The HxC Emulator and Disk Systems of some HP Computers

1. SONY Floppy Disk Drive MFD-52-W10

This floppy disk drive is used for example in the HP 9153A/B/C combo disk system containing a hard disk and the floppy disk drive. These systems came with a HP-IB (IEEE-488) interface and were usually connected to HP computers of the Series 80, 100, or 9000. Besides the infamous „Nighthawk“ hard disks also many of the old floppy disk drives are failing due to age.

The SONY 3.5 inch floppy disk drives in these systems[1] have a 34 pin connector for data and power. These drives have a rectangular eject button.

The same disk drive was also used in the 9114B HP-IL disk drive and the 9123 systems. The HP part number of the drive is 9123-69101 - the manufacturer's designation is SONY MFD-52-W10. The disk drives have a 4 position switch for drive select 0…3, but this is not used by HP equipment (factory setting is 3).

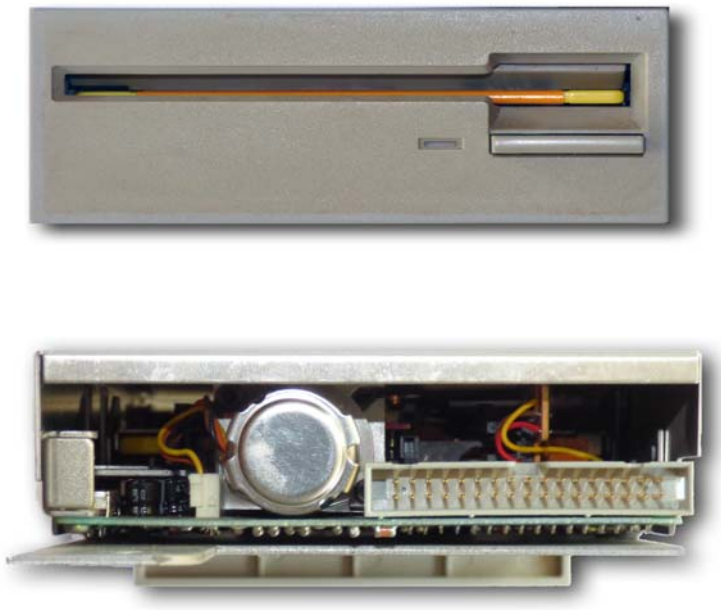


Figure 1: Front and rear view of SONY MFD-52-W10 flexible disk drive. Note that there is no separate power connector.

[1] HP 9153A with serial numbers 2702A and above, all 9153B and C systems. Older HP 9153A systems with serial numbers below 2702A still have a SONY OA-D32W or OA-D32V disk drive with a square eject button and a 26 pin connector and a separate power connector. These were also used in the 9133 drive systems.

1.1. Connection

The wiring scheme is straightforward. The only tedious work is to cut every odd line in the ribbon cable. If you would not cut the lines you would short 5 V and 12 V to ground.

HxC	SONY Connector				HxC
pin	Signal	pin	pin	Signal	pin
n.c.	Disk Change Reset (in)	1	2	Disk Change Indicator (out)	2
VCC	5V	3	4	Drive LED (In Use)	4 (n.c.)
n.c.	5V	5	6	Drive Select 3 (in)	6 (n.c.)
n.c.	5V	7	8	Index Pulse (out)	8
n.c.	5V	9	10	Drive Select 0 (in)	10
n.c.	5V	11	12	Drive Select 1 (in)	12
n.c.	GND	13	14	Drive Select 2 (in)	14
GND	GND	15	16	Motor On (in)	16
n.c.	GND	17	18	Direction Select (in)	18
n.c.	GND	19	20	Step (in)	20
n.c.	GND	21	22	Write Data (in)	22
n.c.	GND	23	24	Write Enable (in)	24
n.c.	GND	25	26	Track 0 Indicator (out)	26
n.c.	GND	27	28	Write Protect Indicator (out)	28
n.c.	12V	29	30	Read Data (out)	30
n.c.	12V	31	32	Head Select (in)	32
n.c.	12V	33	34	Drive Ready(out)	34

Table 1 The connections between cable and the HxC emulator board.

Notes:

1) Pinout according to the HP 9153B Service Manual.
2) All even lines are connected to their corresponding line on the HxC emulator.
3) The two wires from pins 3 and 15 are routed to the separate power connector of the HxC Emulator.

