File No. S360-19 Form A26-1586-1





# Systems Reference Library

# IBM 2312/2313 Disk Storage Original Equipment Manufacturers' Information

This manual provides the definitions and functional descriptions of the interface lines between the IBM 2312/2313 Disk Storage and the Control Unit. In addition, it contains electrical and cabling considerations, and specifications of this interface. It is assumed that the reader of this manual is engineering oriented and understands computer engineering techniques and terminology.















### PREFACE

This document provides information of interest to designers and manufacturers of equipment to be attached to the IBM 2312/2313 Disk Storage. IBM's responsibilities resulting from such an attachment are defined in the Multiple Supplier System Bulletin, Form 120-6648.

Original equipment manufacturers are cautioned that specifications are subject to change by IBM. The data contained in this manual is current as of May 1969. Complete logic diagrams and maintenance manuals, at the latest engineering change level, are included with each machine shipment.

### Reference Publications

The following manual is recommended as a reference:

IBM	System/	360 C	omp	onent	Des	criptic	on	
2314	Direct A	Acces	s Sto	rage	Faci	ility ar	nd	
2844	Auxiliar	y Sto	rage	Cont	rol,	Form	A26-	3599

The manual pertains to the 2314 storage control, but contains a detailed description of programming commands, operating procedures, sense and status indicators, which may aid the non-IBM engineer.

### Second Edition (July 1969)

This edition, A26-1586-1, is a major revision of A26-1586-0, which is now obsolete. An index has been added, metric equivalents and timing specifications have been corrected, and various editorial alterations have been made. Technical changes are indicated by a vertical line to the left of the change.

Significant changes or additions to the specifications contained in this publication are continually being made. Before using this publication in connection with the operation of IBM equipment, check the latest SRL Newsletter for revisions or contact the local IBM Branch Office.

The illustrations in this manual have a code number in the lower corner. This is a publishing control number and is not related to the subject matter.

Copies of this and other IBM publications can be obtained through IBM Branch Offices.

A form for reader's comments is provided at the back of this publication. If the form has been removed, send your comments to the address below.

This manual was prepared by the IBM Systems Development Division, Product Publications, Department G24, San Jose, California 95114.

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### INTRODUCTION

This manual is intended to provide sufficient data to satisfy the special needs of equipment designers who wish to attach the IBM 2312/2313 Disk Storage to their equipment. It provides definitions and functional descriptions of the interface lines for the Disk Storage. It also contains specifications, timings, and cable information.

<u>Note:</u> Where a statement refers to "Disk Storage," it applies to both the 2312 and 2313.

### GENERAL DESCRIPTION

The IBM Disk Storage (Figure 1) is a random access storage device designed as a key component of a data processing system. It uses a removable and interchangeable IBM 2316 Disk Pack, which provides virtually unlimited off-line storage capacity. The Disk Storage is not a separate operational entity, but operates as a slave to a storage control unit (SCU), which in turn serves a central processing unit. This manual describes the standard production 2312 and 2313 units, which do not have metering facilities. Two models of disk storage are available: the 2312 and the 2313. The differences in the two models are:

- The 2312 contains a single disk module.
- The 2313 contains four disk modules.
- The 2312 contains one electronic gate.
- The 2313 contains two electronic gates. Each gate serves two modules.

### Dimensions

The external dimensions and heat dissipation of the disk storage are given in Figure 2.



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Figure 1. IBM 2312/2313 Disk Storage

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Unit	Length	Width	Height	Weight	BTU
2312	32"	28"	60"	500 lbs	2150
2313	32"	56"	60"	1375 lbs	8480
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Figure 2. Physical Dimensions

### Safety

The 2312 and the 2313 Disk Storage units do not have Underwriters Laboratories (UL) approval except when part of a 2314 Direct Access Storage Facility.

The 2312 and 2313 Disk Storage are not standalone units.

### DANGER

The 2312 and 2313 Disk Storage units must be bolted down. Either unit will tip over when the drawers are pulled out unless the units are secured. Until secured, <u>do not</u> pull out the disk storage drawers.

### FUNCTIONAL CHARACTERISTICS

The disk storage consists of two main components: the IBM 2312 (or 2313) Disk Storage and the IBM 2316 Disk Pack.

### DISK STORAGE MODULE

### Access Mechanism

The access mechanism consists of a rack mounted movable carriage which supports 20 read/write heads. These heads are mounted on a common block and are placed in pairs, each pair lying between two disk surfaces of the disk pack. A hydraulic actuator moves the carriage and positions the read/write heads to any of 203 cylinders. When the disk pack is mounted in the disk storage module, information can be written or read from twenty disk surfaces. Once put in motion, the hydraulic actuator moves the recording mechanism horizontally to any one of the cylinder positions. After motion ceases, the drive sends a 'seek complete' signal to the control unit. At this time, the system selects the desired read/ write head by electronic switching. In this manner, all records within a module can be located.

The module utilizes direct accessing between cylinder locations, which allows the access mechanism to proceed from any cylinder position to another without returning to home (reference) position.

The use of a comb-type access on a multi-disk module provides a cylinder of storage area at each of the physical settings of the access mechanism. The cylinder concept (Figure 3) may be visualized as cylinders or drums, one inside the other. Once the proper access location is made, any area in the cylinder is available in one revolution of the disk pack. One revolution requires 25 milliseconds.

### Access Times

Cylinder-to-cylinder (horizontal) access time varies according to the number of cylinders traveled. Access time from one cylinder to the adjacent cylinder is 25 milliseconds. Other access times are given in Figure 4. After the access mechanism has reached a cylinder position, additional time may be required for the disk to rotate to the desired storage area. At 2,400 revolutions per minute, one complete revolution takes 25 milliseconds, where the average rotational time is 12.5 milliseconds (onehalf revolution).



Figure 3. Cylinder Concept

Access Time*	Milliseconds
Maximum	130
Average Random	60
Minimum (Cylinder-to-Cylinder)	25
*These access times include settling-down time, but do delay. Average rotationa milliseconds.	a provision for o not include rotational l delay is 12.5

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The following curve is a plot of the cylinders traveled against time for the access mechanism and can be used as an aid in programming for the most efficient use of the disk storage.



In addition, an Access Timing Chart in Appendix C (Figure 26) illustrates a typical access operation.

### Operational and Timing Specifications

A summary of the specifications for operation and timing of the disk storage is given in Figure 5.

## Disk Storage Addressing

Each disk pack has 20 usable surfaces with 203 tracks on each surface. The vertical alignment of tracks can be thought of as a cylinder of tracks (Figure 3). In order to provide maximum accessibility of a storage area, the tracks are numbered vertically within the cylinder. Therefore, a track-to-track operation only requires microseconds of switching time rather than milliseconds of access time. To place the recording mechanism at a specific cylinder of tracks, a seek command must be given to the module. The command must provide the identification of the module and the cylinder to which the access mechanism should move. In addition, in order to select individual tracks within the cylinder, the command must designate the recording head.

### DISK PACK

The IBM 2316 Disk Pack, as shown in Figure 6, is composed of eleven disks, 14 inches in diameter and spaced 0.35 inches apart on a vertical shaft. Circular protective plates are mounted above the top disk and under the bottom disk to protect the assembly. The upper surface of the top disk and the lower surface of the bottom disk are not available for data storage because of the protective plates. The entire assembly of disks, vertical shaft and protective plates rotates at a speed of 2,400 revolutions per minute, 25 ms per revolution.

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ltem	Nominal	Maximum	Minimum
Disk Rotational Speed	2400 rpm	2448 rpm	2352 rpm
*Oscillator Frequency	5.00 MHz	5.0025 MHz	4.9975 MHz
*Write Clock Pulse Period	400.0 nanoseconds	400.2 nanose conds	399.8 nanoseconds
*Write Clock Pulse Rate	5.00 Megabits	5.0025 Megabits	4.9975 Megabits
*Write Data Bit Rate	2.50 Megabits	2.50125 Megabits	2.49875 Megabits
*Write Data Bit Width	70 nanoseconds	80 nanoseconds	60 nanoseconds
Read Data Bit Rate	2.50 Megabits	2.6025 Megabits	2.3975 Megabits
Read Data Bit Width	80 nanoseconds	100 nanoseconds	60 nanose conds
Read Back Data Rate	312 k Bytes	328 k Bytes	296 k Bytes

Figure 5. Operational and Timing Specifications



Figure 6. 2316 Disk Pack

A two-piece plastic cover for the entire pack assembly, is designed to protect disks against damage. A built in handle on the top cover makes carrying easy. A self-locking device in the handle permits removal of the top cover only when the pack is mounted on the disk storage.

## Disk Pack Capacity

The maximum capacity of the 2316 Disk Pack is 29,176,000 eight-bit bytes. In packed decimal mode the maximum capacity is 58,352,000 digits (numeric only). See Figure 5 for the read/write electronic

specifications. Using the worst case figures (2.49875 MHz write data bit rate and 2,448 rpm) indicates a total track capacity of 7,652 eight-bit bytes. However, the data should be checked for recording accuracy by the control unit, and this checking requires time. The IBM control units require data gaps following each record field, which reduces the track capacity. The track capacity of the 2316 Disk Pack, when used in a disk storage system attached to the 2314 Storage Control is 7,294 eight-bit bytes if one data record is written per track. The total capacity is reduced as the number of records per track increases

Note: IBM guarantees that the 2316 has 4000 error-free tracks. Therefore, the total capacity quoted is based on 4,000 tracks. Up to 60 alternate tracks are provided. The IBM control units have the facility to assign alternate tracks to replace defective tracks.

Data is transferred between the control unit and the disk storage module serially, one bit at a time.

DATA RECORDS AND FORMAT

The organization of data and the capacity of the disk storage module are dependent on the format used to store information. The read/write format should be designed to satisfy the needs of the attaching system.

Component tolerances and specific requirements of data flow electronics in the disk storage, which may affect the design of the control unit, are as follows:

- Disk Speed: 2,400 rpm  $\pm 2\%$ .
- Write oscillator frequency: 5.0 MHz ±0.05%.
- Radial dimension of magnetic tracks: Track 202 4.64 inches (approximately) Track 000 6.506 inches (approximately).
- Read back data bit cell time: Nominal 400 nanoseconds Maximum 416.4 nanoseconds Minimum 383.6 nanoseconds.
- Minimum time from head deselect to head advance: 11.2 microseconds.
- Minimum time from head advance to head select: 1.6 microseconds.

- Relative position of one index pulse to all other index pulses: ±18 microseconds.
- Relative position of all read/write heads to a given pulse: Position tolerance ±0.0125 inches.
- Read gate: This must occur a minimum of 60 microseconds after head select or the fall of 'write gate'.
- Unavailable disk area: A section of each disk surface is not available for data storage. The centerline of this section is located under the head at the leading edge of the index pulse. This area is contained within ±0.088 inches of the centerline. Refer to Figure 5 for additional information.

## Data Checking

The engineer designing a control unit for the disk storage should provide some means of data checking.

## DATA TRANSFER ELECTRONICS

The data transfer electronics include circuits for head selection, writing, and reading. Safety circuits are also included to provide protection for recorded data.

A full complement of data transfer electronic circuits is installed in each drive. This includes the head selection circuitry, the write data line receiver, the write trigger, the write driver, the erase driver, safety circuits, read preamplifier and the main read amplifier.

When data transfer to or from a particular disk surface is desired, the appropriate head address and module lines are conditioned by the control unit.

Write gate and erase gate signals must be provided by the control unit for writing data on the disk storage pack. The write data to the disk storage module must be in serial pulse form and driven by a special line driver. (See "Signal Specifications" section of this manual.)

During read operations, the recorded signals from the disk surface are sensed by the read/write head and directed to the input of the read amplifier. The read amplifier produces raw data at its output in the form of one discrete pulse for each transition on the recording disk. The output stage of the read amplifier is a coaxial line driver which provides 80 nanosecond wide pulses through an impedance of 95 ohms. Usually only a particular portion of the signal at the read amplifier output is usable. The control unit must provide a read gate signal to gate the read amplifier output. When the read gate signal is present, the read amplifier output is allowed to be sent to the control unit. At the recording frequency of 5.0 megahertz it is absolutely necessary to minimize the time shift of recording and read-back bits along the data flow path. To achieve this, it is best to think of the whole data path as an integral unit. The data flow path consists of a read and write clock, located in the control unit, and recording and detection circuitry which is located in the disk storage module.

## Write Circuitry

The write circuitry contains the necessary components for changing the write data pulses from the control unit into a current drive for the write coil of the magnetic head. Current in the write coil of the magnetic head produces a flux which magnetizes the oxide material on the disk.

The input write data to the disk module is under control of the control unit. The write data signal must be driven by a special coaxial line driver. The line receiver terminates the coaxial write data line in addition to supplying an output to the write trigger. The write trigger converts the discrete pulse data into binary levels, with each pulse defining a change of state. The control unit conditions the write gate and erase gate lines to signal the write circuitry for a write operation. When the write gate is on, the write driver follows the output of the write trigger. The write driver provides the current drive through the address matrix to the write coil. The write driver has two outputs, one for each write element in the write coil. Current passes through only one element at a time depending on which of the two outputs from the write driver is active. Following recording the erase driver provides current for a tunnel erase to constrain the width of the recorded track.

The frequency of the write data signal is 5.0 megabits per second. Thus a minimum of 200 nano-seconds occurs between the leading edges of any two successive bits. The duty cycle of writing with a particular write driver shall not exceed 50% -- averaged over 1 second. This limitation provides adequate protection for the write driver as well as the magnetic heads.

## Read Circuitry

The read circuitry includes the necessary components for converting signals sensed by the read heads into discrete pulses that can be interpreted as being data or clock bits. The output stage of the read amplifier is a coaxial line driver which provides pulses, 80 nanoseconds wide, for the control unit read clock.

The same diode and transistor head select matrix employed in the write head selection is used when read information is desired. One of 20 heads is electronically selected, and the output sensed by the head is fed into the read amplifier. The read amplifier is used to increase the amplitude of the head signals originating from the selected read head.

The head signal is amplified and differentiated by the read amplifier and the resulting pulses are fed through a shaper and line driver, which provides a standard level pulse. The nominal pulse width of the read amplifier output is 80 nanoseconds. One bit, 80 nanoseconds wide, is put on the data line for each change of magnetic state sensed by the read head from the disk surface.

The nominal output frequency of the read data is that frequency at which the data was written. The instantaneous output data frequency is dependent upon: the relative clocking oscillation frequency and relative disk rotational speed during writing and reading; the bit pattern written; and the bit shift caused by the head, disk, and electronic circuitry.

### SAFETY CIRCUITRY

Write safety circuits are provided to protect recorded information in the disk module. The outputs of all safety circuits are joined together and form a single unsafe line that is available to the control unit.

The following conditions in a disk module cause an unsafe signal to be sent to the control unit:

- 1. Multiple head select.
- 2. DC write current and not write gate.
- 3. Erase current and not erase gate.

- 4. Write gate and not erase current.
- 5. Write gate and no ac write current.
- 6. Read gate or not seek ready and either write gate or erase gate.
- 7. Overvoltage or undervoltage on +6, +3, -3, and -36 Vdc.
- 8. Loss of line voltage.

For any of the above unsafe conditions, the disk module deselects the heads, turns off selected write and erase gates, and holds them off until the unsafe condition is corrected.

The following conditions should be checked by the control unit and an unsafe status generated if:

- 1. More than one module selected line is up.
- 2. Write gate is up but no selected write current is sensed.

### SELECTION CIRCUITRY

It is necessary to select out of 20 heads for transferring data into and from the disk pack. This is done by setting a head number into the head address register which has 20 outputs. Each output of this register is connected to the center-tap lead of each read/write head. The head is selected when 'head select' comes up. Selecting a head brings the voltage level at its center tap from -36 Vdc to +3.0 Vdc. Once a head is selected, conditioning the write and erase gates causes the write and erase drivers to supply current to the selected head.

After selecting a head in a read operation, a selected read gate is used to gate the output of the read amplifier, thus allowing raw read data to be detected by the control unit read clock.

## SIGNAL INTERFACE

## INPUT COMMUNICATION LINES

The input communication interface is composed of an eight line time-shared bus (address bus), four tag lines that select the information from the bus, a module select line, and a write data line.

Only one of the four tag lines is up at a time to describe the information on the bus. (See Figure 7.)

Control Tag: This line conditions the drive for a control cycle. Simultaneously activating one of the signals on the bus determines which operation is performed (such as write, read, seek, etc.).

<u>Set Cylinder Tag</u>: This line is used for carriage operations so that the signals on the bus function to

identify the cylinder to be addressed. The 'set cylinder' pulse must be completely contained within the time that the cylinder address is on the eight-line bus.

Set Head Tag: This line and one of the bus signals perform a head select function. In addition, two other operations can be designated: select lock reset and turning on the 'forward' latch. A reset is given to the head register before a head selection.

<u>Note:</u> The pulse width of the tag lines is 1.5 microseconds minimum. The bus line information must be present for the full duration of the tag line pulse.

<u>Set Difference Tag</u>: This line, when it is on, identifies the signals on the bus as the calculated difference between the present cylinder position and the newly addressed cylinder.

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		<u> </u>							
						F	unction During		
		B	us Line	Conversion In Storage Module	Control Cycle	Set Cylinder	Set Head	Set Difference	Set Half Counter
		Fil " " "	e Bus 0 "1 "2 "3 "4 "5 "6 "7	A128 A64 A32 A16 A8 A4 A2 A1	Write Gate Read Gate Seek Start Reset Head Reg Erase Gate Select Head Return to 000 Head Advance	Cyl 128 Cyl 64 Cyl 32 Cyl 16 Cyl 8 Cyl 4 Cyl 2 Cyl 1	Forward Latch Select Lock Reset Hd Add 16 Hd Add 8 Hd Add 4 Hd Add 2 Hd Add 1	Not 128 Not 64 Not 32 Not 16 Not 8 Not 4 Not 2 Not 1	64 32 16 8 4 2 1 Not Used
Storage Control Unit		/	Control		0	<b>A</b>			
	ĮĮ	ag ines	Set Cylinde	er	1				
		(	Set Head	nce	3				

Module Select - One for each module

Read/Write Data - Coaxial Cable

Figure 7. Input Signal Lines

<u>Module Select:</u> This signal is a line, in the multiplex cable, used to gate signal lines to the proper disk storage modules. This signal is gated to the proper module through the use of the module identification plug inserted in the operator panel. (See Figure 16.)

