TO CONTROLLER AT A MAX. RATE OF 58.6K BITS/SEC.
16	/RWI	1	REDUCED WRITE CURRENT IS A SIGNAL THAT INDICATES TO DRIVE THAT LESS WRITE CURRENT IS REQUIRED AT THE INSIDE TRACKS WHICH HAVE MUCH HIGHER FLUX CHANGE PER INCH (FCI).
17	SI	1	SERVO SERIAL DATA IN IS AN INPUT SIGNAL THAT SHIFTS SERVO COMMANDS FROM CONTROLLER TO DRIVE AT A MAX. RATE OF 58.6K BITS/SEC.

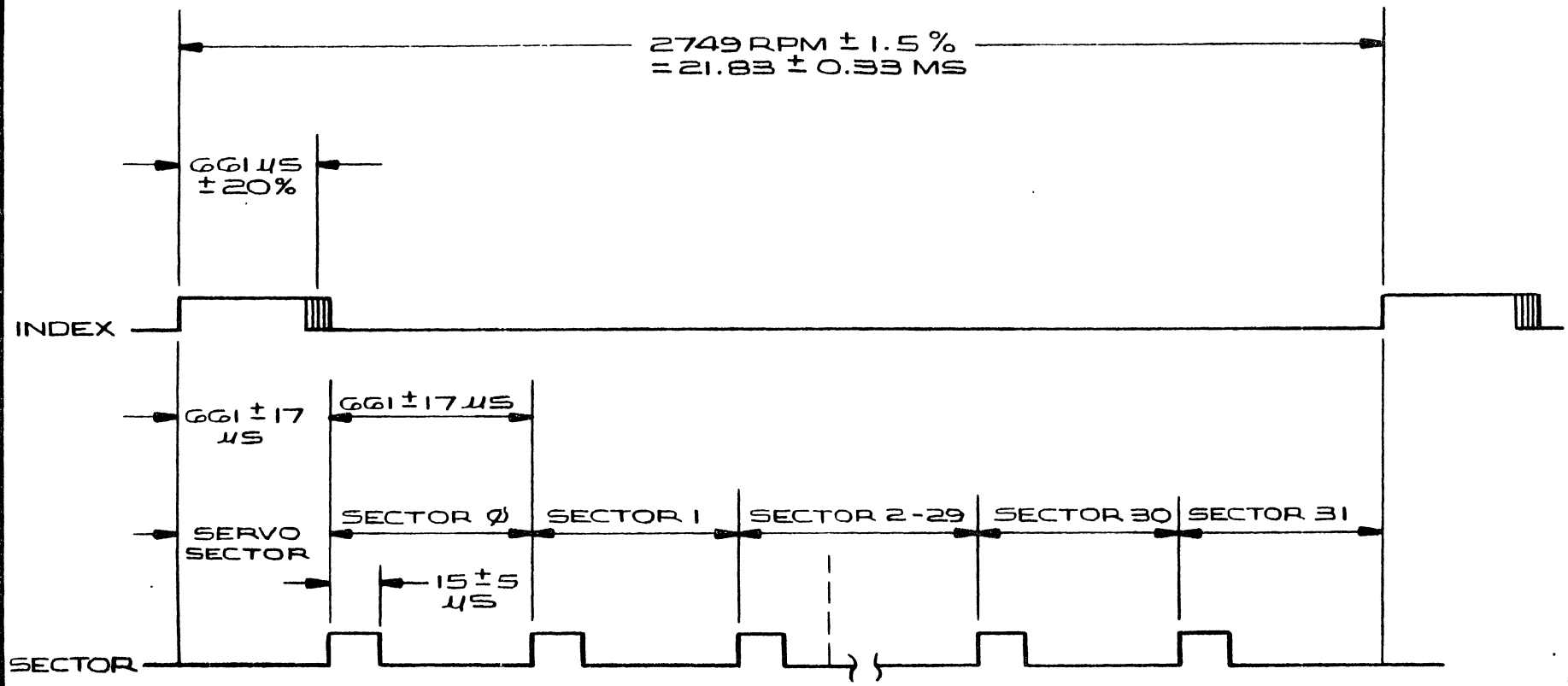
18	/RESET	1	SERVO RESET IS AN INPUT SIGNAL THAT RESETS THE SERVO CONTROL FUNCTIONS.
19	SIORDY	0	SERVO INPUT/OUTPUT READY IS AN INDICATION FROM DRIVE TO CONTROLLER THAT SERVO COMMUNICATION IS READY.
21	SERVORDY	0	SERVO READY IS AN OUTPUT SIGNAL THAT DRIVE INDICATES TO CONTROLLER THAT READ/WRITE HEAD IS ON TRACK AND IS READY FOR READ/WRITE DATA TRANSFER.
23	/WRITESAFE	0	WRITESAFE WHEN LOW INDICATES FROM DRIVE TO CONTROLLER THAT WRITING IS SAFE TO BE PROCEEDED. WRITESAFE WHEN HIGH INDICATES FROM DRIVE TO CONTROLLER THAT WRITING IS PROHIBITED OR SERVO COMMUNICATIONS HAS AN ERROR. WRITESAFE CAN GO HIGH DURING THE WRITING CYCLE AND WILL NOT BE LATCHED. IT IS THE RESPONSIBILITY OF THE CONTROLLER TO LATCH THE STATUS AND REWRITE THE DATA SECTOR.

12.0 NISHA INTERFACE (con't)

PIN	SIGNAL NAME	I/O	FUNCTION
8	+5V	1	POWER SUPPLY INPUT
10	+5V	1	POWER SUPPLY INPUT
2	GND	1	GROUND
4	GND	1	GROUND
6	GND	1	GROUND
20	+12V	1	POWER SUPPLY INPUT
22	+12V	1	POWER SUPPLY INPUT
24	-12V	1	NEGATIVE POWER SUPPLY INPUT
25	MOTOR 12V	1	POWER SUPPLY TO MOTOR (ISOLATED FROM +12V IN NISHA)
26	MOTOR GND	1	MOTOR GROUND(ISOLATED FROM GND IN NISHA)

12.1 DC ELECTRICAL CHARACTERISTICS
(TEMPERATURE=10 DEG TO 60 DEG CELSIUS)

PARAMETER	MIN	TYP	MAX	UNITS	COMMENTS
VIL INPUT					
LOW VOLTAGE	-0.3		0.8	V	IOL MAX=-400UA
VHI INPUT					
HIGH VOLTAGE	2.0		VCC	V	IOH MAX=+40UA
VOL OUTPUT LOW					
VOLTAGE			0.4	V	3 LSTTL=+1.2MA
VOL OUTPUT HIGH					
VOLTAGE	2.4			V	3 LSTTL=-120MA
5V POWER SUPPLY					
VOLTAGE	4.75	5.00	5.25	V	1A MAX
+12V POWER SUPPLY					
VOLTAGE	12.0		13.2	V	
-12V NEG POWER					
SUPPLY VOLTAGE	-12.0		-13.2	V	
MOTOR +12V MOTOR					
SUPPLY VOLTAGE	12.0		13.2	V	
CABLE LENGTH			1	FT	
CABLE CAPACITANCE		15	25	PF	
RISE TIME		35	40	NS	
FALL TIME		20	25	NS	