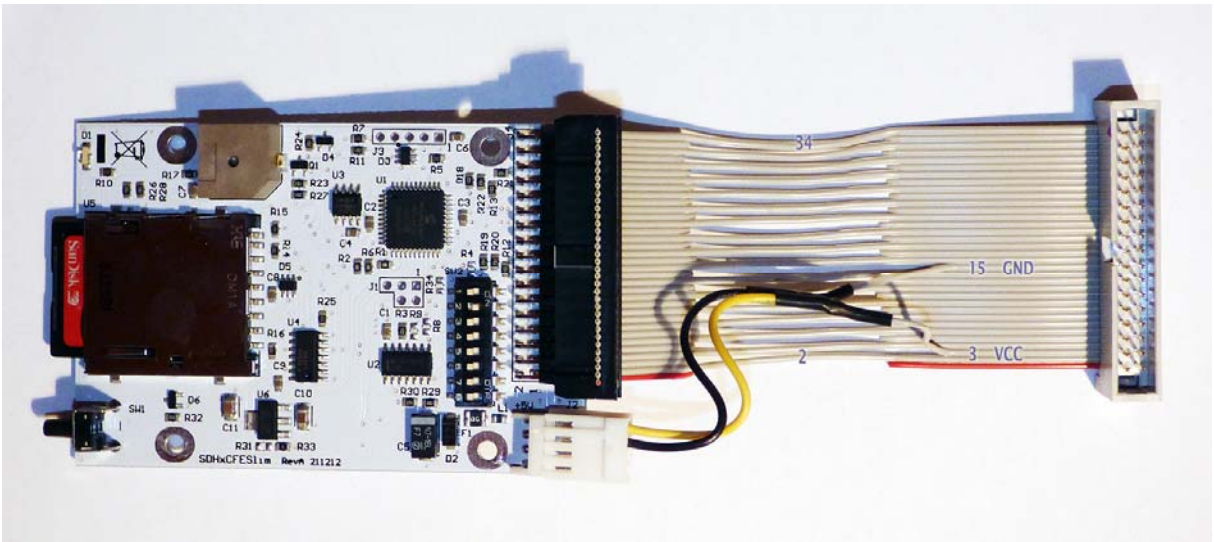


Figure 2: Adapter cable with power supply lines. All odd lines except 3 and 15 are cut. All lines with even numbers are connected to the upper row on the HxC connector. The plug on the original cable in the HP 9153 system is plugged into the connector at the right hand side.

1.2. Emulator Switches

On the HxC emulator only the dip switch #2 must be set to the "ON" position. All other switches are left in their "OFF" position.

1.3. Disk Format for Series-80 Computers

The HP Series 80 computers (HP-85, 86, 87, 9915) use a disk format which is characterized by 2 sides with 77 tracks on each side. Each track has sectors with a length of 256 bytes. Therefore the settings as shown in Figure 3 can be used to create a new raw disk (see also section 4).

Another special feature of the disk drives as used by HP is that they rotate at 600 rpm. This yields a higher data rate than e.g. on the IBM PC. Therefore the data rate must be set to 500'000 bits per second. The recording format is MFM. In the *HxC Floppy Emulator* software you can select the "Load RAW image" command button to open the "RAW File format configuration" dialog. Here you can specify the desired disk parameters.