Write Data: This signal is a simplex line, one per module.

## OUTPUT COMMUNICATION LINES

The disk storage supplies 19 lines that can be used by the control unit to determine the status of the disk module. The following lines are available to the control unit.

### Cylinder Address Register

Eight output lines from the cylinder address register (CAR) may be used to indicate the present disk module cylinder address. These lines are active when the module is selected and changed to a new address at 'set cylinder' time. The line names are:

CAR 1 CAR 2 CAR 4 CAR 8 CAR 16 CAR 32 CAR 64 CAR 128

### Gated Attention

This line indicates that a seek has been completed or that 600 milliseconds has passed since the seek command was given without a detent-in being detected. It is reset by the read gate. 'Gated attention' is a line in the multiplex cable from the control unit, controlled by the module identification plug inserted in the operator panel. This line is not module selected.

### Selected Module

This line indicates that a module has been selected. It is used in the 2314 Storage Control for the multimodule select safety logic. It is a simplex line and is module selected.

### Selected File Busy

This line, when it is up, indicates that the access mechanism is in the seeking process. When the line is down, it indicates that the disk storage is ready to perform. This line is module selected.

### Selected Index

This is an index pulse generated by the disk module once per disk revolution. This line is module selected.

### Write Current Sense

This line indicates that the selected module is writing on the disk pack.

### Unsafe

This line indicates that the disk module is unsafe and will not perform any operation. This line is module selected.

### Seek Incomplete

This line indicates that the seek complete operation did not occur within 600 milliseconds after a seek command was given. This line is module selected.

### End of Cylinder

The 'end of cylinder' signal occurs if, during a cylinder operation, the head select register in the disk drive goes from 19 to 20. This line is module selected.

### Read Data

The 'read data' line is driven with a special line driver through a coaxial line. It is active during all read operations and is module selected.

#### Heads Extended

This line indicates that the heads are extended. It is used in the control unit for sequencing power-off logic. In a control unit power down sequence, the dc voltages to the disk storage modules cannot be removed until the last heads extended switch has opened, indicating that the heads are unloaded.

### Selected On Line

This line indicates that the heads are extended and ready to read or write. This line is module selected.

### Sequence Pick

The signal on this line starts each module drive motor in sequence when the control unit is powered up. 'Sequence pick' remains energized as long as power is on. The 'controlled ground' line is opened to power down the disk storage drive motors when the control unit power is turned off.

## Pack Change

This line indicates that a pack change has occurred.

### SIGNAL CONNECTOR AND CABLE

The signal connector for connection at the disk storage is shown in Figure 9. The pin connections and signal names are listed in Figure 10. Figure 8 lists the logic voltage levels.

## Cable Lengths

The disk storage is designed to operate with a max- - imum cable length of 16 feet.

## POWER INTERFACE

### AC Power Requirements

Three phase ac power is connected to each disk storage. However, an individual module draws power from only one phase. Therefore, in multiphase systems, phases should be rotated for disk storage units in sequence. The ac voltage requirements for the disk storage are listed in Figure 11. Machines wired for 50 hertz can be operated in delta or wye systems.

The disk storage takes 3.2 amperes steady and 25 amperes starting load, for each module. The power requirement for the 2312 is 0.63 kilowatt. The 2313 requires 2.37 kilowatts.

Up Level	Maximum	Minimum
+L	+ 6.28	+ 2.0
+V	+38.9	+28.4
+W	+38.9	+28.4
+Q	+ 3.5	+ 0.65
Down Level	Maximum	Minimum
-L	+ 0.3	0.0
-V	+ 0.4	0.0
-W	+ 1.3	0.0
-Q	- 0.5	-3.5

Figure 8. Logic Voltage Levels

## AC Power Distribution

The ac power connections are made directly to TS1 (terminal strip) in the disk storage. Figure 12 illustrates the wiring for 50 and 60 hertz systems. Refer to Figure 25 (Appendix B) for the location of TS1.

### DC Power Requirements

The control unit must supply all dc voltages for the disk storage units. The dc power requirements for each module are as follows:

- +3.0 Vdc at 0.90 amperes.
- -3.0 Vdc at 0.60 amperes.
- +6.0 Vdc at 1.10 amperes.
- +36.0 Vdc at 1.45 amperes.
- -36.0 Vdc at 0.39 amperes.

The currents specified are at nominal voltage and duty cycle. Voltage tolerances, except for +36V, are  $\pm 4\%$ , measured at the voltage bus on the SLT gates. The tolerance of the +36V is  $\pm 8\%$ . The voltage tolerances include any variable combinations of steady state or short duration transients.

## DC Connector and Cable

The dc power connector along with the pin assignments and signal lines is illustrated in Figure 13. In addition, Figure 27 in Appendix D shows the dc connector assembly and the mating plug in the disk module and lists the IBM part numbers for all parts of the connectors. Equivalent part numbers are also listed. Pins 3 and 4 are ground returns for +3, +6 and +12 volt power supplies. Pins 10 and 11 are grounds for +36V.

Note: Maximum cable length is 16 feet.

## POWER SEQUENCING

Power sequencing of the disk storage is the joint responsibility of the disk storage and the control unit. Each module provides the logic and interlocks for its operation and supplies the control unit with a 'heads extended' line (i.e., an access on-line signal). One set of contacts of relay K4 are provided for the purpose of multi-module turn-on power sequencing. Relay K4 energizes when the disk has reached 70% of the rated rpm.



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*AMP Incorporated,	
Harrisburg, Pennsylvani	a 17105

