STANDARD
MICROSYSTEMS
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TECHNICAL NOTE TN 6-6

Programming the FDC765A, FDC9266 and FDC9267

by David Cragg

Introduction

This technical note describes how to program the Standard Microsystems line of industry-standard floppy disk controllers based on the industry-standard FDC765A. Devices covered by this technical note include:

FDC765A	Industry-Standard Floppy Disk Controller
FDC9266	Enhanced Floppy Disk Controller and Data Separator
FDC9267	Enhanced Floppy Disk Controller and High-Performance Analog Data Separator

Because all of the above devices share a common command syntax, the system designer and software engineer are given the flexibility of selecting the level of performance and integration required.

This manual describes, in detail, each of the 15 commands the FDC is capable of executing. A simple flow chart details the steps a programmer must follow to insure reliable operation of the device. In addition, a narrative description of each command and a “command map” (similar to a register file) are included for each command.

The FDC765A and its derivatives all follow a consistent command syntax. Each command can be best though of as having three distinct “phases”. It is important to remember that each phase must be executed entirely. The three phases and their functions are listed below:

COMMAND PHASE	Receive command byte and parameters from host microprocessor
EXECUTION PHASE	FDC performs requested command
RESULT PHASE	Host microprocessor MUST read out ALL status bytes from the FDC

The consistent structure of the commands allows system programmers to easily implement the FDC into a wide variety of popular operating systems, including UNIX, MS-DOS®, and CP/M™.

If you need additional information or technical assistance, please contact your local SMSC representative or field applications engineer.

Standard Microsystems Corporation
80 Arkay Drive
Hauppauge, NY 11788
516-435-6000
516-231-6004 FAX

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READ DATA

The FDC loads the head, waits the specified head setting time, and begins reading ID Address Marks and ID fields. When the current sector number ("R") stored in the internal ID Register (IDR) matches the sector number read off the diskette, the FDC outputs data (from the data field) byte-by-byte to the main system via the data bus.

Command Phase:	Call FDCBusyW subroutine ↓ Output Read Data command ↓ Call FDCBusyW subroutine ↓ Output Disk Drive Select • head (bit 2) • drive (bits 1,0) ↓ Call FDCBusyW subroutine ↓ Output Cylinder Number desired 0-76 ↓ Call FDCBusyW subroutine ↓ Output Head Number 0-1 desired ↓ Call FDCBusyW subroutine ↓ Output Sector Number desired ↓ Call FDCBusyW subroutine ↓ Output Data Bytes in the sector (0=128, 1=256, etc.) ↓ Call FDCBusyW subroutine ↓ Output last sector to read on the track ↓ Call FDCBusyW subroutine ↓ Output length of Gap 3 ↓ Call FDCBusyW subroutine ↓ Output data length in bytes if N=00 (Normally set to FF)
Execution Phase:	Data is transferred between the floppy disk drive and the main system using DMA, Polled or Interrupt modes. The user must issue TC prior to reading the last data byte.
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 1) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 2) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current head number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Sector number of last sector read) ↓ Call FDCBusyR subroutine ↓ Read Data Register (number of data bytes)

READ DATA

Command Phase: Read Data Word

MT	MF	SK	0	0	1	1	0
X	X	X	X	X	Head	Drive Unit Select	
Cylinder Number 0-76							(C)
Head number 0 or 1 as specified in ID field							(H)
Sector number							(R)
Number of data bytes in sector (0=128, 1=256, etc.)							(N)
The last sector number to be read							(EOT)
Gap 3 Length							(GPL)
Data length in bytes if N=00 (Normally set to FF)							(DTL)

Execution Phase: Data is transferred between the floppy disk drive and the main system using DMA, Polled or Interrupt modes. The user must issue TC prior to reading the last data byte.

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (Status Register 1)	(ST 1)
Read Data Register (Status Register 2)	(ST 2)
Read Data Register (New Cylinder Number)	(C)
Read Data Register (Head Number)	(H)
Read Data Register (Sector Number)	(R)
Read Data Register (Number of data bytes written)	(N)

Command Word Abbreviations:

MT Multi-Track. If MT is high, a multi-track operation is to be performed.
MF FM or MFM Mode. If MF is low, FM mode is selected, and if high MFM mode is selected.
SK Skip. SK stands for Skip Deleted Data Mark.

READ DELETED DATA

This command is the same as the Read Data Command except that when the FDC detects a Data Address Mark at the beginning of a Data Field and SK=0 (low), it will read all the data in the sector and set the CM flag in Status Register 2 to a 1 (high) and then terminate the command. If SK=1, then the FDC skips the sector with the Data Address Mark and reads the next sector.