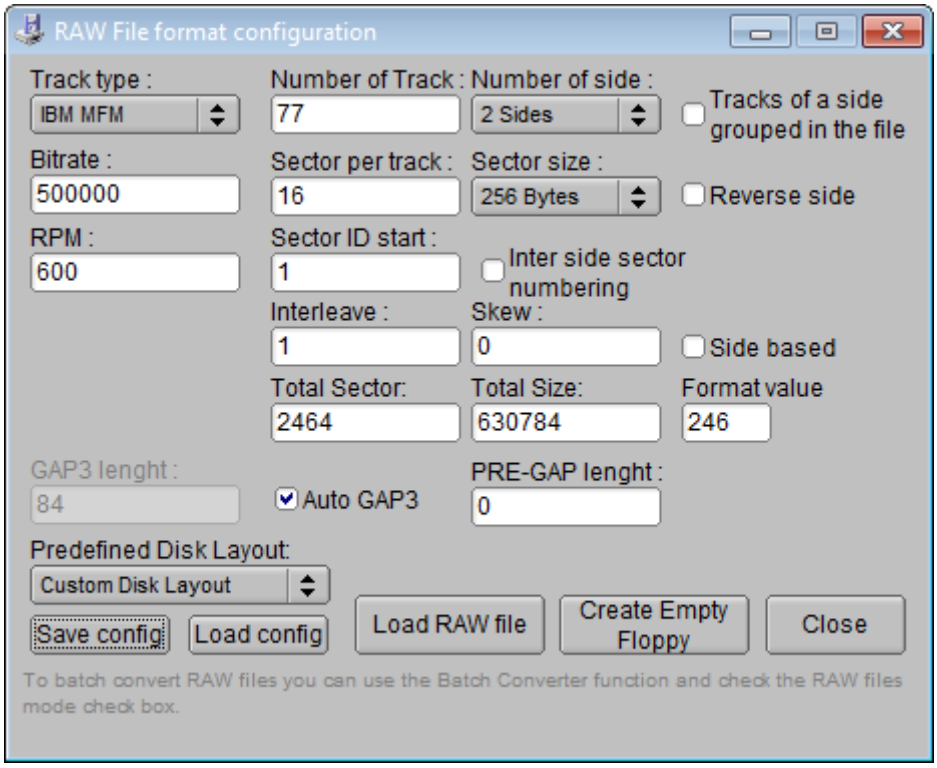


Figure 3: Settings for HP-85/86/87 disk images. This information is recorded in each HFE image file.

After adjusting the values as shown in Figure 3 you should use the "Save config" command button to save the settings for this file format to a file with extension .fcf. Then you can use the "Create Empty Floppy" button to create a new disk image. This image must then be written to the SD card using the "Export" command. Use a file name of the form "DSKA0000.HFE". It is sufficient to export a single disk image to the SD card first.

For the curious: if you examine the header of a HFE file it should look like shown in Figure 4.

```
00000000 48 58 43 50 49 43 46 45 00 4D 02 00 F4 01 00 00 HXCPICFE.M......
00000010 07 01 01 00 FF FF FF FF FF FF FF FF FF FF FF FF ................
```

Figure 4: Hex dump of the first part of a HFE file for the SONY drive used in the 9153C disk drive with HP Series-80 computers.

Besides the disk images, the emulator also needs a configuration file which controls its operating mode. You can create this file with the "SD HxC Floppy Emulator settings" command button. This displays another dialog where you enter the settings shown in Figure 5 below.

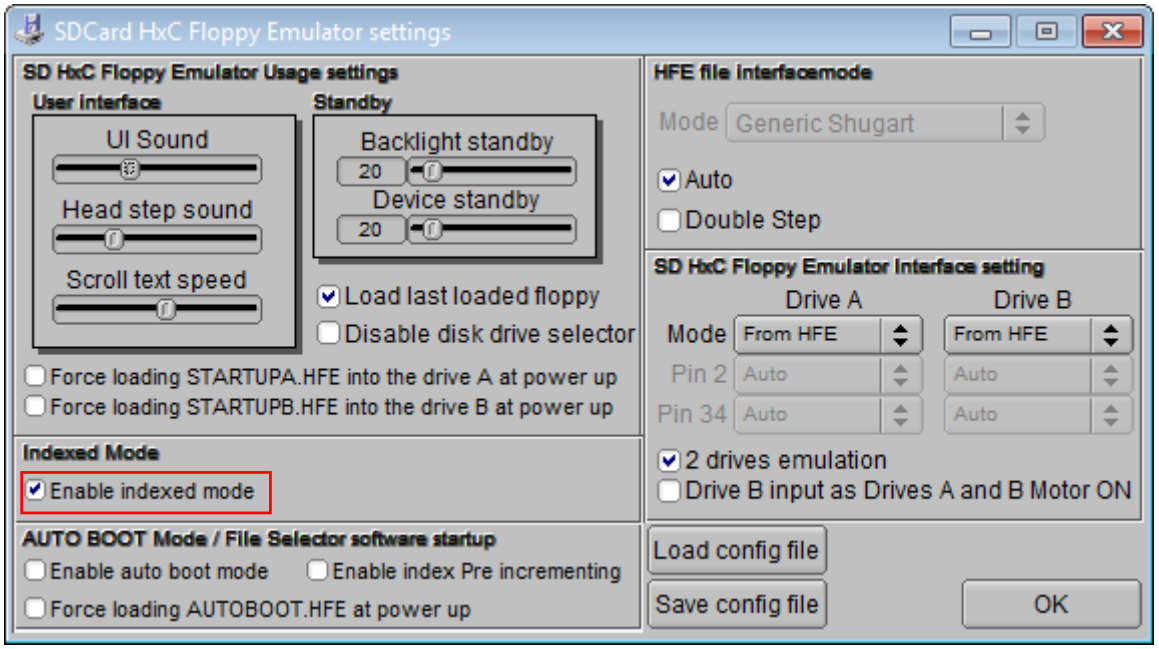


Figure 5: Emulator configuration for HP Series-80 disks. This information is stored in the CFG file.