Figure 9. Signal Connector

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Figs WF011         -signed Lord         Signed Print         File File Regist         File File Print         File File Regist         File File File Regist         File File File File Regist         File File File File File File Regist         File File File File File File File File	Control Unit to Disk Storage						
Line Trite         Legic         PDs         Twinted Wire         Legic         PDs         File Line Title           File Bu 0         O         Sig = A         Sig = A         Sig = A         PD (10)         2.5 V 1: SV File Bu 0           File Bu 2         O         Sig = A         Sig = A         PD (10)         2.5 V 1: SV File Bu 3           File Bu 3         O         Sig = A         Sig = A         PD (10)         2.5 V 1: SV File Bu 3           File Bu 3         O         Sig = A         Sig = A         File Bu 3         Sig = A         File Bu 3           File Bu 6         O         Sig = A         Sig = A         File DU 2         Sig = A         File DU 2         Sig = A           File Bu 6         O         Sig = A         File DU 2         FOID         File DU 2         Sig = A           Sig File Bu 7         Sig = A         File DU 2         FOID         FILE DU 7         Sig = A           Sig File Bu 7         Sig = A         FU/FU/2         FOID         FILE DU 7         Sig = A           Sig File Bu 7         Sig = A         FU/FU/2         FOID         FILE DU 7         Sig = A           Sig File Bu 7         Sig = A         FU/FU/2         FOID         FILE DU 7         Sig =	From WE011	*Signal	Sig Ca	onnector	File	File	
International Program         Program </td <td>Line Title</td> <td>Level</td> <td>Pin</td> <td>Twisted Wire</td> <td>Logic</td> <td>FD's</td> <td>File Line Title</td>	Line Title	Level	Pin	Twisted Wire	Logic	FD's	File Line Title
Life Boy 2       O       Sig = C       Sig = C       Sig = F       P(P/D020)       PD101       2.37 + 1.37 PH Is Boy 2         File Box 3       O       Sig = H       Sig = P       F(P/D020)       FD101       2.37 + 1.37 PH Is Boy 2         File Box 3       O       Sig = H       Sig = P       F(P/D020)       FD101       2.37 + 1.37 PH Is Boy 3         File Box 3       O       Sig = P       Sig = A       F(P/D020)       FD101       2.37 + 1.37 PH Is Boy 3         File Box 6       O       Sig = P       Sig = A       F(P/D020)       FD101       2.37 + 1.37 PH Is Boy 3         Sig Difference       O       Sig = A       F(P/D020)       FD101       2.37 + 1.37 PH Is Boy 3         Sig Difference       O       Sig = A       F(P/D021)       FD101       2.37 + 1.37 PH Is Boy 3         Sig Difference       O       Sig = A       F(P/D021)       FD101       2.37 + 1.37 PH Is Boy 3         Sig Difference       O       Sig = A       F(P/D021)       FD101       2.37 + 1.37 PH Is Boy 3         Sig Difference       O       Sig = A       F(P/D021)       FD101       2.37 + 1.37 PH Is Boy 3         Sig Difference       O       Sig = A       F(P/D021)       FD101       2.37 + 1.37 PH Is Boy 3       Si	File Bur O	0	St. A			50101	
File Bur 2       Q       Sin = F       F(270200 - F010)       2.2 VF 1.5 VF lie Bur 2         File Bur 3       Q       Sin = H       Sin = T       F(270200 - F010)       2.2 VF 1.5 VF lie Bur 3         File Bur 4       Q       Sin = H       Sin = T       F(27020 - F010)       2.2 VF 1.5 VF lie Bur 3         File Bur 5       Q       Sin = H       Sin = T       F(27020 - F010)       2.2 VF 1.5 VF lie Bur 4         File Bur 5       Q       Sin = T       F(27020 - F010)       2.2 VF 1.5 VF lie Bur 4       Sin = T         File Bur 6       Q       Sin = V       Sin = T       F(27020 - F010)       2.2 VF 1.5 VF lie Bur 6         Set Hierd       Q       Sin = A       Sin = T       F(27020 - F010)       2.2 VF 1.5 VF lie Bur 6         Set Hierd       Q       Sin = A       Sin = A       Sin = A       F(27020 - F010)       2.2 VF 1.5 VF lie Bur 6         Set Hierd       Q       Sin = A       Sin = A       F(27020 - F010)       2.2 VF 1.5 VF lie Bur 6       Sin A         Set Hierd       Q       Sin = A       Sin = A       F(27010)       F(2101 - Sin + J)       Sin A       Sin A         Set Hierd       Q       Sin = A	File Bus 1	<u> </u>	Sig - A	Sig = D	FL/FU020	FD101	-2.5V +1.5V File Bus U
File Bu. 3       O       Sig = H       Sig = J       FL/FU202       FD101       -2. SV +1. SV File Bu. 3         File Bu. 4       O       Sig = A       FL/FU202       FD101       -2. SV +1. SV File Bu. 4         File Bu. 7       O       Sig = A       FL/FU202       FD101       -2. SV +1. SV File Bu. 4         File Bu. 7       O       Sig = A       Sig = A       FL/FU202       FD101       -2. SV +1. SV File Bu. 7         Set Difference       O       Sig = A       Sig = A       FL/FU202       FD101       -2. SV +1. SV File Bu. 7         Set Difference       O       Sig = A       Sig = A       FL/FU202       FD101       -2. SV +1. SV File Bu. 7         Set Difference       O       Sig = A       Sig = A       PU/FU21       FD101       -2. SV +1. SV End Difference         Control       O       Sig = A       Sig = A       PU/FU21       FD101       -2. SV +1. SV End Difference         Control       O       Sig = A       Sig = A       PU/FU21       FD101       -2. SV +1. SV End Difference         Set Difference       O       Sig = A       Sig = A       PU0102       -2. SV +1. SV End Difference         Set Difference       O       Sig = A       Sig = A       Sig = A       PU0102	File Bus 2	Q	Sig - E	Sig - F	FL/FU020	FD101	-2.5V +1.5V File Bus 2
File Bas 4         O         Sin - K         FL/FU220         FDI01         -2.52 / v1.327 File Bas 4           File Bas 5         O         Sin - K         FL/FU237         FOI01         -2.52 / v1.327 File Bas 5           File Bas 7         O         Sin - K         Sin - K         FL/FU237         FOI01         -2.52 / v1.327 File Bas 5           File Bas 7         O         Sin - U         Sin - V         FL/FU237         FOI01         -2.52 / v1.327 Eis Bas 7           Set Difference         O         Sin - V         Sin - K         FL/FU237         FDI01         -2.52 / v1.37 Eis Bas 7           Set Difference         O         Sin - V         Sin - K         FL/FU237         FDI01         -2.52 / v1.37 Eis Bas 7           Set Difference         O         Sin - K         Sin - B         FL/FU231         FDI01         -2.52 / v1.37 Mod 5 Siete1           Mod 1 Select         O         Sin - K         Sin - B         V1200         -2.52 / v1.37 Mod 5 Siete1           Mod 4 Select         O         Sin - B         Sin - B         V1200         -2.52 / v1.37 Mod 5 Siete1           Mod 4 Select         O         Sin - B         Sin - B         V1200         -2.52 / v1.37 Mod 5 Siete1           Mod 4 Select         O         Sin -	File Bus 3	Q	Sig - H	Sig - J	FL/FU020	FD101	-2.5V +1.5V File Bus 3
File Bus 3       Q       Sig - M       Sig - N       FL/Fu21       FD101       -2.57 V it -SY File Bus 3         Set Difference       Q       Sig - M       Sig - V       FU/Fu21       FD101       -2.57 V it -SY Set Difference         Set Explined       Q       Sig - W       Sig - K       FU/Fu21       FD101       -2.57 V it -SY Set Id + Difference         Set Explined       Q       Sig - K       Sig - G       Sig - G       FU/Fu21       FD101       -2.57 V it -SY Bid V is Set Id + Difference         Mod 1 Saleet       Q       Sig - K       Sig - G       Sig - G       VE/Fu21       FD101       -2.57 V it -SY Med Saleet         Mod 2 Saleet       Q       Sig - F       Sig - G       <	File Bus 4	Q	Sig – K	Sig - L	FL/FU020	FD101	-2.5V +1.5V File Bus 4
File Bu 0       G       Sin = R       FL/FU021       FD101      2.5V + 1.3V File Bu 6         Sin Difference       G       Sin = V       FL/FU021       FD101      2.5V + 1.3V File Bu 6         Sin Cyfinder       G       Sin = V       FL/FU021       FD101      2.5V + 1.3V En Bur 6         Sin Cyfinder       G       Sin = V       Sin = Z       FL/Fu021       FD101      2.5V + 1.3V En Bur 6         Sin Cyfinder       G       Sin = V       Sin = Z       FL/Fu021       FD101      2.5V + 1.3V End Sined         Gantol       G       Sin = -1       Sin = 0       FD101      2.5V + 1.3V End Sined      2.5V + 1.3V End Sined         Mod 2 Sined       G       Sin = -1       Sin = -1       FD201      2.5V + 1.3V Mod 2 Sined         Mod 3 Sined       G       Sin = -1       FD201      2.5V + 1.3V Mod 2 Sined      2.5V + 1.3V Mod 2 Sined         Mod 3 Sined       G       Sin = -1       FD201      2.5V + 1.3V Mod 2 Sined      2.5V + 1.3V Mod 2 Sined         Mod 3 Sined       G       Sin = -1       FD201      2.5V + 1.3V Mod 2 Sined      2.5V + 1.3V Mod 2 Sined         Mod 3 Sined       G       Sin = -       Y8001      2.5V + 1.3V Mod 2 Sined      2.5V + 1.3V Mod 2 Sined	File Bus 5	Q	Sig – M	Sig – N	FL/FU021	FD1CI	-2.5V +1.5V File Bus 5
Intervane         O         Sign - V         Sign - V         C/U02         PDI01        2.97.1 sy Trie Start.           Set Hold         O         Sign - V         Sign -	File Bus 6	Q	Sig - P	Sig - R	FL/FU021	FD101	-2.5V +1.5V File Bus 6
Set Vintering         O         Sig = V         Sig = V         Sig = V         Vintering         P(V102)         P(D10)         -2.5 V + 3 V = 3	File Bus /	2	Sig - S	<u>Sig - T</u>	FL/FU021	FD101	-2.5V +1.5V File Bus /
Can Head         Q         Sig - Y         Cig - 2         FU/FU21         FD101         -2.5 V+1.5V Set H4 Placetion           Mod O State1         Q         Sig - c         Sig - b         FU/FU21         FD101         -2.5 V+1.5V Set H4 Placetion           Mod O State1         Q         Sig - c         Sig - b         FU/FU21         FD101         -2.5 V+1.5V Centrol           Mod O State1         Q         Sig - c         Sig - a         Y8001         -2.5 V+1.5V Med State2           Mod State1         Q         Sig - a         Y8001         -2.5 V+1.5V Med State2         Med State2           Mod State1         Q         Sig - a         Y8001         -2.5 V+1.5V Med State2         Med State2           Mod State1         Q         Sig - a         Y8001         -2.5 V+1.5V Med State2         Med State2           State F         Q         Sig - a         Y8001         -2.5 V+1.5V Med State2         Med State2           State F         Q         Sig - a         Y8001         -2.5 V+1.5V Med State2         Med State2           State F         Q         Sig - a         Y8001         -2.5 V+1.5V Med State2         Med State2           State F         Q         Sig - a         Y8001         -2.5 V+1.5V Med State2         Med	Set Cylinder	0	<u>Sig - U</u>		FU/FL021	FD101	-2.5V +1.5V Set Cylinder
$ \begin{array}{c} Control & Q & Sig = 0 & Sig = 0 & FU/F(D2) & FD(D) & -2, SV + 1, SV Control & Model Select & Model Select & Q & Sig = c & Sig = d & Y8001 & -2, SV + 1, SV Model Select & Model Select & Q & Sig = r & Sig = a & Y8001 & -2, SV + 1, SV Model Select & Model Select & Q & Sig = r & Sig = a & Y8001 & -2, SV + 1, SV Model Select & Model Select & Q & Sig = r & Sig = a & Y8001 & -2, SV + 1, SV Model Select & Model Select & Q & Sig = r & Sig = a & Y8001 & -2, SV + 1, SV Model Select & Model Select & Q & Sig = r & Sig = a & Y8001 & -2, SV + 1, SV Model Select & Model Select & Q & Sig = r & Sig = a & Y8001 & -2, SV + 1, SV Model Select & Model Select & Model Select & Q & Sig = r & Sig = a & Y8001 & -2, SV + 1, SV Model Select & Model Select & Q & Sig = r & Sig = a & Y8001 & -2, SV + 1, SV Model Select & Model Select & Q & Sig = r & Sig = a & Y8001 & -2, SV + 1, SV Model Select & Controlled God from FCU & Q & Sig = r & Y8001 & -2, SV + 1, SV Model Select & Controlled God from FCU & Q & Sig = r & Y8001 & -2, SV + 1, SV Model Select & Controlled God from FCU & Q & Sig = r & Y8001 & -2, SV + 1, SV Model Select & Controlled God from FCU & Q & Sig = r & Y8001 & -2, SV + 1, SV Model Select & Controlled God from FCU & Q & Sig = r & Y8001 & -2, SV + 1, SV Model Select & Controlled God from FCU & Q & Y800 & -3, SV + 0, S$	Set Head	0	Sig = V	Sig = 7	FU/FL021	FD101	-2.5V +1.5V Set Hd + Direction
Mod 0 Select         Q         Sig - c         Sig - a         Yeo0         -2.5 V + 1.5V Med 0 Select           Mod 1 Select         Q         Sig - h         Sig - a         Yeo0         -2.5 V + 1.5V Med 2 Select           Mod 2 Select         Q         Sig - h         Sig - a         Yeo0         -2.5 V + 1.5V Med 2 Select           Mod 2 Select         Q         Sig - h         Sig - a         Yeo0         -2.5 V + 1.5V Med 2 Select           Mod 3 Select         Q         Sig - h         Sig - a         Yeo0         -2.5 V + 1.5V Med 2 Select           Mod 4 Select         Q         Sig - t         Sig - a         Yeo0         -2.5 V + 1.5V Med 5 Select           Mod 5 Select         Q         Sig - t         Sig - a         Yeo0         -2.5 V + 1.5V Med 5 Select           Commole Select         Q         Sig - t         Sig - a         Yeo0         -2.5 V + 1.5V Med 5 Select           Commole Select         Q         Sig - a         Yeo0         -2.5 V + 1.5V Med 5 Select           Commole Select         Q         Sig - a         Yeo0         -2.5 V + 1.5V Med 5 Select           Commole Select         Sig - a         -         Yeo0         -2.5 V + 1.5V Med 5 Select           Commole Select         Sig - a         -	Control	Q	Sig - a	Sig - b	FU/FL021	FD101	-2.5V +1.5V Control
Med 1 Salect         Q         Sig - f         Sig - f <thsig -="" f<="" th=""> <thsig -="" f<="" th=""> <ths< td=""><td>Mod 0 Select</td><td>Q</td><td>Sig - c</td><td>Sia - d</td><td>YB001</td><td></td><td>-2.5V +1.5V Mod 0 Select</td></ths<></thsig></thsig>	Mod 0 Select	Q	Sig - c	Sia - d	YB001		-2.5V +1.5V Mod 0 Select
Mod 2 Select         Q         Sig - h         Sig - h         Ye001         -2.5V + 1.5V Mod 2 Select           Mod 3 Select         Q         Sig - h         Sig - h         Ye001         -2.5V + 1.5V Mod 2 Select           Mod 3 Select         Q         Sig - h         Sig - h         Ye001         -2.5V + 1.5V Mod 2 Select           Mod 5 Select         Q         Sig - h         Sig - h         Ye001         -2.5V + 1.5V Mod 5 Select           Mod 5 Select         Q         Sig - h         Sig - h         Ye001         -2.5V + 1.5V Mod 5 Select           Mod 5 Select         Q         Sig - h         Sig - h         Ye001         -2.5V + 1.5V Mod 5 Select           Controlled God from FCU         Sig - K          Ye001         -2.5V + 1.5V Mod 5 Select           Controlled God from FCU         Sig - K          Ye001         -5.5V + 1.5V Mod 5 Select           Controlled God from FCU         Sig - A         -         Ye001         -5.5V + 1.5V Mod 5 Select           Controlled God from FCU         Sig - A         -         Ye001         -5.5V + 1.5V Mod 5 Select           Controlled Form FCU         Sig - A         -         Ye001         -5.5V + 1.5V Mod 5 Select           Sig - A         Ye001         -         -<	Mod 1 Select	Q	Sig – f	Sig – g	YB001		-2.5V +1 5V Mod 1 Select
Med S Select         Q         Sig - n         Sig - n         Yead         Select         Q. Sig - n         Yead           Med S Select         Q         Sig - n         Sig - n         Yead	Mod 2 Select	Q	Sig – h	Sig – i	YB001		-2.5V +1.5V Mod 2 Select
Mode A select         Q         Sig - n         Yeb (0)         -2.3V 1.3V Mode A select           Mode J Select         Q         Sig - n         Yeb (0)         -2.3V 1.3V Mode A select           Mode J Select         Q         Sig - n         Yeb (0)         -2.3V 1.3V Mode A select           Mode J Select         Q         Sig - n         Yeb (0)         -2.3V 1.3V Mode A select           Controlled God fram FCU         Sig - n         Yeb (0)         -2.3V 1.3V Mode A select           Controlled God fram FCU         Sig - N         Yeb (0)         -2.3V 1.7V J.Spror Mode Select           Catrolled God fram FCU         Sig - N         Yeb (0)         -3V 64.           Save File Terminetor         Int - AL         -         Yeb (0)         Yeb (3)           Catrolled God fram FCU         Sig - 4.5V         -         Yeb (0)         -756 V.           Catrolled Sol fram FCU         Sig - 4.5V         -         Yeb (0)         -756 V.           Catrolled Sol fram FCU         Sig - 4.5V         -         -         Yeb (0)         -756 V.           Catrolled Sol fram FCU         Sig - 4.5V         -         -         Yeb (0)         -756 V.           Catrolled Sol fram FCU         Sig - 5.4V         -         -         Yeb (0)	Mod 3 Select	Q	<u>Sig-j</u>	<u>Sig-k</u>	YB001		-2.5V +1.5V Mod 3_Select
None 3: Streth         O         Sig - P         Sig - A         Yeb00        2: SV: 1: SV: Mod 3: Streth           Spare Med Select         Q         Sig - V         Sig - W         Yeb01        2: SV: 1: SV: Mod 3: Streth           Spare Med Select         Q         Sig - V         Sig - V         Yeb01        2: SV: 1: SV: Spare Mod Select           Secure Pick In         W         Sig - CK         -         Yeb01         -2: SV: 1: SV: Spare Mod Select           Secure Pick In         W         Sig - CK         -         Yeb01         -3: Steet           Secure Pick In         W         Sig - CK         -         Yeb01         -3: SV: 4: Steet           Secure Pick In         W         Sig - Steet         Yeb01         -3: SV:         Yeb01         -3: SV:           Sig - Steet         TS: 4/:         Yeb01         -3: SV:          Yeb01         -3: SV:           -3: V         TS: 4/: 5          Yeb01         -3: SV:          Yeb01             -3: V         TS: 4/: 5          Yeb01           Yeb01 </td <td>Mod 4 Select</td> <td><u> </u></td> <td>Sig - m</td> <td>Sig - n</td> <td>YB001</td> <td></td> <td>-2.5V +1.5V Mod 4 Select</td>	Mod 4 Select	<u> </u>	Sig - m	Sig - n	YB001		-2.5V +1.5V Mod 4 Select
Today Select         So         Sig - I         Sig - V         Yes	Mod 5 Select	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Sig - p	<u>Sig - q</u>	YB001		-2.5V +1.5V Mod 5 Select
Space Med Select         Sig         V         Sig         V         Sig         Sig         Sig         Sig         Sig         Sig         Sig         Sig         <	Mod 7 Select	<u> </u>	Sig - r	Sig - s			-2.5V +1.5V Mod 7 Select
Controlled Grid from FCU         Sig - CK         N         Y8001         Controlled Grid from FCU           Sequence Pick In         W         Sig - CK          Y8001         Seq. Pick (Incoming)           137 Elie Terminotor         Int - AT          W6001          Y30 de           AC Power         TS         K          Y4001         208 Vac         Y40           26 V         TS         K          Y4001          Y40           26 V         TS         K/S          Y4001          Y40           26 V         TS         K/S          Y4001          Y40           27 Ver on Reset         Sig - SP         FU/R000         FD101          Y4001          Y4001          Y4001          Y4001          Y4001         FD101          Y4001          Y4001          Y4001          Y4001          Y4001           Y4001           Y4001          Y4001          Y4001 <td>Spare Mod Select</td> <td>- <del>0</del></td> <td>Sig = 1</td> <td><u>Sig - w</u></td> <td>YB001</td> <td>-</td> <td>=2.5V +1.5V Mod 7 Select</td>	Spare Mod Select	- <del>0</del>	Sig = 1	<u>Sig - w</u>	YB001	-	=2.5V +1.5V Mod 7 Select
Sequence Pick In         W         Sig = CL         -         Y Biol         Seq. Pick (Incoming)           3Y File Terminator         Int - AU         -         -         WE001         +3 Vdc           AC Power         IS         K         -         -         WE001         +3 Vdc           430 /         IS         K/S         -         -         Y0001         208 Vac - 3 Phase           +340 /         IS         K/S         -         -         Y0001         +30 Vac           +350 /         IS         K/S         -         -         Y0001         +30 Vac           -350 // Status         IS         K/S         -         -         Y8001         +30 Vac           -370 // Status         IS         K/S         -         -         Y8001         -31 Vac           Selected Module         Q         Edge Conn         Y8001         FD101         -2.5V +1.5V Select Lock           Selected Module         Q         Sig - x         Sig - A         Y8001         -2.5V +1.5V Goted Attention 1           Gated Attention 1         Q         Sig - A         Sig - A         Y8001         -2.5V +1.5V Goted Attention 1           Gated Attention 2         G         Sig - A <td>Controlled Gnd from FCU</td> <td></td> <td>Sia - CK</td> <td></td> <td>YB001</td> <td></td> <td>Controlled Grid from FCU</td>	Controlled Gnd from FCU		Sia - CK		YB001		Controlled Grid from FCU