Command Phase:	Call FDCBusyW subroutine ↓ Output Read Deleted Data command ↓ Call FDCBusyW subroutine ↓ Output Disk Drive Select • head (bit 2) • drive (bits 1,0) ↓ Call FDCBusyW subroutine ↓ Output Cylinder Number desired 0-76 ↓ Call FDCBusyW subroutine ↓ Output Head Number 0-1 desired ↓ Call FDCBusyW subroutine ↓ Output Sector Number desired ↓ Call FDCBusyW subroutine ↓ Output Data Bytes in the sector (0=128, 1=256, etc.) ↓ Call FDCBusyW subroutine ↓ Output last sector to read on the track ↓ Call FDCBusyW subroutine ↓ Output length of Gap 3 ↓ Call FDCBusyW subroutine ↓ Output data length in bytes if N=00 (Normally set to FF)
Execution Phase:	Data is transferred between the floppy disk drive and the main system using DMA, Polled or Interrupt modes. The user must issue TC prior to reading the last data byte.
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 1) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 2) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current head number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Sector number of last sector read) ↓ Call FDCBusyR subroutine ↓ Read Data Register (number of data bytes)

READ DELETED DATA

Command Phase: Read Deleted Data Word

MT	MF	SK	0	1	1	0	0
X	X	X	X	X	Head	Drive Unit Select	
Cylinder Number 0-76							(C)
Head Number 0 or 1 as specified in ID field							(H)
Sector Number							(R)
Number of data bytes in sector (0=128, 1=256, etc.)							(N)
The last sector number to be read							(EOT)
Gap 3 Length							(GPL)
Data length in bytes if N=00 (Normally set to FF)							(DTL)

Execution Phase: Data is transferred between the floppy disk drive and the main system using DMA, Polled or Interrupt modes. The user must issue TC prior to reading the last data byte.

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (Status Register 1)	(ST 1)
Read Data Register (Status Register 2)	(ST 2)
Read Data Register (New Cylinder Number)	(C)
Read Data Register (Head Number)	(H)
Read Data Register (Sector Number)	(R)
Read Data Register (Number of data bytes written)	(N)

Command Word Abbreviations:

MT Multi-Track. If MT is high, a multi-track operation is to be performed.
MF FM or MFM Mode. If MF is low, FM mode is selected, and if high MFM mode is selected.
SK Skip. SK stands for Skip Deleted Data Mark.

WRITE DATA

The FDC loads the head (if it is in the unloaded state), waits the specified Head Setting Time (defined in the Specify Command), and begins reading ID fields. When all four bytes loaded during the command (Cylinder Number, Head Address, Sector Number, Number of Data Bytes written in a sector) match the four bytes of the ID field from the diskette, the FDC takes data from the processor (or DMA controller) byte-by-byte via the data bus and outputs it to the Floppy Disk Drive.

Command Phase:	Call FDCBusyW subroutine ↓ Output Write Data command ↓ Call FDCBusyW subroutine ↓ Output Disk Drive Select • head (bit 2) • drive (bits 1,0) ↓ Call FDCBusyW subroutine ↓ Output Cylinder Number desired 0-76 ↓ Call FDCBusyW subroutine ↓ Output Head Number 0-1 desired ↓ Call FDCBusyW subroutine ↓ Output Sector Number desired ↓ Call FDCBusyW subroutine ↓ Output Data Bytes in the sector (0=128, 1=256, etc.) ↓ Call FDCBusyW subroutine ↓ Output last sector to write on the track ↓ Call FDCBusyW subroutine ↓ Output length of Gap 3 ↓ Call FDCBusyW subroutine ↓ Output data length in bytes if N=00 (Normally set to FF)
Execution Phase:	Data is transferred between the main system and floppy disk drive using DMA, Polled or Interrupt modes. The user must issue TC prior to writing the last data byte.
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 1) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 2) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current head number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Sector number of last sector written) ↓ Call FDCBusyR subroutine ↓ Read Data Register (number of data bytes)

WRITE DATA

Command Phase: Write Data Word

MT	MF	0	0	0	1	0	1
X	X	X	X	X	Head	Drive Unit Select	
Cylinder Number 0-76							(C)
Head number 0 or 1 as specified in ID field							(H)
Sector number							(R)
Number of data bytes in sector (0=128, 1=256, etc.)							(N)
The last sector number to be read							(EOT)
Gap 3 Length							(GPL)
Data length in bytes if N=00 (Normally set to FF)							(DTL)

Execution Phase: Data is transferred between the main system and floppy disk drive using DMA, Polled or Interrupt modes. The user must issue TC prior to writing the last data byte.

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (Status Register 1)	(ST 1)
Read Data Register (Status Register 2)	(ST 2)
Read Data Register (New Cylinder Number)	(C)
Read Data Register (Head number)	(H)
Read Data Register (Sector number)	(R)
Read Data Register (Number of data bytes written)	(N)

Command Word Abbreviations:

MT Multi-Track. If MT is high, a multi-track operation is to be performed.
MF FM or MFM Mode. If MF is low, FM mode is selected, and if high MFM mode is selected.
SK Skip. SK stands for Skip Deleted Data Mark.

READ A TRACK

This command allows the FDC to read physically consecutive sectors from the disk. Immediately after encountering the Index Hole, the FDC starts reading all data fields on the track as continuous blocks of data. If the FDC finds an error in the ID or Data CRC check bytes, it continues to read data from the track. This command terminates when the number of sectors read equals EOT.