NISHA INTERFACE
AC ELECTRICAL CHARACTERISTICS

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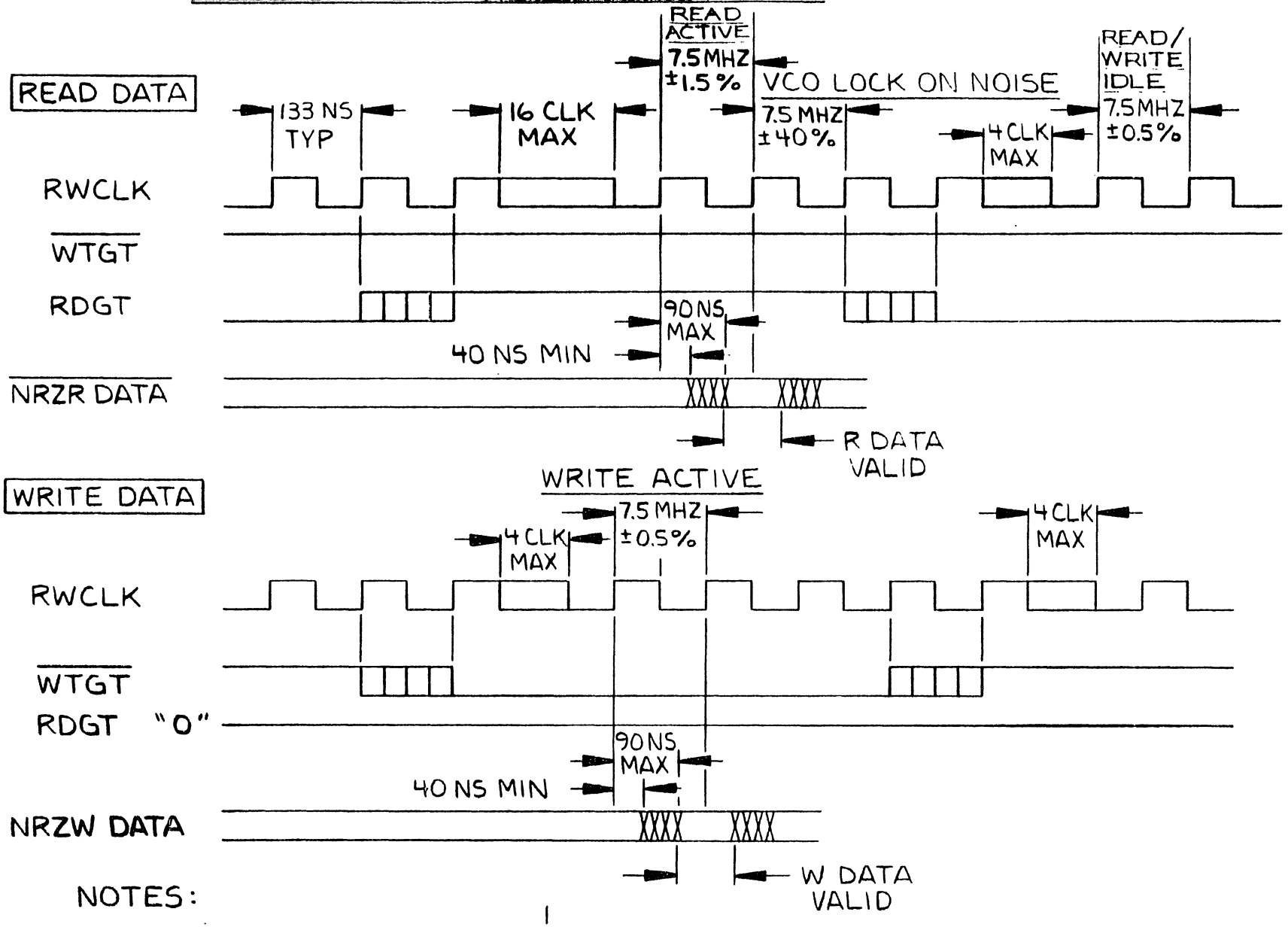
AC ELECTRICAL CHARACTERISTICS



NOTES:

1 - RWCLK PERIOD = $\frac{1}{7.5\ \text{MHZ}}$ = 133.33 NS (WITH 50 ± 10% DUTY CYCLE).

2 - HEAD SWITCHING RECOVERY TIME = 1 µS.

3 - WRITE TO READ RECOVERY TIME = 80 ± 20 µS.

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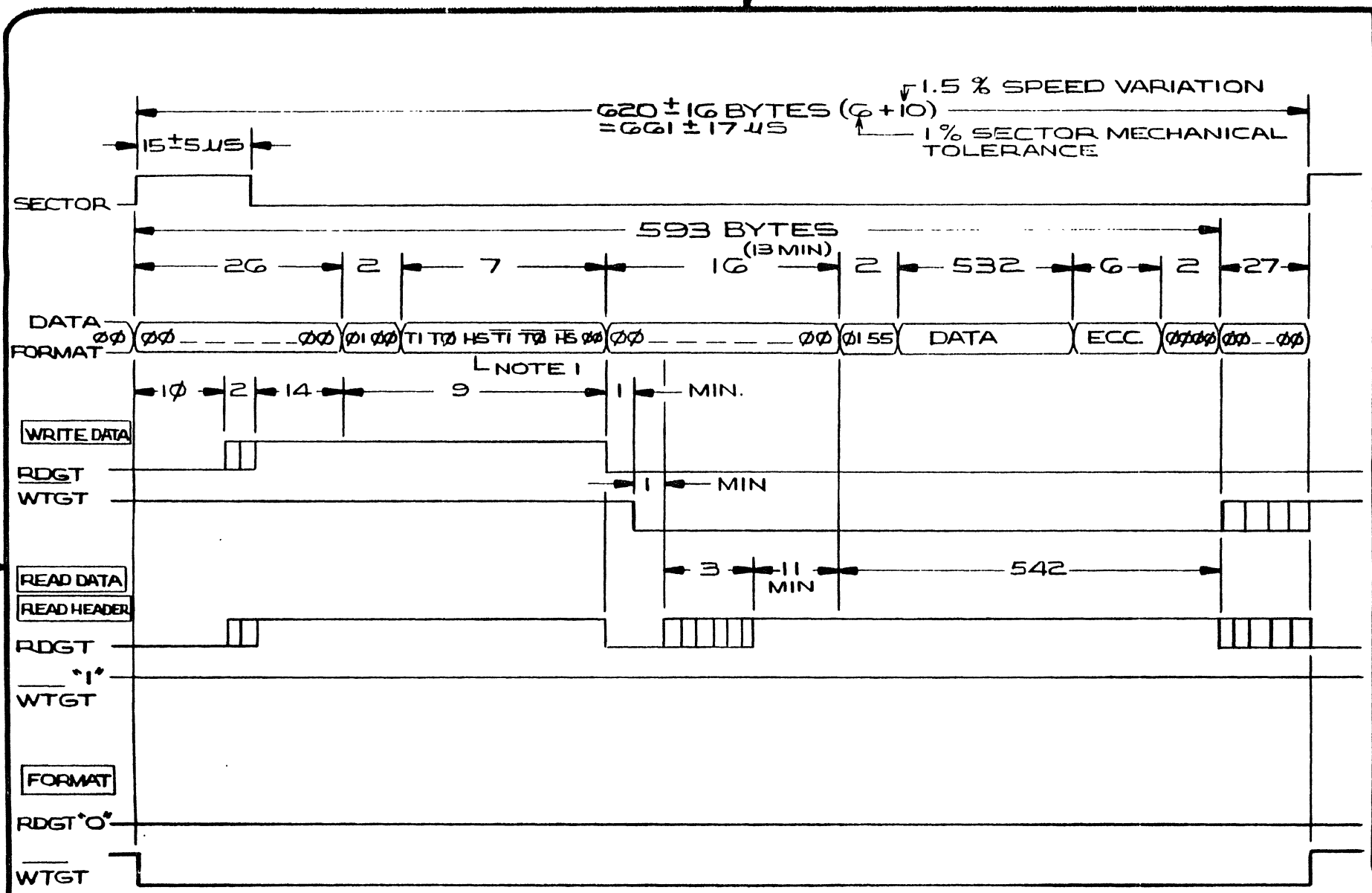

