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# **Freescale MQX™ RTOS MFS User's Guide for Kinetis Software Development Kit (KSDK)**

MQXMFSKSDKUG  
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## Revision History

To provide the most up-to-date information, the revision of our documents on the World Wide Web will be the most current. Your printed copy may be an earlier revision. To verify you have the latest information available, refer to [freescale.com](http://freescale.com) and navigate to Design Resources>Software and Tools>All Software and Tools>Freescale MQX Software Solutions.

The following revision history table summarizes changes contained in this document.

Revision Number	Revision Date	Description of Changes
Rev. 0	01/2009	Initial Release coming with MQX software version 3.0
Rev. 0B	04/2009	Text edited and formatting changed for MQX RTOS 3.1 release.
Rev. 2	01/2010	Updated for MQX software version 3.5. New configuration options described (MFSCFG_READ_ONLY_CHECK and similar).
Rev. 2.1	03/2010	Example for IO_IOCTL_GET_DATE_TIME corrected.
Rev. 2.2	08/2010	Chapter 3.8.1.9 IO_IOCTL_FIND_NEXT_FILE updated.
Rev. 2.3	07/2011	Chapter 3.8.1.15 IO_IOCTL_FREE_SPACE updated.
Rev. 2.4	08/2012	Partition Manager Device Driver - related parts of the Chapter 3 updated.
Rev. 2.5	11/2012	Minor changes in _io_part_mgr_install section.
Rev. 2.6	06/2013	Language improvements and editing for MQX software version 4.0.2 Beta1 release.
Rev. 2.7	10/2013	Updated content to reflect the switch from MQX RTOS types to C99 types.
Rev. 2.8	12/2014	Updated for Kinetis SDK 1.1.0 release.
Rev. 2.9	04/2015	Updated for Kinetis SDK 1.2.0 release.

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# Chapter 1 Before You Begin

## 1.1 About This Book

This book is a guide and a reference manual for using the MQX™ RTOS MFS Embedded File System which is a part of Freescale MQX Real-Time Operating System distribution.

This document is written for experienced software developers who have a working knowledge of the C language and the target processor.

## 1.2 Where to Look for More Information

- Release Notes, accompanying Freescale MQX release, provide information that was not available at the time this User Guide was published.
- The *Freescale MQX™ RTOS User's Guide* (document MQXUG) describes how to create embedded applications that use MQX RTOS.
- The *Freescale MQX™ RTOS Reference Manual* (document MQXRM) describes prototypes for the MQX API.

## 1.3 Typographic Conventions

Throughout this book, we use typographic conventions to distinguish terms.

Font style	Usage	Example
<b>Bold</b>	Function families	The <b>_io_mfs</b> family of functions.
<b>Bold</b>	Function names	<b>_io_mfs_install()</b>
<i>Italic</i>	Data types (simple)	<i>uint32_t</i>
	Data types (complex)	See following example.
Constant-width	Code and code fragments	—
	Data types in prototype definitions	See following example.
	Directives	#include "mfs.h"
	Code and code fragments	
<i>Italic</i>	Filenames and path names	<i>part_mgr.h</i>
<i>Italic</i>	Symbolic parameters that you substitute with your values.	See following example.
<i>UPPERCASE Italic</i>	Symbolic constants	<i>MFS_NO_ERROR</i>

### 1.3.1 Example: Prototype Definition, Including Symbolic Parameters

```
uint32_t _io_mfs_install(
```

```
int dev_fd,  
char * identifier,  
uint32_t partition_num)
```

## 1.3.2 Example: Complex Data Types and their Field Names

The structure *MFS\_DATE\_TIME\_PARAM* contains the following fields:

- *DATE\_PTR*
- *TIME\_PTR*

## 1.4 Other Conventions

### 1.4.1 Cautions

Cautions tell you about commands or procedures that could have unexpected or undesirable side effects or could be dangerous to your files or your hardware.