Command Phase:	Call FDCBusyW subroutine ↓ Output Read a Track command ↓ Call FDCBusyW subroutine ↓ Output Disk drive select • head (bit 2) • drive (bits 1,0) ↓ Call FDCBusyW subroutine ↓ Output Cylinder Number desired 0-76 ↓ Call FDCBusyW subroutine ↓ Output Head Number 0-1 desired ↓ Call FDCBusyW subroutine ↓ Output Sector Number desired ↓ Call FDCBusyW subroutine ↓ Output Data Bytes in the sector (0=128, 1=256, etc.) ↓ Call FDCBusyW subroutine ↓ Output last sector to read on the track ↓ Call FDCBusyW subroutine ↓ Output length of Gap 3 ↓ Call FDCBusyW subroutine ↓ Output data length in bytes if N=00 (Normally set to FF)
Execution Phase:	Data is transferred between the main system and floppy disk drive using DMA, Polled or Interrupt modes. The FDC reads all data fields from the index hole to EOT. The user must issue TC prior to reading the last data byte.
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 1) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 2) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current head number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Sector number of last sector read) ↓ Call FDCBusyR subroutine ↓ Read Data Register (number of data bytes)

READ A TRACK

Command Phase: Read A Track Word

0	MF	SK	0	0	0	1	0
X	X	X	X	X	Head	Drive Unit Select	
Cylinder Number 0-76							(C)
Head number 0 or 1 as specified in ID field							(H)
Sector number							(R)
Number of data bytes in sector (0=128, 1=256, etc.)							(N)
The last sector number to be read							(EOT)
Gap 3 Length							(GPL)
Data length in bytes if N=00 (Normally set to FF)							(DTL)

Execution Phase: Data is transferred between the main system and floppy disk drive using DMA, Polled or Interrupt modes. The FDC reads all data fields from the index hole to EOT. The user must issue TC prior to reading the last data byte.

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (Status Register 1)	(ST 1)
Read Data Register (Status Register 2)	(ST 2)
Read Data Register (New Cylinder Number)	(C)
Read Data Register (Head number)	(H)
Read Data Register (Sector number)	(R)
Read Data Register (Number of data bytes written)	(N)

Command Word Abbreviations:

MF FM or MFM Mode. If MF is low, FM mode is selected, and if high MFM mode is selected.
SK Skip Deleted Address Mark.

WRITE DELETED DATA

This command is the same as the Write Data Command except a Deleted Data Address Mark is written at the beginning of the Data Field instead of the normal Data Address Mark.

Command Phase:	Call FDCBusyW subroutine ↓ Output Write Deleted Data command ↓ Call FDCBusyW subroutine ↓ Output Disk Drive Select • head (bit 2) • drive (bits 1,0) ↓ Call FDCBusyW subroutine ↓ Output Cylinder Number desired 0-76 ↓ Call FDCBusyW subroutine ↓ Output Head Number 0-1 desired ↓ Call FDCBusyW subroutine ↓ Output Sector Number desired ↓ Call FDCBusyW subroutine ↓ Output Data Bytes in the sector (0=128, 1=256, etc.) ↓ Call FDCBusyW subroutine ↓ Output last sector to read on the track ↓ Call FDCBusyW subroutine ↓ Output length of Gap 3 ↓ Call FDCBusyW subroutine ↓ Output data length in bytes if N=00 (Normally set to FF)
Execution Phase:	Data is transferred between the main system and floppy disk drive using DMA, Polled or Interrupt modes. The user must issue TC prior to writing the last data byte to the floppy disk controller.
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 1) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 2) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current head number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Sector number of last sector read) ↓ Call FDCBusyR subroutine ↓ Read Data Register (number of data bytes)

WRITE DELETED DATA

Command Phase: Write Deleted Data Word

MT	MF	0	0	1	0	0	1
X	X	X	X	X	Head	Drive Unit Select	
Cylinder Number 0-76							(C)
Head number 0 or 1 as specified in ID field							(H)
Sector number							(R)
Number of data bytes in sector (0=128, 1=256, etc.)							(N)
The last sector number to be read							(EOT)
Gap 3 Length							(GPL)
Data length in bytes if N=00 (Normally set to FF)							(DTL)

Execution Phase: Data is transferred between the main system and floppy disk drive using DMA, Polled or Interrupt modes. The user must issue TC prior to writing the last data byte to the floppy disk controller.

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (Status Register 1)	(ST 1)
Read Data Register (Status Register 2)	(ST 2)
Read Data Register (New Cylinder Number)	(C)
Read Data Register (Head number)	(H)
Read Data Register (Sector number)	(R)
Read Data Register (Number of data bytes written)	(N)

Command Word Abbreviations:

MT Multi-Track. If MT is high, a multi-track operation is to be performed.
MF FM or MFM Mode. If MF is low, FM mode is selected, and if high MFM mode is selected.

READ ID

The Read ID command is used to give the present position of the selected drive's read/write head. The FDC stores the values from the first ID field it is able to read. During this command there is no data transferred between the FDC and the CPU except during the result phase.