137 Ellis Terminator       Int - AT       -       WE001       +13 Vdc         AC Power       15 K       -       Ya001       208 Vac - 3 Phase         136 V       15 4 / 2       -       Ya001       236 V         136 V       15 4 / 2       -       Ya001       236 V         137 V       15 4 / 2       -       Ya001       236 V         138 V       15 4 / 2       -       Ya001       236 V         137 V       15 4 / 5       -       Ya001       -35 V         137 V       15 4 / 5       -       Ya001       -37 V         137 V Por on Reset       Sig - 8 P       FU/FL090       PD103       -37 V Por on Reset + C.E.         Read/Write Coox       Q       R/W Board       Y8001       -2.5 V + 1.5 V Read/Write Coox         Selected Module       Q       Sig - 2       Sig - 2       Ya01       -2.5 V + 1.5 V Cated Attention 0         Cated Attention 1       Q       Sig - 2       Sig - 2       Ya001       -2.5 V + 1.5 V Cated Attention 2         Cated Attention 2       Q       Sig - A       Ya001       -2.5 V + 1.5 V Cated Attention 2         Cated Attention 3       Q       Sig - A       Ya001       -2.5 V + 1.5 V Cated Attention 2	Sequence Pick In	W	Sig - CL		YB001		Seg. Pick (Incoming)
Ac         Power         13         K          YA001         200 Vac. 3 Phose           736 V         13         4/5          Y8001         -36V           736 V         13         4/5          Y8001         -36V           737 V         13         4/5          Y8001         -36V           737 V         13         4/5          Y8001         -36V           737 V         13         4/5          Y8001         -60V           737 V         13         4/5          Y8001         -60V           737 Pwr on Reset         Sig - 8P         FU/FL090         FD103         -3V Pwr on Reset + C.E.           Read/Write Coox         Q         Edge Con         Y8001         FD101         -2.5V + 1.5V Selectel Module           Cented Attention 0         Sig - 2         Sig - 4A         Y8001         -2.5V + 1.5V Grated Attention 0           Cented Attention 1         Q         Sig - 2A         Y8001         -2.5V + 1.5V Grated Attention 1           Cented Attention 3         Q         Sig - AA         Y8001         -2.5V + 1.5V Grated Attention 1           Cented Attention 4         Q         Sig - AF	+3V File Terminator		Int – AT		WE001		+3 Vdc
AC Bower       TS       K        YA001       208 Vec - 3 Phose         Ya6V       TS       4/5        Ya001       -36V         Ya6V       TS       4/5        Ya001       -36V         Ya7V       TS       4/5        Ya001       -36V         Ya7V       TS       4/5        Ya001       -46V         Ya7V       TS       4/5        Ya001       -43V         Ya7V       TS       4/5        Ya001       -23V         GND       TS       4/5        Ya001       -23V       -23V Pri on Reset + C.E.         Read/Write Coax       Q       R/W Board       Y8001       FD102       -2.5V +1.5V Gated Attention 0         Gated Attention 0       Q       Sig - X       Sig - A       Y8001       -2.5V +1.5V Gated Attention 1         Gated Attention 1       Q       Sig - A       Y8001       -2.5V +1.5V Gated Attention 1       Gated Attention 1       -2.5V +1.5V Gated Attention 3       Gated Attention 1       -2.5V +1.5V Gated Attention 1       Gated Attention 1       -2.5V +1.5V Gated Attention 1       Gated Attention 1       -2.5V +1.5V Gated Attention 1       Gated Attention 3       -2.5V +1.5V Gated Attention 3			Int – AU				+3 Vdc
136 V       15       4/2        Y800       -36 V         -36 V       15       4/3        Y800       -36 V         +6 V       15       4/3        Y800       -36 V         +6 V       15       4/3        Y800       -36 V         -37 W       15       4/3        Y800       -37 V         -37 W on Reset       51       4/3        Y800       -37 V         -37 W on Reset       51       4/3        Y800       -37 V         Selected Module       Q       Edge Conn       Y8001       FD101       -2.57 V+1.57 Read/Write Coax         Selected Module       Q       Edge Conn       Y8001       -2.57 V+1.57 Read/Write Coax         Cated Attention 0       Q       Sig - X       Y8001       -2.57 V+1.57 Gated Attention 0         Cated Attention 2       Q       Sig - A       Y8001       -2.57 V+1.57 Gated Attention 1         Gated Attention 3       Q       Sig - A       Y8001       -2.57 V+1.57 Gated Attention 3         Gated Attention 4       Q       Sig - A       Y8001       -2.57 V+1.57 Gated Attention 3         Gated Attention 5       Q       Sig - A	AC Power		<u>TS K</u>		YA001		208 Vac - 3 Phase
130         13         4/3          1800         - 46V           13         4/3          1900         - 46V           13V         13         4/3          1900         - 46V           13V         13         4/3          1900         - 46V           3V         13         2/3          1900         - 46V           GND         13         2/3          1900         - 46V           GND         13         2/3          1900          1700           GND         13         2/3          1900         FD103            1700           Selected Module         Q         K/W Board         YB001         -2.5V +1.5V Gated Attention 0         Gated Attention 0	+36 V		$\frac{15}{15} \frac{4/5}{4/5}$		YB001		+36 V
13         2/5         -         19001         13         2/5           3V         15         4/5         -         Y8001         -         73           3V         15         4/5         -         Y8001         -         73           -3V Pwr on Reset         51         4/5         -         Y8001         FD103         Raset Select Look           Read/Write Coox         Q         K/W Board         Y8001         FD101         -2.5 V+1.5V Bad/Write Coox           Selected Module         Q         Edge Conn         Y8001         FD101         -2.5 V+1.5V Gated Attention 0           Gated Attention 1         Q         Sig - x         Sig - y         Y8001         -2.5 V+1.5V Gated Attention 1           Gated Attention 2         Q         Sig - x         Sig - A         Y8001         -2.5 V+1.5V Gated Attention 1           Gated Attention 3         Q         Sig - A         Y8001         -2.5 V+1.5V Gated Attention 1         Gated Attention 3           Gated Attention 5         Q         Sig - A         Y8001         -2.5 V+1.5V Gated Attention 3         Gated Attention 5         Ga	-30 V		<u>15 4/5</u> TS 4/5		YB001		-36 V
3V         13         2/5         -         Y8001         -3V           GND         15         4/5         -         Y8001         -3V           GND         15         4/5         -         Y8001         -3V           Sile         Sile         FP         FU/FL090         FD102         -2:SV +1:SV Read/Write Coox           Selected Module         Q         Edge Conn         Y8001         -2:SV +1:SV Read/Write Coox           Gated Attention 0         Q         Sig - x         Sig - y         Y8001         -2:SV +1:SV Gated Attention 0           Gated Attention 1         Q         Sig - x         Sig - A         Y8001         -2:SV +1:SV Gated Attention 1           Gated Attention 3         Q         Sig - AB         Sig - AE         Y8001         -2:SV +1:SV Gated Attention 3           Gated Attention 4         Q         Sig - AF         Sig - AK         Y8001         -2:SV +1:SV Gated Attention 3           Gated Attention 5         Q         Sig - AK         Sig - AK         Y8001         -2:SV +1:SV Gated Attention 5           Gated Attention 6         Q         Sig - AK         Sig - AK         Y8001         -2:SV +1:SV Gated Attention 5           Gated Attention 7         Q         Sig - AK         Sig	+31/		TS 4/5		VB001		+3 V
ChD         15         4/5          YB001         CND           -3V Pwr on Reset         Sig - BP         FU/FL090         FD102         -3V Pwr on Reset + C.E.           Read/Write Coax         Q         R/W Board         YB001         FD102         -2.5V + 1.5V Read/Write Coax           Selected Module         Q         Edge Conn         YB001         FD101         -2.5V + 1.5V Gated Attention 0           Gated Attention 0         Q         Sig - x         Sig - y         YB001         -2.5V + 1.5V Gated Attention 1           Gated Attention 1         Q         Sig - x         Sig - A         YB001         -2.5V + 1.5V Gated Attention 1           Gated Attention 2         Q         Sig - A         YB001         -2.5V + 1.5V Gated Attention 1           Gated Attention 3         Q         Sig - AB         Sig - AC         YB001         -2.5V + 1.5V Gated Attention 1           Gated Attention 4         Q         Sig - AL         Sig - AK         YB001         -2.5V + 1.5V Gated Attention 3           Gated Attention 4         Q         Sig - A         Sig - AK         YB001         -2.5V + 1.5V Gated Attention 5           Gated Attention 4         Q         Sig - AK         Sig - AK         YB001         -2.5V + 1.5V Gated Attention 5 <tr< td=""><td>-3V</td><td></td><td><math>\frac{15}{15} \frac{4}{5}</math></td><td></td><td>YB001</td><td></td><td>-3V</td></tr<>	-3V		$\frac{15}{15} \frac{4}{5}$		YB001		-3V
-3V Pwr on Reset         Sig - BP         FU/FL090         FD103         -3V Pwr on Reset + C.E.           Read/Write Coax         Q         R/W Board         Y8001         FD102         -2.5V +1.5V Selected K           Selected Module         Q         Edge Conn         Y8001         FD101         -2.5V +1.5V Selected Module           Cated Attention 0         Q         Sig - x         Sig - x         Y8001         -2.5V +1.5V Selected Attention 0           Cated Attention 1         Q         Sig - x         Sig - AA         Y8001         -2.5V +1.5V Gated Attention 1           Gated Attention 2         Q         Sig - AB         Sig - AC         Y8001         -2.5V +1.5V Gated Attention 1           Gated Attention 3         Q         Sig - AB         Sig - AC         Y8001         -2.5V +1.5V Gated Attention 3           Gated Attention 4         Q         Sig - AH         Sig - AF         Sig - AL         Sig - AL           Gated Attention 5         Q         Sig - AH         Sig - AF         Sig - AL         Sig - AF           Gated Attention 6         Q         Sig - AR         Sig - AS         Y8001         -2.5V +1.5V Gated Attention 5           Gated Attention 6         Q         Sig - AR         Sig - AF         Sig - AV         Sig - CA </td <td>GND</td> <td></td> <td>TS 4/5</td> <td></td> <td>YB001</td> <td></td> <td>GND</td>	GND		TS 4/5		YB001		GND
Or Michael         Dig St         Control         Ford         Reset Select Lock           Read/Write Coax         Q         Edge Conn         Y8001         FD102         -2.5V +1.5V Selected Module           Selected Module         Q         Edge Conn         Y8001         FD102         -2.5V +1.5V Selected Module           Cated Attention 1         Q         Sig - x         Sig - x         Y8001         -2.5V +1.5V Gated Attention 0           Cated Attention 1         Q         Sig - A         Y8001         -2.5V +1.5V Gated Attention 1           Gated Attention 3         Q         Sig - AE         Y8001         -2.5V +1.5V Gated Attention 2           Gated Attention 4         Q         Sig - AF         Sig - AF         Y8001         -2.5V +1.5V Gated Attention 2           Gated Attention 5         Q         Sig - AF         Y8001         -2.5V +1.5V Gated Attention 4           Gated Attention 5         Q         Sig - AL         Sig - AA         Y8001         -2.5V +1.5V Gated Attention 5           Gated Attention 5         Q         Sig - AX         Sig - AS         Y8001         -2.5V +1.5V Gated Attention 5           Gated Attention 5         Q         Sig - AX         Sig - AS         Y8001         -2.5V +1.5V (JAdd Reg 1           Cylinder Addr Reg 1	-3V Pwr on Reset		Sig - BP		EU/EL090	FD103	-3V Pwr on Reset + C.E.
Read/Write Coox         Q         K/W board         Y8001         FD101         -2.5V +1.5V Read/Write Coox           Selected Module         Q         Edge Conn         Disk Storage to Control Unit            Gated Attention 0         Q         Sig - x         Sig - x         Y B001         -2.5V +1.5V Gated Attention 0           Gated Attention 1         Q         Sig - x         Sig - A         Y B001         -2.5V +1.5V Gated Attention 0           Gated Attention 2         Q         Sig - A         Sig - A         Y B001         -2.5V +1.5V Gated Attention 1           Gated Attention 3         Q         Sig - A         Y B001         -2.5V +1.5V Gated Attention 3           Gated Attention 4         Q         Sig - A         Y B001         -2.5V +1.5V Gated Attention 3           Gated Attention 5         Q         Sig - A         Y B001         -2.5V +1.5V Gated Attention 3           Gated Attention 5         Q         Sig - A         Y B001         -2.5V +1.5V Gated Attention 5           Gated Attention 6         Q         Sig - A         Y B001         -2.5V +1.5V Gated Attention 5           Gated Attention 7         Q         Sig - A         Y B001         -2.5V +1.5V Coled Attention 5           Gated Attention 7         Q         Sig - A         <					10/12070	FD103	Reset Select Lock
Disk         Storage to Control         Unit         Function	Selected Module	<u> </u>	K/W Board		YB001	FD102	-2.5V +1.5V Kead/Write Coax
Disk Storage to Control Unit           Gated Attention 0         Q         Sig - x         Sig - X         Y8001         -2.5V +1.5V Gated Attention 1           Gated Attention 1         Q         Sig - AB         Sig - AA         Y8001         -2.5V +1.5V Gated Attention 1           Gated Attention 3         Q         Sig - AB         Sig - AE         Y8001         -2.5V +1.5V Gated Attention 3           Gated Attention 3         Q         Sig - AF         Sig - AE         Y8001         -2.5V +1.5V Gated Attention 3           Gated Attention 4         Q         Sig - AL         Sig - AK         Y8001         -2.5V +1.5V Gated Attention 3           Gated Attention 5         Q         Sig - AL         Sig - AK         Y8001         -2.5V +1.5V Gated Attention 6           Gated Attention 5         Q         Sig - AR         Sig - AS         Y8001         -2.5V +1.5V Gated Attention 6           Gated Attention 5         Q         Sig - AZ         Sig - AS         Y8001         -2.5V +1.5V Gated Attention 6           Gated Attention 6         Gated Attention 6         Gated Attention 5         Gated Attention 6         Gated Attention 6         Gated Attention 6           Gylinder Addr Reg 1         Q         Sig - AZ         Sig - AS         Y8001         -2.5V +1.5V Cyl Addr Reg 1 </td <td>Selected Wodole</td> <td>Q</td> <td>Luge Conn</td> <td>I</td> <td></td> <td>PDIO</td> <td></td>	Selected Wodole	Q	Luge Conn	I		PDIO	
Gated Attention 0         Q         Sig - x         Sig - y         Y8001         -2.5V +1.5V Gated Attention 0           Gated Attention 1         Q         Sig - AB         Sig - AC         Y8001         -2.5V +1.5V Gated Attention 1           Gated Attention 2         Q         Sig - AB         Sig - AC         Y8001         -2.5V +1.5V Gated Attention 2           Gated Attention 3         Q         Sig - AF         Sig - AH         Y8001         -2.5V +1.5V Gated Attention 3           Gated Attention 4         Q         Sig - AF         Sig - AK         Y8001         -2.5V +1.5V Gated Attention 5           Gated Attention 5         Q         Sig - AL         Sig - AK         Y8001         -2.5V +1.5V Gated Attention 5           Gated Attention 5         Q         Sig - AL         Sig - AK         Y8001         -2.5V +1.5V Gated Attention 5           Gated Attention 5         Q         Sig - AX         Sig - AP         Y8001         -2.5V +1.5V Gated Attention 7           Gated Attention 5         Q         Sig - AX         Sig - AS         Y8001         -2.5V +1.5V Gated Attention 7           Gated Attention 5         Q         Sig - AZ         Sig - AZ         Y8001         -2.5V +1.5V Gated Attention 7           Gated Attention 5         Q         Sig - BZ				Disk Storage to	Control Unit		
Gated Attention 1         Q         Sig - z         Sig - AC         YB001         -2.5V +1.5V Gated Attention 2           Gated Attention 3         Q         Sig - AD         Sig - AE         YB001         -2.5V +1.5V Gated Attention 2           Gated Attention 4         Q         Sig - AF         Sig - AF         YB001         -2.5V +1.5V Gated Attention 2           Gated Attention 5         Q         Sig - AI         Sig - AK         YB001         -2.5V +1.5V Gated Attention 4           Gated Attention 5         Q         Sig - AL         Sig - AK         YB001         -2.5V +1.5V Gated Attention 6           Gated Attention 5         Q         Sig - AN         Sig - AS         YB001         -2.5V +1.5V Gated Attention 6           Gated Attention 5         Q         Sig - AS         Sig - AS         YB001         -2.5V +1.5V Gated Attention 6           Gated Attention 5         Q         Sig - AS         Sig - AS         YB001         -2.5V +1.5V Gated Attention 5           Gated Attention 5         Q         Sig - AS         Sig - AS         YB001         -2.5V +1.5V Gated Attention 5           Gated Attention 5         Q         Sig - AS         Sig - AS         YB001         -2.5V +1.5V Cyl Addr Reg 1           Cylinder Addr Reg 1         Q         Sig - BS	Gated Attention 0	Q	Sig – x	Sig - y	YB001		-2.5V +1.5V Gated Attention 0
Gated Attention 2         Q         Sig - AB         Sig - AC         YB001         -2.5V +1.5V Gated Attention 3           Gated Attention 4         Q         Sig - AF         Sig - AH         YB001         -2.5V +1.5V Gated Attention 3           Gated Attention 4         Q         Sig - AF         Sig - AH         YB001         -2.5V +1.5V Gated Attention 3           Gated Attention 6         Q         Sig - AL         Sig - AM         YB001         -2.5V +1.5V Gated Attention 5           Gated Attention 6         Q         Sig - AL         Sig - AM         YB001         -2.5V +1.5V Gated Attention 5           Gated Attention 7         Q         Sig - AR         Sig - AS         YB001         -2.5V +1.5V Gated Attention 7           Gated Attention 7         Q         Sig - AR         Sig - AS         YB001         -2.5V +1.5V Gated Attention 7           Gated Attention 7         Q         Sig - AR         Sig - AS         YB001         -2.5V +1.5V Gated Attention 7           Gated Attention 7         Q         Sig - AR         Sig - AS         YB001         -2.5V +1.5V Gated Attention 7           Gated Attention 7         Q         Sig - AR         Sig - BA         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 16           Cylinder Addr Reg 16         Q	Gated Attention 1	Q	Sig - z	Sig - AA	YB001		-2.5V +1.5V Gated Attention 1
Geted Attention 3         Q         Sig - AL         Sig - BL	Gated Attention 2	Q	Sig - AB	Sig - AC	YB001		-2.5V +1.5V Gated Attention 2
Operation         Stig         All         Stig	Gated Attention 3	<u> </u>	Sig - AD	Sig - At	YB001		-2.5V +1.5V Gated Attention 3
Observe         Observe <t< td=""><td>Gated Attention 5</td><td></td><td></td><td></td><td>VR001</td><td></td><td>2 5V +1 5V Gated Attention 4</td></t<>	Gated Attention 5				VR001		2 5V +1 5V Gated Attention 4
Gated Attention 7         Q         Sig - AN         Sig - AP         YB001         -2.5V +1.5V Gated Attention 7           Gated Attention Spare Mod         Q         Sig - AX         Sig - AX         Sig - AY         FU/FL026         FD101         -2.5V +1.5V Gated Attention 5pare Mod           Cylinder Addr Reg 1         Q         Sig - AX         Sig - AX         Sig - AY         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 1           Cylinder Addr Reg 2         Q         Sig - BB         Sig - BC         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 2           Cylinder Addr Reg 8         Q         Sig - BD         Sig - BE         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 1           Cylinder Addr Reg 16         Q         Sig - BD         Sig - BK         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 16           Cylinder Addr Reg 128         Q         Sig - BN         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 42           Cylinder Addr Reg 128         Q         Sig - BN         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 432           Cylinder Addr Reg 128         Q         Sig - BN         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 44           Cylinder Addr Reg 128         Q         Sig - B	Gated Attention 6	<u> </u>	Sig - AL	Sig - AM	YB001		-2.5V +1.5V Gated Attention 6
Gated Attention Spare Mod         Q         Sig - AR         Sig - AX         YB001         -2.5V +1.5V Gated Attention Spare Mod           Cylinder Addr Reg 1         Q         Sig - AX         Sig - AY         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 1           Cylinder Addr Reg 2         Q         Sig - AZ         Sig - BA         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 2           Cylinder Addr Reg 4         Q         Sig - BD         Sig - BC         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 2           Cylinder Addr Reg 16         Q         Sig - BD         Sig - BE         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 3           Cylinder Addr Reg 32         Q         Sig - BL         Sig - BK         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 16           Cylinder Addr Reg 32         Q         Sig - BL         Sig - BK         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 16           Cylinder Addr Reg 18         Q         Sig - BL         Sig - BK         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 16           Cylinder Addr Reg 128         Q         Sig - BL         Sig - BL         FU/FL025         FD104         -2.5V +1.5V Sel On Line           Selected Index         Q	Gated Attention 7	Q	Sig - AN	Sig - AP	YB001		-2.5V +1.5V Gated Attention 7