Make sure that the option "indexed mode" is enabled to use the numbered disk files names. Also check that the interface is set to the default value of Shugart compatible. You must save the configuration file to the SD card using the "Save config file" command button to the file named HXCSDFE.CFG.

Your SD card must finally have this configuration file plus one or more numbered disk image files in HFE format.

1.4. Preparing a new Disk Image

You must INITIALIZE each new disk image with the Series-80 computer. This can be affected by the well-known formatting command

```
INITIALIZE "0000",":D831"
```

Here we assume that your disk system is connected to an HP-IB interface with select code 8 and that the system has the address 3 and that the disk is unit number 1 (0 should be the hard disk). Giving the disk a volume label corresponding to the file number makes it later easier to navigate through the file sequence.

If you have initialized a first disk image, you can use the following Windows command script to create as many copies of this initialized disk image for future application as you need. Remember that you must name each file according to the "indexed" operating mode with a name like "DSKA0000.HFE", incrementing the number for each additional file. The file numbers must form a contiguous sequence, i.e. no gaps are allowed.

```
@ECHO OFF
REM ======================================================
REM This Windows Command script creates multiple copies of
REM the file "DSKA0000.HFE" for usage in the HxC Floppy
```

```
REM Emulator using "indexed mode".
REM ====================================================
REM
REM Usage:
REM ------
REM 1) Prepare a file named DSKA0000.HFE.
REM    This can be produced e.g. by the Create RAW file
REM    option of the HxC Floppy Software
REM 2) Run this script.
REM
REM Actions performed:
REM ------------------
REM Create COUNT copies of the file with sequenced file numbers.
REM
REM ====================================================
REM Created: September 2016, Martin Hepperle
REM ====================================================
SETLOCAL ENABLEDELAYEDEXPANSION

REM number of copies to create (1...COUNT)
SET COUNT=10

REM walk through all *.hfe files
REM S=source file name, T=target file name
FOR /L %%N IN (1,1,%COUNT%) DO (
      REM prepare numbered trailer part with 4 digit number
   SET K=000%%N%.hfe
      REM prepare target name, take the last 8 characters only
      SET T=DSKA!K:~-8!

      COPY DSKA0000.HFE !T! 1> NUL
)

ECHO *** %COUNT% copies of DSKA0000.HFE created.
```

Figure 6: This command script "replicateDisk.cmd" creates copies of a first disk image for indexed operation.

When you later select the next image using the pushbutton of the emulator, it will beep once for the first file, twice for the second file etc. Holding the button longer will reset the index to the first file "DSKA0000.HFE".

1.5. Converting LIF Disk Images

If you have one or several disk images in LIF format (HP's Logical Interchange Format), you can easily convert these to the HFE format. Such images come e.g. with Everett Kaser's Series-80 computer emulator. The LIF format is just a sequence of "logical" sectors. There is no information about interleaving, heads or tracks. This is the same as the so called "RAW" format.

You can use the *HcX Floppy Emulator* software to convert a single file or to batch convert a larger number of files.

For batch conversion you open the "Batch converter" dialog and tick the "Treat input files as RAW files" option, which opens the "Raw File format configuration" dialog. Here you can load the configuration file with extension ".fcf" created before or specify the parameters again. When done, close this dialog.

Specify the source directory and the target directory and convert all files using the "Convert" command button.

