Title:

FDC705 Flexible Disk Controller
Programmers Reference Manual

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RCSL No: 44-RT1664
Edition: April 1978
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Keywords:

Flexible Disk, RC3787, RC3751
FDC705, FDD705

Abstract:

This paper describes the logical structure of the FDC705 Flexible Disk Controller in connection with the FDD705 double sided Flexible Disk Drive. The FDC705 is capable of driving up to four Flexible Disk Drives in single density mode. The Channel is format compatible in accordance with the IBM3740, 5132, 4964 and 3600 serie diskette systems.

Printed by A/S Regnecentralen, Copenhagen

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1. MAIN CHARACTERISTICS. 1.

1.1. Description. 1.1.

The FDC705 Flexible Disk Controller is an interface between RC3600 and FDD705 double sided Flexible Disk Drive. The FDC705 is capable of driving up to four FDD705 flexible disk drives. This provides the system with an on-line disk-storage capacity of app. 2 Mbytes. Off-line capacity is unlimited by use of the removable diskettes.

Fig. 1.1. shows the physical structure of a maximum system. It should be noted that the controller has only two ports to which drives can be connected. One port is able to operate two drives in a daisy chain.

Drives connected to the same port cannot be operated simultaneously, whereas two drives connected to different ports can be operated independently in full parallel.

The FDC705 Flexible Disk Controller is connected to the RC3600 Direct Memory Access Channel and features hardware code conversion. The controller contains four separated code converters (one for each drive).

Other features included in the FDC705 controller are: Bad track handling, Variable sector length, Multi-Sector capability and Format Track commands.

The FDD705 Flexible Disk Drive is composed of drive mechanism, read/write heads, head actuater and associated control circuits. It can write and read double sided as well as single sided disk cartridges (diskettes) interchangeably from unit to unit.

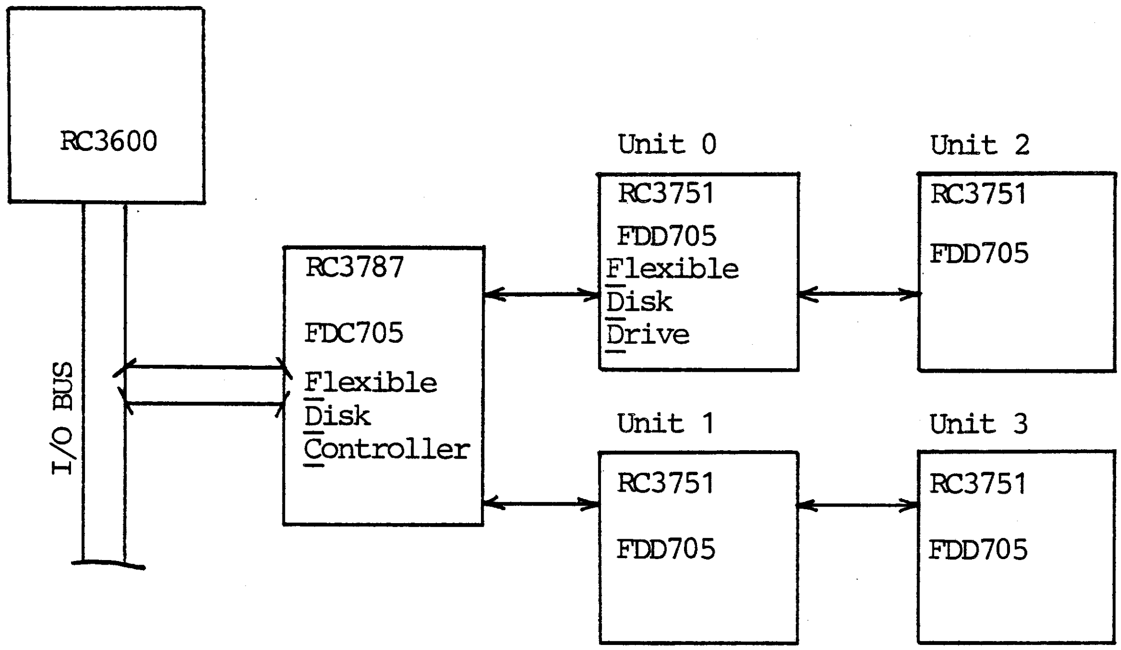


Fig. 1.1. Physical structure of a maximum disk system.

It enables data transfer rates at max. 31,250 bytes per sec., random access capability and storage capacity of over 250 kilobytes on a single diskette surface (meaning a total of over 500 kilobytes on a double sided diskette).

Diskettes can be write-protected by cutting the write-protect slot in the diskette jacket, or by pressing the write-protect pushbutton on the front panel (write-protect indicator illuminated).

1.2. Data Medium. 1.2.

The IBM formatted flexible disk cartridge - also called the diskette - used as data media in the FDD705 disk drives is a flat disk composed of a Mylar substrate coated on one or both sides with a magnetic oxide. For protective purposes during handling, operating and storage the disk is incased in a flexible plastic envelope, eight inches square. The disk itself rotates, during operation inside the plastic envelope, which protects and cleans the surfaces.

The disk, 7.5 inches in diameter, has one hole for indexing.

Fig. 1.2. shows the disk cartridge and disk configuration.

