RC 4818 MAGNETIC DISC

and

DFC 403 DISC FILE CONTROLLER

REFERENCE MANUAL

ABSTRACT: This paper describes the logical structure of the RC 4818
magnetic disc and the DFC 403 disc file controller when used in connec-
tion with the RC 4000 computer.

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1. MAIN CHARACTERISTICS

The disc file controller DFC 403 is designed to control 1 to 8 disc stores
of the type RC 4818.

The disc RC 4818 has a capacity of 9,354,240 words each of 24 bits. The
total capacity per controller with 8 discs is therefore 74,833,920 words.
Physically the disc is organized as follows:

- Segments : 3640 segments each of 256 words.
- Cylinders: 203 cylinders, i.e. possible head positions, each of
  180 segments.
- Heads   : 20 heads, each having access to one track with 9
  segments.

A transfer of a data block to or from the disc is seperated in two
operations, - namely a cylinder selection followed by the actual data
transfer.

The cylinder selection can be executed on several discs simultaneously.
This is possible because the discs are connected to the controller via
a party line system and because neither the controller nor the party
line system is busy during the cylinder selection, only during the
initiation.

The cylinder selection time varies from 7 to 70 milliseconds depen-
ding on the number of cylinder displacements. Nominal disc speed is
2400 revolutions per minute and nominal bit rate is 2,5 megabits per
second.

The data transfer is done via the RC 4000 high-speed data channel,
i.e. a data block is transferred directly to or from the internal
store. The data block is composed of a variable number of consecu-
tive segments. The data transfer times are specified as follows:

1) Average transfer rate:

   92000 words per second.

2) Transfer rate within a segment:

   104000 words per second.

3) Average transfer time for transport inside a selected and
   positioned cylinder:

   (13 + 2.8 * number of segments) milliseconds.

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4) Average transfer time for transports including cylinder shifts:
(48 + 2.8 * number of segments + 8.3 * number of cylinder
shifts) milliseconds.

The data transfer operation can only be executed on one disc at a time,
and the controller will be busy in the transfer period. Therefore new
cylinder selections cannot be initiated during the data transfer operation.

The disc controller delivers an interrupt signal when a data transfer
operation is completed.

Cylinder selections and data transfers are initiated via the RC 4000
low-speed data channel by means of control commands as described in
the following sections.

2. I/O COMMANDS

2.1. Control Commands

2.1.1. Control Command Modifications

The control commands are used to specify and initiate cylinder selections and data block transfers. The disc controller accepts 10 modifications of the control command:

5	select disc	< disc number >
9	return to zero	< irrelevant >
13	transfer forward	< abs (cylinder difference) >
17	transfer reverse	< abs (cylinder difference) >
21	transfer first	< cylinder, head, sector >
25	transfer size	< number of segments >
29	input data	< first storage address >
33	output data	< first storage address >
37	input address	< first storage address >
41	output address	< first storage address >

The integers denote the values of bits 18-23 in the effective address of the input/output instruction. The parameters in the brackets < and > denote the contents of the working register selected by the input/output instruction.

The parameters are interpreted as follows:

< disc number >	modulo 8
< abs (cylinder difference) >	modulo 512
< cylinder, head, sector >	modulo 512, 32, 16
< number of segments >	modulo 512
< first storage address >	modulo 262144

2.1.2. Select Disc

While the disc controller is addressed by means of the device address of the input/output command, the disc itself must be selected by the control command select disc. The discs are numbered 0 to 7. In the disc select command a disc address word with the following format is transferred:

irrelevant	disc no.
0	20 21 23

The effect of the select disc command is that all succeeding commands operate on the disc defined in the disc address word.

The disc and the controller are available immediately after the execution of the select disc command.

2.1.3. Return to Zero

The control command return to zero moves the read/write heads to cylinder 0. The command is normally used when the head positioning is not known. This is the case after intervention (status bit 0), synchronization error (status bit 2) or data overrun (status bit 3). The reason for this is that the data operation is terminated as soon as the error is recognized, and that a possible cylinder shift may or may not have taken place.

The disc controller is busy during the return to zero operation. When the controller becomes available again an interrupt signal is generated.

2.1.4. Transfer Forward and Transfer Reverse

These control commands initiate the cylinder selections, i.e. the positioning of read/write heads. In the transfer forward command the cylinder address is increased with abs (cylinder difference) as specified in the transferred parameter word. The format of this is

irrelevant	abs (cyl.diff.)
0 15	16 23

In the transfer reverse command the cylinder address is decreased with abs (cylinder difference).

As neither the disc controller nor the party line system is busy during the cylinder selection, just in the initiation moment, it is possible immediately after the transfer forward/reverse command to initiate new cylinder selections or a data transfer operation.

When a cylinder selection is initiated by the transfer forward/reverse command, bit 13 in the status word (heads moving) is set until the operation has been completed or terminated.