The resulting HFE files carry the names of the input files. In order to prepare them for the "indexed mode", you must rename them. The following script does this automatically. The resulting files with numbered file names plus a text file with an index assignment catalogue are stored in a new subdirectory "HFE_NUM". You can then copy these files to the SD(HC) card, together with the CFG file as created in section 1.3.

```
@ECHO OFF
REM =======================================================
REM This Windows Command script prepares a set of files for
REM usage in the HxC Floppy Emulator using "indexed mode".
REM =======================================================
REM
REM Usage:
REM ------
REM 1) Copy all desired named .hfe files to a empty directory.
REM    These can be produced e.g. by the batch conversion
REM    option of the HxC Floppy Software
REM    A typical file name could be "HP85_StdPac.hfe"
REM 2) Run this script.
REM
REM Actions performed:
REM ------------------
REM 1) Create a directory HFE_NUM
REM 2) Copy each *.hfe file in the current directory to the
REM    directory HFE_NUM replacing the file name with
REM    DSK????.HFE, where ???? is a 4-digit sequential number.
REM 3) Create a file "CAT.TXT" in the directory HFE_NUM which
REM    contains the translation table from the original file
REM    name to the indexed file name.
REM
REM =======================================================
REM Created: September 2016, Martin Hepperle
REM =======================================================
SETLOCAL ENABLEDELAYEDEXPANSION

REM suppress error messages if directory is already existing
RMDIR /S /Q HFE_NUM 2> NUL
MKDIR HFE_NUM 2> NUL
REM create the index file
DEL HFE_NUM\CAT.TXT 2> NUL
ECHO SD Card Catalog > HFE_NUM\CAT.TXT
```

```
REM start numbering at zero
SET N=0

REM walk through all *.hfe files
REM S=source file name, T=target file name
FOR %%S IN (*.hfe) DO (
   ECHO %%S%

   REM prepare numbered trailer part with leading zeros
   SET K=000!N!.hfe
   REM prepare target name, take the last 8 characters only
   SET T=DSKA!K:~-8!

   COPY %%S% HFE_NUM\!T! 1> NUL

   REM add to CATalog
   ECHO !T! == %%S% >> HFE_NUM\CAT.txt

      REM increment index
      SET /A N=!N!+1
)
```

Figure 7: This command script "convertDisks.cmd" creates copies of all disk images renamed for indexed operation plus an index file.

2. Other SONY Floppy Disk Drives

HP introduced 3-1/2" inch disk drives quit early. The first drives were the SONY OA-D31V-1. These were single sided drives which used manually operated shutters first. Later the double sided variants SONY OA-D32W, and OA-D32V were introduced. All these can be recognized by the square eject button and the often sticky disk lift and eject mechanism. This problem leads to many destroyed disk drives when impatient users unintentionally ripped of the upper read-write head.

The single sided types were installed in the 9121 and early 9133A and B drive systems, the double sided versions were used e.g. in early 9153A, 9114A, 9122, and later 9133 variants. All these disk drives have 26 pin connectors and a separate power connector with +5V, +12V and GND.

They use MFM recording scheme at 600 rpm. Tracks are numbered 0-69, sector IDs are 1-16. The sector size is HP typical with 256 bytes. The typical capacity is 270 KBytes (SS, DD).

The drives have a switch with 4 positions for drive select. The drive select lines 0 and 1 represent a binary number (11=1, 01=2, 10=3, 00=4). The head load signal lowers the head to the surface.

I have not yet tried to connect a HxC Emulator to these systems.

	 Figure 1. MicroFloppy Disk Drive	
OA-D31V-1	**OA-D32V**	**OA-D32W**

Specifications

	OA-D32W		OA-D32V	
	SINGLE DENSITY	DOUBLE DENSITY	SINGLE DENSITY	DOUBLE DENSITY
Capacity				
Unformatted Per Disk	500 Kbytes	1.0 Mbytes	250 Kbytes	500 Kbytes
Unformatted Per Track	3.125 Kbytes	6.25 Kbytes	3.125 Kbytes	6.25 Kbytes
Burst TRANSFER RATE	250 Kbits/sec	500 Kbits/sec	250 Kbits/sec	500 Kbits/sec
Access Time				
Track to Track	12 msec.		12 msec.	
Average*	350 msec.		350 msec.	
Settling Time	30 msec.		30 msec.	
Head Load Time	60 msec.		60 msec.	
Average Latency	50 msec.		50 msec.	
Functional				
Rotational Speed	600 RPM		600 RPM	
Recording Density (inside track)	4359 bpi	8717 bpi	4094 bpi	8187 bpi
Track density	approx. 135 TPI		approx.135 TPI	
Cylinders	80		80	
Tracks	160		80	
R/W Heads	2		1	
Encoding Method	FM, MFM		FM, MFM	
Heat Dissipation				
Operating Mode (Head Load)	6.0 W		6.0 W	
Standby mode (Head Unload)	3.9 W		3.9 W	
Media Requirements 3.5" x 3.7" (90 mm x 94 mm)	SONY OM-D4440		SONY OM-D3440	

*Average access time = 1/3 x (Track Nos.) x (Track to track time) + (Settling Time)