<b>CAUTION</b>	If an application calls read and write functions with the partition manager, the file system will be corrupted.
----------------	---

## Chapter 2 Using MFS

### 2.1 MFS at a Glance

MFS provides a library of functions that is compatible with the Microsoft MS-DOS file system. The functions let an embedded application access the file system in a manner that is compatible with MS-DOS Interrupt 21 functions. All the functions guarantee that the application task has a mutually exclusive access to the file system.

MFS is a device driver that an application must install over a lower-level device driver. Examples of lower-level drivers are drivers for memory devices, flash disks, floppy disks, or partition-manager devices. MFS uses the lower-level driver to access the hardware device.

MFS functions do the following:

- Traverse MS-DOS directory structure.
- Create and remove subdirectories.
- Find files.
- Create and delete files.
- Open and close files.
- Read from files and write to files.
- View and modify file characteristics.
- Get the amount of free space in the file system.

### 2.2 MS-DOS File System Characteristics

#### 2.2.1 Directory Path Names

MFS allows an application to traverse a directory tree. When you specify a directory path, you can use \ and / as directory separators.

You can specify a directory path in one of two ways:

- By starting with a directory separator — the path is assumed to be an absolute path.
- By starting without a directory separator — the path is assumed to be relative to the current directory.

#### 2.2.2 File Attributes

Each file entry in the MS-DOS file system has an attribute byte associated with it. The attribute byte is described in more detail in the following table.

### 2.2.2.1 Bit Number

7	6	5	4	3	2	1	0	Meaning if bit is set to one.
							x	Read-only file
						x		Hidden file
					x			System file
				x				Volume label
			x					Directory name
		x						Archived file
x	x							RESERVED

The volume-label and directory-name bits are mutually exclusive.

### 2.2.2.2 Volume Label

A file entry can be marked as a volume label. There can be only one volume label in a file system and it must reside in the root directory. Also, that label cannot act as a directory name.

## 2.2.3 File Time

Each file entry has a 16-bit write time field associated with it. In MFS, the time is written into the field when the file entry is created, when the file is closed, and as a result of calling *IO\_IOCTL\_SET\_DATE\_TIME*. The format of the time field is as follows:

Element	Bits used	Values
Seconds	0 – 4	0 – 29 (multiply by two for seconds)
Minutes	5 – 10	0 – 60
Hours	11 – 15	0 – 24 (24-hour clock)

## 2.2.4 File Date

Each file entry has a 16-bit write date field associated with it. In MFS, the date is written into the field when the file entry is created, when the file is closed, and as a result of calling *IO\_IOCTL\_SET\_DATE\_TIME*. The format of the date field is as follows:

Element	Bits used	Values
Days	0 – 4	1 – 31
Months	5 – 8	1 – 12
Year	9 – 15	0 – 119 (1980 – 2099)

In addition to mandatory write time and write date a FAT filesystem may contain also optional creation time and date and last access time and date. These optional time stamps are not supported by MFS.

## 2.2.5 File Allocation Table

The MS-DOS file system can have multiple copies of the file allocation table. MFS updates as many FATs as it is configured for. It only reads from the first FAT.

## 2.2.6 Filename Wildcards

The characters \* and ? are treated as wildcards in a filename.

## 2.3 High-Level Formatting

An application can perform high-level formatting on a disk by calling **ioctl()**. The function writes a new boot sector, deallocates all clusters in the file allocation table, and deletes all entries in the root directory.

There is one input/output control command that formats the disk, and one that formats and checks for bad clusters.

The *MFS\_IOCTL\_FORMAT\_PARAM* structure is used:

```
typedef struct mfs_ioctl_format
{
    MFS_FORMAT_DATA_PTR    FORMAT_PTR;
    uint32_t *              COUNT_PTR; /* To count bad clusters */
} MFS_IOCTL_FORMAT_PARAM, * MFS_IOCTL_FORMAT_PARAM_PTR;
```