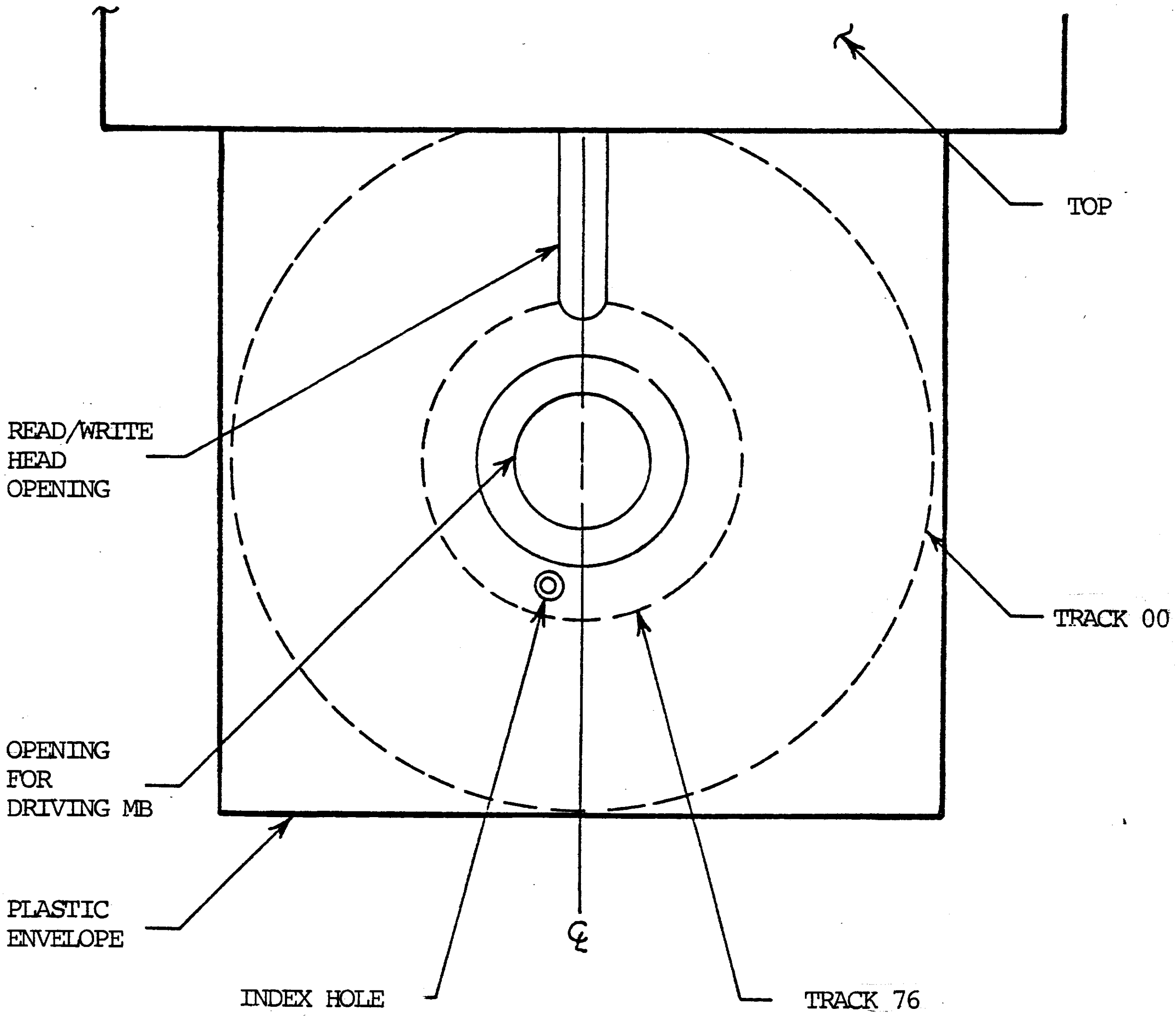


Fig. 1.2. Disc Cartridge and Disc Configuration.

1.3. IBM Compatible Data Formats. 1.3.

1.3.1. Cylinder Format. 1.3.1.

The disk is divided into 77 cylinders, numbered physically from 00 to 76, with cylinder 00 being the outhermost cylinder. On a single sided diskette a cylinder consists of only one track, whereas a cylinder on a double sided diskette consists of two associated tracks on each side of the disk.

There are logically 75 data cylinders and 2 alternate cylinders on a disk. Any two cylinders may be initialized as bad cylinders. The data cylinders are numbered logically in sequence from 00 to 74, skipping over bad cylinders.
Note: IBM format cylinder 00 cannot be a bad cylinder.

1.3.2. Sector Format. 1.3.2.

Each track is divided into 26,15 or 8 sectors of 128, 256 or 512 bytes length respectively (cylinder 00 is always divided into 26 sectors). The first sector is numbered 01, and is physically the first sector after the physical index mark. The logical sequence of the remaining sectors may be non sequential physically. The location of these is determined at initialization by CPU software.

A sector is the smallest amount of data that can be randomly accessed. It consists of an identification field (ID field) and a data field. All fields are separated by gaps.

1.3.3. Address Marks. 1.3.3.

Address marks are unique bit patterns one byte in length, which are used to identify the beginning of ID and Data fields.

There are four different types of address marks used. Each of these is used to identify different types of fields.

1. The Index Address Mark is located at the beginning of each track in front of the first record.

2. The ID Address Mark is located in the beginning of each ID field on the diskette.

3. The Data Address Mark is located in the beginning of each non-deleted Data Field on the diskette.

4. The Deleted Data Address Mark is located at the beginning of each deleted Data Field on the diskette.

Address Mark Summary	Clock Pattern	Data Pattern
Index Address Mark	D7	FC
ID Address Mark	C7	FE
Data Address Mark	C7	FB
Deleted Data Address Mark	C7	F8

1.3.4. ID Field. 1.3.4.

The ID field consists of 7 bytes with the following definition:

1	2	3	4	5	6	7
ID ADDRESS MARK	CYLINDER ADDRESS	HEAD ADDRESS	SECTOR ADDRESS	SECTOR LENGTH	CRC BYTE 1	CRC BYTE 2

ID Address Mark:	Refer to section 1.3.3.
Cylinder Address:	$(00)_H$ through $(4A)_H$ (Decimal 0 through 74).
Head Address:	$(00)_H$ for one-sided diskettes and side 0 of two sided diskettes. $(01)_H$ for side 1 of two sided diskettes.
Sector Address:	$(01)_H$ through $(1A)_H$ (Decimal 1 through 26).
Sector Length:	$(00)_H$ through $(02)_H$. From this number (called N) the actual sector length is calculated as $128x2^N$.
CRC byte 1 and 2:	See section 1.3.6.

1.3.5. Data Field. 1.3.5.

The data field has the following layout.

DATA FIELD ADDRESS MARK	DATA	CRC BYTE 1	CRC BYTE 2

Data field Address Mark:	See section 1.3.3.
Data:	125, 256 or 512 bytes of data.
CRC byte 1 and 2:	See section 1.3.6.

1.3.6. CRC Character. 1.3.6.

The 16 bit Cyclic Redundancy Check character is generated during a write operation using the generator polynomial $X^{16} + X^{12} + X^5 + 1$, initialized to $(FF)_H$.

It is generated including all characters except the CRC in the ID or Data field, including the data (not the clocks) in the mark. It is recorded and read most significant bit first. The Check Bytes are used during a read operation to verify that data is read correctly.