NISHA INTERFACE
AC ELECTRICAL CHARACTERISTICS

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SHEET 14 OF 30
SIZE A
SCALE: ——
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12.3 AC ELECTRICAL CHARACTERISTICS

NOTE 1: ID BYTES FORMAT

	M S B 7 6 5 4 3 2 1 0 L S B
T1 =	TRACK BYTE 1
T0 =	TRACK BYTE 0
HS =	HEAD SECTOR
/T1 =	INVERSE OF TRACK 1
/T0 =	INVERSE OF TRACK 0
/HS =	INVERSE OF HD,STR
00 =	LAST 00 BYTE

12.4

-RESET P-18 Input. Resets the Servo z8 and the TL7705 (U24) power monitor I.C

$\overline{\text{RESET}}$ Output from the TL7705 I.C.

RESET Output from the TL7705 I.C. complement of $\overline{\text{RESET}}$

12.5 NORMAL POWER UP (SEE FIG. A)

When +5V crosses a trigger threshold of 4.3V the TL7705 initiates a 140MS timing period.
At the end of this timing period $\overline{\text{RESET}}$ will go high and RESET will go low and the Spindle Motor will restart.
If +5V goes below the 4.3V threshold $\overline{\text{RESET}}$ will go low, RESET will go high and the TL7705 will initiate a new 140MS timing cycle.

12.6 POWER UP WITH SPINDLE MOTOR HOLDOFF (SEE FIG. B)

If the -RESET line is held low the TL7705 is held in a RESET state. $\overline{\text{RESET}}$ is low and RESET is high. Upon releasing the -RESET line the TL7705 will continue to hold $\overline{\text{RESET}}$ low and RESET high for approximately 100MS. The Spindle Motor drive circuitry is enabled only when RESET from the TL7705 is low. Sending a -RESET longer than 1MS +10% will cause the TL7705 to go into a RESET state.

12.7 SPECIFICATIONS

-RESET 1MS -0% +10%

TL7705 Timeout Period.

Power Up -	140MS ± 10%
External RESET -	100MS ± 15%

TL7705 Threshold 4.3V ± 10%

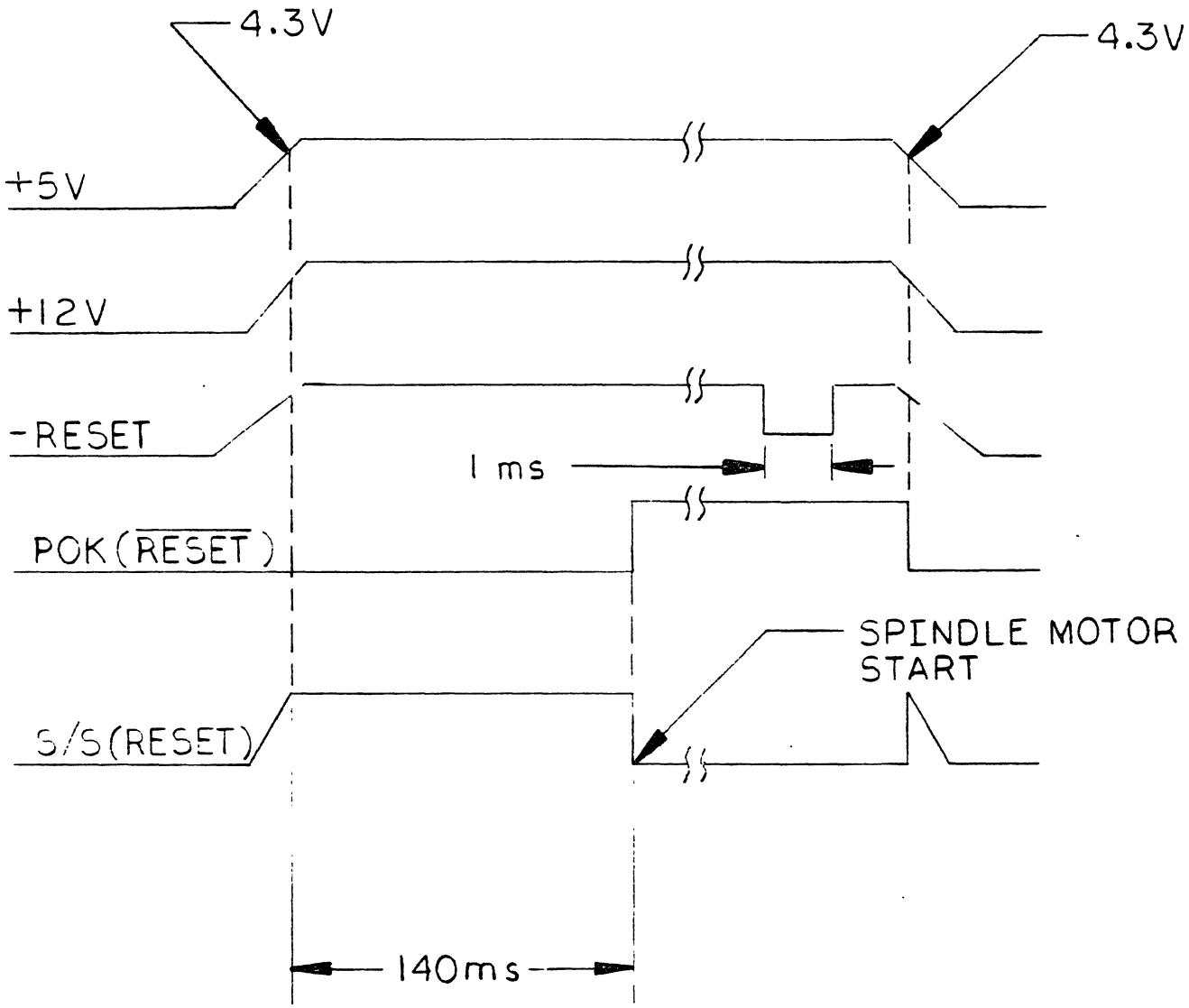

FIGURE "A"