Command Phase:	Call FDCBusyW subroutine ↓ Output Read ID command ↓ Call FDCBusyW subroutine ↓ Output Disk drive select • head (bit 2) • drive (bits 1,0)
Execution Phase:	Information from the first readable ID field on the current Cylinder is stored in the Data Register
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 1) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 2) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current head number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Sector number of sector read) ↓ Call FDCBusyR subroutine ↓ Read Data Register (number of data bytes)

READ ID

Command Phase: Read ID Word

0	MF	0	0	1	0	1	0
X	X	X	X	X	Head	Drive Unit Select	

Execution Phase: The first correct ID information on the Cylinder is stored in the Data Register.

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (Status Register 1)	(ST 1)
Read Data Register (Status Register 2)	(ST 2)
Read Data Register (New Cylinder Number)	(C)
Read Data Register (Head number)	(H)
Read Data Register (Sector number)	(R)
Read Data Register (Number of data bytes written)	(N)

Command Word Abbreviations:

MF FM or MFM Mode. If MF is low, FM mode is selected, and if high MFM mode is selected.

FORMAT A TRACK

This command formats an entire track. After the Index Hole is detected, Gaps, Address Marks, ID fields and Data fields are written on the diskette. The particular format which will be written is controlled by the values programmed into N (number of bytes/sector), SC (sectors/cylinder), GPL (Gap Length), and D (Data Pattern) which are supplied by the processor during the Command Phase. The data field is filled with the byte of data stored in D. The FDC will request 4 bytes from the host for each sector formatted. This transfer may be done via DMA, Interrupt or Polled mode. It is important to activate TC prior to the transfer of the last byte for each sector. The information transferred (for each sector) includes Cylinder, Head, Sector and number of bytes per sector. This information is written to the ID field of the sector to be formatted.

Command Phase:	Call FDCBusyW subroutine ↓ Output Format command ↓ Call FDCBusyW subroutine ↓ Output Disk Drive Select • head (bit 2) • drive (bits 1,0) ↓ Call FDCBusyW subroutine ↓ Output Data Bytes in the sector (0=128, 1=256, etc.) ↓ Call FDCBusyW subroutine ↓ Output number of sectors per cylinder ↓ Call FDCBusyW subroutine ↓ Output length of Gap 3 ↓ Call FDCBusyW subroutine ↓ Output the data byte that will be written into a sector
Execution Phase:	The FDC formats an entire track.
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 1) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 2) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current head number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Sector number of last sector written) ↓ Call FDCBusyR subroutine ↓ Read Data Register (number of data bytes/sector)

FORMAT A TRACK

Command Phase: Format A Track Word

0	MF	0	0	1	1	0	1
X	X	X	X	X	Head	Drive Unit Select	
Number of data bytes in sector (0=128, 1=256, etc.)							(N)
The number of sectors per cylinder							(SC)
Gap 3 Length							(GPL)
Data Pattern to be written into sector							(D)

Execution Phase: FDC formats an entire track.

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (Status Register 1)	(ST 1)
Read Data Register (Status Register 2)	(ST 2)
Read Data Register (New Cylinder Number)	(C)
Read Data Register (Head number)	(H)
Read Data Register (Sector number)	(R)
Read Data Register (Number of data bytes written)	(N)

Command Word Abbreviation:

MF FM or MFM Mode. If MF is low, FM mode is selected, and if high MFM mode is selected.

SCAN EQUAL

This command allows data which is being read from the diskette to be compared against data which is being supplied from the main system. The FDC compares the data on a byte-by-byte basis and looks for a sector of data which meets the condition of $DATA_{fdd} = DATA_{processor}$. An $FF_{(HEX)}$ from either the disk drive or system processor will always meet the conditions of a match.

Command Phase:	Call FDCBusyW subroutine ↓ Output Scan Equal command ↓ Call FDCBusyW subroutine ↓ Output Disk Drive Select • head (bit 2) • drive (bits 1,0) ↓ Call FDCBusyW subroutine ↓ Output Cylinder Number desired 0-76 ↓ Call FDCBusyW subroutine ↓ Output Head Number 0-1 desired ↓ Call FDCBusyW subroutine ↓ Output Sector Number desired ↓ Call FDCBusyW subroutine ↓ Output Data Bytes in the sector (0=128, 1=256, etc.) ↓ Call FDCBusyW subroutine ↓ Output last sector to read on the track ↓ Call FDCBusyW subroutine ↓ Output length of Gap 3 ↓ Call FDCBusyW subroutine ↓ Continuous sectors or alternate sectors compared byte-by-byte with data sent from the processor
Execution Phase:	Data is compared between the floppy disk drive and the main system
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 1) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 2) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) • Bit 2 = Scan not met (SN) • Bit 3 = Scan conditions met (SH) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current head number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Sector number of last sector read) ↓ Call FDCBusyR subroutine ↓ Read Data Register (number of data bytes)

SCAN EQUAL

Command Phase:

MT	MF	SK	1	0	0	0	1
X	X	X	X	X	Head	Drive Unit Select	
Cylinder Number 0-76							(C)
Head number 0 or 1 as specified in ID field							(H)
Sector number							(R)
Number of data bytes in sector (0=128, 1=256, etc.)							(N)
The last sector number to be read							(EOT)
Gap 3 Length							(GPL)
Contiguous sectors or alternate sectors compared							(STP)

Execution Phase: Data compared between the main system and the floppy disk drive

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (Status Register 1)	(ST 1)
Read Data Register (Status Register 2)	(ST 2)
Read Data Register (New Cylinder Number)	(C)
Read Data Register (Head number)	(H)
Read Data Register (Sector number)	(R)
Read Data Register (Number of data bytes written)	(N)

Command Word Abbreviations:

MT Multi-Track. If MT is high, both sides (of the current cylinder) will be read.