Cylinder Addr Reg 1       Q       Sig - AX       Sig - AX       Sig - AX       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 1         Cylinder Addr Reg 2       Q       Sig - BA       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 2         Cylinder Addr Reg 4       Q       Sig - BB       Sig - BC       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 4         Cylinder Addr Reg 16       Q       Sig - BF       Sig - BF       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 16         Cylinder Addr Reg 16       Q       Sig - BF       Sig - BH       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 16         Cylinder Addr Reg 128       Q       Sig - BF       Sig - BN       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 128         Cylinder Addr Reg 128       Q       Sig - BN       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 128         Selected Dn Line       Q       Sig - BN       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 128         Selected Index       Q       Sig - BN       Sig - BN       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 128         Selected Index       Q       Sig - BN       Sig - BN       FU/FL026       FD104       -2.5V +1.5V Sel Index         File	Gated Attention Spare Mod	Q	Sig - AR	Sig - AS	YB001		-2.5V +1.5V Gated Attention Spare Mod
Cylinder Addr Reg 2       Q       Sig - AZ       Sig - BA       FU/FL026       FD101       -2.5V + 1.5V Cyl Addr Reg 2         Cylinder Addr Reg 4       Q       Sig - BD       Sig - BE       FU/FL026       FD101       -2.5V + 1.5V Cyl Addr Reg 4         Cylinder Addr Reg 16       Q       Sig - BD       Sig - BF       FU/FL026       FD101       -2.5V + 1.5V Cyl Addr Reg 16         Cylinder Addr Reg 16       Q       Sig - BJ       Sig - BK       FU/FL026       FD101       -2.5V + 1.5V Cyl Addr Reg 16         Cylinder Addr Reg 32       Q       Sig - BJ       Sig - BK       FU/FL026       FD101       -2.5V + 1.5V Cyl Addr Reg 12         Cylinder Addr Reg 128       Q       Sig - BN       FU/FL026       FD101       -2.5V + 1.5V Cyl Addr Reg 128         Cylinder Addr Reg 128       Q       Sig - BN       FU/FL026       FD101       -2.5V + 1.5V Cyl Addr Reg 128         Selected File Busy       Q       Sig - BN       FU/FL025       FD104       -2.5V + 1.5V Cyl Addr Reg 128         Selected Index       Q       Sig - BN       FU/FL025       FD104       -2.5V + 1.5V Cyl Addr Reg 128         Selected Index       Q       Sig - BN       Sig - BN       FU/FL025       FD104       -2.5V + 1.5V Sel Fol f	Cylinder Addr Reg 1	Q	Sig - AX	Sig - AY	FU/FL026	FD101	-2.5V +1.5V Cyl Addr Reg 1
Cylinder Addr Reg 4       Q       Sig - BB       Sig - BC       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 4         Cylinder Addr Reg 16       Q       Sig - BF       Sig - BF       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 16         Cylinder Addr Reg 16       Q       Sig - BF       Sig - BF       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 16         Cylinder Addr Reg 14       Q       Sig - BL       Sig - BK       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 16         Cylinder Addr Reg 128       Q       Sig - BN       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 128         Cylinder Addr Reg 128       Q       Sig - BN       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 128         Selected Dn Line       Q       Sig - BN       FU/FL026       FD104       -2.5V +1.5V Cyl Addr Reg 128         Selected Index       Q       Sig - BN       FU/FL025       FD104       -2.5V +1.5V Cyl Addr Reg 128         Selected Index       Q       Sig - BN       Sig - BS       FU/FL025       FD104       -2.5V +1.5V Cyl Addr Reg 128         Selected Index       Q       Sig - BN       Sig - BS       FU/FL025       FD104       -2.5V +1.5V Sel Index         File Unsofe       Sig - CB       Sig	Cylinder Addr Reg 2	Q	Sig – AZ	Sig – BA	FU/FL026	FD101	-2.5V +1.5V Cyl Addr Reg 2
Cylinder Addr Reg 16       Q       Sig - BD       Sig - BL       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 8         Cylinder Addr Reg 32       Q       Sig - BJ       Sig - BK       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 16         Cylinder Addr Reg 32       Q       Sig - BL       Sig - BK       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 32         Cylinder Addr Reg 64       Q       Sig - BL       Sig - BM       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 42         Cylinder Addr Reg 128       Q       Sig - BN       FU/FL026       FD101       -2.5V +1.5V Cyl Addr Reg 44         Selected File Busy       Q       Sig - BR       Sig - BS       FU/FL025       FD104       -2.5V +1.5V Syl Addr Reg 128         Selected Index       Q       Sig - BX       Sig - BV       FU/FL025       FD104       -2.5V +1.5V Sel Index         Selected Index       Q       Sig - BX       Sig - BY       FU/FL025       FD104       -2.5V +1.5V Sel Index         Selected Index       Q       Sig - BZ       Sig - CA       FU/FL025       FD104       -2.5V +1.5V Sel Rel Addr Reg 128         Selected Index       Q       Sig - CD       Sig - CC       FU/FL025       FD104       -2.5V +1.5V Sel Rel Addr Reg 64 <t< td=""><td>Cylinder Addr Reg 4</td><td>Q</td><td>Sig - BB</td><td>Sig - BC</td><td>FU/FL026</td><td>FD101</td><td>-2.5V +1.5V Cyl Addr Reg 4</td></t<>	Cylinder Addr Reg 4	Q	Sig - BB	Sig - BC	FU/FL026	FD101	-2.5V +1.5V Cyl Addr Reg 4
Cylinder Addr Reg 10         Cylinder Addr Reg 12         Cylinder Addr Reg 13         Sig - Br         Sig - Br         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 32           Cylinder Addr Reg 32         Q         Sig - BL         Sig - BK         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 32           Cylinder Addr Reg 128         Q         Sig - BN         FU/FL026         FD101         -2.5V +1.5V Cyl Addr Reg 128           Selected File Busy         Q         Sig - BN         Sig - BS         FU/FL025         FD104         -2.5V +1.5V Sel File Busy           Selected Index         Q         Sig - BV         Sig - BS         FU/FL025         FD104         -2.5V +1.5V Sel File Unsofe           Selected Index         Q         Sig - BV         Sig - BY         FU/FL025         FD104         -2.5V +1.5V Sel Index           File Unsofe         Q         Sig - BZ         Sig - CA         FU/FL025         FD104         -2.5V +1.5V Sel Index           Selected End of Cyl         Q         Sig - CB         Sig - CA         FU/FL025         FD104         -2.5V +1.5V Sel Index           Selected Pack Change         Q         Sig - CB         Sig - CC         FU/FL025         FD104         -2.5V +1.5V Sel Pack Change           Write Current Sense <td< td=""><td>Cylinder Addr Reg 8</td><td><u> </u></td><td>Sig - BD</td><td>Sig - BE</td><td>FU/FL026</td><td>FD101</td><td>-2.5V +1.5V Cyl Addr Reg 8</td></td<>	Cylinder Addr Reg 8	<u> </u>	Sig - BD	Sig - BE	FU/FL026	FD101	-2.5V +1.5V Cyl Addr Reg 8
Cylinder Addr Reg 54         G         Sig - BJ         Sig - BL         Fly - Ministry         Fly - Ministry         Sig - BL         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - BL         Sig - BL         Fly - Ministry         Sig - BL         Sig - CL         Sig - CL         Sig - CL         Sig - CL         Fly/FL025         FD104         -2.5V + 1.5V Sel Sk Incomp           S	Cylinder Addr Reg 10		Sig - Bl			ED101	-2.5V +1.5V Cyl Addr Keg 10
Optimizer         Construction         Construction <td>Cylinder Addr Reg 64</td> <td>- <del>0</del></td> <td>Sig - B1</td> <td>Sig = BM</td> <td>FU/FL026</td> <td>FD101</td> <td>-2.5V +1.5V Cyl Addr Reg 52</td>	Cylinder Addr Reg 64	- <del>0</del>	Sig - B1	Sig = BM	FU/FL026	FD101	-2.5V +1.5V Cyl Addr Reg 52
Selected File Busy       Q       Sig - BR       Sig - BS       FU/FL025       FD104       -2.5V +1.5V Sel File Busy         Selected On Line       Q       Sig - BT       Sig - BU       FU/FL025       FD104       -2.5V +1.5V Sel On Line         Selected Index       Q       Sig - BX       Sig - BW       FU/FL025       FD104       -2.5V +1.5V Sel Index         File Unsofe       Q       Sig - BX       Sig - BY       FU/FL025       FD104       -2.5V +1.5V Sel Index         Selected Seek Incomp       Q       Sig - BX       Sig - BY       FU/FL025       FD104       -2.5V +1.5V Sel Index         Selected End of Cyl       Q       Sig - CB       Sig - CC       FU/FL025       FD104       -2.5V +1.5V Sel Inde of Cyl         Selected Pack Change       Q       Sig - CB       Sig - CC       FU/FL025       FD104       -2.5V +1.5V Sel Pack Change         Write Current Sense       Q       Sig - CF       Sig - CH       FU/FL025       FD104       -2.5V +1.5V Sel Pack Change         W       Sig - CF       Sig - CH       FU/FL025       FD104       -2.5V +1.5V Sel Pack Change         Write Current Sense       Q       Sig - CL       -       YB001       OV +36V Reads Extended         W       Sig - CL       -       <	Cylinder Addr Reg 128	- õ	Sig - BN	Sig bitt	FU/FL026	FD101	-2.5V +1.5V Cyl Addr Reg 128
Selected On Line       Q       Sig - BT       Sig - BU       FU/FL025       FD104       -2.5V +1.5V Sel On Line         Selected Index       Q       Sig - BV       Sig - BW       FU/FL025       FD104       -2.5V +1.5V Sel Index         File Unsafe       Q       Sig - BX       Sig - BY       FU/FL025       FD104       -2.5V +1.5V Sel Index         Selected Seek Incomp       Q       Sig - BZ       Sig - CA       FU/FL025       FD104       -2.5V +1.5V Sel Sk Incomp         Selected End of Cyl       Q       Sig - CB       Sig - CC       FU/FL025       FD104       -2.5V +1.5V Sel End of Cyl         Selected Pack Change       Q       Sig - CB       Sig - CC       FU/FL025       FD104       -2.5V +1.5V Sel End of Cyl         Write Current Sense       Q       Sig - CF       Sig - CE       FU/FL025       FD104       -2.5V +1.5V WR Current Sense         Heads Extended       W       Sig - CJ       -       -       YB001       OV +36V Heads Extended         W       Sig - CM       -       YB001       OV +36V Sequence Pick (Outgoing)       -3V         +6v       YB003       -3V       -3V       -3V       -3V         +6V       YB003       -3V +6V - Enable A       -Disable A       -70 + 1003	Selected File Busy	Q	Sig - BR	Sig - BS	FU/FL025	FD104	-2.5V +1.5V Sel File Busy
Selected Index       Q       Sig - BV.       Sig - BW       FU/FL025       FD104       -2.5V +1.5V Sel Index         File Unsafe       Q       Sig - BZ       Sig - BY       FU/FL025       FD104       -2.5V +1.5V Sel Index         Selected Seek Incomp       Q       Sig - BZ       Sig - CA       FU/FL025       FD104       -2.5V +1.5V Sel Sk Incomp         Selected End of Cyl       Q       Sig - CB       Sig - CC       FU/FL025       FD104       -2.5V +1.5V Sel Index (Campo)         Selected Pack Change       Q       Sig - CB       Sig - CC       FU/FL025       FD104       -2.5V +1.5V Sel Index (Change)         Write Current Sense       Q       Sig - CD       Sig - CE       FU/FL025       FD104       -2.5V +1.5V Sel Pack Change         Write Current Sense       Q       Sig - CJ       -       YB001       OV +36V Heads Extended         W       Sig - CM       -       YB001       OV +36V Sequence Pick (Outgoing)          YB003       -3V         +6V        YB003       -3V         +6V        YB003       -3V          YB003       -3V +6V -Enable A          YB003       -3V +6V -Enable A	Selected On Line	Q	Sig – BT	Sig - BU	FU/FL025	FD104	-2.5V +1.5V Sel On Line
File Unsafe       Q       Sig - BX       Sig - BY       FU/FL025       FD104       -2.5V +1.5V File Unsafe         Selected Seek Incomp       Q       Sig - BZ       Sig - CA       FU/FL025       FD104       -2.5V +1.5V Sel Sk Incomp         Selected End of Cyl       Q       Sig - CB       Sig - CC       FU/FL025       FD104       -2.5V +1.5V Sel Sk Incomp         Selected Pack Change       Q       Sig - CD       Sig - CE       FU/FL025       FD104       -2.5V +1.5V Sel Pack Change         Write Current Sense       Q       Sig - CF       Sig - CE       FU/FL025       -2.5V +1.5V WR Current Sense         Heads Extended       W       Sig - CJ       -       YB001       OV +36V Heads Extended         W       Sig - CM       -       YB001       OV +36V Sequence Pick (Outgoing)         -3V       -       -       YB003       -3V         +6V       -       YB003       -3V         -Enable A       -       YB003       -3V +6V -Enable A         -Disable A       -       YB003       -3V +6V -Enable A         -Disable B       -       YB003       -3V +6V -Enable B         -Disable B       -       YB003       -3V +6V -Enable B         -Disable B       -	Selected Index	Q	Sig - BV	Sig – BW	FU/FL025	FD104	-2.5V +1.5V Sel Index
Selected seek incomp       Q       Sig - CA       FU/FL025       FD104       -2.5V +1.5V Sel Sk Incomp         Selected End of Cyl       Q       Sig - CB       Sig - CC       FU/FL025       FD104       -2.5V +1.5V Sel End of Cyl         Selected Pack Change       Q       Sig - CD       Sig - CE       FU/FL025       FD104       -2.5V +1.5V Sel Pack Change         Write Current Sense       Q       Sig - CF       Sig - CH       FU/FL025       -2.5V +1.5V WR Current Sense         Heads Extended       W       Sig - CM       -       YB001       0V +36V Heads Extended         W       Sig - CM       -       YB001       0V +36V Sequence Pick (Outgoing)         -3V       -       YB003       -3V         +6V       YB003       -3V         -Enable A       YB003       -3V +6V -Enable A         -Disable A       YB003       -3V +6V -Disable A         -Enable B       YB003       -3V +6V -Enable B         -Disable B       YB003       -3V +6V -Enable B         -Disable B       YB003       -3V +6V -Disable B         -Disable B       YB003       -3V +6V -Disable B         -Disable B       YB003       -3V +6V -Disable B         -Disable B       YB003       -3V +	File Unsafe	<u>Q</u>	Sig - BX	Sig - BY	FU/FL025	FD104	-2.5V +1.5V File Unsafe
Selected trad of Cy1       Ck       Sig - CD       Sig - CC       FU/FL025       FD104       -2.5V +1.5V Sel End of Cy1         Selected Pack Change       Q       Sig - CD       Sig - CE       FU/FL025       FD104       -2.5V +1.5V Sel End of Cy1         Write Current Sense       Q       Sig - CF       Sig - CH       FU/FL025       FD104       -2.5V +1.5V Sel Pack Change         Heads Extended       W       Sig - CJ       -       YB001       OV +36V Heads Extended         W       Sig - CM       -       YB001       OV +36V Sequence Pick (Outgoing)         -3V       (To Next File Frame)       -3V         +6V       YB003       -3V         -Enable A       YB003       -3V         -Disable A       YB003       -3V +6V - Enable A         -Disable B       YB003       -3V +6V - Disable A         -Disable B       YB003       -3V +6V - Disable B         *See Figure 8 for m	Selected Seek Incomp		Sig - BZ	Sig - CA		FD104	-2.5V +1.5V Sel Sk Incomp
Stelected rous Groupe       Stig - CF       Stig - CF       FU/FL025       FD104       -2.5V +1.5V WR Current Sense         Write Current Sense       Q       Sig - CF       Sig - CH       FU/FL025       -2.5V +1.5V WR Current Sense         Heads Extended       W       Sig - CJ       -       YB001       0V +36V Heads Extended         W       Sig - CM       -       YB001       0V +36V Sequence Pick (Outgoing)         -3V       YB003       -3V         +6V       YB003       -3V         -3V       YB003       -3V         -2.5V +1.5V WR Current Sense       YB003       -3V         -3V       YB003       -3V         -5V       YB003       -3V         -5V       YB003       -3V         -5V       YB003       -3V         -5030       YB003       -3V         -513cble A       YB003       -3V +6V -Enable A         -513cble B       YB003       -3V +6V -Disable A         -513cble B       YB003       -3V +6V -Enable B         -513cble B       YB003       -3V +6V -Disable B         -513cble B       YB003       -3V +6V -Disable B         +6 to -3 Multi-Tag SW       YB003       +6 to -3 Multi-Tag SW	Selected Pack Change	<u> </u>	Sig - CB	Sig - CC		FD104	-2.5V +1.5V Sel End of Cyl
Heads Extended     W     Sig - CJ     -     YB001     OV +36V Sequence Pick (Outgoing)       W     Sig - CM     -     YB001     OV +36V Sequence Pick (Outgoing)       -3V     (To Next File Frame)       -3V     YB003     -3V       -3V     YB003     -3V       -3V     YB003     -3V       -3V     YB003     -3V       -5bcble A     YB003     -3V +6V -Enable A       -5bcble B     YB003     -3V +6V -Enable B       +6 to -3 Multi-Tag SW     YB003     -3V +6V -Disable B       *See Figure 8 for minimum and maximum limits     YB003     +6 to -3 Multi-Tag SW	Write Current Sense	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Sig = CD	Sig - CH	FU/FL025	FD104	-2.5V +1.5V Sel Pack Change
W     Sig - CM     -     YB001     OV + 36V Sequence Pick (Outgoing)       -3V     (To Next File Frame)     (To Next File Frame)       +6V     YB003     -3V       +6V     YB003     -3V       -3V     YB003     -3V       +6V     YB003     -3V       -3V     YB003     -3V       -3V     YB003     -3V       -5V     YB003     -3V       -5V     YB003     -3V       -5V     YB003     -3V       -5V     YB003     -3V +6V -Enable A       -5V     YB003     -3V +6V -Enable A       -5V     YB003     -3V +6V -Disable A       -5V     YB003     -3V +6V -Enable B       +6 to -3 Multi-Tag SW     YB003     +6 to -3 Multi-Tag SW       *See Figure 8 for minimum and maximum limits     YB003     +6 to -3 Multi-Tag SW	Heads Extended	- ŵ	Sig - CJ		YB001		0V +36V Heads Extended
-3V     YB003     -3V       +6V     YB003     +6V       -3V     YB003     +6V       -3V     YB003     -3V       -50     YB003     -3V +6V -Enable A       -50     YB003     -3V +6V -Disable A       -50     YB003     -3V +6V -Enable B       -50     YB003     -3V +6V -Disable B       -50     YB003     -46 to -3 Multi-Tag SW		Ŵ	Sig - CM		YB001		0V +36V Sequence Pick (Outgoing)
-3V       YB003       -3V         +6V       YB003       +6V         -3V       YB003       -3V         -3V       YB003       -3V         -Enable A       YB003       -3V +6V -Enable A         -Disable A       YB003       -3V +6V -Disable A         -Disable B       YB003       -3V +6V -Disable B         -Disable B       YB003       -3V +6V -Enable B         +6 to -3 Multi-Tag SW       YB003       +6 to -3 Multi-Tag SW         *See Figure 8 for minimum and maximum limits       YB003       +6 to -3 Multi-Tag SW							(To Next File Frame)
+ov         YB003         +6V           -3V         YB003         -3V           -Enable A         YB003         -3V +6V - Enable A           -Disable A         YB003         -3V +6V - Disable A           -Disable B         YB003         -3V +6V - Disable B           -Disable B         YB003         -3V +6V - Enable B           -Disable B         YB003         -3V +6V - Disable B           +6 to -3 Multi-Tag SW         YB003         +6 to -3 Multi-Tag SW           *See Figure 8 for minimum and maximum limits         YB003         +6 to -3 Multi-Tag SW	-3V				YB003	L	-3V
-Sv     YB003     -3V       -Enable A     YB003     -3V + 6V - Enable A       -Disable A     YB003     -3V + 6V - Disable A       -Enable B     YB003     -3V + 6V - Enable B       -Disable B     YB003     -3V + 6V - Enable B       +6 to -3 Multi-Tag SW     YB003     +6 to -3 Multi-Tag SW	+0V				YB003		+6V
- Disable A       YB003       -3V +6V - Enable A         - Disable B       YB003       -3V +6V - Disable A         - Enable B       YB003       -3V +6V - Enable B         - Disable B       YB003       -3V +6V - Enable B         +6 to -3 Multi-Tag SW       YB003       +6 to -3 Multi-Tag SW				<u> </u>	YB003		
TDU03     -3V +6V - Disable A       -Enable B     YB003     -3V +6V - Enable B       -Disable B     YB003     -3V +6V - Enable B       +6 to -3 Multi-Tag SW     YB003     +6 to -3 Multi-Tag SW       *See Figure 8 for minimum and maximum limits     YB003     +6 to -3 Multi-Tag SW					YB003	<u> </u>	-3V +0V -Engble A
Poischle B     YB003     -3V +6V - Dischle B       +6 to -3 Multi-Tag SW     YB003     +6 to -3 Multi-Tag SW       *See Figure 8 for minimum and maximum limits     YB003     +6 to -3 Multi-Tag SW	-Engble B		·	·	YB003		-3V +6V -Engble B
+6 to -3 Multi-Tag SW +6 to -3 Multi-Tag SW +6 to -3 Multi-Tag SW *See Figure 8 for minimum and maximum limits	-Disable B			1	YB003		-3V +6V -Disable B
*See Figure 8 for minimum and maximum limits	+6 to -3 Multi-Tag SW				YB003		+6 to -3 Multi-Tag SW
	*See Figure 8 for minimum a	nd maximum	limits				