1.3.7. Bad Track Format.

The bad track format is the same as the good track format except that all ID fields on the bad track is initialized as follows:

Cylinder Address = $(FF)_H$
Head Address = $(FF)_H$
Sector Address = $(FF)_H$
Sector length = $(FF)_H$

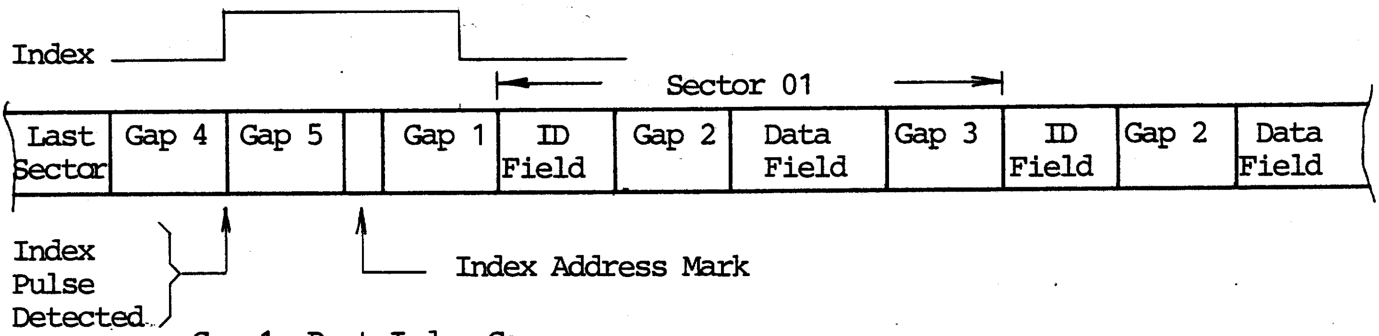
The track number that would have been recorded in the ID fields of the defective track is recorded in the ID fields of the next physical track.

1.3.8. Data Track Gaps.

Fig. 1.3 is a schematic outline of the track format. 5 different gaps are used to separate different fields. The last six bytes of gaps 1, 2, 3 and 5 are $(00)_H$, all other bytes are $(FF)_H$. The size of the gaps may vary but the nominal values are:

Data Field Length	Number of bytes in gap: Gap 1	Gap 2	Gap 3	Gap 4	Gap 5
128	32	17	33	app. 274	46
256	32	17	48	app. 212	46
512	32	17	63	app. 376	46

Gap 4 is written until the leading edge of the index pulse, therefore no exact gap length can be given.



Gap 1: Post Index Gap

$26B(FF)_H$	$6B(00)_H$

Gap 2: Post ID field Gap

$11B(FF)_H$	$6B(00)_H$

Gap 3: Post Data Field Gap

$N_3B(FF)_H$	6B(00)H

Gap 4: Final Gap

$XB(FF)_H$

Gap 5: Pre Index Gap

$40B(FF)_H$	$6B(00)_H$

ID field: 7 bytes

1	2	3	4	5	6	7
ID ADDRESS MARK	CYLINDER ADDRESS	HEAD ADDRESS	SECTOR ADDRESS	SECTOR LENGTH	CRC BYTE 1	CRC BYTE 2

Data field:

DATA FIELD AM	DATA	CRC BYTE 1	CRC BYTE 2

Index Address Mark: 1 byte

Note: B = Bytes, $(\ )_H$ = Hex Byte

Fig. 1.3. Track Format.

On diskettes formatted by certain equipment gap 5 and gap 1 may be combined resulting in a total of $73B(FF)_H$ and $6B(00)_H$. Consequently the index address mark is not present. However, this is of no importance since the index address mark is not used in IBM compatible systems.

1.4. Applicable Documents.

1. RC3603 CPU, Programmers Reference Manual RCSL 52-AA705.

2. The IBM Diskette for Standard Data Interchange, IBM document GA21-9182-1.

3. IBM system 132, Functions Reference Manual, IBM document GA21-9176-0.

4. SA850/851 Double sided Diskette Storage Drive, Shugart Associates. (OEM Manual + Service Manual).

5. IBM Two-sided Diskette Original Equipment Manufacturers Information, IBM document GA21-9257-1.

2. PERFORMANCE CHARACTERISTICS. 2.

The Disk is rotated at a normal speed of 360 RPM, given a full revolution time of 166.67 msec.. Average access time within a track is equal to half the revolution time, i.e. 83.3 msec.

The time for a single track move is 20 msec. including settling time. This is defined as the time required to move the head between any pair of adjacent tracks. Multiple track moves can be made at 6 msec. per step plus 14 msec. settling time.

Settling time is the time required for the head to stabilize after it has been moved.

The time required to read one sector (T_S) depends on the sector length and must be calculated using the formular:

$$T_S = (7 + Gap_2 + \text{Sector Length} + 3 + Gap_3) \cdot 32 \text{ us}$$

(the time required to read one byte equals 32 us).

The random average positioning time is 173 msec. This is defined as the summation of the move times for all possible moves divided by the number of all possible moves.

The maximum positioning time is 471 msec. This is defined as the time required to move the head from track 00 to 76 plus settling time.

The controller automatically loads the heads when data on the diskette is to be accessed. The heads can be loaded when the diskette is fully installed and the front panel door is closed. The head load time is 35 msec.

If more than three revolutions of the disk have occurred without any data transfer or head movements, hardware unloads the heads from the disk surface in order to minimize wear.

For the same reason, the spindle drive motor is turned off, if more than half a minut has elapsed without any data transfer or head movements.

The time for the spindle motor to reach operational speed when turned on again, is approximately 2 sec. The same delay is encounted powering up the drive.

Specification summary:

Capacity (IBM format)

Bytes per sectors	Bytes per track	Bytes per diskette (incl. index track)
128	3328	249600
256	Cylinder 00: 3328 Cylinder 01-74: 3840	One sided: 287488 Two sided: 574976
512	Cylinder 00: 3328 Cylinder 01-74: 4096	306432

Transferrate	31.25 kilobytes/sec.
Track to track head move time	6 msec.
Head settling time	14 msec.
Head load time	35 msec.
Average positioning time (including settling)	173 msec.
Maximum positioning time	471 msec.
Average latency time	83.3 msec.
Maximum latency time	166.6 msec.