The first variable is a pointer to a *MFS\_FORMAT\_DATA* structure described below. The second is **uint32\_t \*** that points to the **uint32\_t** variable which is used to contain the count of bad sectors. It is used only if the *IO\_IOCTL\_FORMAT\_TEST* function is used.

```
typedef struct mfs_format_data
{
    unsigned char          PHYSICAL_DRIVE;
    unsigned char          MEDIA_DESCRIPTOR;
    uint16_t               BYTES_PER_SECTOR;
    uint16_t               SECTORS_PER_TRACK;
    uint16_t               NUMBER_OF_HEADS;
    uint32_t               NUMBER_OF_SECTORS;
    uint32_t               HIDDEN_SECTORS;
    uint16_t               RESERVED_SECTORS;
} MFS_FORMAT_DATA, * MFS_FORMAT_DATA_PTR;
```

The *MFS\_FORMAT\_DATA* structure has the following fields:

- *PHYSICAL\_DRIVE*
  - 0x00 for floppy disks; 0x80 for hard disks.
- *MEDIA\_DESCRIPTOR*
  - 0xFD for 5.25" 360 K diskettes.
  - 0xF9 for 5.25" 1200 K diskettes.

- 0xF9 for 3.5" 720 K diskettes.
- 0xF0 for 3.5" 1440 K diskettes and other removable media.
- 0xF8 for hard disk and other non-removable media.
- **BYTES\_PER\_SECTOR**
  - Size of a block in bytes (usually 512).
- **SECTORS\_PER\_TRACK**
  - Number of sectors in a track.
- **NUMBER\_OF\_HEADS**
  - Number of disk heads.
- **NUMBER\_OF\_SECTORS**
  - Total number of sectors on the disk including reserved sectors.
- **HIDDEN\_SECTORS**
  - For hard disks, it is the number of sectors from the beginning of the disk to the beginning of the partition. This is the same number as the *relative sectors* field in a hard disk partition table. For floppy disks, the field is zero.
- **RESERVED\_SECTORS**
  - Number of sectors from the beginning of the file system to the first FAT sector. It is usually one.

## 2.4 Version of MFS

The constant *MFS\_VERSION* defines the version and revision numbers for MFS.

## 2.5 Customizing MFS

The following constant definitions can be overridden to customize MFS. To override any of these definitions, simply define the desired value in the */config/<board>/user\_config.h* file.

```
#define MFSCFG_MINIMUM_FOOTPRINT 1
— Normally not defined. Define to build MFS for small memory devices.

#define MFSCFG_READ_ONLY 0
— Set to one to build MFS in read-only mode without create, write, or format capability. This reduces the
code size and may be useful in certain applications such as boot loaders. Set to one to enable write
functionality.

#define MFSCFG_READ_ONLY_CHECK 1
— This compilation option is obsolete and does not have any effect on resulting code. Runtime read-only
checks are integral parts of write support so they are always present unless MFSCFG_READ_ONLY
compilation option is set.

#define MFSCFG_READ_ONLY_CHECK_ALWAYS 0
— This compilation option is obsolete and it is no more used.

#define MFSCFG_ENABLE_FORMAT 1
— Set to one to build MFS with the format command, zero otherwise.

#define MFSCFG_CALCULATE_FREE_SPACE_ON_OPEN 1
```

- Set to one to calculate the available free space on the drive when the drive is mounted. Calculating the available free space is time-consuming on large drives, as the entire FAT must be read. When set to zero, this operation is deferred until the first time the free space is required which may be never.

```
#define MFSCFG_MINIMUM_FOOTPRINT 1
```

- Set to one to build MFS for small-memory devices, zero otherwise.

```
#define MFSCFG_MAX_READ_RETRIES 1
```

```
#define MFSCFG_MAX_WRITE_RETRIES 1
```

- Number of times MFS attempts to read or write to the device unsuccessfully before it reports an error.

```
#define MFSCFG_FAT_CACHE_SIZE 2
```

- This compilation option is obsolete. Dedicated FAT cache is no longer used. Access to FAT sectors is performed through common sector cache.

```
#define MFSCFG_SECTOR_CACHE_SIZE
```

- Defines number of sectors which MFS is able to keep in cache at a time. Minimum is 2 sectors. Maximum recommended size of sector cache for typical embedded applications is 16.

```
#define MFSCFG_NUM_OF_FATS 2
```