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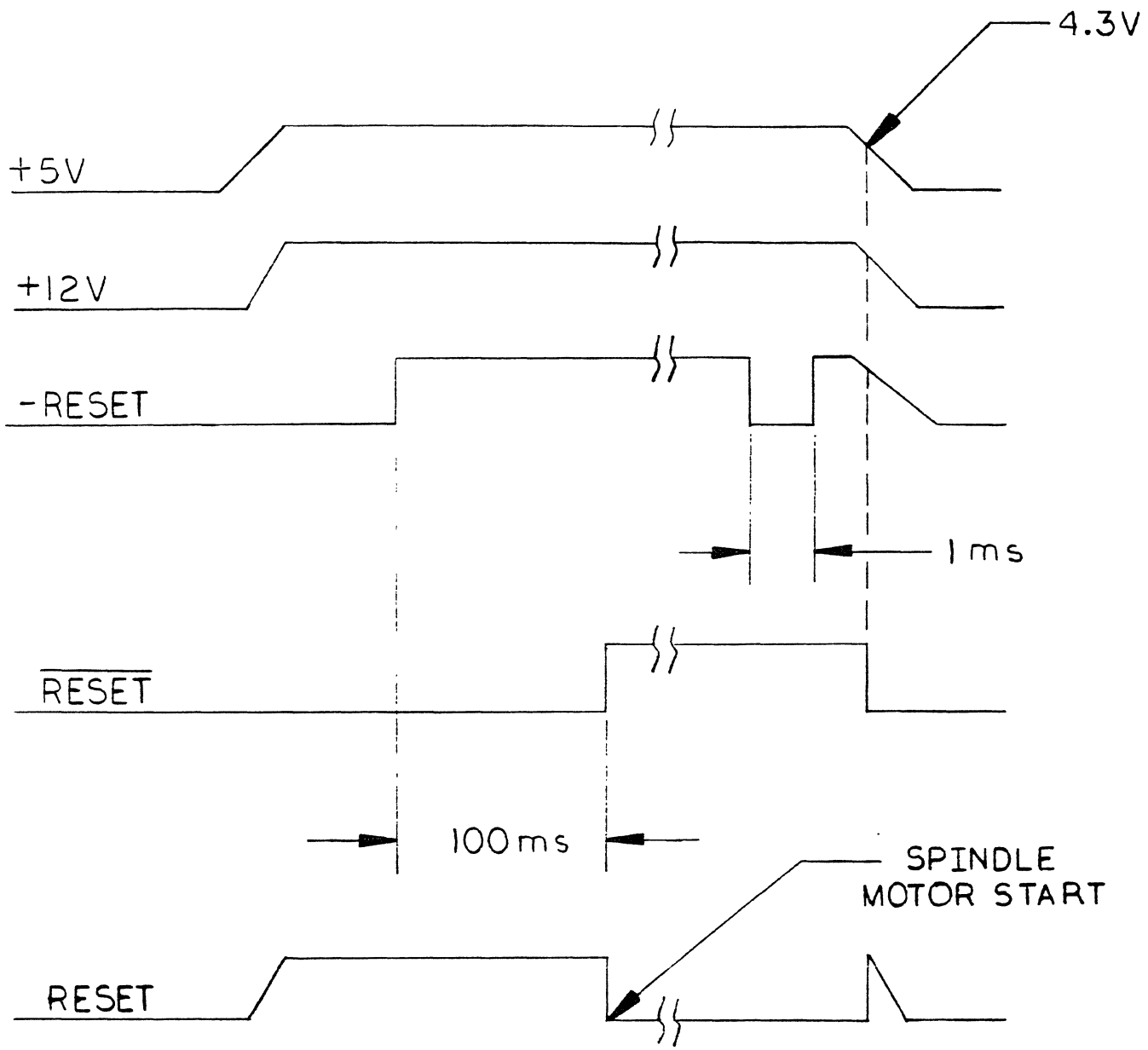

FIGURE "B"

apple computer inc.

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13.0 SERVO

13.1 BASIC SERVO FUNCTIONS

Nisha servo control functions are handled by a Z8 microprocessor. The Z8 handles all I/O operations, timing operations and communication with a host controller. Control functions to the Z8 Servo Controller are made through the serial I/O.

The following commands for the Nisha servo are:

A. INHIBIT SERVO - not detented, heads off data zones located at the inner stop. Inhibit Servo is also generated following a reset of Z8.

B. SET BRAKE - performs recal operation all the way to outer crash stop, holds brake to insure latching then inhibits servo back to inner crash stop.

C. RECAL - 72, -0, +3 tracks from HOME Used to initialize into data zone.

D ACCESS - coarse track positioning of data head to any desired track location.

E. OFFSET TRACK FOLLOWING - controlled microstepping of fine position system during TRACK FOLLOWING (two modes).

1. COMMAND OFFSET - direction and amount of offset is specified to the servo.

2. AUTO OFFSET - command allows the servo to automatically move off track by the amount indicated by the embedded servo signal on the data surface (disk).

F. STATUS - command can read servo status.

See Table 1(Section IV) for the actual command description. With the present command structure a SEEK COMMAND can be augmented with an OFFSET COMMAND. Upon completion of a seek, the offset command bit is tested to determine if an offset will occur following a seek (either auto or command offset).

When a SERVO ERROR occurs the Z8 SERVO will attempt to do a short RECAL (ERROR RECAL). Two attempts are made by the system to do the ERROR RECAL function. If either of the two RECAL operations terminate successfully the protocol status will be SERVO READY, SIO READY and -WRITE SAFE. Should the ERROR RECAL fail then the system will complete the error recovery by a inhibit servo function.

The two OFFSET commands will be described. First COMMAND OFFSET is a predetermined amount of microstepping of the fine position servo. Included in the OFFSET BYTE (STATREG) bit B6=0 is a COMMAND OFFSET. Bit B7-1 is a forward offset step (toward the spindle); B7=0 is a reverse step. If bit B6-1, the OFFSET command is AUTO OFFSET

AUTO OFFSET command normally occurs during a write operation. When the HDA was initially formatted at the factory, special encoded servo data was written on each track "near" the index zone The reason for this follows:

> "Normal coarse and fine position information for the position servos is derived from an optical signal relative to the actual data head-track location. Over a period of time, the relative position (optical signal) will be mis-aligned to the absolute head-track position by some unknown amount (less than 100 uin). This small change is important for reliability during the write operation. Write/Read reliability can be degraded due to this mis-alignment. The special disk encoded servo signal is available to the fine position servo. It will correct the difference between the relative position signal of the optics and the absolute head to track position under the data head only a index time. The correction signal can be held indefinitely or updated (if desired at each index time) until a new OFFSET command or move command (SEEK or RECAL) occurs."

13.1 COMMUNICATION FUNCTIONS

The servo functions described in the previous section only occur when the servo Z8 microprocessor is in the communication state. Communication states occur immediately after a system reset, upon completing head setting after a recal, seek, offset, read servo status or set servo diagnostic command. If + SIO READY is not active, no communication can exist between the external controller and the servo Z8 processor.