Rotational speed	360 rpm
Max. recording density	3408 bpi
Track density	48 tpi
Encoding method	FM

Media	Any IBM compatible diskettes

Ambient Temperature	$4^{o}C - 46^{o}C$
Reletive Humidity	20 - 80 %
AC Power requirement	170 - 253 V/50 HZ, 0.23 Amp
AC frequency tolerance	± 0.5 %
DC Voltage requirements	+24 V ± 10 % , 0.8 Amp
	+5 V ± 5 % , 1.1 Amp
	-5 V ± 5 % , 0.7 Amp

Physical Dimensions (exclusive of front panel):

Height	4.62 in. (117 mm)
Width	8.55 in. (217 mm)
Depth	14.25 in. (363 mm)
Weight	13.0 lbs. (5.91 kg)

Heat Dissipation	195 BTU/hr. (57 W)

3. LOGIC SPECIFICATION.

3.1. Channel Program.

The FDC705 operates by means of channel programs stored in the RC3600 core memory, i.e. the controller fetches instructions in the core memory and executes them. From the programmer's point of view, the four disk drives are four separate devices, i.e. each may run its own program at the same time as the others are running theirs.

Data to be written on or read from the disk are transferred between the core memory and the disk using the DMA channel.

A channel program consists of one command and a number of parameters of which some provides information from the software to the controller, some provides information from the controller to the software, and some serves both purposes.

When the controller has processed the command in the channel program, it notifies the CPU by requesting an interrupt. The controller is then able to answer an INTA instruction (Interrupt acknowledge), i.e. if it is the device physically closest to the processor on the I/O bus requesting an interrupt, the device code of the controller will be transferred to the addressed accumulator.

To identify the channel program (i.e. disk drive) that caused the interrupt, the Interrupt Identification Register in the controller can be sensed by a DIA instruction (section 3.3.). The interrupt must now be cleared by means of a DOA instruction (section 3.4.).

Before each interrupt the paramters in the channel program containing information from the controller to the software are updated.

After the interrupt has been cleared, the execution of a new channel program is started by means of a DOA instruction.

At the time of initialization the software must transfer a Base Address to the controller by means of a DOB instruction (section 3.2.). The Base Address is the address of the first location of a four word channel program address buffer area in the core memory. The contents of each location in this buffer area is the address of the first location of a channel program. Fig. 3.1. shows the structure of the channel program addresses.

Only the base address is transferred to the controller by programmed I/O transfer. The controller will fetch the relevant addresses when needed. This implies that the base address must not be altered while the controller is executing a channel program.

It should be pointed out that even though unit 0 and unit 2 (or unit 1 and unit 3) can not be physically operated simultaneously, a channel program for each unit may be started at the same time.

The FDC705 is assigned device code 61 (second device code 64) and interrupt mask out bit 7.

The normal I/O clear function (NIOC) clears all 4 channel program executions and resets all control logic in the controller. The disk drives will also be reset, i.e. the heads are moved to track 00.

The function of an IORST instruction is identical to that of an NIOC.

The I/O start function (NIOS) is used to autoload the system from flexible disk. After the controller has been reset by either an NIOC or an IORST instruction the start function causes the 26 sectors located on track 00, side 0, on unit 0 to be transferred to memory location 0-3177 octal. Once the controller has performed this autoload function or a normal channel program has been started, the I/O start function is ignored.

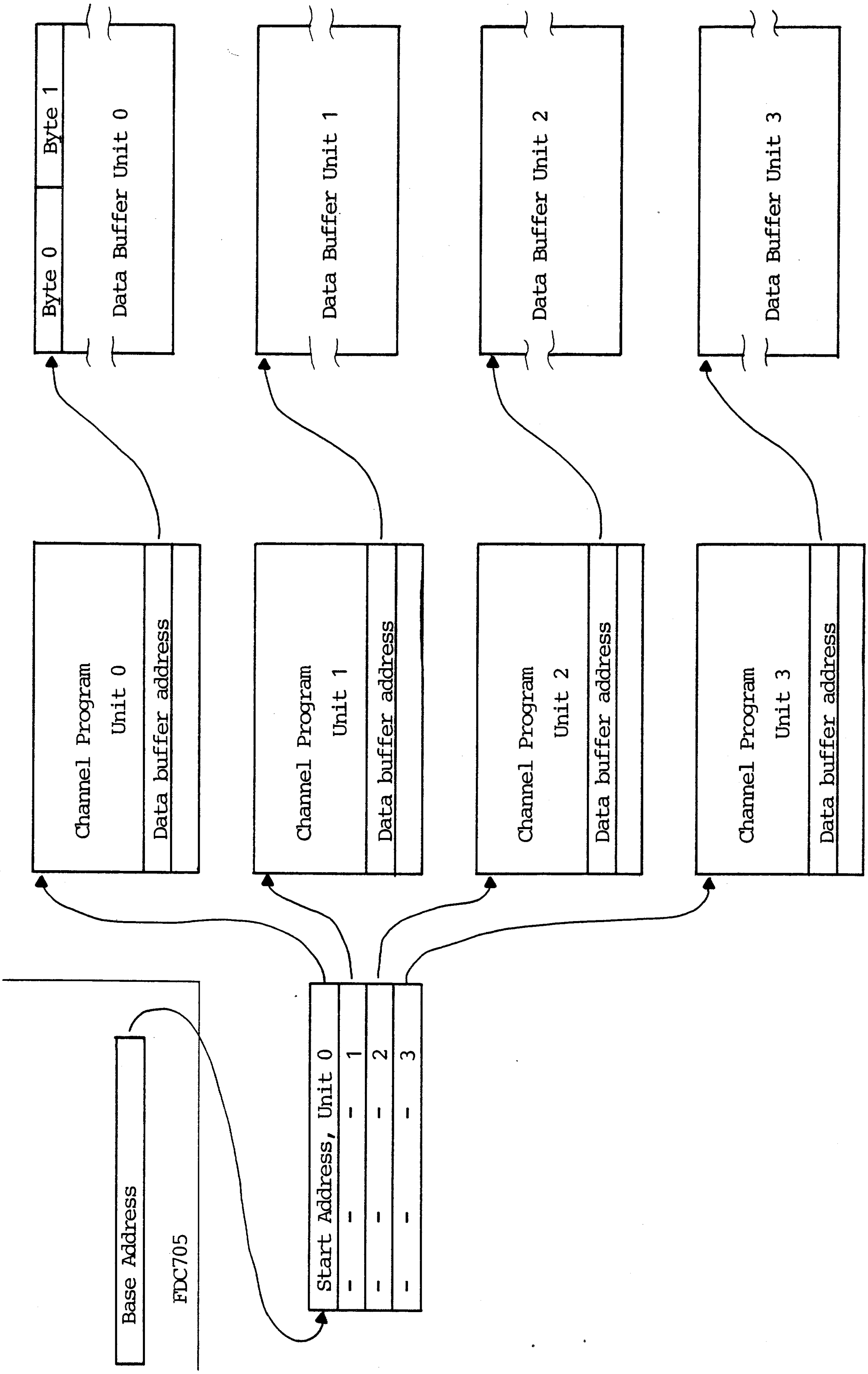


Fig. 3.1. Core Memory layout.