- This parameter is only used when formatting and specifies the number of file allocation tables that is placed on the drive. One is required. The first FAT is used by MFS. The others are backups. Microsoft Windows® operating system uses two as its standard. If you choose one, MFS operates somewhat faster when it writes to the disk because it has half the number of FAT write operations to do.

```
#define MFSCFG_HANDLE_INITIAL 4
```

```
#define MFSCFG_HANDLE_GROW 4
```

```
#define MFSCFG_HANDLE_MAX 0
```

- These compilation options are obsolete and they are no longer used.

```
#define MFSCFG_FIND_TEMP_TRIALS 300
```

- This compilation option is obsolete and it is no longer used. MFS no longer generates file names for temporary files. The application must generate a unique file name for a temporary file according to the use case.

**Table 2-1. Summary: MFS Functions**

<b>_io_mfs_install</b>	Installs MFS.
<b>_io_mfs_uninstall</b>	Uninstalls MFS.
<b>ioctl</b>	Issues a control command.

Functions are described in “Reference: Functions”

## 2.6 Partition Manager Device Driver

The partition manager device driver is designed to be installed under the MFS device driver. It lets the MFS work independently of the multiple partitions on a disk. It also enforces mutually exclusive access to the disk which means that two concurrent write operations from two different MFS devices cannot be in conflict. The partition manager device driver can remove partitions as well as create new ones.

The partition manager device driver creates multiple primary partitions. It does not support extended partitions.

The partition manager device driver is installed and opened like other devices. It must also be closed and uninstalled when an application no longer needs it.

An application follows these steps to use the partition manager. Functions are described in [Chapter 3, “Reference: Functions.”](#)

1. Installs the partition manager (**\_io\_part\_mgr\_install()**).
2. Opens the partition manager (**open()**).
3. Issues input/output control commands (**ioctl()**).
4. Closes the partition manager (**close()**).
5. Uninstalls the partition manager device driver (**\_io\_part\_mgr\_uninstall()**).

**CAUTION**

If an application calls read and write functions with the partition manager, the file system will be corrupted.

**Table 2-2. Summary: Partition Manager Device Driver Functions**

<b>_io_part_mgr_install</b>	Installs the partition manager device driver.
<b>_io_part_mgr_uninstall</b>	Uninstalls the partition manager device driver.
<b>close</b>	Closes the partition manager.
<b>open</b>	Opens the partition manager.
<b>ioctl</b>	Issues a control command to the partition manager.

## 2.7 Working with Removable Media

Removable-media devices are a class of device, in which the medium, upon which files are written to and read from, can be inserted and removed. Examples include:

- USB mass storage devices (flash drives, and so on)
- ATA PCMCIA (PC card) flash cards
- SD Cards
- removable hard drives
- floppy-disk drives

An application that installs MFS on the removable media must take some standard precautions.

### 2.7.1 Buffering and Caching

MFS features scalable sector caching. The number of sectors which may be kept in the memory at a moment is defined by `MFSCFG_SECTOR_CACHE_SIZE` compilation option.

When writing, an application can control how the buffers are flushed. There are three modes:

- *WRITE\_THROUGH* — the buffer contents are immediately written to disk when modified.
- *WRITE\_BACK* — the buffer contents are written to disk on application command, or when MFS device is closed.

- *MIXED\_MODE* — the buffer contents are written to disk on application command or when a file is closed.

If MFS detects that the lower-layer device is removable, the FAT cache will be placed in write through mode, and the directory and file caches will be placed in mixed mode. If the lower-layer device is not removable, all caches will be placed in write back mode.

An application can modify the cache modes with the appropriate **ioctl()** calls. When using removable media, the application must ensure that all files are closed and the MFS device itself is closed before the media is removed. These steps ensure that the caches are flushed and the media is updated.

## 2.7.2 Writing to Media

Writing to the media, either to partition the media, format the media, or write a file, must be completed before the media is removed. If the media is removed during a write operation, the media may be corrupted.

