MEMOTECH
MFX SYSTEM
OPERATOR'S
MANUAL

Credits :

       Martin Allcorn   : Co-designers, CFX, CFX-II, MFX
       Dave Stevenson

       Bill Brendling   : 80 Column Card emulation (CFX-II), FTPD
                                       Additional graphics modes, SD Extended Storage Interface

       Andy Key   : SDX ROM and enhancements, REMEMOTECH, ReMemoRizer

       Memotech   : For the MTX series

Table of Contents

1   Introduction

This document is a supplement to the MFX (Multi-Function Expansion) card Operator's Manual. It describes the enhancements to MFX that are available with systems that use the Cyclone IV FPGA module. Such systems can be easily identified by the colour of the FPGA module which is RED.

2   Hardware Differences

The Cyclone IV FPGA contains more logic resources that the Cyclone II. MFX uses the Cyclone IV EP4CE10 which has 10320 Logic Elements and 423,936 RAM bits, compared to the 4608 Logic Elements and 119,808 RAM bits in the Cyclone II EP2C5.

The most significant difference for MFX is that the additional FPGA RAM makes it possible to do away with the Video RAM chip needed on the Cyclone II based MFX PCB.

The VRAM socket can be repurposed to provide additional I/O capabilities to MFX. In the first instance, support for a battery backed Real Time Clock has been added.
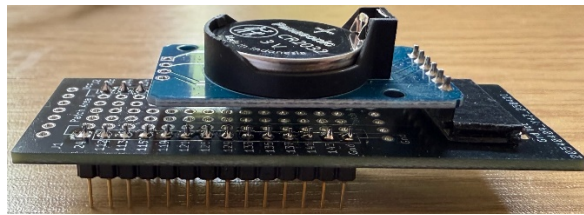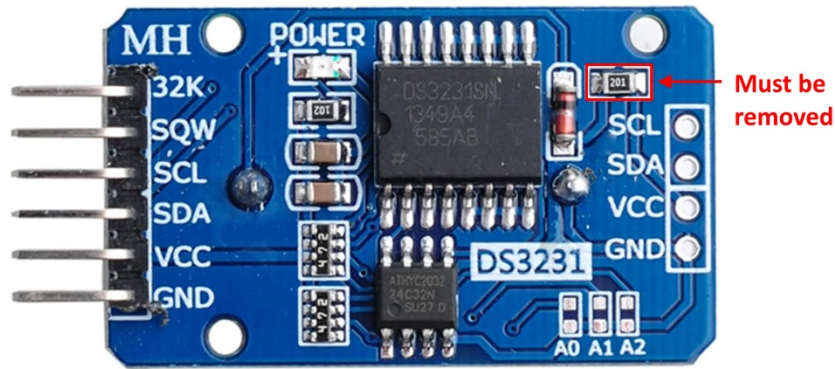
2.1   Real Time Clock Installation

The RTC functions were designed to utilise a readily available plug-in module based on the Dallas (Maxim) DS3231 RTC, plugged in to the now unused VRAM socket. The first versions of MFX PCBs to use the EP4CE10 FPGA were shipped with duel leaf contact sockets for the VRAM chip, later boards were shipped with turned pin sockets. An I/O adapter board has been created that allows the RTC module to be plugged in to either type of socket.

The RTC module can be fitted to the I/O adapter either before or after the adapter is installed in the socket, but it is easier to do it afterwards, particularly if the MFX board has already be installed in the MTX. There is no orientation indication on the adapter board, the adapter should be inserted such that the pin marked "24" is inserted into Pin 1 of the VRAM socket. With the MFX PCB viewed from above, Pin 1 of the VRAM socket is adjacent to the lower leg of its associated capacitor, "C1".

Ensure that the adapter is inserted squarely, with all pins mated with the corresponding socket pin. The RTC module should then be connected to the square pin socket on the I/O adapter board.

NB: The RTC module that you have received with your MFX should have had the 200 Ohm resistor, originally located in the top right corner of its PCB removed. This is necessary to correct a design flaw with the module and prevent the 3.3v supply being applied to a non-rechargeable battery. If the RTC module is replaced with one of the same type in future, this modification should be made to the replacement module.