PIN NO	Description	Mnemonic
1	Motor On	MTON
2	Drive Select 0	SELECT 0
3	Disk Change	DSKCHG
4	Drive Select 1	SELECT 1
5	Disk Change Reset	CHGRST
6	Direction Select	DIRTN
7	Return	RETURN
8	Step	STEP
9	Return	RETURN
10	Write Data	WRTDATA
11	Return	RETURN
12	Write Gate	WRTGATE
13	Return	RETURN
14	Head Load	HDLOAD
15	Return	RETURN
16	Head Select	HDSL
17	Return	RETURN
18	Index	INDEX
19	Return	RETURN
20	Track00	TRK00
21	Return	RETURN
22	Write Protect	WRTPRT
23	Return	RETURN
24	Read Data	RDDATA
25	Return	RETURN
26	Ready	READY

HxC	SONY Connector				HxC
pin	Signal	pin	pin	Signal	pin
16	Motor On (in)	1	2	Drive Select 0 (in)	to 10?
2	Disk Change Indicator (out)	3	4	Drive Select 1 (in)	n.c.?
n.c.	Disk Change Reset (in)	5	6	Direction Select (in)	to 18
	GND	7	8	Step (in)	to 20
	GND	9	10	Write Data (in)	to 22
	GND	11	12	Write Enable (in)	to 24
	GND	13	14	Head Load (in)	to ?
	GND	15	16	Head Select (in)	to 32
	GND	17	18	Index Pulse (out)	to 8
	GND	19	20	Track 0 Indicator (out)	to 26
	GND	21	22	Write Protect Indicator (out)	to 28
	GND	23	24	Read Data (out)	to 30
	GND	25	26	Drive Ready (out)	to 34

Table 2 The connections between cable and the HxC emulator board.

Power Connector	
1	+5V
2	GND (5V)
3	GND (12V)
4	12V

Table 3 The pinout of the power connector. Only 5V and GND line should be routed to the HxC emulator board.

3. Tandon Floppy Disk Drive TM-100-2A

This 5-1/4" disk drive was used in the IBM PC and other computers as well as in in older HP gear, for example in the 9130A drives for the HP 86A, the 82901M and 82902M, or in the first HP 9000 series machines like the 9826.

3.1. Connection

The Tandon drive uses a 34 pin edge connector and a separate power connector with +5V, +12V and GND. The wiring scheme is straightforward. However, in the plug mounted on the cable not all pins are present. Thus, the higher drive select signals are missing as each drive is wired as drive "0".

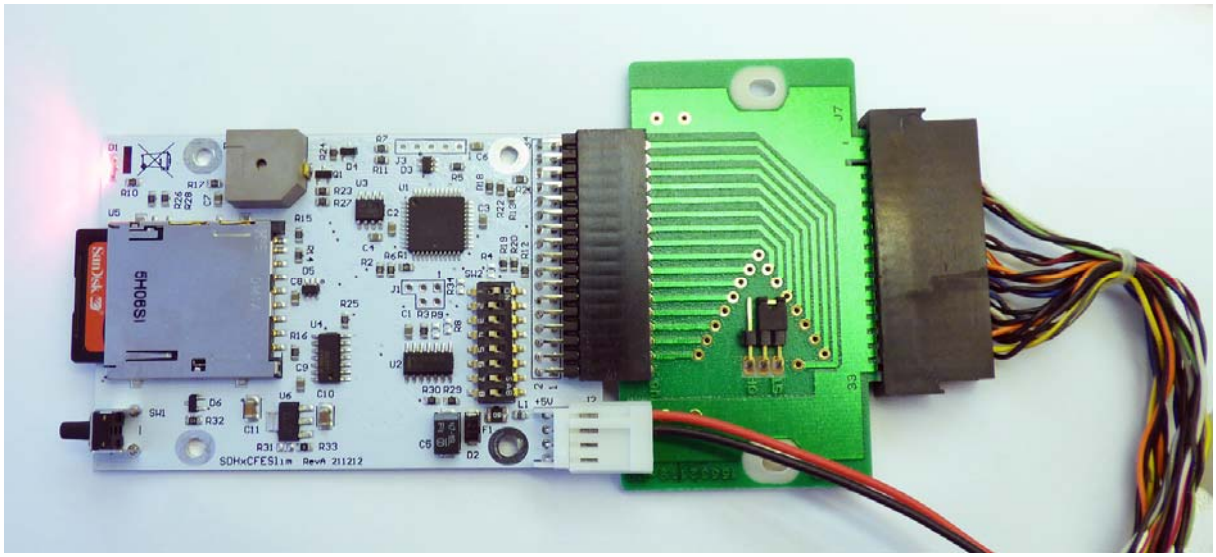


Figure 8: A simple adapter was used to connect the HxC Emulator to the edge connector provided by the HP 86A computer. These adapters were supplied in the 1980s with TEAC 3.5" floppy disk drives. The power supply is connected to the separate 5V/12V connector.