It is possible to initiate a data transfer operation on a disc even if the cylinder selection has not been completed. In this case the controller will delay the data transfer until the heads are positioned.

The transfer forward/reverse command can be omitted if the segment address corresponds to the previous cylinder address.

The transfer forward/reverse command must be executed before the transfer size command.

Positioning of heads to a nonexisting cylinder will be terminated with bit 2 of the status word set (synchronization error).

Cylinder shifts will take place automaticly during a data transfer operation, if the specified data block is (or is to be) placed on more than one cylinder. This must be considered during the calculation of the next cylinder difference.

2.1.5. Transfer First and Transfer Size

A data transfer operation requires specification of a set of consequtive segments on the disc and a storage location. This specification must be presented for the disc controller in the mentioned order:
The control commands transfer first and transfer size are used to specify the set of consequtive segments. The first command transfers the address of the first segment and the second command the number of segments.
The segment address word is interpreted as follows:

irrelevant	cylinder	head	sector
0 3	4 11	12 18	19 23

where $0 \leq$ cylinder ≤ 202, $0 \leq$ head ≤ 19, and $0 \leq$ sector ≤ 8.
The relation between a segment number and the segment address constituents is:

segment number $= 180 * $ cylinder $+ 9 *$ head $+$ sector

In the transfer size command the parameter word has the following format:

irrelevant	number and segments
0 14	15 23

The disc controller is available immediately after the execution of the transfer first and transfer size commands.

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2.1.6. Input Data and Output Data

These control commands define a storage location and initiate a block transfer. The storage location is given by the first storage address word, transferred and interpreted as follows:

irrelevant	first storage address
0 5	6 23
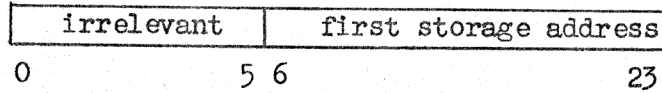
The data block will be transferred with the first word in the storage location specified by first storage address. The rightmost bit of this parameter (bit 23) is ignored. Thus it is irrelevant whether the parameter refers to the left or right half of the storage word.

The input data command initiates a transfer from disc to internal store. The output data command initiates a transfer from internal store to disc. After initiation of a data transfer, the disc controller is busy until the data operation is either completed sucessfully or terminated by an error condition. The disc delivers an interrupt signal when it after a data transfer becomes available.

2.1.7. Input Address and Output Address

The disc surface is physically divided into sectors seperated from each other by sector gaps. Each sector contains a sector mark, a segment address word and a segment of 256 data words. The sector mark is used to detect a sector start. The segment address word identifies the segment. A new disc pack must be supplied with sector marks and segment addresses before use. The segment addresses may afterwards be input for checking. The input and output of segment addresses follow a similar scheme as given for input data and output data.

In details, writing of segment addresses is done in 3 steps:

1) Positioning of heads to actual cylinder by means of the commands return to zero, transfer forward and transfer reverse.

2) Head selection by means of the transfer first command. The parameter word is interpreted as follows:

irrelevant	head	irrelevant
0 11	12 18	19 23
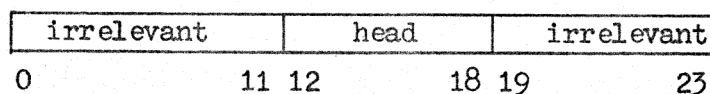
3) Writing of segment address words on the now selected track by means of output address. This command initiates writing of 9 segment address words in the sectors 0 to 8. The first storage address in the command refers to a buffer area of 9 words, the contents of which must be 9 consequtive segment address words. The format of each word should be:

zero	cylinder	head	sector
0 3 4	11 12	18 19	23

The sector marks are generated automaticly by the disc controller during the executing of the segment address writing.

The disc controller is busy during writing of segment addresses, and when it afterwards becomes available an interrupt signal is generated.

Use of the command transfer size is irrelevant (will be ignored) because the controller always writes 9 segment addresses per operation.

The sequence of the segment addresses should be shifted 3 per cylinder to enable cylinder shifts in 1/3 revolution (8.3 msec).

All segment addresses must be written before checking is relevant. The checking is carried out in 3 steps:

1) Equivalent to step 1 of segment address writing.
2) Equivalent to step 2 of segment address writing.
3) Reading of segment addresses by means of input address. This command initiates reading of 9 segment address words in the sectors 0 to 8.

First storage address of the command refers to a buffer area to which the 9 segment address words are transferred.

The format of the segment address word for the commands input and output address are identical.

The disc controller is busy during reading of segment addresses, and when it afterwards becomes available an interrupt signal is generated.