The RTC module installed on the I/O adapter, ready for insertion into the MFX VRAM socket.

3   Firmware Enhancements

Support for the Cyclone IV FPGA was added in firmware version 19:01 19/01/25 and includes support for a Dallas DS3231 Real Time Clock (RTC) from SDX BASIC and CP/M.

The MFX boot ROM has been modified to allow the system to be booted into either CP/M 2.2, using the existing <*Reset*><*C*> option, or CP/M 3.1 using the new <*Reset*><*3*> option.

Retaining support for the traditional CPM 2.2 on the MTX requires a separate boot ROM for CPM3. Since MFX is already using ROM pages 4,5 and 6, that meant re-programming the GAL to open up ROM slot 3 as well. The MFX boot screen has been given a make over and the colours changed to red on black to match the MTX themed black PCB & red FPGA board used for the most recent revisions of MFX. Other hardware changes are an RTC fitted to the old VRAM socket and changes to the FPGA to provide access to both the SPI clock and set up an off CPU memory buffer to support the banked memory.

4   CP/M Operating System Enhancements

MFX was designed to use the same version of CP/M as Memotech's original disk systems, i.e., CP/M 2.2. Digital Research released a later version of CP/M as Versions 3.0, also referred to as CP/M Plus. Backwards compatible with version 2.2, CP/M 3's main enhancements were better memory management (including the ability to offload elements of the BIOS into banked memory, increasing the Transient Program Area) and the addition of date/time functions that supported the use of a RTC.
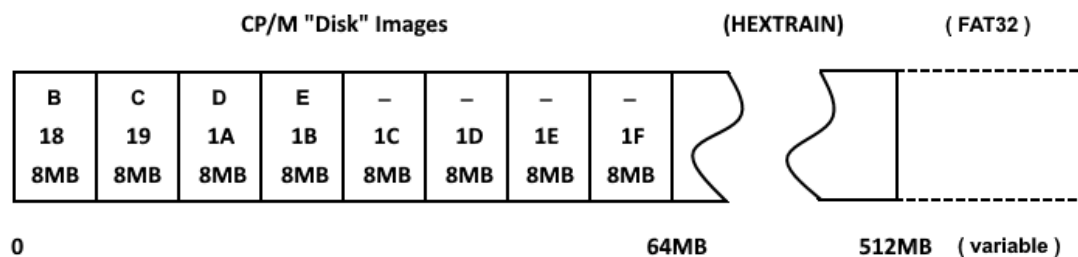
Note: Memotech SDX BASIC and all published games rely on the underlying CP/M 2.2 disk structure and will therefore not run on CP/M 3.x.

To take advantage of the RTC functions, CP/M 3.1 has been ported to MFX. The 3.1 version includes some bug fixes from the 3.0 release and includes support for Y2K compliant dates and UK date format.

To minimise the impact of the changes to the MFX "disk" structure and retain compatibility with HEXTRAIN, the layout of the logical drives on the SD card has changed slightly.
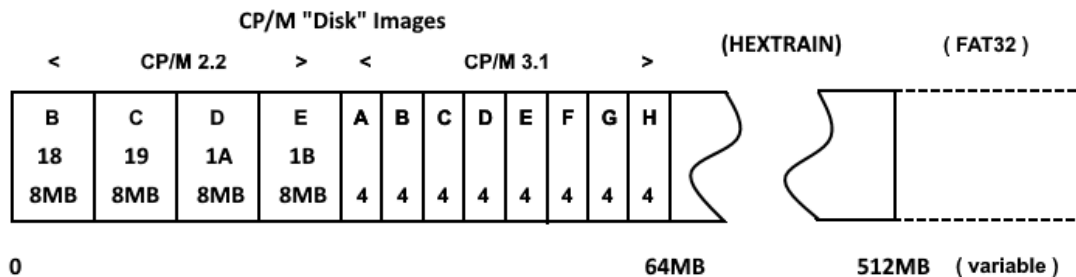
Since CP/M 3 was going to be incompatible with Memotech SDX BASIC, including games, it was essential that support for the CP/M 2.2 system was retained. CP/M3 more or less required a new partition format. CP/M 2 expects each track to be 26 sectors of 128 bytes, that works out at 3.25k per track. CP/M3 works with the native sector size, for CF and SD that's 512 bytes, meaning there's no way to define a track that is 3.25k long. It is possible that the track could have been made to be 6.5K long and things made to work. However a 4k track size and a 4K block size makes the disc geometry calculations incredibly simple.