3.2. Base Address Register. 3.2.

DOB instruction

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	1	1	AC		1	0	0	F		1	1	0	0	0	1

Contents of AC

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
BASE ADDRESS															

The DOB instruction loads the contents of AC (accumulator) into the Base Address Register.

This instruction must be used when power has been off and for initial use of the controller. The Base Address Register will remain set until changed by another DOB instruction.

The base address is the first address of the four word channel program address area in the core memory.

3.3. Interrupt Identification Register. 3.3.

DIA instruction

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	1	1	AC		0	0	1	F		1	1	0	0	0	1

Contents of AC

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
IRRELEVANT												I0	I1	I2	I3

The DIA instruction loads AC (accumulator) with the contents of the Interrupt Identification Register.

If IX is set, channel program X has sent interrupt. These bits are cleared by a DOA instruction (section 3.4.). The controller will request an interrupt as long as one or more of the IX bits is set.

3.4. Selection of Drive.

DOA instruction

0	1	1	AC		0	1	0	F		1	1	0	0	0	1
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Contents of AC

0	0	0	0	0	0	0	0	0	0	0	0	0	S	UNIT	
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

This instruction selects the disk drive (and corresponding channel program) and performs the function specified by S. The UNIT field is the binary coded unit number.

S (bit 13): 1: Start Channel Program

0: Clear Interrupt or/and stop channel program execution.

If S = 0 this instruction operates on the Interrupt Identification Register which indicates the channel programs that have given interrupt (see DIA instruction).

3.5. Channel Program Commands.

A channel program consists of 12 bytes of which the first two are interpreted as a command. The last two bytes make up a status word, stored in memory by the controller when the execution of the channel program is terminated. The definition and use of the remaining 8 bytes depends on the command and will be described in connection with each command.

The command repertoire of the FDC705 is made up by the following commands:

- Read Sectors
- Write Sectors
- Verify Sectors
- Recalibrate
- Load Bad Cylinders
- Load Code Converter
- Clear Code Converter
- Track format
- Read ID fields
- Read Bad Cylinders
- Read Code Converter
- Read Track

A description of the Channel Program Status Word (common to all commands) is given in section 3.6.

3.5.1. Read Sectors. 3.5.1.

The Read Sectors command transfers data from a specified group of diskette sectors to memory.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
D	0	1	1	0	0	0	0	1	0	1	1	0	0	0	1
SECTORS PER TRACK								CYLINDER ADDRESS							
S	SECTOR ADDRESS							NUMBER OF SECTORS							
NUMBER OF BYTES															
DATA BUFFER ADDRESS															
STATUS WORD															

Fig. 3.5.1. Read Sectors Channel Program Layout.

Fig. 3.5.1. shows the layout of a Read Sectors channel program. In the following a description of each byte is provided.

<u>Byte 0 and 1: Read Sectors Command code</u>

D (bit 0): When set, deleted sectors as well as non-deleted sectors are transferred to memory. When reset, deleted sectors are skipped.

The command word is not altered during the execution of the command.

Byte 2: Sectors per track.

This byte contains the octal number of sectors on the track. For IBM compatible diskettes the number must be

Sector Length	Sectors per track
128_{10}	32_8 (= 26_{10})
256_{10}	17_8 (= 15_{10})
512_{10}	10_8 (= 8_{10})
1024_{10}	N/A

The sectors per track byte is not altered during execution of the command.

Byte 3: Cylinder Address

This byte specifies the cylinder number from which sectors are to be read. This byte is not altered during the execution of the command.

Byte 4: Sector Address

The Sector Address is the number of the first sector which is to be read.

S (bit 0): When reset surface 0 is selected, when set surface 1 is selected.

At termination of the channel program the value of this byte is one greater than the address of the last sector read (or skipped, if in the skip deleted sector mode).

Byte 5: Number of sectors

This byte specifies the number of sectors which are to be read from the diskette.

At termination of the channel program this byte contains the initial value minus the number of sectors read.

If in the skip deleted sector mode, deleted sectors are not counted nor read.

Byte 6 and 7: Number of bytes

This sixteen bit word contains the maximum number of bytes which are to be transferred to memory.

If the specified number of bytes are transferred before the specified number of sectors are read the Block Length Error status bit will be set and no more bytes will be transferred. Still the controller continues to read from the diskette, checking for valid CRC.

At completion, this word contains the initial value minus the number of bytes read.

Byte 8 and 9: Data buffer address

This is a sixteen bit address, pointing to the first word of the data buffer area. (Refer to fig. 3.1.).

At termination the contents of this word is one greater than the address to which the last byte has been transferred.

Byte 10 and 11: Status Word

The Status Word does not contain any relevant information until the channel program execution is terminated. At this time the status word is written by the controller.

For a description of the status word refer to section 3.6.

The controller starts a read sectors command by positioning the heads, using the specified bad cylinders to compute the physical cylinder. Then sectors are read from the diskette, starting with the sector specified in byte 4. Before each byte is transferred to memory, a code conversion is performed using the internal hardware code converter.

The command is terminated and an interrupt is requested as a respond to one of the following events:

1. The specified number of bytes and sectors has been transferred.
2. The sector address has exceeded the number of sectors per track, but the specified number of sectors has not yet been transferred. This means that the remaining sectors must be found on another track.
3. An error has occured during the execution of the command.

3.5.2. Write Sectors. 3.5.2.

The Write Sectors command transfers data from memory to a specified group of diskette sectors.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
D	0	1	1	1	1	0	0	1	0	1	1	0	0	0	1
SECTORS PER TRACK								CYLINDER ADDRESS							
S	SECTOR ADDRESS							NUMBER OF SECTORS							
NUMBER OF BYTES															
DATA BUFFER ADDRESS															
STATUS WORD															

Fig. 3.5.2. Write Sectors Channel Program Layout.

Fig. 3.4.2. shows the layout of a Write Sectors channel program. In the following each byte in the program is described.

Byte 0 and 1: Write Sectors Command code

D (bit 0): When set, sectors are written with a deleted data address mark in the beginning of each data field. When reset normal address marks are written.

The command word is not altered during the execution of the command.

Byte 2: Sectors per Track

Refer to the Read Sectors command.

Byte 3: Cylinder Address

Refer to the Read Sectors command.