MF FM or MFM Mode. If MF is low, FM mode is selected, and if high MFM mode is selected.

SK Skip. SK stands for Skip Deleted Data Mark. If SK=0 and the FDC finds a sector with a deleted data mark, then the operation will stop after the current sector is read and the Control Mark flag (Bit 6, Status Register 2) will be set.

SCAN LOW OR EQUAL

This command allows data which is being read form the diskette to be compared against data which is being supplied from the main system. The FDC compares the data on a byte-by-byte basis and looks for a sector of data which meets the condition of $DATA_{fdd}$ $DATA_{processor}$. An $FF_{(HEX>}$ from either the disk drive or system processor will always meet the conditions of a search.

Command Phase:	Call FDCBusyW subroutine ↓ Output Scan Low or Equal command ↓ Call FDCBusyW subroutine ↓ Output Disk Drive Select • head (bit 2) • drive (bits 1,0) ↓ Call FDCBusyW subroutine ↓ Output Cylinder Number desired 0-76 ↓ Call FDCBusyW subroutine ↓ Output Head Number 0-1 desired ↓ Call FDCBusyW subroutine ↓ Output Sector Number desired ↓ Call FDCBusyW subroutine ↓ Output Data Bytes in the sector (0=128, 1=256, etc.) ↓ Call FDCBusyW subroutine ↓ Output last sector to read on the track ↓ Call FDCBusyW subroutine ↓ Output length of Gap 3 ↓ Call FDCBusyW subroutine ↓ Continuous sectors or alternate sectors compared byte-by-byte with data sent from the processor
Execution Phase:	Data is compared between the floppy disk drive and the main system
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 1) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 2) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) • Bit 2 = Scan not met (SN) • Bit 3 = Scan conditions met (SH) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current head number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Sector number of last sector read) ↓ Call FDCBusyR subroutine ↓ Read Data Register (number of data bytes)

SCAN LOW OR EQUAL

Command Phase:

MT	MF	SK	1	1	0	0	1
X	X	X	X	X	Head	Drive Unit Select	
Cylinder Number 0-76							(C)
Head number 0 or 1 as specified in ID field							(H)
Sector number							(R)
Number of data bytes in sector (0=128, 1=256, etc.)							(N)
The last sector number to be read							(EOT)
Gap 3 Length							(GPL)
Contiguous sectors or alternate sectors compared							(STP)

Execution Phase: Data compared between the main system and the floppy disk drive

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (Status Register 1)	(ST 1)
Read Data Register (Status Register 2)	(ST 2)
Read Data Register (New Cylinder Number)	(C)
Read Data Register (Head number)	(H)
Read Data Register (Sector number)	(R)
Read Data Register (Number of data bytes written)	(N)

Command Word Abbreviations:

MT Multi-Track. If MT is high, both sides (of the current cylinder) will be read.

MF FM or MFM Mode. If MF is low, FM mode is selected, and if high MFM mode is selected.

SK Skip. SK stands for Skip Deleted Data Mark. If SK=0 and the FDC finds a sector with a deleted data mark, then the operation will stop after the current sector is read and the Control Mark flag (Bit 6, Status Register 2) will be set.

SCAN HIGH OR EQUAL

This command allows data which is being read form the diskette to be compared against data which is being supplied from the main system. The FDC compares the data on a byte-by-byte basis and looks for a sector of data which meets the condition of $DATA_{fdd}$ $DATA_{processor}$. An $FF_{(HEX>}$ from either the disk drive or system processor will always meet the conditions of a search.

Command Phase:	Call FDCBusyW subroutine ↓ Output Scan High or Equal command ↓ Call FDCBusyW subroutine ↓ Output Disk Drive Select • head (bit 2) • drive (bits 1,0) ↓ Call FDCBusyW subroutine ↓ Output Cylinder Number desired 0-76 ↓ Call FDCBusyW subroutine ↓ Output Head Number 0-1 desired ↓ Call FDCBusyW subroutine ↓ Output Sector Number desired ↓ Call FDCBusyW subroutine ↓ Output Data Bytes in the sector (0=128, 1=256, etc.) ↓ Call FDCBusyW subroutine ↓ Output last sector to read on the track ↓ Call FDCBusyW subroutine ↓ Output length of Gap 3 ↓ Call FDCBusyW subroutine ↓ Continuous sectors or alternate sectors compared byte-by-byte with data sent from the processor
Execution Phase:	Data compared between the floppy disk drive and the main system
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 1) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Status Register 2) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current cylinder number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (current head number) ↓ Call FDCBusyR subroutine ↓ Read Data Register (Sector number of last sector read) ↓ Call FDCBusyR subroutine ↓ Read Data Register (number of data bytes)