To allow the system to be able to boot existing MFX SD cards and to avoid breaking HEXTRAIN, the MFX CP/M 3 SD card structure was kept the same as that used for CP/M 2.2. MFX ROM firmware version 140124 added support for Bill's enhanced storage functions which enabled the MFX to support usage of larger capacity SD cards, allowing the extra storage space to be FAT formatted. The card structure was made up of the Master Boot Record, followed by 8 x 8MB partitions, then the HEXTRAIN data block, with the remaining card capacity able to be FAT formatted. Only 4 of the 8MB partitions were visible to CP/M at any one time, normally, partitions 18 to 1B were mapped to drives B to E, but partitions 1C to 1F could be remapped to a drive letter using the **RECONFIG** program. Normally, the 4 higher 8MB partitions were not actually used, leaving a 32MB block that could be made available to CP/M 3. The **syscopy.com** utility could be used to write a copy of the CP/M system tracks to any of the available partitions, which, when mapped to drive letters, were bootable.

CP/M "Disk" Images   (HEXTRAIN)   (FAT32)

B	C	D	E	–	–	–	–
18	19	1A	1B	1C	1D	1E	1F
8MB	8MB	8MB	8MB	8MB	8MB	8MB	8MB

0   64MB   512MB   (variable)

Although the 8MB partitions supported up to 512 directory entries, as CP/M does not support subdirectories, 512 files in the root directory was not very user friendly and thought unnecessary. We decided that the 32MB of space could be better used by CP/M 3 if configured as a more, smaller, "disks" and decided that 8 x 4MB partitions was more appropriate. By default, CP/M 3 would have supported 256 directory entries, but enabling timestamping for a "disk" uses one of the four directory areas, reducing the number of directory entries to 192. A bit more restrictive, but unlikely to be a problem.

With 8 x 4MB "disks", the online disk capacity is the same as the 4 x 8MB "disks" available in CP/M 2.2, albeit that the number of available directory entries will be slightly less if date/time stamping is used.

CP/M "Disk" Images

<	CP/M 2.2		>	<		CP/M 3.1				>	(HEXTRAIN)	(FAT32)
B	C	D	E	A	B	C	D	E	F	G	H	
18	19	1A	1B									
8MB	8MB	8MB	8MB	4	4	4	4	4	4	4	4	

0   64MB   512MB   (variable)

The CP/M 2.2 and CP/M 3 disk image areas are only visible to the associated system version, there is no facility to directly transfer files between the two. However, this isn't really a problem as both systems can use FTP to transfer files via a host PC.

Bill Brendling's *fatcopy.com* is available when CP/M 2.2 is booted from the MFX ROM. The program makes use of Bills Extended Storage ABI which relies on some hooks in the MFX ROM and CP/M 2.2 BIOS. The CP/M 3 BIOS is loaded entirely from "disk" and does not have any driver code loaded into high memory, thus the Enhanced Storage ABI and *facopy* program are not available.

In Memotech's implementation of CP/M 2.2, Drive A was always mapped to the boot drive. By default, the system booted from drive B which was then mapped to Drive A, although they appeared as different drive, the contents of both drives were the same. For CP/M 3, there are 8 partitions of 4 meg each from A to H, with the system booting off A. Drive C is intended to be the system backup, the other 6 partitions hand back 24k storage space by not having space allocated for system tracks.

The Bootstrap ROM includes an option to write a copy of the CP/M 3.1 system tracks to the backup partition (backup) and copy the system tracks to the primary partition (restore).