Byte 4: Sector Address

The sector address is the number of the first sector on which data are to be written.

S (bit 0): When reset surface 0 is selected, when set surface 1 is selected.

At termination of the channel program the value of this byte is one greater than the address of the last sector written.

Byte 5: Number of Sectors

This byte specifies the number of sectors to be written on the track.

At termination of the channel program this byte contains the inital value minus the number of sectors written.

Byte 6 and 7: Number of bytes

This sixteen bit word contains the maximum number of bytes which are to be written on the diskette.

If the specified number of bytes are written before the specified number of sectors are written, the block length error status bit will be set and all zeros will be written on the rest of the current sector.

Byte 8 and 9: Data buffer Address

Refer to the Read Sectors command

Byte 10 and 11: Status word

Refer to the Read Sectors command.

The execution characteristics of the write sectors command is quite simular to those of the read sectors command.

3.5.3. Verify Sectors. 3.5.3.

The Verify sectors command is used to check that a specified group of sectors has been written correctly through verifying the CRC characters. No data is transferred between memory and the diskette.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
D	0	1	1	1	0	1	0	1	0	1	1	0	0	0	1
SECTORS PER TRACK								CYLINDER ADDRESS							
S	SECTOR ADDRESS							NUMBER OF SECTORS							
IRRELEVANT															
IRRELEVANT															
STATUS WORD															

Fig. 3.5.3. Verify sectors channel program layout.

The verify sectors command is identical to a Read Sectors command except that data is not transferred to memory. Therefore the number of bytes and the data buffer address parameters are irrelevant.

3.5.4. Recalibrate.

The Recalibrate command moves the heads of the selected drive to cylinder 00 by applying step out pulses to the drive until the cylinder 00 photosensor becomes active.

0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1
IRRELEVANT															
IRRELEVANT															
IRRELEVANT															
IRRELEVANT															
STATUS WORD															
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Fig. 3.5.4. Recalibrate channel program layout.

The controller performs a recalibrate operation whenever the drive has been off-line, power has been off or the controller is cleared.

3.5.5. Load Bad Cylinders.

If the diskette makes use of the alternate cylinders, this command is used to specify the bad cylinders.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	1	0	0	0	0	1	0	1	1	0	0	0	1
BAD CYLINDER NO 1								BAD CYLINDER NO 2							
IRRELEVANT															
IRRELEVANT															
IRRELEVANT															
STATUS WORD															

Fig. 3.5.5. Load Bad Cylinders channel program layout.

Byte 2 and 3 contains the numbers of the physical cylinders that are bad.

If the diskette contains only one bad cylinder, byte 3 (Bad cylinder No. 2.) must be set to 377 octal.

If no bad cylinders are present both byte 2 and 3 is set to 377 octal. In this case the command is redundant since no bad cylinders is assumed each time the drive has been off-line, the power has been off or the controller has been cleared.

Bad cylinder number 1 must be numerically less than bad cylinder number 2.

3.5.6. Load Code Converter.

This command is used to load the hardware code converter from memory.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	1	0	0	0	0	0	0	1	0	1	1	0	0	0	1
IRRELEVANT															
IRRELEVANT															
IRRELEVANT															
DATA BUFFER ADDRESS															
STATUS WORD															

Fig. 3.5.6.1 Load Code Converter channel program layout.

The command causes 256 bytes to be transferred from the specified data buffer area to the code converter. Fig. 3.5.6.2. shows a layout of the core memory data buffer.

Address	Contents	
B	y(0)	y(1)
B + 1	y(2)	y(3)
B + 2	y(4)	y(5)
	⋮	⋮
B + 176	y(374)	y(375)
B + 177	y(376)	y(377)

Fig. 3.5.6.2. Core Memory conversion table layout. All numbers are octal.

During write operations the character x is converted to the character y(x) before written on the diskette.

When reading, the character z read from the diskette is converted to the character y(z) before it is transferred to memory.

When the channel program is terminated, the data buffer address equals the initial value plus 200 octal.

3.5.7. Clear Code Converter. 3.5.7.

If no code conversion is wanted this command is used to clear the code converter. Clearing the code converter means that a one to one conversion is used. I.e. y(x):= x.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	1	1	0	0	0	0	0	1	0	1	1	0	0	0	1
IRRELEVANT															
IRRELEVANT															
IRRELEVANT															
IRRELEVANT															
STATUS WORD															

Fig. 3.5.7. Clear Code Converter channel program layout.

If the controller is reset and if power has been off, the code converter is reset. An off-line status will <u>not</u> clear the code converter.

3.5.8. Track Format.

The track format command is used to initialize an IBM compatible diskette track.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	1	0	1	0	1	0	1	0	1	1	0	0	0	1
IRRELEVANT								CYLINDER ADDRESS							
S	IRRELEVANT														
NUMBER OF BYTES															
DATA BUFFER ADDRESS															
STATUS WORD															

Fig. 3.5.8. Track format channel program layout.

The execution of this command requires a complete track image stored in the core memory data buffer.

Byte 4, bit 0 (S): When set surface one is selected, when reset surface zero is selected.

The controller starts the execution of this command by positioning the heads, using the specified bad cylinders to compute the physical cylinder.

Upon receipt of the leading edge of the first encountered index pulse the controller starts writing the track image store in memory on the diskette. Writing continues until the next index pulse.

If the specified number of bytes are written before the next index pulse is detected, the block length error status bit will be set, and all ones will be written on the rest of the track. If the next index pulse is detected before the specified number of bytes are written, the block length error status bit is not set.

At termination the value of the Number of Bytes parameter equals the initial value minus the number of bytes written on the diskette. The value of the Data Buffer Address is one greater than the address from which the last byte has been read.

For a description of the track layout refer to section 1.3.

In order to generate the missing clock pulses in the address marks, the controller detects certain byte patterns in the outgoing data stream.

The CRC characters are generated in the controller during the execution of the command. The CRC generator is initialized to all ones just before any data byte from $F8_H$ TO FE_H is about to be transferred to the diskette. Two CRC characters in written if one byte of $F7_H$ is detected. (The $F7_H$ byte is not written).

Special formatting bytes summary	Byte from memory	Data/Clock written on the diskette
Write Index Address Mark	FC	FC/D7
Write ID Address Mark	FE	FE/C7
Write Data Address Mark	FB	FB/C7
Write Deleted Data AM	F8	F8/C7
Write Two CRC characters	F7	Two CRC bytes

Note: Since data is transferred through the code converter, the code converter must normally be cleared prior to this command.