Servo commands are serial bits grouped as five seperate bytes total. Refer to Table 1 parts I through V for the total communication string. The first byte is the command byte (i.e. seek, read status, recal, etc.). The second byte is the low order difference for a seek (i.e. Byte 2 = $0A is a ten track seek). The third byte is the offset byte (AUTO or COMMAND OFFSET and the magnitude/direction for command offset). The fourth byte is the status byte (use for reading internal servo status) Byte five is the check sum byte used to check verify that the first four bytes were correctly transmitted (communication error checking).

Part of the communication function requires a specific protocol between the servo Z8 processor and the external controller.

13.2 Z8 SERVO PROTOCOL

The protocol between the Z8 SERVO microcomputer and the CONTROLLER is based on five I/O lines. Two of the I/O lines are serial input (to Z8 servo from controller) serial output (from Z8 servo to controller). Data stream between the Z8 servo and controller is 8 bit ASCII with no parity bit (the fifth byte of the command string contains check sum byte use for error checking). There are three additional output lines between the Z8 servo used as control lines to the controller. Combining the two serial I/O lines and the three unidirectional port lines generates the bases of the protocol between the Z8 servo and controller. The important operations between the Z8 servo and controller are:

1. Send commands to Z8 servo.
2. Read Z8 servo status.
3. Check validity of all four command bytes.
4. I/O timing signals between the Z8 servo and controller.
5. Z8 servo reset.

Sequencing the Z8 servo controller is an important process following a Power Up or if the controller should issue a Z8 Servo Reset at any time. After a Z8 Servo Reset is inhibited, the Z8 I/O ports and internal register are initialized. This takes approximately 75 msec after the Z8 Servo Reset is inhibited. The protocol baud rate is automatically set to 58.59KB and then the system is parked at HOME position by inhibiting the SERVO and SIO READY is set active.

Before the controller transmits the command byte the controller must poll the SIO READY line from the Z8 servo to determine if it is active (+5 volts). If the line is active then a command can be transmitted to the Z8 servo. The program in the Z8 servo will determine what to do with the command bytes (depending upon the current status of the Z8 servo). After the command (five bytes long) has been transmitted to the Z8 servo, the program in the Z8 servo will determine if the command bytes (first four bytes) are in error by evaluating the check sum byte (fifth byte transmitted). After the controller has transmitted the last serial string and -WRITE SAFE is true (0V) it must wait 250 U sec then test for -WRITE SAFE.

If -WRITE SERVO is high the command was rejected (check sum error or invalid command). If -WRITE SAFE is set inactive 600 U sec after the command is sent (and not 250 U sec), this was a command reject. This unsafe condition must be cleared by a READ STATUS COMMAND or RECAL COMMAND before transmitting another command. If SERVO READY is low then this protocol is not valid since SERVO READY is gated with SERVO ERROR and on track to generate -WRITE SAFE. This protocol is only effective if the drive is track following (SERVO READY is true).

As long as SIO READY is active the controller can communicate with the Z8 Servo Controller. If SERVO READY is not active the only command that will cause the Nisha Servo to set SERVO READY active is a RECAL COMMND. Read Status will only clear SERVO ERROR if SERVO READY is also true, and all other commands will be rejected.

Next, if SERVO READY is high and -WRITE SAFE is also high, -WRITE SAFE can be cleared by:

1 Any READ STATUS COMMAND.

2. Any RECAL COMMAND.

3. Any other commands will be rejected and maintain -WRITE SAFE

If a SEEK COMMAND is transmitted with both SERVO READY and -WRITE SAFE active, the command will be rejected.

It is important to check the status of all three status lines from the Z8 Servo. It is best to avoid sending a SEEK COMMAND with SERVO READY and -WRITE SAFE inactive. If a seek length of 1024 or great is sent, the command will be rejected and -WRITE SAFE will go high.

Chart V, parts A-I, illustrate some of the serial communciation commands and error conditions that can occur between the controller and Z8 SERVO.

13.3 ERROR HANDLING

-WRITE SAFE will be generated during the following conditions:

1. During Recal mode (velocity control only) access time-out. If a Recal function exceeds 220 msec then an access timeout occurs.

2. During Seek mode (velocity control only) access time-out. If a Seek function exceeds 220 msec then an access time-out occurs.

3. During Settling mode (following a Recal, Seek, or Offset) if there is excessive On Track pulses (3 crossings) indicating excessive head motion, a Settling error check will occur.

4. During a command transmission if a communication error occurs (check sum error).

5. During a command transmission if a invalid command is sent.

Z8 SERVO COMMAND BYTES

TABLE 1

I. BYTE 1: COMMAND BYTE (DIFCNTH)

		B7	B6	B5	B4	FUNCTIONS
	---	1	0	0	0	access only
	B7	1	0	0	1	access with offset
command	B6	0	1	0	0	data recal
bits	B5	0	1	1	1	set broke
	B4	0	0	0	1	offset-trk following
	---	1	1	0	0	inhibit servo
		0	0	0	0	read status command

B3 - access direction

access bits B2 - NOT USED(command will be rejected -WRITE SAFE will go high)

B1 - hi diff2 (512)

B0 - hi diff1 (256)

MAXIMUM seek length is +/-1023

access direction = 1 (FORWARD: toward the spindle)
= 0 (REVERSE: away from the spindle)

hi diff2 (512) = 1 (512 tracks to go)
= 0 (not set)

hi diff1(256) = 1 (256 tracks to go)
= 0 (not set)

II BYTE 2: DIFF BYTE (DIFCNTL)

command BYTE 2 contains the LOW ORDER DIFFERENCE COUNT for a seek

---

B7-bit7 = 128 tracks
B6-bit6 = 64 tracks
B5-bit5 = 32 tracks
B4-bit4 = 16 tracks
B3-bit3 = 8 tracks
B2-bit2 = 4 tracks
B1-bit1 = 2 tracks
B0-bit0 = 1 track

III. BYTE 3: OFFSET BYTE (STATREG)

command BYTE 3 contains the INSTRUCTION for an OFFSET COMMAND (seek or during track following)

B7-offset direction
B6-auto offset function
B5-not used
B4-offset Bit4=16
B3-offset Bit3=8
B2-offset Bit2=4
B1-offset Bit1=2
B0-offset Bit0=1

---

1. if offset command from BYTE 1 is followed by bit6 set (auto offset); offset direction (bit7) read offset (bit5) and bits 4-0 are ignored but should be set to 0 if not used.

2. OFFSET DIRECTION = 1 (FORWARD OFFSET: toward the spindle)
= 0 (REVERSE OFFSET away from the spindle

3 AUTO OFFSET = 1 (normally used preceeding a write operation)
= 0 (manual offset: MUST send direction and magnitude of offset)

IV BYTE 4: STATUS BYTE (CNTREG)

B7 - NOT USED
B6 - NOT USED
B5 - NOT USED
B4 - NOT USED
B3 - status or diagnostic bits
B2 - status or diagnostic bits
B1 - status or diagnostic bits
B0 - status or diagnostic bits

Status call = $00,$00,$00,$02: The return will be 4 bytes (exclude check sum) = $01 (Drive ID for Nisha), $0A (ROM CODE Version), $5A (Byte filler), $A5 (Byte filler).