5 CP/M 3 Software

5.1 Digital Research Utilities

The SD card image includes versions of the suite of utilities originally distributed with CP/M 3. For a full description of these utilities, please refer to the original Digital Research documentation.

The subset of program described in this section are included to highlight the date/time functions available with CP/M 3.

5.1.1 Date/Time Reporting

The *DATE* command returns the current Date and Time from the Real Time Clock. At this point, it is not possible to set the RTC from CP/M, that must be done from SDX BASIC using the USER RTX commands described in Section 6.

5.1.2 Date Format

As might be expected, the default date format used in CP/M 3 is US format, i.e., mm/dd/yy. However, the *SETDEF* command may be used to set the format to UK, i.e., dd/mm/yy.

> *SETDEF [UK]*

The Date functions include the CP/M 3 patches that introduced Y2K compatibility so dates post the millennium are fully supported.

5.1.3 File Date/Time Stamping

Date/Time stamping is not enabled by default as there is a trade-off to be made when opting to use this function. The Date/Time stamps are stored in one of CP/M 3's file directory areas, reducing the number of areas from 4 to 3. For the 4MB CP/M 3 partitions used in MFX, this reduces the number of files that can be stored (i.e., the number of directory entries) on the "disk" from 256 to 192.

Before a particular "disk" can use Date/Time stamps, the *INITDIR* command must be used

> e.g., *INITDIR B:*

This command only *prepares* the disk for timestamping, for any files already on the disk, the actual timestamps will remain blank until further commands are issued.

There are three options available for the timestamps that are enabled using the *SET* command

Option	Function
[CREATE=ON]	Turns on CREATE time stamps on the disk in the

	default or specified drive. To record the creation time of a file, the CREATE option must be turned on before the file is created.
[ACCESS=ON]	Turns on ACCESS time stamps on the disk in the default or specified drive. ACCESS and CREATE options are mutually exclusive; only one can be in effect at a time. If you turn on the ACCESS time stamp on a disk that previously had CREATE time stamp, the CREATE time stamp is automatically turned off.
[UPDATE=ON]	Turns on UPDATE time stamps on the disk in the default or specified drive. UPDATE time stamps record the time the file was last modified.

Examples

A>*SET [ACCESS=ON]*

A>*SET [CREATE=ON,UPDATE=ON]*

SET {d:} *[UPDATE=ON|OFF]*

5.1.4   Autoexec.bat - the CP/M 3 equivalent

On startup, CP/M 3 looks for a startup command file called ***profile.sub***, this file can contain an optional list of CP/M commands (.com files) that are to be run when the system starts. These commands are executed in turn by the ***SUBMIT*** program. To have the system use UK date format and display the current Date/Time, I have created a ***profile.sub*** file that contains the following commands :

SETDEF [UK]
DATE

5.2   Application Software

CP/M 3 was designed to be backward compatible with the broad range of software written for CP/M 2.2 so most programs available for CP/M 2.2 should run without issue.

The biggest potential problem is the video configuration. The graphics capabilities of most CP/M systems were very limited, typically just using screen cursor positioning control codes. Some CP/M programs came preconfigured with a selection of video "drivers" for defined hardware such as Keypro computers and known terminal types such as VT52, very few (no?) programs, other than

NewWord and SuperCalc distributed by Memotech, included screen definitions for Memotech's FDX/SDX 80 column video boards. Some software, such as Wordstar, allowed the users to configure their output using the screen control codes for their hardware.

It can be time consuming and awkward to configure software in this way but the version of Wordstar on the updated MFX SD card has been configured to use the emulated Memotech 80 column card driver.