3.5.9. Read ID Fields.

This command transfers a specified group of ID fields to memory.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	1	0	0	1	0	0	1	0	1	1	0	0	0	1
SECTORS PER TRACK								CYLINDER ADDRESS							
S	IRRELEVANT							NUMBER OF ID FIELDS							
NUMBER OF BYTES															
DATA BUFFER ADDRESS															
STATUS WORD															

Fig. 3.5.9. Read ID fields channel program layout.

The controller starts a Read ID Fields command by positioning the heads, using the specified bad cylinders to compute the physical cylinder. Then ID fields are read off the diskette, starting with the first ID field after Index. Only six bytes is transferred from each ID field, i.e. the ID address mark is not transferred.

Although the CRC characters are transferred to memory, the controller checks for validity and the CRC error status bit will be set (but the command is not terminated) in case of CRC errors.

The use and definition of the different parameters are similar to those of the Read Sectors command.

Note: Since data is transferred through the code converter, the code converter must normally be cleared prior to this command.

3.5.10 Read Bad Cylinders. 3.5.10

The Read Bad Cylinders command is used to read the numbers of the previously loaded bad cylinders.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	1	1	0	0	0	1	0	1	1	0	0	0	1
Irrelevant															
Bad Cylinder No. 1								Bad Cylinder No. 2							
Irrelevant															
Irrelevant															
Status word															

Fig. 3.5.10 Read Bad Cylinders Channel Program Layout.

Byte 4 and 5 are returned from the controller at completion of the command and contain the numbers of the physical cylinders that are treated as bad cylinders by the controller.

If an off-line status is returned, byte 4 and 5 contains the bad cylinders used by the controller before the command was executed.

3.5.11 Read Code Converter. 3.5.11

The read code converter command is used to transfer the current contents of the code converter into core memory.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	1	0	1	0	0	0	0	1	0	1	1	0	0	0	1
Irrelevant															
Irrelevant															
Irrelevant															
Data Buffer Address															
Status word															

Fig. 3.5.11 Read Code Converter channel program layout.

The command causes 256 bytes to be transferred from the code converter to the specified data buffer area in core memory. The data buffer format is identical to that of the load code converter command (section 3.5.6.)

3.5.12. Read Track.

The read Track Command is used to read an entire track, including gabs, ID fields, address marks and CRC characters.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	1	0	0	0	1	D	1	0	1	1	0	0	0	1
Irrelevant								Cylinder Address							
S	Irrelevant														
Number of bytes															
Data Buffer Address															
Status word															

Fig. 3.5.12. Read track channel program command layout.

The controller starts the execution of this command by positioning the heads, using the specified bad cylinders to compute the physical cylinder.

Byte 4, bit 0 (S): When set, surface one is selected, when reset, surface zero is selected.

Upon receipt of the leading edge of the first encountered index pulse the controller starts reading the track, transferring the data to the core memory data buffer. Reading continues until the next index pulse is detected or the specified number of bytes have been transferred (Block length error status bit set).

If the next index pulse is detected before the specified number of bytes are read, the block length error status bit is not set.

Byte 0, bit 7 (D): When set, the accumulation of bytes is synchronized to each Address Mark encountered. When set no synchronization is done.

3.5.13. Command Summary.

Fig. 3.5.13. summarizes the characteristics of the various commands. In the following a short explanation of each column in the table is given.

1. Drive Ready Check.
   This column indicates if the ready status from the selected drive is checked before the command is executed. A not ready state is latched by the drive until the controller reads the drive status.

   Those commands marked "NO" in this column are executed even if the drive is not ready. Still, the not ready (off-line) status is transferred to the channel program and updated at completion of the command.

2. Write protect check.
   Commands marked "YES" in this column are aborted - after the heads have been positioned and the track verified - if the diskette is write protected.

3. Seek check.
   Many of the commands cause a seek to the desired track. Operations that perform Seek Check verify that the head is correctly positioned by reading the cylinder address part of the first encountered ID field.

4. Head.
   This column specifies whether the Read/Write heads will be loaded or not. If LOAD is specified, the heads will be loaded during the end of the seek operation. Once loaded the heads remain loaded until three Index pulses have been detected, or until the other drive in the same daisy chain is selected.

Command	1 Drive Ready Check	2 Write Protect Check	3 Seek Check	4 Head	5 Command Code (octal)
Read sectors	YES	NO	YES	load	D30261
Write sectors	YES	YES	YES	load	D36261
Verify sectors	YES	NO	YES	load	D35261
Recalibrate	NO	NO	NO	unload	000261
Load bad cylinder	YES	NO	-	no change	010261
Load Code converter	NO	NO	-	no change	040261
Clear Code converter	NO	NO	-	no change	060261
Track format	YES	YES	NO	load	025261
Read ID	YES	NO	NO	load	022261
Read Bad Cylinders	YES	NO	-	no change	014261
Read Code Converter	NO	NO	-	no change	050261
Read Track	YES	NO	NO	load	123261

Fig. 3.5.13. Command Summary Table

3.6. The Status Word.

The status word is updated and written in the last location of the channel program at completion of each program. The status word has the following layout:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
N	N	N	N	N	N	N	0	N	N	N	0	N	0	0	0

Bit No.	Mnemonic
0	Hardware Error
1	Off-line
2	Remaining Sectors
3	Seek Error
4	Deleted Data
5	Write Protect
6	Illegal Command
8	Block Length Error
9	Data Late
10	CRC Error
12	Position Error

The status bits are flag signal and the mnemonics refer to the active onestate. The meaning of each status bit is explained in detail below.

3.6.1. Hardware Error. (Bit 0).

Indicates the controller and/or the drive is malfunctioning. All errors which cannot be classified among the other status signals are covered by this bit.

3.6.2. Off-line. (Bit 1). 3.6.2.

Indicates that the diskette drive has been off-line (not ready) in the period since status previously was updated.

The drive is considered off-line if

1. The Door is open
2. No diskette is loaded into the drive
3. The drive power is off
4. The drive is disconnected

Whenever an off-line status is returned to the channel program, the controller recalibrates the drive and resets the bad cylinder registers.

3.6.3. Remaining Sectors. (Bit 2). 3.6.3.

At completion of a Read-, Write- or Verify Sectors channel program this bit indicates that the specified number of sectors have not been processed. If no other status bits are set the channel program execution has been successful so far, but the remaining sectors must be found on another track.

At completion of a Read ID Fields channel program this bit indicates equivalently that the specified number of ID fields have not been read.