AC Power	Single Phase 60 Hz VAC	Single Phase 50 Hz VAC ∆ or Y Connected				
Power Input	208,230	195,220,235: △ 220,238: Y				
Convenience Outlet	115	195,220,235: ∆ 220,238: Y				
Tolerance: Voltage ±10% Frequency ±1/2 Hz						

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Figure 11. AC Voltage Requirement

### Turn-on Sequencing

In order to make a module 'ready', a disk pack must be installed and the front cover interlock must be closed. Assuming that the control unit is not poweredup then, if the start-stop switch for the module (see Figure 16) is placed in start position, the module will power-up when the control unit is powered-up.

The timing diagram, Figure 14, illustrates the sequential events which occur when the module is turned on. A brief explanation of the events follows.

- 1. The 'sequence pick' signal, which is energized, and remains energized as long as the control unit has power up, activates the sequence relay in the disk module. The sequence relay then energizes the motor relay. The disk cleaning cycle starts and the heads are extended into the disk pack. Presence of ac voltage to the drive motor, energizes the ac safety relay.
- 2. When the disk pack reaches 70% of the rated rpm, the speed relay is energized which then signals the next module (in a multimodule system) to start.
- 3. After a disk cleaning cycle is completed, the access mechanism drives forward to positive stop at high speed. The heads load while the access mechanism moves toward positive stop.
- 4. At positive stop the access mechanism changes direction and then moves at fast reverse speed toward hydraulic home position.
- 5. At hydraulic home position, the access mechanism changes direction again and moves forward at slow speed. A detent is made at cylinder 000.

- 6. The control unit is then sent a signal indicating that the access is ready.
- 7. The disk module generates the gated attention signal.

### Turn-Off Sequencing

The disk module can be turned off locally by switching the module start-stop switch to the stop position or remotely by the control unit opening the 'controlled ground' line. Either action unloads and retracts the heads from the disk pack. At the same time the drive motor shuts off.

When the heads retract, the selected on-line signal will drop and the 'heads extended' line opens. The control unit must never drop all the voltages to the logic and special circuits of the module until the 'heads extended' signal is dropped.

For a multimodule system, the turn-off sequence remains unchanged for a particular module. However, the power to those circuits in the control unit that are common to all the modules in the system must not be dropped until the head extended signals from all modules are dropped.

Thermal Shutdown: The turn-off sequence must be executed during thermal shutdown.

Emergency Power Off (EPO): All voltages may be

dropped immediately for an emergency off situation. A turn-off sequence timing chart is shown in Figure 15.

## CAUTION

All dc voltages must be at the proper level before ac power is applied to the drive motor. To prevent damage to the internal circuits of the disk storage, these dc voltages must be applied and removed at the same time.

Other than normal power-off, serious damage to internal circuits will result if the dc cable is disconnected during a power-on condition. Disconnecting the signal cable, during a power-on condition, causes the drive motor to stop.

The signal out connector on the last disk storage in the system must be terminated. Erroneous results will occur if this terminator is disconnected during a power-on condition.



Figure 12. AC Power Distribution



Wiring Side

Pin         Signal           1         +6 Vdc           2         -3 Vdc           3         DC Gnd           4         DC Gnd           5         -           6         -           7         -           8         -           9         -           10         DC Gnd           11         DC Gnd           12         Read/Write Data           13         +3 Vdc           14         +3 Vdc           15         -36 Vdc           16         -           17         -           18         -           19         +36 Vdc           20         +36 Vdc           21         -           22         Selected Mod           23         -           24         -           25         -           26         -           27         DC Gnd           28         -		File DC Power
1       +6 Vdc         2       -3 Vdc         3       DC Gnd         4       DC Gnd         5	Pin	Signal
2       -3 Vdc         3       DC Gnd         4       DC Gnd         5	1	+6 Vdc
3         DC Gnd           4         DC Gnd           5	2	-3 Vdc
4         DC Gnd           5	3	DC Gnd
5	4	DC Gnd
6	5	
7         8         9         10       DC Gnd         11       DC Gnd         12       Read/Write Data         13       +3 Vdc         14       +3 Vdc         15       -36 Vdc         16	6	
8         9         10       DC Gnd         11       DC Gnd         12       Read/Write Data         13       +3 Vdc         14       +3 Vdc         15       -36 Vdc         16	7	
9           10         DC Gnd           11         DC Gnd           12         Read/Write Data           13         +3 Vdc           14         +3 Vdc           15         -36 Vdc           16	8	
10       DC Gnd         11       DC Gnd         12       Read/Write Data         13       +3 Vdc         14       +3 Vdc         15       -36 Vdc         16	9	
11       DC Gnd         12       Read/Write Data         13       +3 Vdc         14       +3 Vdc         15       -36 Vdc         16	10	DC Gnd
12       Read/Write Data         13       +3 Vdc         14       +3 Vdc         15       -36 Vdc         16	11	DC Gnd
13       +3 Vdc         14       +3 Vdc         15       -36 Vdc         16	12	Read/Write Data
14       +3 Vdc         15       -36 Vdc         16	13	+3 Vdc
15       -36 Vdc         16	14	+3 Vdc
16         17         18         19       +36 Vdc         20       +36 Vdc         21       20         22       Selected Mod         23       24         25       26         27       DC Gnd         28       28	15	-36 Vdc
17         18         19       +36 Vdc         20       +36 Vdc         21       22         22       Selected Mod         23       24         25       26         27       DC Gnd         28       28	16	
18         19       +36 Vdc         20       +36 Vdc         21	17	
19       +36 Vdc         20       +36 Vdc         21	18	
20       +36 Vdc         21       22         22       Selected Mod         23       24         24       25         26       27         28       28	19	+36 Vdc
21         22       Selected Mod         23         24         25         26         27       DC Gnd         28	20	+36 Vdc
22         Selected Mod           23	21	
23 24 25 26 27 DC Gnd 28	22	Selected Mod
24 25 26 27 DC Gnd 28	23	
25 26 27 DC Gnd 28	24	
26 27 DC Gnd 28	25	
27 DC Gnd 28	26	
28	27	DC Gnd
	28	

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Figure 13. DC Power Connector and Pin Assignment

	Motor Starts, Disks Up To Speed, Brushes Cycle	Fast Forward Heads Extend	Rev Fast	Slow Fwd
1 Start			·	
2 K8 Motor				
3 R3 + R9		<b>-</b>		
4 Brush in Pack		<b>.</b>		
5 Sense Speed				
6 Hd Load Speed			and the second second	
7 K1 Speed	and the second sec			
8 +36V to Solenoid	and the second	He was a construction of the	and the second	
9 Extend Sol and Head Latch			an a	
10 Reset Forward Solenoid	Response - Other States 14			
11 Forward Drive and Latch				an a
12 Slow				
13 Intermediate				B_22.2
14 Sequence Pick (to following module)		St. Constants of the first	and the second	han da i ya i taki mu kata ku ya
15 Inhibit		$z_{\mu} = \overline{z_{\mu}} + \overline{z_{\mu}} + \overline{z_{\mu}}$	Provide States	
16 Initial Seek Latch			e Menter de l'este de l'este de la sec	
17 First Seek Line				
18 Detent Drive and Latch				kan tana Katabatan Katabatan Ing
19 On Line				
20 Gated On Line			·····	Crist saiden e
21 Cylinder Pulse				A
22 Detent In				
23 Set Forward		a Real Topological Autor (Calabia		
24 Seek Ready	·			
25 Gated Attention			·	
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Figure 14. Power On Sequence



 $t_1$  off occurs at the time + 36V to solenoids is dropped.

 ${\rm t_2}$  off occurs after heads have unloaded from disk pack.

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Figure 15. Turn-Off Sequence

### OPERATOR CONTROLS AND INDICATORS

The operator panel for the disk storage is shown in Figure 16. Each module of the disk storage has a start-stop switch and two indicators: access ready and select lock.

### Start-Stop Switch

The start-stop switch is inoperable unless all ac and dc power are applied. Also, the disk pack must be in place and the cover must be closed so that the index block switch is closed. Placing the switch in the start position energizes the disk drive motor, loads the heads, and moves the carriage to cylinder position 000.



Figure 16. Operator Panel

Assuming the module is on-line, placing the switch in the stop position deenergizes the disk drive motor, unloads the heads, and retracts the carriage.

## Access Ready Indicator (Labeled A-J)

This is a green lens with the physical device location (A-J) imprinted on it, this indicator will turn on following completion of the head loading sequence, this indicator turns off during the following times:

- 1. When a seek operation is being performed this is a normal condition.
- 2. When the access mechanism has not detented properly this is an abnormal condition.

### Select Lock Indicator (Red)

The select lock indicator lights if any of the conditions monitored by the drive safety circuits is detected.

Resetting the safety circuit and turning off the select lock lamp is accomplished by moving the start-stop switch to STOP.

### SERVICING CONTROLS

### AC Disconnect Switch (Sequence Panel)

With the AC Line switch off, ac power cannot be applied to the drive motor, the brush motor, or the card gate fan.

### Front Cover Switch

The front cover switch prevents making the module ready if the switch is open. If the module is on-line and the access drawer is slid out (for changing the disk pack, etc.), the heads unload, the drive motor turns off, and the carriage retracts.

CAUTION See "Safety" section of this manual.

### SIGNAL SPECIFICATIONS

### General

d

Signal lines to the disk storage can be driven by single or multiple drivers and can feed single or multiple receivers. All signal lines must terminate with an impedance of 95 ohms.

### Single Driver and Receiver

When a transmission line is supplied by a single driver and feeds a single receiver, the driver and receiver must be located at the ends of the line but not beyond the line terminator.

### Multiple Drivers and Receivers

Transmission lines can be driven by a maximum of eight drivers and can supply a maximum of eight receivers. Any combination of drivers or receivers, up to a maximum of eight drivers and eight receivers, can be logically ORed to the transmission line.

Multiple receivers on a line should not be less than 3 feet apart. However, no minimum spacing requirements have been set for:

- The distance between drivers.
- The distance between an end-of-line terminator and a driver.
- The distance between an end-of-line terminator and a receiver.



Figure 17. Line Receiver

Figure 17 is a diagram of the typical line receiver. Figure 18 shows a line driver.

### GENERAL ELECTRICAL CONSIDERATIONS

## Current Flow

The direction of current flow (conventional) is minus (-) if it flows into a component or positive (+) if it flows out of a component.

### Voltage Levels

Refer to Figure 8 for the logic voltage levels used in the disk storage. A signal line is considered active when it has a value specified in the table.

### Impedance

Line terminators must have a characteristic impedance of 95 ohms  $\pm$  10 ohms. Figure 19 shows the line terminator.



Figure 18. Line Driver



Figure 19. Line Terminator

### Noise

The maximum noise coupled onto any signal line within a cable and due to any combination of changes external to that line must not exceed 300 millivolts.

### Fault Conditions

The signal line may be grounded with no damage to drivers, receivers, or terminators.

Loss of power at either end does not cause any damage. Loss of power at the terminator may cause random errors in information transmission. The line operation is unaffected if power is off in any driver or receiver unit.

### SPECIFIC ELECTRICAL REQUIREMENTS

The receiver circuits in the disk storage are designed to interpret input signals as follows:

- 1. The more negative line signal is a logical 1.
- 2. The more positive line signal is a logical 0.
- 3. An open input is treated as positive (logical 0).
- 4. The switching level from logical 1 to logical 0 is 2.0 volts.
- 5. The switching level from logical 0 to logical 1 is -1.0 volts. The receiver must not be subjected to a voltage level more positive than +3.5 volts or more negative than -3.5 volts. Refer to Figure 17 for the line receiver input circuit.

### Input Requirements

Up Level: The dc voltage must be less than +3.50 volts and greater than +0.65 volts.

Down Level: The dc voltage must be greater than -0.50 volts and less than -3.50 volts.

Direct Current: The direct current requirements are 1.03 milliamps at -0.50 volts and 0.00 milliamps at +0.65 volts.

### Terminator

The terminator is considered a two-terminal network, consisting of resistors and power supplies, and must meet the following requirements:

- The terminal connected to the signal line must present an open-circuit voltage between +1.0 and +2.0 volts.
- Impedance between the terminals must not be less than 90 ohms or greater than 105 ohms.

### Driver

To transmit a logical 1, the voltage source driver draws approximately 25 milliamps from the line. To transmit a logical 0, the driver is off. (See Figure 18 for the driver circuit.)

### Cables

The cables may consist of any combination of twisted pair, coaxial cable, and printed circuit wire within the following limitation: the maximum allowable internal cable resistance offered is 1.5 ohms. The measurement of this value is made between the external connector pins.

The nominal characteristic impedance of coaxial cable is 92 ohms. The characteristic impedance of twisted pair ranges from about 90 to 105 ohms.

## Connectors

The maximum allowed coupled noise due to all connectors in each control unit, and including external cable connectors, is 250 millivolts. The IBM System/360 Channel Interface used by the 2314 Storage Control is described in the following manual:

• <u>IBM System/360 I/O Interface Channel to</u> <u>Control Unit Original Equipment Manufacturers'</u> Information -- A26-6843.

There are unique timings used by the 2314 Storage Control when controlling the 2312/2313 Disk Storage. The following supplemental timings are required and apply to the IBM 2314 Storage Control.

### OVERRUN LIMITS

The 2314 Storage Control will post 'overrun' if all the indicated requisites are not met for the chaining cases listed in Figure 20. Unless stated otherwise, all times are given with reference to the rise of 'status in', measured at the control unit, for the previous ending status.

### Requisites for Case A

• 'Command out' must rise within 70  $\mu$ s.

- Initial status acceptance within 98  $\mu$ s.
- First byte of data available within  $134 \,\mu s$ .

## Requisites for Case B\*

- 'Command Out' must rise within 79  $\mu$ s.
- Initial status acceptance within 88  $\mu$ s.
- First byte of data available within  $134 \ \mu s$ .

Requisites for Case C\*

- Initial status acceptance within  $116 \ \mu s$ .
- First byte of data available within 129  $\mu$ s.

## Requisites for Case D\*

• Initial status acceptance within 116  $\mu$ s.

### Requisites for Case E

- 'Command Out' must be received within 183  $\mu$ s.
- Requisites for Case D apply if 'Command Out' rises before 75  $\mu$ s.

\*Detection of 'Command Out' between 77 through 85  $\mu$ s will be delayed until 86  $\mu$ s 'Status In' will not rise until 8  $\mu$ s after detection of 'Command Out'.

First Command (s)	Second Command (s)	Case
Search Key, Read ID, Search ID	Search ID, Read ID, Read Count/Key/Data	E
Read ID, Search ID	Read Key/Data, Read Data	D
Search ID	Write Key/Data, Write Data (KL is 0)	A
Search ID	Write Data (K <sub>L</sub> is not 0)	, D
Read Count/Key/Data	Read Count/Key/Data	D
Write Count/Key/Data	Write Count/Key/Data	В
Search Key	Read Data	D
Search Equal Home Address	Read Record Zero	D
Search Equal Home Address	Write Record Zero	А
Read Count	Search Key	с

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Figure 20. Chaining Cases

## APPENDIX B. LOCATIONS



Figure 21. 2312 Disk Storage - Front View



Figure 22. 2312 Disk Storage - Rear View



Figure 23. 2313 Disk Storage - Front View



Figure 24. 2313 Disk Storage - Rear View



Figure 25. Disk Storage - Power Panel

## APPENDIX C. ACCESS TIMING CHART

•	Value						
Address Bus 0	128	1					-
Address Bus 1	64		C.A.				
Address Bus 2	32						<sup>1</sup> H
Address Bus 3	16						
Address Bus 4	8						
Address Bus 5	4						
Address Bus 6	2						
Address Bus 7	1		19.3				
Control			2				2402 (175)
Set Cylinder (Note	2)						
Set Head			yinn 1 ag				
Set Difference			<u>ŝk</u>				
Forward Drive Late	۱	Station Network	States and the second	an a	77 41 045 J. F. A. S. M		alles da viel d'Alle
Forward Solenoid La	atch			-18-41% C + 255 PS	19 (MAR & 19 (MAR) /		nation during the
Detent Latch			Seek Start	← Mechanica	ıl Delay	je j	Reits est
Detent In		2 (19 <b>8</b> 8) (1997) 2 (19 <b>88</b> 8) (1997)			Mechanical	Delay 📕	
Gated Cylinder Pul	se		-	30 Cy	linder Pulses	· · · · · ·	
Difference Counter		Full	30		18	0 	<u> </u>
Half Counter			1,5		3 	3	 
Intermediate					S. A.M.		
Slow						Note 1*	
Stop						ba	 81
Gated Attention					2.5	ms Delay	
CAR		50 Note 2*	an ya magamangki kalakiya ngamiya ka pat	n a shundar a shundar ta shundar ta shundar a sh	ander for all interfaces receiving a property	an an an ann an an an an an an an an an	ander a station and a second
Note 1. Delayed b 2. Assume Ac	y 0.2 ms i cess was c	f hydraulic oil i at Cylinder 20.	s less than 134	°F			

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Figure 26. Access Timing for Cylinder 020 to 050

## APPENDIX D. DC POWER CONNECTOR



Cross Reference					
IBM Part Number	Equivalent Part Number	IBM Part Number	Equivalent Part Number		
2122260	AMP* 66098-1	2180670	AMP 66253-2		
2122261	AMP 66100-1	2180671	AMP 66251-2		
2180667	AMP 329013	2180672	AMP C-202477-4		
2180668	AMP 329014	2244725	AMP C-202476-6		

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The following parts will be provided with all 2312/2313 Disk Storage orders:

Installation instructions and diagrams --Theory of Operation manuals, MDM's.

Maintenance Manual and Parts Catalogs.

Logic diagrams.

Terminator plug.

Cleaning paddle and tissue.

Head adjusting tool.

Head cleaning brush.

Head clearance gage.

Isopropyl alcohol.

Hexadecimal label.

Covers and kickstrips: front, rear and left end.

The following is a continuation of the parts listing for parts that are unique for each model:

### 2312

One module select (relocatable address) plug -- selective.

One dc cable.

One signal cable.

One ac cable.

<u>2313</u>

Four module select plugs.

Four dc cables -- selective first or second quad.

One signal cable.

One ac cable.