V. BYTE 5: CHECKSUM BYTE (CKSUM)

[B7 B6 B5 B4 B3 B2 B1 B0]

results of the transmitted CHECKSUM BYTE are derived as:

$$\overline{(\text{BYTE 1} + \text{BYTE 2} + \text{BYTE 3} + \text{BYTE 4})} = \text{CHECKSUM BYTE}$$

(+) is defined as the addition of each BYTE

$\overline{(\text{BYTE})}$ is defined as the compliment of the BYTES (1-4)

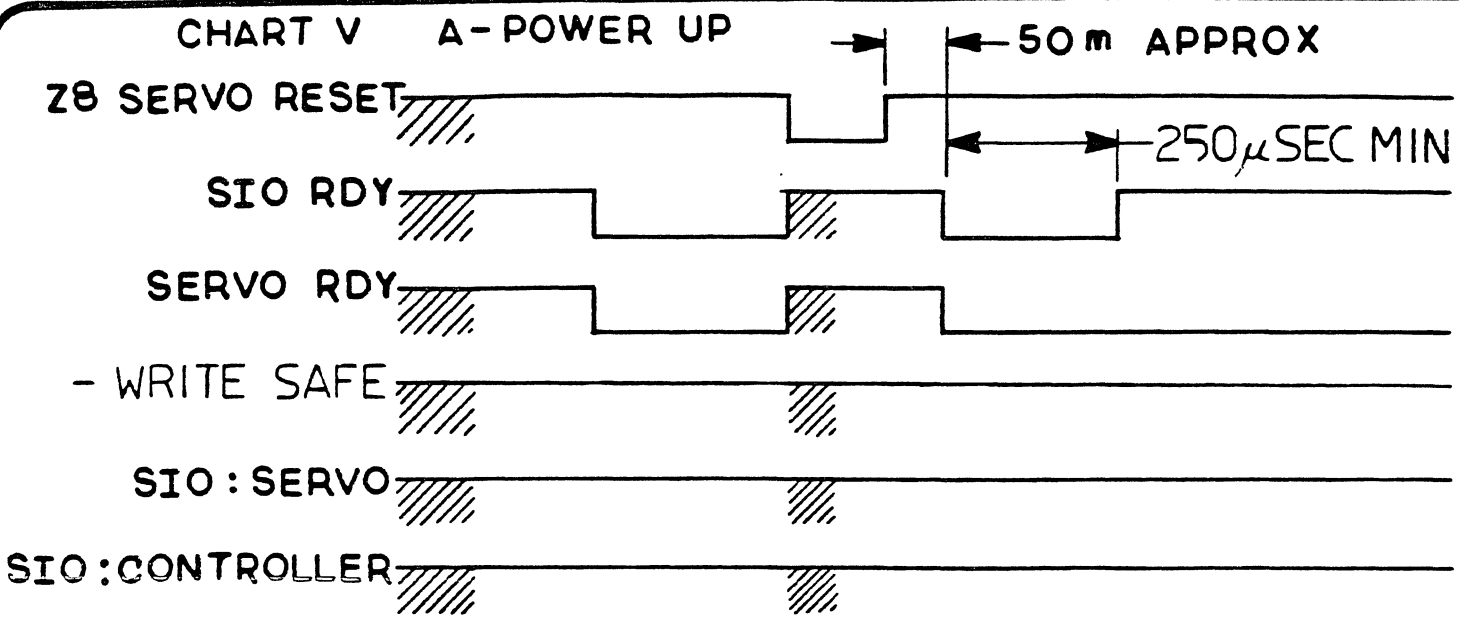
VI. The SERVO STATUS lines (SIO RDY, SERVO RDY, SERVO ERROR) must have the following conditions in order to send the listed Z8 COMMANDS:

	SERVO STATUS		
		(-)	
S	S	W	
I	R	R	
O	V	T	
R	R	S	
D	D	A	
Y	Y	F	

Z8 SERVO CMD	HEX			
access (only)	8X	1	1	0
access(offset)	9X	1	1	0
recal(data)	40	1	X	X
set brake	70	1	X	X
inhibit servo	C0	1	X	X
offset(detent)	10	1	1	0
status	00	1	X	X