3.6.4. Seek Error. (Bit 3). 3.6.4.

Indicates that the desired track was not verified.

During a Read-, Write- or Verify command the track is verified by reading the cylinder address part of the first encountered ID field.

At completion of a Recalibrate channel program this bit is set if the heads have not been positioned to cylinder 00 before 256 step out pulses have been applied to the head positioning stepper motor. (Execution time: app. 1.5 sec.).

3.6.5. Deleted Data. (Bit 4).

Indicates that data fields with a deleted data address mark have been encountered during the execution of a Read- or Verify Sectors channel program.

3.6.6. Write Protect. (Bit 5).

Indicates that an attempt has been made to write on a write protected diskette.

3.6.7. Illegal Command. (Bit 6).

Indicates one of the following errors:

1. The channel program contained a non implemented command code.
2. An attempt has been made to write on a write protected diskette (bit 5 set as well).
3. An attempt has been made to access side two on a single sided diskette.

3.6.8. Block Length Error. (Bit 8).

Indicates that the specified number of bytes have been transferred before the specified number of sectors have been processed, or visa versa.

3.6.9. Data Late. (Bit 9).

Indicates the data channel has not been able to acknowledge an access request from the controller within a proper time. The transferred data are invalid.

3.6.10. CRC Error. (Bit 10).

Indicates that an invalid CRC character has been encounted during the execution of the channel program. Both ID field CRC errors and data field CRC errors are covered by this bit.

All commands, except the Read ID fields, are terminated immediately after a CRC error is detected. (Even if the invalid CRC character is encountered while searching for the correct sector).

3.6.11. Position Error. (Bit 12). 3.6.11.

Indicates one of the following error conditions:

1. Track address not verified (bit 3 set as well).
2. No correct ID field encountered during three revolutions of the diskette. A correct ID field must contain the correct cylinderaddress, the correct sector address and a valid CRC character.
3. The data address mark was not encountered within 28 bytes of the correct ID field.

4. OPERATION.

4.1. Diskette Loading.

Remove the diskette from the storage envelope. Depress latch. Carefully slide diskette into Disk Drive with the label facing up until jacket is solidly seated against stop. Press the latch handle down to lock the diskette on the drive spindle. Protect the empty envelope from liquids, dust and other foreign materials.

4.2. Diskette Unloading.

Depress latch. Remove the diskette from the disk drive and put it in the storage envelope.

4.3. Diskette Handling.

1. Return the diskette to its storage envelope whenever it is removed from file.

2. Keep cartridges away from magnetic fields and from ferromagnetic materials which might become magnetized. Strong magnetic fields can distort recorded data on the disk.

3. Replace storage envelopes when they become worn.

4. Do not write on the plastic envelope with a pencil or ball point pen. Use a filt tip pen.

5. Do not expose diskettes to heat or sunlight. Storage temperature should be in the interval from 10^{o}C to 50^{o}C (50^{o}F to 125^{o}F).

6. Do not touch or attempt to clean the disk surface.

7. If the diskette is stored vertically, support the diskette so it do not lean or lag.

4.4. Write-Protected Diskettes. 4.4.

To write-protect a diskette a notch must be punched out as specified in figure 4.4.

The write-protect notch is closed by placing a tab over the front of the hole, and the tab folded over covering the back of the hole.

When the hole is open the diskette is write-protected; when covered, writing is allowed.

A diskette may temporarily be write-protected by pressing the write-protect push button to light.

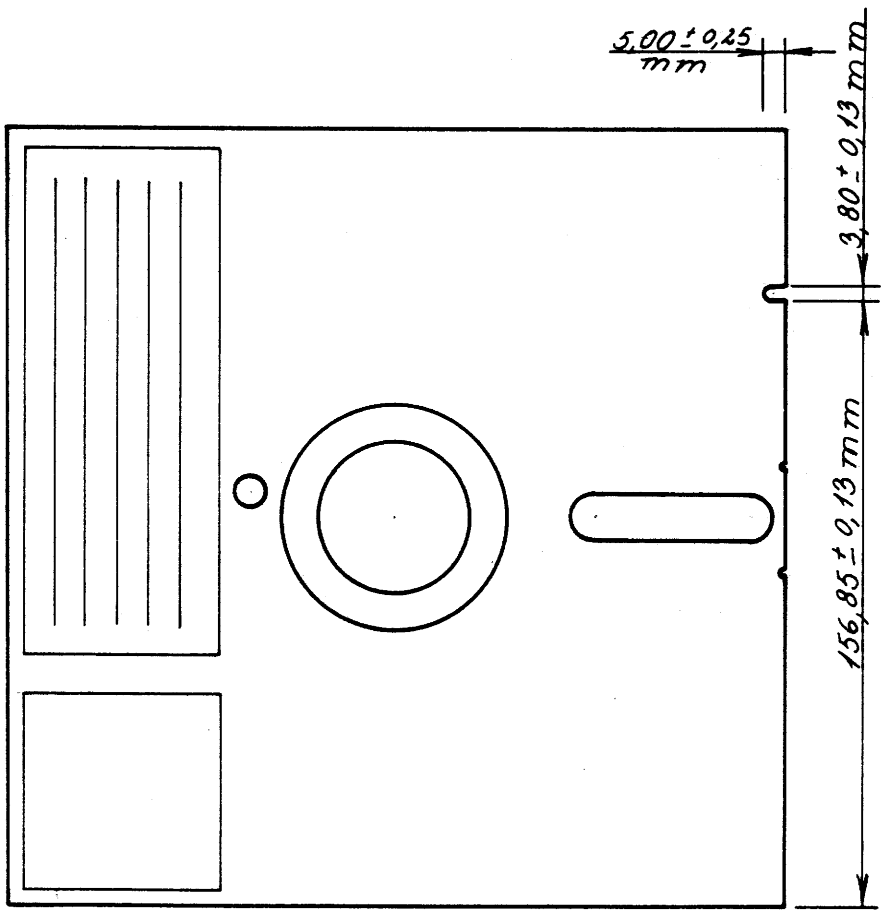


Fig. 4.4.

4.5. Indicators and Switches.

4.5.1. Activity Indicator.

This light emitting diode (LED) mounted in the push bar on the front panel is illuminated whenever the head is loaded. As the head is loaded only in connection with disk operations, the LED indicates that the drive is in use.

4.5.2. Write-Protect. (pushbutton/indicator).

When pressed to light, all write operations are inhibited. When depressed (no light), write operations are allowed provided that the diskette does not have a write-protect hole in the jacket (see section 4.4.).