The signal cable and plug (AMP #201345-1) extend beyond the right end of the frame so that it can be connected to a mating plug (AMP #201037-1) in the adjacent module or control unit to the right.

The ac cable also extends beyond the frame to the right and connects to the adjacent unit with ring terminals.

### INSTALLATION

When the disk storage unit(s) are installed, a solid member to which to attach the disk storage frames must be provided by the customer. This is absolutely necessary in order to prevent the disk storage unit(s) from tipping over when drawers are pulled out. The locations of the holes in the disk storage frame are shown in Figure 28. Slots should be provided in the solid member for ease of installation. The solid member should be located to the right of the disk storage frame.

When the disk storage is serviced by IBM, a facility to turn power on/off must be provided adjacent to the unit.



Figure 28. Location of Holes in Disk Storage Frame

AC Power Distribution 10 AC Power Requirements 10 Access Times 3 Access Timing Chart 25 Actuator 3 Addressing, Disk Storage 4 Cable Lengths 10 Capacity, Disk Pack 5 Chaining Cases 21 Characteristics, Functional 3 Circuitry Safety 7 Selection 7 Control Tag 8 Cylinder Address Register 9 Cylinder Concept 3 Data Checking 6 Data Records Format 5 Mode 5 Numeric 5 Packed Decimal 5 Data Transfer Electronics Read Circuitry 6 Output 7 Read Amplifier 7 Write Circuitry 6 Duty Cycle 6 Write Coil 6 Write Driver 6 Write Gate 6 DC Power Connector 26 DC Power Requirements 10 Dimensions, Physical 1 Disk Pack, Description 4 Disk Rotational Speed 4 Disk Storage 2312 1 2313 2 Disk Storage Addressing 4 Disk Storage Module 3 Electrical Requirements, Specific Cables 20 Connectors 20 Driver 20 Input 20 Down Level 20 Up Level 20 Terminator 20 End of Cylinder 9 Erase Driver 6

AC Disconnect Switch 18

Fault Conditions 20 Front Cover Switch 18 **Functional Characteristics** Disk Pack 4 Disk Storage Module Access Mechanism 3 Access Times 3 Addressing Disk Storage 4 Specifications 4 Gated Attention 9 **General** Description Dimensions 1 Safetv 1 **General Electrical Considerations** Current Flow 19 Fault Conditions 20 Impedance 19 Noise 20 Voltage Levels 19 Heads Extended 9 Impedance 19 Input Communication Lines 8 Installation 27 Interface Signal Input 8 Output 9 Introduction 1 Dimensions 1 Safety 1 Locations 22 Logic Voltage Levels 10 Module Select 9 Module, Disk Storage Access Mechanism 3 Addressing, Disk Storage 4 Specifications Operational 4 Timing 4 Multiple Drivers and Receivers 19 Noise, Maximum 20 **Operator** Panel Controls Servicing 18 Start-Stop 18 Indicators Access Ready 18 Select Lock 18 Oscillator Frequency 4 Overrun Limits 21

Power Interface AC 10 DC Cable 10 Connector 10 Power Panel 24 Power Sequencing Turn-Off Emergency Power Off 13 Thermal Shutdown 13 Turn-On 13 Preface ii Read Back Data Rate 4 Read Circuitry 6 Read Data 9 Read Data Bit Rate 4 Bit Width 4 Reference Publications ii Safety 1 Seek Incomplete 9 Select Lock Lamp 18 Selected File Busy 9 Selected Index 9 Selected Module 9 Selected On Line 9 Sequence Pick 9 Servicing Controls AC Disconnect 18 Front Cover 18 Set Cylinder Tag 8 Set Difference Tag 8 Set Head Tag 8 Shipping Group 27 Signal Interface Cable 10 Connector 10 Input Communication Lines Control Tag 8 Module Select 9 Set Cylinder Tag 8 Set Difference Tag 8 Set Head Tag 8 Write Data 9 Output Communication Lines Cylinder Address Register 9 End of Cylinder 9 Gated Attention 9 Heads Extended 9 Pack Change 10 Read Data 9

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IBM World Trade Corporation 821 United Nations Plaza, New York, New York 10017 [International] Signal Interface (Continued) Output Communication Lines (Continued) Seek Incomplete 9 Selected File Busy 9 Selected Index 9 Selected Module 9 Selected On Line 9 Sequence Pick 9 Unsafe 9 Write Current Sense 9 Signal Specifications General 19 Multiple Drivers and Receivers 19 Single Driver and Receiver 19 Single Driver and Receiver 19 Specific Electrical Requirements 20 Start-Stop Switch 18

## Track

Capacity 5 Dimension 5 Tunnel Erase 6 Turn-Off Sequencing Emergency Power Off 13 Thermal Shutdown 13

Unsafe 9

Voltage Levels 19

Write Circuitry 6 Write Clock Pulse Period 4 Pulse Rate 4 Write Current Sense 9 Write Data 9 Bit Rate 4 Bit Width 4

2312, Locations Front View 22 Rear View 22

2313, Locations Front View 23 Rear View 23

2314 Overrun Limits 21 Chaining Cases 21

## **READER'S COMMENT FORM**

## 2312/2313 OEMI

Form A26-1586-1

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As a reference source	
As a classroom text	
As	

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As a reference source:	Very Good	Good	Fair	Poor	Very Poor
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## **Technical Newsletter**

File Number	S360-1	.9
Re: Form No.	GA26-	-1586-1
This Newsletter	No.	GN26-0259
Date June 1	2, 1970	
Previous Newsle	tter Nos	. GN26-0252

IBM 2312/2313/2318 Disk Storage – Original Equipment Manufacturers' Information © IBM Corp. 1969

This Technical Newsletter provides replacement pages for the subject manual. Pages to be inserted and/or removed are:

3 through 6 6.1, 6.2 added 7 through 10 13, 14 19, 20

A change to the text or a small change to an illustration is indicated by a vertical line to the left of the change; a changed or added illustration is denoted by the symbol  $\bullet$  to the left of the caption.

### Summary of Amendments

- 1. Provide correction for read data bit rate.
- 2. Clarify bit cell times.
- 3. Provide additional information for read data detection.
- 4. Provide additional information for line termination.

Note: Please file this cover letter at the back of the manual to provide a record of changes.

IBM Corporation, Product Publications, Dept. G24, San Jose, California 95114

The disk storage consists of two main components: the IBM 2312/2313/2318 Disk Storage and the IBM 2316 Disk Pack.

### DISK STORAGE MODULE

### Access Mechanism

The access mechanism consists of a rack mounted movable carriage which supports 20 read/write heads. These heads are mounted on a common block and are placed in pairs, each pair lying between two disk surfaces of the disk pack. A hydraulic actuator moves the carriage and positions the read/write heads to any of 203 cylinders. When the disk pack is mounted in the disk storage module, information can be written or read from twenty disk surfaces. Once put in motion, the hydraulic actuator moves the recording mechanism horizontally to any one of the cylinder positions. After motion ceases, the drive sends a 'seek complete' signal to the control unit. At this time, the system selects the desired read/ write head by electronic switching. In this manner, all records within a module can be located.

The module utilizes direct accessing between cylinder locations, which allows the access mechanism to proceed from any cylinder position to another without returning to home (reference) position.

The use of a comb-type access on a multi-disk module provides a cylinder of storage area at each of the physical settings of the access mechanism. The cylinder concept (Figure 3) may be visualized as cylinders or drums, one inside the other. Once the proper access location is made, any area in the cylinder is available in one revolution of the disk pack. One revolution requires 25 milliseconds.

#### Access Times

Cylinder-to-cylinder (horizontal) access time varies according to the number of cylinders traveled. Access time from one cylinder to the adjacent cylinder is 25 milliseconds. Other access times are given in Figure 4. After the access mechanism has reached a cylinder position, additional time may be required for the disk to rotate to the desired storage area. At 2,400 revolutions per minute, one complete revolution takes 25 milliseconds, where the average rotational time is 12.5 milliseconds (onehalf revolution).



Figure 3. Cylinder Concept

Access Time*	Milliseconds	
Maximum	130	
Average Random	60	
Minimum (Cylinder-to-Cylinder)	25	
*These access times include a provision for settling-down time, but do not include rotational delay. Average rotational delay is 12.5 milliseconds.		

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The following curve is a plot of the cylinders traveled against time for the access mechanism and can be used as an aid in programming for the most efficient use of the disk storage.



In addition, an Access Timing Chart in Appendix C (Figure 26) illustrates a typical access operation.

## Operational and Timing Specifications

A summary of the specifications for operation and timing of the disk storage is given in Figure 5.

## Disk Storage Addressing

Each disk pack has 20 usable surfaces with 203 tracks on each surface. The vertical alignment of tracks can be thought of as a cylinder of tracks (Figure 3). In order to provide maximum accessibility of a storage area, the tracks are numbered vertically within the cylinder. Therefore, a track-to-track operation only requires microseconds of switching time rather than milliseconds of access time. To place the recording mechanism at a specific cylinder of tracks, a seek command must be given to the module. The command must provide the identification of the module and the cylinder to which the access mechanism should move. In addition, in order to select individual tracks within the cylinder, the command must designate the recording head.

## DISK PACK

The IBM 2316 Disk Pack, as shown in Figure 6, is composed of eleven disks, 14 inches in diameter and spaced 0.35 inches apart on a vertical shaft. Circular protective plates are mounted above the top disk and under the bottom disk to protect the assembly. The upper surface of the top disk and the lower surface of the bottom disk are not available for data storage because of the protective plates. The entire assembly of disks, vertical shaft and protective plates rotates at a speed of 2,400 revolutions per minute, 25 ms per revolution.

ltem	Item Nominal		Minimum
Disk Rotational Speed	2400 rpm	2448 rpm	2352 rpm
*Oscillator Frequency	5.00 MHz	5.0025 MHz	4.9975 MHz
*Write Clock Pulse Period	400.0 nanoseconds	400.2 nanose conds	399.8 nanoseconds
*Write Clock Pulse Rate	5.00 Megabits	5.0025 Megabits	4.9975 Megabits
*Write Data Bit Rate	2.50 Megabits	2.50125 Megabits	2.49875 Megabits
*Write Data Bit Width	70 nanoseconds	80 nanoseconds	60 nanoseconds
Read Data Bit Rate	2.50 Megabits	2.625 Megabits	2.375 Megabits
Read Data Bit Width	80 nanoseconds	100 nanoseconds	60 nanose conds
Read Back Data Rate 312 k Bytes		328 k Bytes	296 k Bytes

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• Figure 5. Operational and Timing Specifications



Figure 6. 2316 Disk Pack

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A two-piece plastic cover for the entire pack assembly, is designed to protect disks against damage. A built in handle on the top cover makes carrying easy. A self-locking device in the handle permits removal of the top cover only when the pack is mounted on the disk storage.

### Disk Pack Capacity

The maximum capacity of the 2316 Disk Pack is 29,176,000 eight-bit bytes. In packed decimal mode the maximum capacity is 58,352,000 digits (numeric only). See Figure 5 for the read/write electronic

specifications. Using the worst case figures (2.49875 MHz write data bit rate and 2,448 rpm) indicates a total track capacity of 7,652 eight-bit bytes. However, the data should be checked for recording accuracy by the control unit, and this checking requires time. The IBM control units require data gaps following each record field, which reduces the track capacity. The track capacity of the 2316 Disk Pack, when used in a disk storage system attached to the 2314 Storage Control is 7,294 eight-bit bytes if one data record is written per track. The total capacity is reduced as the number of records per track increases.

Note: IBM guarantees that the 2316 has 4000 error-free tracks. Therefore, the total capacity quoted is based on 4,000 tracks. Up to 60 alternate tracks are provided. The IBM control units can assign alternate tracks to replace defective tracks, when so directed by the stored program.

Data is transferred between the control unit and the disk storage module serially, one bit at a time.

### DATA RECORDS AND FORMAT

The organization of data and the capacity of the disk storage module are dependent on the format used to store information. The read/write format should be designed to satisfy the needs of the attaching system.

Component tolerances and specific requirements of data flow electronics in the disk storage, which may affect the design of the control unit, are as follows:

- Disk Speed:  $2,400 \text{ rpm } \pm 2\%$ .
- Write oscillator frequency: 5.0 MHz ±0.05%.
- Radial dimension of magnetic tracks: Track 202 4.5 inches (approximately) Track 000 6.6 inches (approximately).
- Minimum time from head deselect to head advance: 11.2 microseconds.
- Minimum time from head advance to head select: 1.6 microseconds.
- Relative position of one index pulse to all other index pulses: ±4 microseconds.
- Relative position of all read/write heads to a given pulse: Position tolerance ±0.0125 inches.

- Read gate: Minimum time of 60 microseconds after head select or the fall of 'write gate'.
- Write and erase gate: Minimum time of 60 microseconds after head select.

## Read Data Detection

During a read operation the signal received from each disk drive module (via the coaxial cable) consists of interleaved clock and data pulses. Normally, controllers contain circuitry to remove the clock pulses, and to use their time relationship to sense the presence or absence of data pulses. Design parameters (based on the use of a 5.0 MHz  $\pm 0.05\%$  write oscillator when the data was written) to accomplish this are as follows:

• Nominal bit cell time is 400 nanoseconds

Note: Bit cell is the time between the rise of any two adjacent clock bits.

• Nominal data bit to clock bit time is 200 nano-seconds.

<u>Note</u>: Data bit to clock bit is the time from the rise of a data bit to the rise of the following clock bit.

• Maximum continuous variation of clock bits is  $\pm 5\%$  of nominal bit cell time.

<u>Note</u>: Continuous variations are slow changes due to write oscillator drift and disk speed changes during writing, and disk speed changes during reading.

- Maximum continuous variation of data bits is  $\pm 5\%$  of nominal data bit to clock bit time.
- Maximum instantaneous variations of clock bits is  $\pm 30\%$  of nominal bit cell time. This includes  $\pm 5\%$  for continuous variations.

<u>Note</u>: Instantaneous variations are fast changes due to magnetic characteristics, and to voltage fluctuations within the specified parameters. Instantaneous variations compensate for each other in several bit cell times.

- Maximum instantaneous variations of data bits is ±30% of nominal data bit to clock bit time. This includes ±5% for continuous variations.
- Recommended synchronization time is 12.8 microseconds.

<u>Note</u>: Synchronization time is the time to completely resynchronize to the read data signal. This is only a recommendation since the final parameter is determined by the synchronization area in the pre-record format. Ŷ

Transient conditions can cause temporary read signal changes in excess of these parameters. To compensate for this, error checking and retry procedures are normally designed into the system using the disk drive.

## DATA TRANSFER ELECTRONICS

The data transfer electronics include circuits for head selection, writing, and reading. Safety circuits are also included to provide protection for recorded data.

A full complement of data transfer electronic circuits is installed in each drive. This includes the head selection circuitry, the write data line receiver, the write trigger, the write driver, the erase driver, safety circuits, read preamplifier and the main read amplifier.

When data transfer to or from a particular disk surface is desired, the appropriate head address and module lines are conditioned by the control unit.

Write gate and erase gate signals must be provided by the control unit for writing data on the disk storage pack. The write data to the disk storage module must be in serial pulse form and driven by a special line driver. (See "Signal Specifications" section of this manual.)

During read operations, the recorded signals from the disk surface are sensed by the read/write head and directed to the input of the read amplifier. The read amplifier produces raw data at its output in the form of one discrete pulse for each transition on the recording disk. The output stage of the read amplifier is a coaxial-line driver which provides 80 nanosecond wide pulses through an impedance of 95 ohms.

Usually only a particular portion of the signal at the read amplifier output is usable. The control unit must provide a read gate signal to gate the read amplifier output. When the read gate signal is present, the read amplifier output is allowed to be sent to the control unit. At the recording frequency of 5.0 megahertz it is absolutely necessary to minimize the time shift of recording and read-back bits along the data flow path. To achieve this, it is best to think of the whole data path as an integral unit. The data flow path consists of a read and write clock, located in the control unit, and recording and detection circuitry which is located in the disk storage module.

### Write Circuitry

The write circuitry contains the necessary components for changing the write data pulses from the control unit into a current drive for the write coil of the magnetic head. Current in the write coil of the magnetic head produces a flux which magnetizes the oxide material on the disk.

The input write data to the disk module is under control of the control unit. The write data signal must be driven by a special coaxial line driver. The line receiver terminates the coaxial write data line in addition to supplying an output to the write trigger. The write trigger converts the discrete pulse data into binary levels, with each pulse defining a change of state. The control unit conditions the write gate and erase gate lines to signal the write circuitry for a write operation. When the write gate is on, the write driver follows the output of the write trigger. The write driver provides the current drive through the address matrix to the write coil. The write driver has two outputs, one for each write element in the write coil. Current passes through only one element at a time depending on which of the two outputs from the write driver is active. Following recording the erase driver provides current for a tunnel erase to constrain the width of the recorded track.

The frequency of the write data signal is 5.0 megabits per second. Thus a minimum of 200 nano-seconds occurs between the leading edges of any two successive bits. The duty cycle of writing with a particular write driver shall not exceed 50% -- averaged over 1 second. This limitation provides ade-quate protection for the write driver as well as the magnetic heads.

### Read Circuitry

The read circuitry includes the necessary components for converting signals sensed by the read heads into Page of GA26-1586-1 Added June 12, 1970 By TNL: GN26-0259

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discrete pulses that can be interpreted as being data or clock bits. The output stage of the read amplifier is a coaxial line driver which provides pulses, 80 nanoseconds wide, for the control unit read clock.

The same diode and transistor head select matrix employed in the write head selection is used when read information is desired. One of 20 heads is electronically selected, and the output sensed by the head is fed into the read amplifier. The read amplifier is used to increase the amplitude of the head signals originating from the selected read head.

The head signal is amplified and differentiated by the read amplifier and the resulting pulses are fed through a shaper and line driver, which provides a standard level pulse. The nominal pulse width of the read amplifier output is 80 nanoseconds. One bit, 80 nanoseconds wide, is put on the data line for each change of magnetic state sensed by the read head from the disk surface.