X = either 0, 1

CHART V A-POWER UP



N/S - NOT SPECIFIED

C - AFTER POWER UP - INVALID CMD

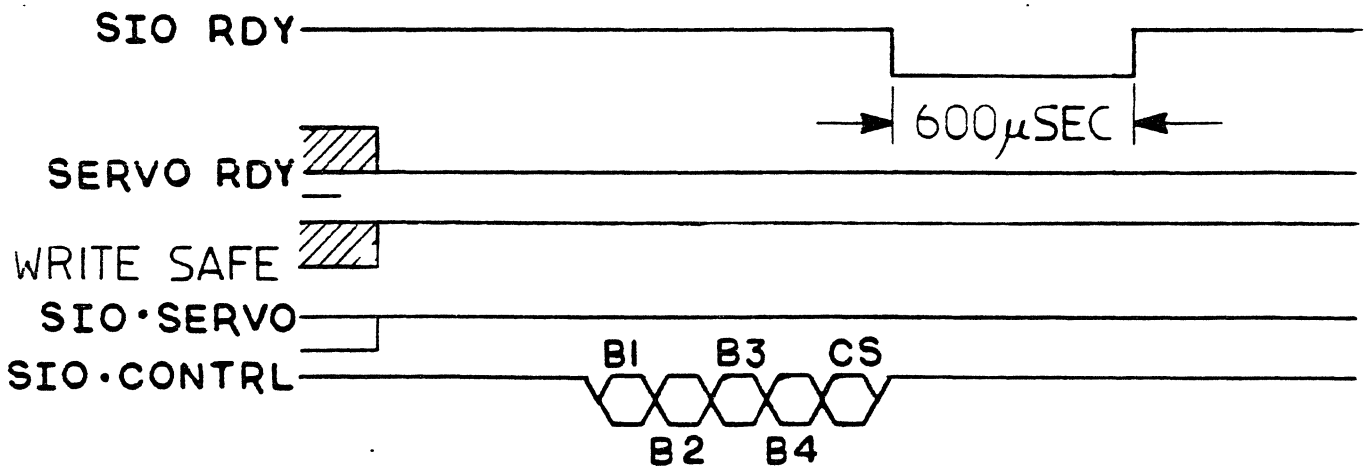
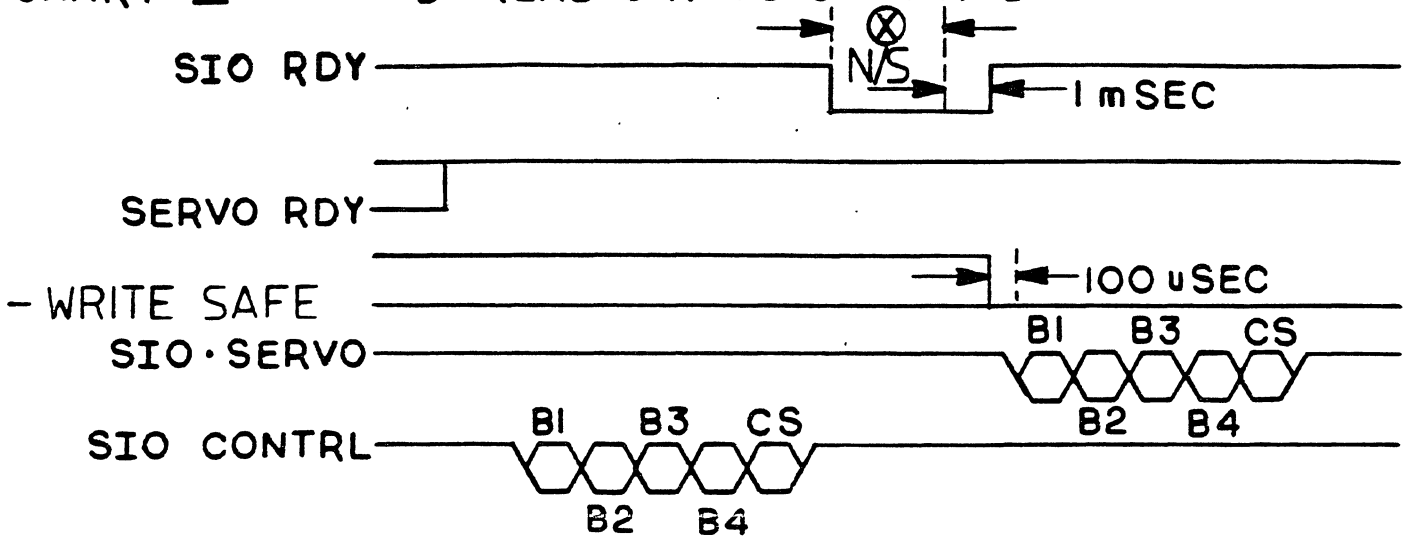
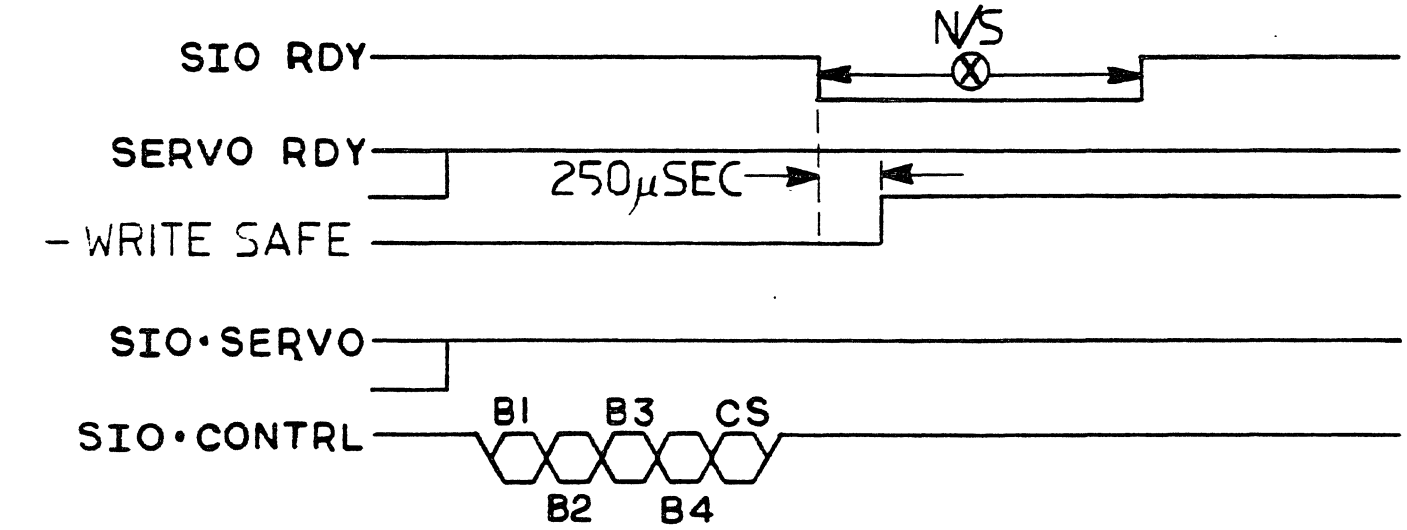