SCAN HIGH OR EQUAL

Command Phase:

MT	MF	SK	1	1	1	0	1
X	X	X	X	X	Head	Drive Unit Select	
Cylinder Number 0-76							(C)
Head number 0 or 1 as specified in ID field							(H)
Sector number							(R)
Number of data bytes in sector (0=128, 1=256, etc.)							(N)
The last sector number to be read							(EOT)
Gap 3 Length							(GPL)
Contiguous sectors or alternate sectors compared							(STP)

Execution Phase: Data compared between the main system and the floppy disk drive

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (Status Register 1)	(ST 1)
Read Data Register (Status Register 2)	(ST 2)
Read Data Register (New Cylinder Number)	(C)
Read Data Register (Head number)	(H)
Read Data Register (Sector number)	(R)
Read Data Register (Number of data bytes written)	(N)

Command Word Abbreviations:

MT Multi-Track. If MT is high, both sides (of the current cylinder) will be read.

MF FM or MFM Mode. If MF is low, FM mode is selected, and if high MFM mode is selected.

SK Skip. SK stands for Skip Deleted Data Mark. If SK=0 and the FDC finds a sector with a deleted data mark, then the operation will stop after the current sector is read and the Control Mark flag (Bit 6, Status Register 2) will be set.

RECALIBRATE (07 HEX)

This command attempts to retract the head to Track 00. The TR00 input is sampled. If TR00 is active low, indicating the Read/Write head is positioned over track 0, the command terminates. If TR00 is not active low, stepping pulses are issued until the TR00 input is activated. A maximum of 77 step pulses are issued. If TR00 is not true after 77 step pulses, the command terminates with the Seek End and Equipment Check flags (in status register 0) both set high.

If the drive selected has more than 77 tracks, it is usually easier to first Seek to Track 1, then issue the Recalibrate command. This avoids having to handle error conditions.

Command Phase:	Call FDCBusyW subroutine ↓ Output Recalibrate command (07 Hex) ↓ Call FDCBusyW subroutine ↓ Output Drive Select Word Drive (bits 1, 0)
Execution Phase:	Head retracted to Track 0
Result Phase:	There is no Result phase for this command. However, an interrupt is generated that requires service by the Sense Interrupt Status Command.

RECALIBRATE

Command Phase:

0	0	0	0	0	1	1	1
X	X	X	X	X	0	Drive Unit Select	

Execution Phase: Head retracted to Track 0.

Result Phase: None

SENSE INTERRUPT STATUS (08 HEX)

The Sense Interrupt command, when issued, resets the interrupt signal and by means of bits 5, 6 and 7 of Status Register 0 (returned during the result phase) identifies the cause of the interrupt. This command is used to identify the completion of Seek or Recalibrate commands and the ready signal from one of the disk drives changing state.

Command Phase:	Call FDCBusyW subroutine ↓ Output Sense Interrupt Status Command (08 Hex)
Execution Phase:	Resets the interrupt signal and via bits 5, 6 and 7 of Status Register 0 identifies the cause of the interrupt
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 0) bits 5, 6 and 7 to determine cause of interrupt ↓ Call FDCBusyR subroutine ↓ Read Data Register for the current cylinder address

SENSE INTERRUPT STATUS

Command Phase:

0	0	0	0	0	1	0	0

Execution Phase: Resets the interrupt signal and via bits 5, 6 and 7 of Status Register 0 identifies the cause of the interrupt

Result Phase:

Read Data Register (Status Register 0)	(ST 0)
Read Data Register (current cylinder address)	(PCN)

SPECIFY (03 HEX)

The Specify command is used prior to performing any disk operation to define drive/FDC operating characteristics. The Specify command parameters set the values for the Head Load Time (HLT), Head Unload Time (HUT) and Step Rate Time (SRT). The Specify command also indicates the choice of DMA or non-DMA operation.

Command Phase:	Call FDCBusyW subroutine ↓ Output Specify Command (03 Hex) ↓ Call FDCBusyW subroutine ↓ Output SRT and HUT SRT - Step Rate Time (bits 7,6,5,4) HUT - Head Unload Time (bits 3,2,1,0) ↓ Call FDCBusyW subroutine ↓ Output HLT and choice of mode HLT - Head Load Time (bits 7,6,5,4,3,2,1) DMA or non-DMA (bit 0)
Execution Phase:	None
Result Phase:	None

SPECIFY

Command Phase:

0	0	0	0	0	0	1	1

Step Rate Time	Head Unload Time

Head Load Time (HLT)	Non-DMA Mode (ND)

Execution Phase: None

Result Phase: None

SENSE DRIVE STATUS (04 HEX)

This command is used by the processor whenever it wishes to obtain the status of the floppy disk drives. Status Register 3 contains the Drive Status information.