6   SDX BASIC RTC Support

The **USER RTX** command has been added to the SDX BASIC ROM to interface with the RTC

6.1   USER RTX0

Sets/reports the RTC time

       USER RTX0   returns time as hh:mm:ss

       USER RTX0,"13:15:17" sets the time to the passed string

6.2   USER RTX 1

Sets/reports the RTC date

       USER RTX1   returns date as dd/mm/yy

       USER RTX1,"13/03/25" sets the date to the passed string

6.3   USER RTX 2

Updates the MTX BASIC TIME$ variable with the current time as hhmmss

       USER RTX2

       PRINT TIME$ returns hhmmss

6.4   USER RTX 3

Returns the temperature of the RTC chip. Gives a useful indication of the temperature inside the MTX case

       USER RTX3   returns, e.g., "Case temperature:20"   (degrees centigrade)

7   CP/M 3 on Cyclone II (Blue) FPGA Systems

As noted above, CP/M 3 is likely to be of most interest to MFX users who have a Real Tume Clock fitted, i.e., MFX boards with serial numbers xx40 and above, where the VRAM socket can be repurposed to allow the installation of an RTC module.

However, it is possible for MFX owners with earlier PCBs to run CP/M 3, albeit, without the benefit of the RTC. A "softload" version of the CP/M 3 system can be loaded by an executeable program, *go3.com*, on the CP/M 2.2 system which invokes the CP/M 3 BIOS and swaps to the associated disk partition.

In this case, a GAL replacement is not required as the system does not need to boot from ROM 3. All that is needed is a replacement SD card loaded with the CP/M 2.2 and 3.1 partitions, depending of the firmware version of MFX, the card may be SD or SD/HC (firmware versions below 167 only support SD media).

8   Games Software

Memotech "disk" games that output to the VDP need to use functions in the CP/M 2.2 ROM so require the system to be booted into CP/M 2.2 or run from SDX BASIC.

Support for HEXTRAIN is unchanged, the program is invoked with HTES.COM and requires that the HEXTRAIN partition exists in its usual position at the end of the 64MB disk image portion of the SD card.

Appendix A   SD Card Maintenance

Appendix A in the MFX manual describes how the MFX SD card can be maintained outside of MFX itself and how SD cards can be created from scratch. The method is slightly different for the CP/M 3 card and this section will be updated in due course. In the meantime, additional SD cards should be prepared by writing the default CP/M 3 SD card image to blank media as required. This will create a bootable CP/M 3 image (with CP/M 2.2 boot capability) and include the HEXTRAIN partition as well as an unformatted FAT32 partition that may be formatted under Windows/Linux if required.

Appendix B   CP/M High Memory

With MFX CP/M 2.2, certain essential routines are located in high memory above the top of CP/M. These routines, which occupy the very top pages of memory right up to 0xFFFF, provide not only the low-level drivers for the disc, display and keyboard hardware but also the drive types supported by CP/M.

The very top of memory contains data and code entry points which may be used by Memotech specific CP/M programs. Some of these were provided by the original Memotech CP/M Boot ROM, others have been added for modern Memotech add-ons. This area also contains hooks for Bill's Extended Storage ABI which allows MFX to write to a FAT formatted partition.

Appendix B in the MFX Manual lists the relevant addresses.

For CP/M 3, this high memory area is not applicable.

The high part of the BDOS code occupies 61k to 62.5k (F400 to F9FF)

The high part of the BIOS code occupies 62.5k to 64k (FA00 to FFFF)

The CPM3 boot ROM is just a bootstrap ROM, in that it just boots the system, it's not needed or used after CPM3 starts, all of the CP/M code is loaded from "disk". That is why the soft load of CPM3 from CPM2 works without the CPM3 boot ROM. This is also why the FATCOPY program does not work (the Extended Storage ABI vectors are not available) and why HEXTRAIN cannot be run from the CP/M 3 partition.

Appendix C   MFX ROM Usage

With the original Memotech disk systems, the distribution of the disk logic between the various ROMs was relatively straightforward. CP/M systems booted from ROM 4 and non-CP/M (SDX) systems booted from ROM 5 (there are no known uses of ROM 6 in Memotech products). (Version 1.1 of MAGROM has the facility to use either ROM ID 6 or 7 but requires a modified GAL which excludes the RAM used by MAGROM from the MFX Memory Map.)