CHART V

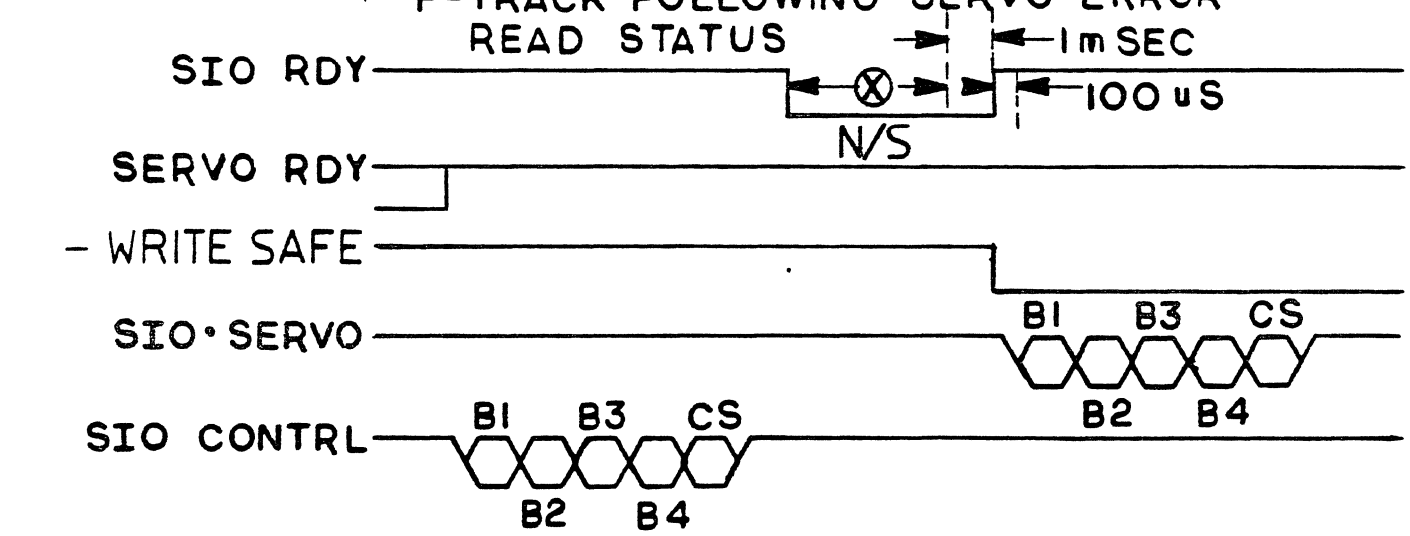
D - READ STATUS COMMAND



E - TRACK FOLLOWING SERVO ERROR - INVALID COMMAND



F - TRACK FOLLOWING SERVO ERROR - READ STATUS



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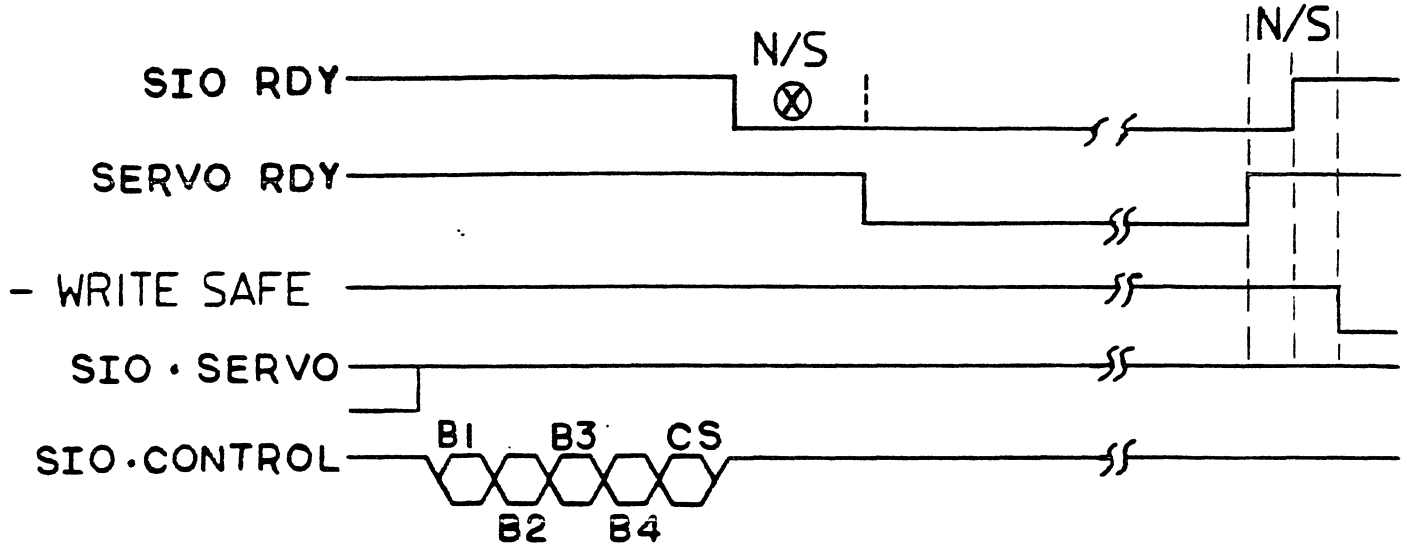
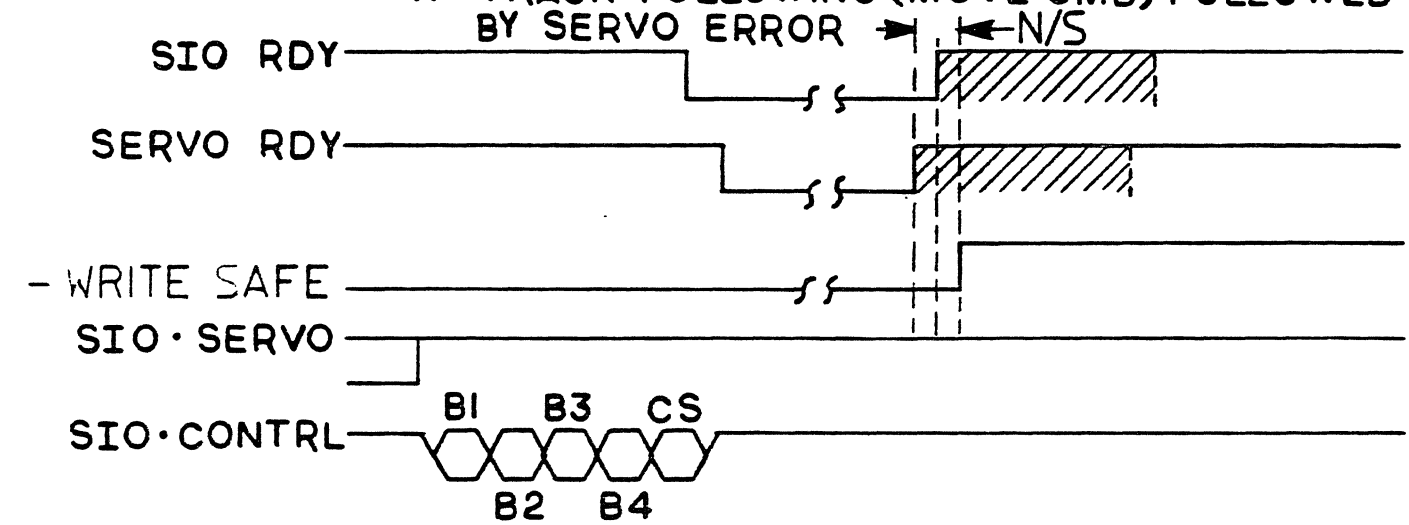
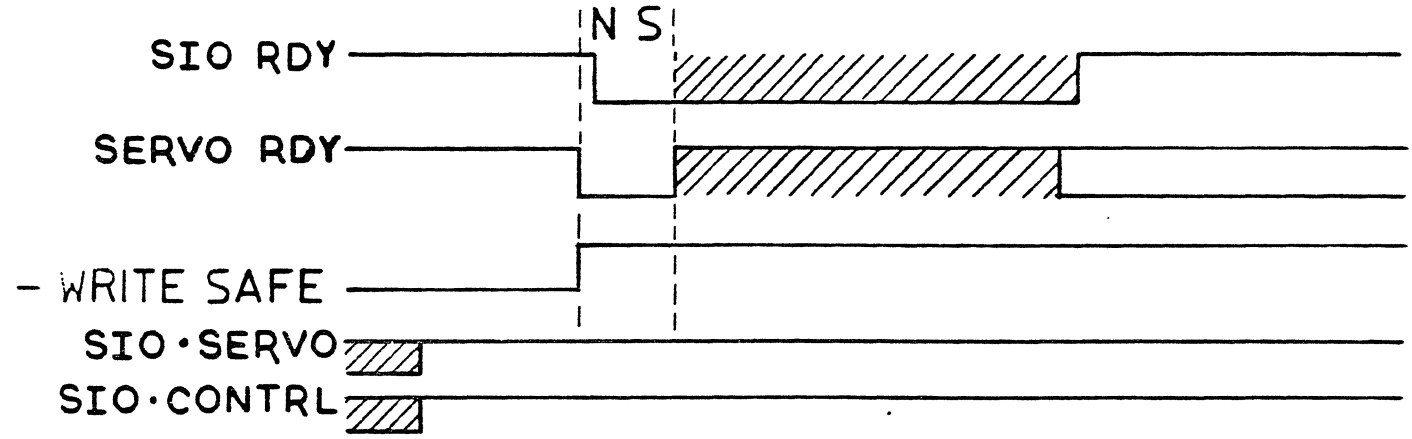
G- TRACK FOLLOWING VALID COMMAND (MOVE)



H- TRACK FOLLOWING (MOVE CMD) FOLLOWED BY SERVO ERROR



I- TRACK FOLLOWING (NO CMD) SERVO ERROR



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A	062-0287-A
SCALE: ____	SHEET 30 OF 30