The nominal output frequency of the read data is that frequency at which the data was written. The instantaneous output data frequency is dependent upon: the relative clocking oscillation frequency and relative disk rotational speed during writing and reading; the bit pattern written; and the bit shift caused by the head, disk, and electronic circuitry.

### SAFETY CIRCUITRY

Write safety circuits are provided to protect recorded information in the disk module. The outputs of all safety circuits are joined together and form a single unsafe line that is available to the control unit.

The following conditions in a disk module cause an unsafe signal to be sent to the control unit:

- 1. Multiple head select.
- 2. DC write current and not write gate.
- 3. Erase current and not erase gate.

- 4. Write gate and not erase current.
- 5. Write gate and no ac write current.
- 6. Read gate or not seek ready and either write gate or erase gate.
- 7. Overvoltage or undervoltage on +6, +3, -3, and -36 Vdc.
- 8. Loss of line voltage.

For any of the above unsafe conditions, the disk module deselects the heads, turns off selected write and erase gates, and holds them off until the unsafe condition is corrected.

The following conditions should be checked by the control unit and an unsafe status generated if:

- 1. More than one module selected line is up.
- 2. Write gate is up but no selected write current is sensed.

### SELECTION CIRCUITRY

It is necessary to select one of 20 heads for transferring data into and from the disk pack. This is done by setting a head number into the head address register which has 20 outputs. Each output of this register is connected to the center-tap lead of each read/write head. The head is selected when 'head select' comes up. Selecting a head brings the voltage level at its center tap from -36 Vdc to +3.0 Vdc. Once a head is selected, conditioning the write and erase gates causes the write and erase drivers to supply current to the selected head.

After selecting a head in a read operation, a selected read gate is used to gate the output of the read amplifier, thus allowing raw read data to be detected by the control unit read clock.

## SIGNAL INTERFACE

### INPUT COMMUNICATION LINES

The input communication interface is composed of an eight line time-shared bus (address bus), four tag lines that select the information from the bus, a module select line, and a write data line.

Only one of the four tag lines is up at a time to describe the information on the bus. (See Figure 7.)

<u>Control Tag</u>: This line conditions the drive for a control cycle. Simultaneously activating one of the signals on the bus determines which operation is performed (such as write, read, seek, etc.).

<u>Set Cylinder Tag</u>: This line is used for carriage operations so that the signals on the bus function to

identify the cylinder to be addressed. The 'set cylinder' pulse must be completely contained within the time that the cylinder address is on the eight-line bus.

Set Head Tag: This line and one of the bus signals perform a head select function. In addition, two other operations can be designated: select lock reset and turning on the 'forward' latch. A reset is given to the head register before a head selection.

<u>Note:</u> The pulse width of the tag lines is 1.5 microseconds minimum. The bus line information must be present for the full duration of the tag line pulse.

<u>Set Difference Tag:</u> This line, when it is on, identifies the signals on the bus as the calculated difference between the present cylinder position and the newly addressed cylinder.

Bus Line       Conversion In Storage Module       Control Cycle       Set Cylinder       Set Head       Set Difference       Set Set Not 128         File Bus       0       A128       Write Gate       Cyl 128       Forward Latch Select Lock Reset       Not 128       Not 64         " " 1       A64       Read Gate       Cyl 32       Forward Latch       Not 164       Not 64         " " 2       A32       Seek Start       Cyl 32       Forward Latch       Not 16       Not 64         " " 3       A16       Reset Head Reg       Cyl 16       Hd Add 16       Not 18       Not 32         " " 3       A16       Reset Head Reg       Cyl 14       Hd Add 2       Not 4       Not 4         " " 5       A4       Select Head       Cyl 2       Hd Add 2       Not 4       Not 1         " " " 6       A2       Return to 000       Cyl 2       Hd Add 2       Not 1       Not 1         Unit       Gontrol			1	[		Function During		<u></u>
Storage Control Unit       Control		Bus Line	Conversion In Storage Module	Control Cycle	Set Cylinder	Set Head	Set Difference	Set Half Counter
Storage Control Unit         Control         0           Tag Lines         Set Cylinder         1           Set Head         2		File Bus 0 " " 1 " " 2 " " 3 " " 4 " " 5 " " 6 " " 7	A128 A64 A32 A16 A8 A4 A2 A1	Write Gate Read Gate Seek Start Reset Head Reg Erase Gate Select Head Return to 000 Head Advance	Cyl 128 Cyl 64 Cyl 32 Cyl 16 Cyl 8 Cyl 4 Cyl 2 Cyl 1	Forward Latch Select Lock Reset Hd Add 16 Hd Add 8 Hd Add 4 Hd Add 2 Hd Add 1	Not 128 Not 64 Not 32 Not 16 Not 8 Not 4 Not 2 Not 1	64 32 16 8 4 2 1 Not Used
	Storage Control Unit	Tag Lines Set Cyline Set Head	der					

Module Select - One for each module

Read/Write Data - Coaxial Cable

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<u>Module Select</u>: This signal is a line, in the multiplex cable, used to gate signal lines to the proper disk storage modules. This signal is gated to the proper module through the use of the module identification plug inserted in the operator panel. (See Figure 16.)

Write Data: This signal is a simplex line, one per module.

## OUTPUT COMMUNICATION LINES

The disk storage supplies the following signal lines that can be used by the control unit to determine the status of the disk module.

### Cylinder Address Register

Eight output lines from the cylinder address register (CAR) may be used to indicate the present disk module cylinder address. These lines are active when the module is selected and changed to a new address at 'set cylinder' time. The line names are:

CAR 1 CAR 2 CAR 4 CAR 8 CAR 16 CAR 32 CAR 64 CAR 128

### Gated Attention

This line indicates that a seek has been completed or that 600 milliseconds has passed since the seek command was given without a detent-in being detected. It is reset by the read gate. 'Gated attention' is a line in the multiplex cable from the control unit, controlled by the module identification plug inserted in the operator panel. This line is not module selected.

#### Selected Module

This line indicates that a module has been selected. It is used in the 2314 Storage Control for the multimodule select safety logic. It is a simplex line and is module selected.

### Selected File Busy

This line, when it is up, indicates that the access mechanism is in the seeking process. When the line is down, it indicates that the disk storage is ready to perform. This line is module selected.

### Selected Index

This is an index pulse generated by the disk module once per disk revolution. This line is module selected.

### Write Current Sense

This line indicates that the selected module is writing on the disk pack.

### Unsafe

This line indicates that the disk module is unsafe and will not perform any operation. This line is module selected.

### Seek Incomplete

This line indicates that the seek complete operation did not occur within 600 milliseconds after a seek command was given. This line is module selected.

### End of Cylinder

The 'end of cylinder' signal occurs if, during a cylinder operation, the head select register in the disk drive goes from 19 to 20. This line is module selected.

### Read Data

The 'read data' line is driven with a special line driver through a coaxial line. It is active during all read operations and is module selected.

### Heads Extended

This line indicates that the heads are extended. It is used in the control unit for sequencing power-off logic. In a control unit power down sequence, the dc voltages to the disk storage modules cannot be removed until the last heads extended switch has opened, indicating that the heads are unloaded.

### Selected On Line

This line indicates that the heads are extended and ready to read or write. This line is module selected.

### Sequence Pick

The signal on this line starts each module drive motor in sequence when the control unit is powered up. 'Sequence pick' remains energized as long as power is on. The 'controlled ground' line is opened to power down the disk storage drive motors when the control unit power is turned off.

## Pack Change

This line indicates that a pack change has occurred.

## SIGNAL CONNECTOR AND CABLE

The signal connector for connection at the disk storage is shown in Figure 9. The pin connections and signal names are listed in Figure 10. Figure 8 lists the logic voltage levels.

## Cable Lengths

The disk storage operates with a maximum DC cable length of 16 feet, and a maximum signal cable length of 19 feet 4 inches from the control unit to the furthest disk drive. The signal cable extends approximately 40 inches past the machine frame for attachment to the control unit or another disk storage unit. Refer to Figure 11 for a cable view.

## POWER INTERFACE

## AC Power Requirements

Three phase ac power is connected to each disk storage. However, an individual module draws power from only one phase. Therefore, in multiphase systems, phases should be rotated for disk storage units in sequence. The ac voltage requirements for the disk storage are listed in Figure 12. Machines wired for 50 hertz can be operated in delta or wye systems.

The disk storage takes 3.2 amperes steady and 25 amperes starting load, for each module. The power requirement for the 2312 is 0.7 kVA; the 2313 requires 2.8 kVA; and the 2318 requires 1.4 kVA.

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Up Level	Maximum	Minimum
+L	+ 6.28	+ 2.0
+V	+38.9	+28.4
+W	+38.9	+28.4
+Q	+ 3.5	+ 0.65
Down Level	Maximum	Minimum
-L	+ 0.3	0.0
-L -V	+ 0.3 + 0.4	0.0 0.0
-L -V -W	+ 0.3 + 0.4 + 1.3	0.0 0.0 0.0

Figure 8. Logic Voltage Levels

## AC Power Distribution

The ac power cable has four wires: three phase leads and one ground lead. The cable extends 5 inches past the machine frame (measured from the cable breakout). See Figure 11 for a cable view.

## DC Power Requirements

The control unit must supply all dc voltages for the disk storage units. The dc power requirements for each module are as follows:

- +3.0 Vdc at 0.90 amperes.
- -3.0 Vdc at 0.60 amperes.
- +6.0 Vdc at 1.10 amperes.
- +36.0 Vdc at 1.45 amperes.
- -36.0 Vdc at 0.39 amperes.

The currents specified are at nominal voltage and duty cycle. Voltage tolerances, except for +36V, are  $\pm 4\%$ , measured at the voltage bus on the SLT gates. The tolerance of the +36V is  $\pm 8\%$ . The voltage tolerances include any variable combinations of steady state or short duration transients.

## DC Connector and Cable

The dc power connector along with the pin assignments and signal lines is illustrated in Figure 13. In addition, Figure 27 in Appendix D shows the dc connector assembly and the mating plug in the disk module and lists the IBM part numbers for all parts of the connectors. Equivalent part numbers are also listed. Pins 3 and 4 are ground returns for +3, +6 and +12 volt power supplies. Pins 10 and 11 are grounds for +36V.

Note: Maximum cable length is 16 feet. Figure 11 lists other available cable lengths.

## POWER SEQUENCING

Power sequencing of the disk storage is the joint responsibility of the disk storage and the control unit. Each module provides the logic and interlocks for its operation and supplies the control unit with a 'heads extended' line (i.e., an access on-line signal). One set of contacts of relay K4 are provided for the purpose of multi-module turn-on power sequencing. Relay K4 energizes when the disk has reached 70% of the rated rpm.



Drive Ready Indicator	Module Select Plug	DC Leng	Cable gth cm		Notes
A B C D E F G H J	0 1 2 3 4 5 6 7 Spare	90 90 90 90 90 154 154 154 154	229 229 229 229 229 391 391 391 391	B	Module select plugs can be interchanged between drives. Cable lengths supplied are based on the assumption that the A-drive is closest to the control unit and additional units are further away. The module select plug address and dc cable lengths listed are standard for a 2314 facility.
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• Figure 11. AC/DC Cable Views and Standard DC Cable Lengths

AC Power	Volts ac Single Phase 60 Hz	Volts ac Single Phase 50 Hz ∆ or.Y Connected
Power Input	208,230	200, 220, 235: △ 220, 238: Y
Convenience Outlet	115	200,220,235: △ 220,238: Y
Tolerance: Voltage ±10% Frequency ±1/2 Hz		

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• Figure 12. AC Voltage Requirement

### Turn-on Sequencing

In order to make a module 'ready', a disk pack must be installed and the front cover interlock must be closed. Assuming that the control unit is not poweredup then, if the start-stop switch for the module (see Figure 16) is placed in start position, the module will power-up when the control unit is powered-up.

The timing diagram, Figure 14, illustrates the sequential events which occur when the module is turned on. A brief explanation of the events follows.

1. The 'sequence pick' signal, which is energized, and remains energized as long as the control unit has power up, activates the sequence relay in the disk module. The sequence relay then energizes the motor relay. The disk cleaning cycle starts and the heads are extended into the disk pack. Presence of ac voltage to the drive motor energizes the ac sofety einguits

motor, energizes the ac safety circuits.

- 2. When the disk pack reaches 70% of the rated rpm, the speed relay is energized which then signals the next module (in a multimodule system) to start.
- 3. After a disk cleaning cycle is completed, the access mechanism drives forward to positive stop at high speed. The heads load while the access mechanism moves toward positive stop.
- 4. At positive stop the access mechanism changes direction and then moves at fast reverse speed toward hydraulic home position.
- 5. At hydraulic home position, the access mechanism changes direction again and moves forward at slow speed. A detent is made at cylinder 000.

- 6. The control unit is then sent a signal indicating that the access is ready.
- 7. The disk module generates the gated attention signal.

### Turn-Off Sequencing

The disk module can be turned off locally by switching the module start-stop switch to the stop position or remotely by the control unit opening the controlled ground' line. Either action unloads and retracts the heads from the disk pack. At the same time the drive motor shuts off.

When the heads retract, the selected on-line signal will drop and the 'heads extended' line opens. The control unit must never drop all the voltages to the logic and special circuits of the module until the 'heads extended' signal is dropped.

For a multimodule system, the turn-off sequence remains unchanged for a particular module. However, the power to those circuits in the control unit that are common to all the modules in the system must not be dropped until the head extended signals from all modules are dropped.

Thermal Shutdown: The turn-off sequence must be executéd during thermal shutdown.

Emergency Power Off (EPO): All voltages may be

dropped immediately for an emergency off situation. A turn-off sequence timing chart is shown in Figure 15.

### CAUTION

All dc voltages must be at the proper level before ac power is applied to the drive motor. To prevent damage to the internal circuits of the disk storage, these dc voltages must be applied and removed at the same time.

Other than normal power-off, serious damage to internal circuits will result if the dc cable is disconnected during a power-on condition. Disconnecting the signal cable, during a power-on condition, causes the drive motor to stop.

The signal out connector on the last disk storage in the system must be terminated. Erroneous results will occur if this terminator is disconnected during a power-on condition.

### General

Signal lines to the disk storage can be driven by single or multiple drivers and can feed single or multiple receivers. All signal lines must terminate with an impedance of 95 ohms.

### Single Driver and Receiver

When a transmission line is supplied by a single driver and feeds a single receiver, the driver and receiver must be located at the ends of the line but not beyond the line terminator.

### Multiple Drivers and Receivers

Transmission lines can be driven by a maximum of eight drivers and can supply a maximum of eight receivers. Any combination of drivers or receivers, up to a maximum of eight drivers and eight receivers, can be logically ORed to the transmission line.

Multiple receivers on a line should not be less than 3 feet apart. However, no minimum spacing requirements have been set for:

- The distance between drivers.
- The distance between an end-of-line terminator and a driver.
- The distance between an end-of-line terminator and a receiver.



Figure 17. Line Receiver

Figure 17 is a diagram of the typical line receiver. Figure 18 shows a line driver.

## ELECTRICAL CONSIDERATIONS

### Current Flow

The direction of current flow (conventional) is minus (-) if it flows into a component or positive (+) if it flows out of a component.

### Voltage Levels

Refer to Figure 8 for the logic voltage levels used in the disk storage. A signal line is considered active when it has a value specified in the table.

### Impedance

Line terminators must have a characteristic impedance of 95 ohms  $\pm 10$  ohms. The terminator network shown in Figure 19 is provided for each signal line by the terminator plug. The terminator plug (included in the ship group) is installed in the last female multiplexer connector position in the 2312/2313/2318.







Figure 19. Line Terminator

### Noise

The maximum noise coupled onto any signal line within a cable and due to any combination of changes external to that line must not exceed 300 millivolts.

### Fault Conditions

The signal line may be grounded with no damage to drivers, receivers, or terminators.

Loss of power at either end does not cause any damage. Loss of power at the terminator may cause random errors in information transmission. The line operation is unaffected if power is off in any driver or receiver unit.

### SPECIFIC ELECTRICAL REQUIREMENTS

The receiver circuits in the disk storage are designed to interpret input signals as follows:

- 1. The more negative line signal is a logical 1.
- 2. The more positive line signal is a logical 0.
- 3. An open input is treated as positive (logical 0).
- 4. The switching level from logical 1 to logical 0 is 2.0 volts.
- 5. The switching level from logical 0 to logical 1 is -1.0 volts. The receiver must not be subjected to a voltage level more positive than +3.5 volts or more negative than -3.5 volts. Refer to Figure 17 for the line receiver input circuit.

### Input Requirements

Up Level: The dc voltage must be less than +3.50 volts and greater than +0.65 volts.

Down Level: The dc voltage must be greater than -0.50 volts and less than -3.50 volts.

Direct Current: The direct current requirements are 1.03 milliamps at -0.50 volts and 0.00 milliamps at +0.65 volts.

## Terminator

The terminator is considered a two-terminal network, consisting of resistors and power supplies, and must meet the following requirements:

- The terminal connected to the signal line must present an open-circuit voltage between +1.0 and +2.0 volts.
- Impedance between the terminals must not be less than 90 ohms or greater than 105 ohms.

### Driver

To transmit a logical 1, the voltage source driver draws approximately 25 milliamps from the line. To transmit a logical 0, the driver is off. (See Figure 18 for the driver circuit.)

### Cables

The cables may consist of any combination of twisted pair, coaxial cable, and printed circuit wire within the following limitation: the maximum allowable internal cable resistance offered is 1.5 ohms. The measurement of this value is made between the external connector pins.

The nominal characteristic impedance of coaxial cable is 92 ohms. The characteristic impedance of twisted pair ranges from about 90 to 105 ohms.

### Connectors

The maximum allowed coupled noise due to all connectors in each control unit, and including external cable connectors, is 250 millivolts.