MFX operates in a similar fashion as Memotech disk systems; CP/M 2.2 is booted from ROM 4 and SDX BASIC is booted from ROM 5. However, there was not enough free space in ROM 5 to cater for the additional graphics modes available in BASIC and additional logic has been created and stored in ROM 6. CP/M 3.1 boots from ROM 3.

Appendix D MFX Revision History

Release History	FPGA	ROM	GAL
Initial Production Release	01-00	134	2.0
Support for SDHC cards	01-00	166	2.0
Fix for USER VGA issue from ROM v166	01-00	167	2.0
Fix for Shadow Page Port issue	01-01	167	2.0
SD Card Partitioning and Extended Storage ABI	01-01	01/01/24	2.0
Additional video modes and BASIC support	02-05	01/01/24	2.0
Support for Cyclone IV FPGA and CP/M 3.1	04-05	19/01/25	3.0
Backup/Restore Boot Partition	04-05	14/02/25	3.0

ROM Revision 166 (2022)

Adds the ability to use SDHC cards with MFX. Legacy SD cards are becoming less common and more expensive, this ROM update allows SDHC cards to be used with MFX in the same RAW format as SD cards. To maintain compatibility with the imaging tools described in Appendix A, the same card structure must be used and FAT formatting is still not supported.

SDHC initialisation code contributed by Bill Brendling

NB: SDHC cards are not compatible with HEXTRAIN's data disc image. Users who want to continue to use HEXTRAIN should continue to use an SD card for HEXTRAIN.

Andy's HEXTRAIN program uses customized code to access the hidden HT data area and will be incompatible with the new ROM. Bill is working on modifying the HT program to correctly handle the SDHC card format. An updated HT program will be available for download in due course.

ROM Revision 167 (2022)

Fix for the error introduced to the **USER VGA** command in ROM version 166.

In tandem with this, Bill created a new version of the HEXTRAIN executable that can handle both SD and SDHC cards. The program is available from the *MFX Firmware* page on the website and has been added to the MFX SD card image file. Though both are present in the image file, HTSD.COM supersedes HT.COM for use with both SD and SDHC cards.

ROM Revision 01-01-2024

Enhancements include :

- Supports the use of SD cards with multiple file system partitions, i.e., both CP/M and FAT partitions can exist on the same card, making better use of higher capacity media (SDHC only, SDXC is not supported.) (Does not require an FGPA upgrade)
- Support for the "Extended Storage" ABI. A new version of the HEXTRAIN executable (HTES.COM) is provided to enable HT to use the "Extended Storage" ABI.
- Additional video modes available under SDX BASIC. Whilst the ROM is compatible with the previous release of FGPA firmware, use of the additional video modes requires that the FPGA is upgraded to Revision 2 or later.

ROM Revision 19-01-2025 (Initial release for Cyclone IV FPGA)

- Adds support for CP/M 3.1

- Adds support for Dallas DS3231 RTC from SDX BASIC and CP/M
- Adds support for the numeric accelerator

ROM Revision 14-02-2025

- Adds functions to backup & restore CP/M 3 system tracks from "C" drive

FPGA Revision 01-01 (2022)

Fix for the Shadow Page Port logic error identified in very early shipments of MFX. This error is only present on MFX boards with serial numbers below xx-10 and unlikely to actually impact any users unless they are writing programs that read the Shadow Page port status.

FPGA Revision 2.05 (2024)

Added:

- 1, 2 and 3 bit graphics modes
- Reprogramable font
- Reprogramable colour palette
- Many additional I/O ports to support the above

FPGA Revision 3.10 (2024)

Unreleased beta version for aborted Cyclone IV EP4CE6 board

FPGA Revision 4.05 (2024)

Adds support for the Cyclone IV EP4CE10 board

Enables use of a hardware RTC installed in the VDP socket and adds a CPU memory buffer to support the use of banked RAM in CP/M 3.1

Adds the Numeric Accelerator code developed by Andy for REMEMOTECH. Use of the accelerator is not described in this manual, for details, see Andy's web pages :-

http://www.nyangau.org/rememotech/hardware.htm#accelerator

http://www.nyangau.org/rememorizer/hardware.htm#accelerator