Command Phase:	Call FDCBusyW subroutine ↓ Output the Sense Drive Status command (04 Hex) ↓ Call FDCBusyW subroutine ↓ Disk drive select • head (bit 2) • drive (bits 1,0)
Execution Phase:	Get status information about the disk drives
Result Phase:	Call FDCBusyR subroutine ↓ Read Data Register (Status Register 3)

SENSE DRIVE STATUS

Command Phase:

0	0	0	0	0	1	0	0

X	X	X	X	X	Head Drive Unit Select	

Execution Phase: Get status information about the disk drives

Result Phase:

Read Data Register (Status Register 3)	(ST 3)

SEEK (0F HEX)

The disk controller will update the contents of the internal Track Register (the current head location) and issue stepping pulses in the appropriate direction until the Track Register is equal to the Data Register (the desired track location).

Command Phase:	Call FDCBusyW subroutine ↓ Output Seek command (0F Hex) ↓ Call FDCBusyW subroutine ↓ Disk drive select • head (bit 2) • drive (bits 1,0)
Execution Phase:	Head is positioned over proper cylinder on diskette
Result Phase:	There is no Result phase for this command. However, an interrupt is generated that requires service by the Sense Interrupt Status command.

SEEK

Command Phase:

0	0	0	0	1	1	1	1
X	X	X	X	X	Head Drive Unit Select		
New Cylinder Number							(C)

Execution Phase: Head is positioned over proper cylinder on diskette

Result Phase: None

FDCBusyW and FDCBusyR Subroutines

These subroutines wait a period of time (12 s or 24 s, depending on device mode) and check the main status register of the FDC, looking at the Request for Master bit (RQM, bit 7) and Direction Input/Output bit (D10, bit 6). When these bits are properly set, the next byte may be output to or input from the FDC.

While it is important to wait the period of time specified, a timing loop in the subroutine is not always needed. In many instances, the time required to "push" the processor registers onto the stack is greater than the minimum period. Alternatively, the operating system may have a "timer" function call which may be used.

```
PROCEDURE FDCBusyW/FDCBusyR  (Drive : Byte) ;
                             {Drive=1 for 8" drive
                             Drive=0 for 5.25" drive}

TYPE uSeconds = integer;

VAR   MainStatusReg :  byte;  {result of the Main Status Register}
      Mask          :  byte;  {used to mask out bits 5-0}
      Time          :  uSeconds;

BEGIN
      Mask  : = 192;
      repeat
            for Time : = 1 to (12 * Drive) do NoOp;          {NoOp = No Operation}
            read (MainStatusReg);                            {read Main Status Register}
            MainStatusReg : = MainStatusReg AND Mask;        {Mask out bits 5-0}
      until MainStatusReg = 128;                             {Data I/O =0
                                                              Request for Master = 1}

END.
```

RECOMMENDED FORMAT PARAMETERS

FORMAT	SECTOR SIZE	N	SC	GPL[1]	GPL[2,3]
8" Standard Floppy					
FM Mode	128 bytes/sector	00	1A	07	1B
	256	01	0F	0E	2A
	512	02	08	1B	3A
	1024	03	04	47	8A
	2048	04	02	C8	FF
	4096	05	01	C8	FF
MFM Mode[4]	256	01	1A	0E	36
	512	02	0F	1B	54
	1024	03	08	35	74
	2048	04	04	99	FF
	4096	05	02	C8	FF
	8192	06	01	C8	FF
5 3 " Minifloppy					
FM Mode	128 bytes/sector	00	12	07	09
	123	00	10	10	19
	256	01	08	18	30
	512	02	04	46	87
	1024	03	02	C8	FF
	2048	04	01	C8	FF
MFM Mode[4]	256	01	12	0A	0C
	256	01	10	20	32
	512	02	08	2A	50
	1024	03	04	80	F0
	2048	04	02	C8	FF
	4096	05	01	C8	FF
3 2 " Sony Micro Floppydisk					
FM Mode	128 bytes/sector	0	0F	07	1B
	256	1	09	0E	2A
	512	2	05	1B	3A
MFM Mode[4]	256	1	0F	0E	36
	512	2	09	1B	54
	1024	3	05	35	74

Notes:
1. Suggested values of GPL in Read or Write commands to avoid splice point between data field and ID field of contiguous sections.
2. Suggested values of GPL in format command.
3. All values except sector size and hexadecimal.
4. In MFM mode FDC cannot perform a Read/Write/format operation with 128 bytes sector (N=00).

MAIN STATUS REGISTER BIT MAP

BIT NUMBER	NAME	SYMBOL	DESCRIPTION
DB_0	FDD 0 Busy	D_0B	FDD number 0 is in the Seek mode. If any of the bits is set FDC will not accept read or write command.
DB_1	FDD 1 Busy	D_1B	FDD number 1 is in the Seek mode. If any of the bits is set FDC will not accept read or write command.
DB_2	FDD 2 Busy	D_2B	FDD number 2 is in the Seek Mode. If any of the bits is set FDC will not accept read or write command.
DB_3	FDD 3 Busy	D_3B	FDD number 3 is in the Seek mode. If any of the bits is set FDC will not accept read or write command.
DB_4	FDC Busy	CB	A read or write command is in process. FDC will not accept any other command.
DB_5	Execution Mode	EXM	This bit is set only during execution phase in non-DMA mode. When DB_5 goes low, execution phase has ended and result phase was started. It operates only during NON-DMA mode of operation.
DB_6	Data Input/Output	DIO	Indicates direction of data transfer between FDC and Data Register. IF DIO="1" then transfer is from Data Register to the Processor. If DIO="0" then transfer is from the Processor to Data Register.
DB_7	Request for Master	RQM	Indicates Data Register is ready to send or receive data to or from the Processor. Both bits DIO and RQM should be used to perform the hand-shaking functions of "ready" and "direction" to the processor.