HxC	Tandon Connector				HxC
pin	Signal	pin	pin	Signal	pin
1	GND	1	2	connector clamp (n.c.)	2
3	GND	3	4	spare (n.c.)	4
5	GND	5	6	Drive Select 3 (in) (n.c.)	6
7	GND	7	8	Index Pulse (out)	8
9	GND	9	10	Drive Select 0 (in)	10
11	GND	11	12	Drive Select 1 (in) (n.c.)	12
13	GND	13	14	Drive Select 2 (in) (n.c.)	14
15	GND	15	16	Motor On (in)	16
17	GND	17	18	Direction Select (in)	18
19	GND	19	20	Step (in)	20
21	GND	21	22	Write Data (in)	22
23	GND	23	24	Write Enable (in)	24
25	GND	25	26	Track 0 Indicator (out)	26
27	GND	27	28	Write Protect Indicator (out)	28
29	GND	29	30	Read Data (out)	30
31	GND	31	32	Head Select (in)	32
33	GND	33	34	connector clamp (n.c.)	34

Table 4 The connections between cable and the HxC emulator board. The lines with grayed text are not connected. Thus only drive select "0" is used.

3.2. Emulator Switches

On the HxC emulator only the dip switch #1 (ID0A) must be set to the "ON" position. All other switches are left in their "OFF" position.

4. Predefined LIF Formats in the HxC Floppy Emulator Software

The HxC Floppy Emulator software contains four predefined LIF image file formats. These can be used to export empty LIF images with the volume header "HPLIF " and an empty directory structure.

Form	Capacity	tracks	sides	sectors / side	RPM	bits / second	sectors / track
5-1/4"	264	40	2	560	300	250'000	16
3-1/2"	264	66	1	1056	600	500'000	16
3-1/2"	616	80	2	1280	600	500'000	16
3-1/2"	1232	80	2	2560	600	500'000	32

Table 5 The predefined and already formatted LIF images available.

All use "GENERIC_SHUGART_DD_FLOPPYMODE" and "ISOIBM_MFM_ENCODING".

Note that the predefined 5-1/4" format uses more tracks than necessary – 35 would be sufficient. According to the hardware and software description of these drives and HP systems the disk drives should be formatted with 35 tracks and 16 sectors. The preformatted files work and contain an empty disk image. The superfluous tracks seem to be no problem.

The preformatted image uses the sector sequence 0,8,1,9,2,10,3,11,4,12,5,13,6,14,7,15 – every second sector is skipped.

Unfortunately a formatting operation (using INITIALIZE) fails after an irregular number of tracks have been formatted. Often 7, 14 or 21 tracks are formatted before the failure occurs. Therefore one must avoid to format the image in the HP system.

Furthermore I was not able to copy a larger file (2000 records) from another (real) floppy disk drive to the HxC emulator. The COPY action always stopped after 3 tracks with "ERROR 130: DISC".

On the other hand I can create a data file of the same size using the CREATE command and later use a BASIC program to write and read data to resp. from this file.

It is unclear why this does not work. In case of the SONY 3-1/2" drive in the 9153C disk drive system formatting is no problem.

TABLE 2-1
ELECTRICAL AND OPERATIONAL SPECIFICATIONS

Media	ANSI-compatible, 5-1/4-inch diskette
Media Life (for reference only)	4×10^6 passes per track
Tracks Per Inch	48 TPI, both drives
Tracks Per Drive	
TM100-1	40 tracks
TM100-2	80 tracks
Track Spacing	0.529 millimeters, 20.8 milinches
Head Life	20,000 media contact hours
Disk Rotational Speed	300 RPM ± 1.5 percent
Average Rotational Latency	100 milliseconds
Instantaneous Speed Variation (ISV)	± 3 percent
Motor Start Time	250 milliseconds, maximum
Motor Stop Time	150 milliseconds, maximum
Seek Time, track-to-track	5 milliseconds
Head Settling Time	15 milliseconds
Average Track Access Time, including head settling time	75 milliseconds
Typical Recording Modes	FM, MFM, MMFM
Data Transfer Rate	250,000 bits per second, double density
Flux Reversals Per Inch (FRPI), inside track	
Both Models, Side 0	5,535 FRPI
TM100-2, Side 1	5,877 FRPI

Tandon CORPORATION, CHATSWORTH, CALIFORNIA 91311 | 179059-001 REV. A

4.1. Test 1

Now using a SanDisk Extreme SDHC UHS-I card (Class 10, U3, 90 MB/s read speed)

- formatting proceeds from track 0 to track 34, sides 0 and 1.
- image contains 0xDB written by formatting routine, which is correct
- HxC seeks back to track 0, but then “ERROR 130 : DISC” is issued.