2.2. Sense Command
2.2.1. Format of Status Word
When the disc controller is available a status word can be transferred to a working register by means of a sense command. The format of the status word is:

status	zero	status	zero
0 3 4	11 12 13	14	23

The status bits have the following meaning:

Bit No.	Signification
0	intervention
1	parity error
2	synchronization error
3	data overrun
12	disc in local
13	heads moving

Bits No. 0, 12, and 13 refer to the status of the selected disc. Bits No. 1, 2, and 3 on the other hand refer to the result of the most recently executed data transfer operation.

2.2.2. Intervention

Intervention indicates that the disc is in local mode or has been in local mode since the most recent data transfer operation.

The intervention bit is set when the disc goes from remote to local state. The bit is reset by the first input/output data or input/output address command, but only if the disc is returned to remote state.

Setting of intervention implies a termination of a possible current operation on the disc.

2.2.3. Parity Error

This status bit indicates a parity error in one or more segments transferred in the most recent data input operation.

The parity error status is set when recognized by the controller. Recognition of the error will not terminate the operation. The status bit is reset by the first input/output data or input/output address command.

2.2.4. Synchronization Error

This status bit indicates one or more of the following errors:

    loss of synchronization signals
    address error
    seek error
    timer (controller has been busy longer than 2 seconds)

When the controller recognizes the error the status bit is set, and the current operation terminates. The status bit is reset by the first input/output data or input/output address command.

2.2.5. Data Overrun

Data overrun indicates overloading of the high-speed data channel. Further data transfers are suppressed and the operation terminates. The status bit is reset by the first input/output data or input/output address command.

2.2.6. Disc in Local

Disc in local indicates that the disc cannot be controlled by the disc controller due to one or more of the following situations:
- cable between controller and disc is removed.
- power to the disc electronics is switched off.
- disc motor not at the proper speed.
- disc number plug has been removed.
- operator has interfered by means of the maintenance panel switches.

The transition to local sets the status bit and terminates a possible current operation. When the disc returns to the remote state, the status bit disc in local is reset.

Operations initiated in local state are not buffered but terminated immediately.

2.2.7. Heads Moving

Heads moving indicates that a head positioning takes place. The status bit is set by a transfer forward/reverse or return to zero command, and is reset when the head positioning has been completed.

3.   INTERRUPT

The disc controller delivers interrupt signals in the following situations:
1) after successfully execution of the commands

     return to zero
     input data
     output data
     input address
     output address

2) after termination of the above mentioned commands due to

     intervention
     synchronization error
     data overrun

4. INDICATOR ON THE RC 4000 OPERATOR PANEL

Even if a disc controller can have up to 8 discs connected, there is just
one indicator on the RC 4000 operator panel. This indicator is lit
(green), when the disc controller itself is connected to RC 4000.
The status of the single disc must be observed by looking at the disc
indicator panel or at the console messages.

5. DISC CONTROL SWITCHES AND INDICATORS

The disc is equipped with an operator control panel, which has the follo-
wing switches and indicators:

START	REMOTE	MAINT	AIR FLOW	FAULT	2

Disc No.
plug
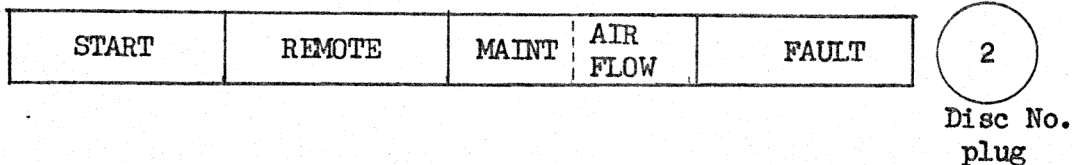
START   is a combined switch and indicator. When the switch is depressed
          once, it will energize the spindle drive motor and begin the first
          seek sequence, provided the following conditions are satisfied:
          1) The disc pack is in place
          2) All covers are closed
          3) Power and circuit breakers are on and maintenance control
             switches are in the right positions.
          Depressing the START switch once more the spindle drive motor will
          be stopped again.
          The START indicator illuminates when the START switch is in the on
          condition, even if a condition exists, which prevents the spindle
          drive motor to start.

REMOTE   is an indicator illuminated when the disc can be controlled by the computer, i.e. when the local bit in the status word is zero.

MAINT   is an indicator illuminated when the disc is in maintenance mode caused by use of different switches on the maintenance control panel.

AIR FLOW   The AIR FLOW lamp, when illuminated, indicates proper air flow rate.

FAULT   This is a combined switch and indicator.

FAULT is illuminated in consequence of different hardware malfunctions or irregular control of the disc.

The FAULT switch, when depressed, clears the FAULT memory element and extinguishes the indicator if no errors are present.

Disc No. plug: This is an interchangeable plug with indicator.

The plug defines the disc address on the party line system. The plug is equipped with a digit indicating the disc address (0 to 7). The plug indicator is illuminated when the disc in question has been selected by the select disc command.