BIT NO.	NAME	SYMBOL	DESCRIPTION
STATUS REGISTER 0			
D_7	Interrupt Code	IC	D_7=0 and D_5=0 Normal Termination of Command (NT). Command was completed and properly executed.
D_5			D_7=0 and D_5=1 Abnormal Termination of Command (AT). Execution of Command was started, but was not successfully completed.
			D_7=1 and D_5=0 Invalid Command issue (IC). Command which was issued was never started.
			D_7=1 and D_5=1 Abnormal Termination because during command execution the ready signal from FDD changed state.
D_5	Seek End	SE	When the FDC completes the SEEK Command, this flag is set to 1 (high).
D_4	Equipment Check	EC	If a fault Signal is received from the FDD, or if the Track 0 Signal fails to occur after 77 Step Pulses (Recalibrate Command) then this flag is set.
D_3	Not Ready	NR	When the FDD is in the not-ready state and a read or write command is issued, this flag is set. If a read of write command is issued to Side 1 of a single sided drive, then this flag is set.
D_2	Head Address	HD	This flag is used to indicate the state of the head at interrupt.
D_1 D_0	Unit Select 1 Unit Select 0	US 1 US 0	These flags are used to indicated a Drive Unit. Number at interrupt.
STATUS REGISTER 1			
D_7	End of Cylinder	EN	When the FDC tries to access a Sector beyond the final Sector of a Cylinder, this flag is set.
D_5			Not used. This bit is always 0 (low).
D_5	Data Error	DE	When the FDC detects a CRC error in either the ID field or the data field, this flag is set.
D_4	Over Run	OR	If the FDC is not serviced by the main-systems during data transfers, within a certain time interval, this flag is set.
D_3			Not used. This bit is always 0 (low).
D_2	No Data	ND	During execution of READ DATA, WRITE DELETED DATA or SCAN Command, if the FDC cannot find the Sector specified in the IDR Register, this flag is set.
			During executing the READ ID Command, if the FDC cannot read the ID field with without an error, then this flag is set.
			During the execution of the READ A CYLINDER Command, if the starting sector cannot be found, then this flag is set.
D_1	Not Writeable	NW	During execution of WRITE DATA, WRITE DELETED DATA, or FORMAT A CYLINDER Command, if the FDC detects a write protect signal from the FDD, then this flag is set.
D_0	Missing Address Mark	MA	If the FDC cannot detect the ID Address Mark after encountering the index hole twice, then this flag is set.
			If the FDC cannot detect the Data Address Mark or Deleted Data Address Mark, this flag is set. Also at the same time, the MD (Missing Address Mark in Data Field) of Status Register 2 is set.

BIT NO.	NAME	SYMBOL	DESCRIPTION
STATUS REGISTER 2			
D_7			Not used. This bit is always 0 (low).
D_6	Control Mark	CM	During executing the READ DATA or SCAN command, if the FDC encounters a sector which contains a Deleted Data Address Mark, this flag is set.
D_5	Data Error in Data Field	DD	If the FDC detects a CRC error in the data field, then this flag is set.
D_4	Wrong Cylinder	WC	This bit is related with the ND bit, and when the contents of C on the medium is different from that stored in the IDR, this flag is set.
D_3	Scan Equal Hit	SH	During execution, the SCAN Command, if the condition of "equal" is satisfied, this flag is set.
D_2	Scan Not Satisfied	SN	During executing the SCAN Command, if the FDC cannot find a Sector on the cylinder which meets the condition, then this flag is set.
D_1	Bad Cylinder	BC	This bit is related with the ND bit, and when the content of C on the medium is different from that stored in the IDR and the content of C is FF, then this flag is set.
D_0	Missing Address Mark in Data Field	MD	When data is read from the medium, if the FDC cannot find a Data Address Mark or Deleted Data Address Mark, then this flag is set.
STATUS REGISTER 3			
D_7	Fault	FT	This bit is used to indicate the status of the Fault signal from the FDD.
D_6	Write Protected	WP	This bit is used to indicate the status of the Write Protected signal from the FDD.
D_5	Ready	RY	This bit is used to indicate the status of the Ready signal from the FDD.
D_4	Track 0	T0	This bit is used to indicate the status of the Track 0 signal from the FDD.
D_3	Two Side	TS	This bit is used to indicate the status of the Two Side signal from the FDD.
D_2	Head Address	HD	This bit is used to indicate the status of the Side Select signal to the FDD.
D_1	Unit Select 1	US 1	This bit is used to indicate the status of the Unit Select 1 signal to the FDD.
D_0	Unit Select 0	US 0	This bit is used to indicate the status of the Unit Select 0 signal to the FDD.