- as a result required volume and directory structure are not written to the image and the image is not useable.

It looks like the HxC would be too slow when seeking back to track 0.

4.2. Test 2

A small BASIC program was used to test the interaction with the HxC emulator.

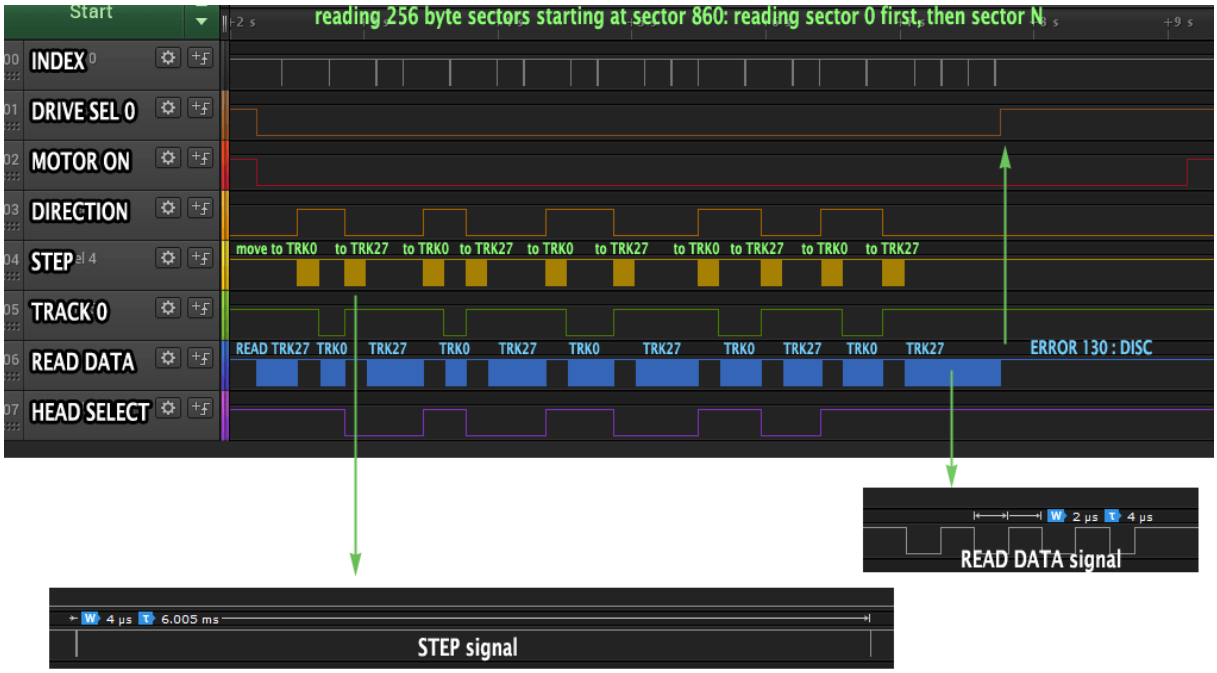
A first variant simply read complete sectors of 256 bytes starting with sector 0 over the whole disk. This worked without problems. All sectors could be read.

Then the program was modified to force the HxC emulator to seek for each sector.

A reading of sector 0 was inserted just before reading the desired sector. Thus the emulator had to seek to sector 0, read it, and then seek to the desired sector and then read this sector.

This procedure worked up to about track 27 was reached. Then it failed. The HP 86 issued “ERROR 130 : DISC”.

Looking at the signals does not show me anything special (but this means nothing). Only the reading attempt of the last sector on track 27 is very long, compared to the previous reads.



some timings

- Index pulse duration 4 ms, interval 0.195 s which corresponds to a speed of 308 1/min, which is slightly out of the 300 ± 1.5% band
- Read data bits duration 2 µs
- Head step pulse duration 4 µs (o.k > 200 ns)