## 2.7.3 Hotswapping

With MFS, an application can implement hotswapping. To properly implement hotswapping, however, the lower-layer device must support a mechanism for notifying the application that the media is removed or inserted.

When an application detects that the media has been inserted, it must do the following:

1. Open the lower-layer device.
2. Optionally install the partition manager on the device.
3. If the partition manager is installed, open the partition manager.
4. Install MFS on the device or on the partition manager if the partition manager is installed.
5. Open the MFS device.

When an application detects that the media has been removed, it must do the following:

1. Close all files that are open on the device.
2. Close the MFS device.
3. Uninstall the MFS device.
4. If the partition manager is installed, close it.
5. If the partition manager is installed, uninstall it.
6. Close the lower-layer device.

### 2.7.3.1 Example: Hotswapping

For an example that demonstrates hotswapping with a USB flash drive, see: *mfs/example/mfs\_usb*.





## Chapter 3 Reference: Functions

### 3.1 In This Chapter

Alphabetically sorted prototype definitions for MFS and the partition manager device driver.

## 3.2 `_io_mfs_install`

Install MFS.

### Synopsis

```
uint32_t _io_mfs_install(
    /*[IN] the device on which to install MFS */
    int dev_fd,
    /*[IN] Name to be given to MFS (e.g., "C:", "MFS1:") */
    /* The name must end in a colon ":" */
    char * identifier,
    /*[IN] Partition number to install MFS on. */
    /* 0 for no partitions */
    uint32_t partition_num)
```

### Description

The function initializes MFS and allocates memory for all of the internal MFS data structures. It also reads some required drive information from the disk, on which it is installed. MFS supports FAT12, FAT16, and FAT32 file systems. If the disk has a different file system or if it is unformatted, you can use MFS to format it to one of the supported file systems.

If the application uses a partitioned disk, you must install MFS on a partition manager device driver. The partition manager device driver can create partitions on the disk if there are none. It can also remove partitions.

Usage of *partition\_num* parameter is deprecated - *\_io\_mfs\_install* should obtain handle to partition manager associated with particular partition as *dev\_fd.partition\_num* parameter should be set to 0 which instructs MFS to simply use the *dev\_fd* as underlying device.

### Return Codes

Returns an error code.

- *IO\_EOF*
  - The **FILE\_PTR** passed into **\_io\_mfs\_install()** was NULL. The error is returned by the input/output subsystem of the MQX Real-Time Operating System.
- *MFS\_ERROR\_UNKNOWN\_FS\_VERSION*
  - MFS was installed on a disk using the FAT32 file system, and the FAT32 version is incompatible with the MFS FAT32 version (version zero).
- *MFS\_INSUFFICIENT\_MEMORY*
  - MFS could not allocate memory for required structures.
- *MFS\_NO\_ERROR*
  - The function call was successful.
- *MFS\_NOT\_A\_DOS\_DISK*
  - The device, on which MFS is being installed is not a valid DOS device. The device must be formatted (by an input/output control command).
- *MFS\_NOT\_INITIALIZED*

- The MFS device name did not end with colon (:).
- *MFS\_READ\_FAULT*
  - The lower-level device driver could not read from the disk. The error is returned from the device, over which MFS is installed.
- *MFS\_SECTOR\_NOT\_FOUND*
  - The error is returned from the device, over which, MFS is installed.
- *PGMR\_INVALID\_PARTITION*
  - The partition number specified was that of an invalid partition. The partition does not exist.

## Example

Install MFS on a RAM disk with no partitions.

```
/* Install the memory device: */
error_code = _io_mem_install("mfsram:",
    NULL, MFS_format.BYTES_PER_SECTOR * RAMDISK_LENGTH1);
if ( error_code != MQX_OK ) {
    printf("Error installing device.\nError: %d\n", error_code);
    _mqx_exit(1);
}

/* Open the device on which MFS will be installed: */
dev_handle1 = open("mfsram:", 0);
if ( dev_handle1 < 0 ) {
    printf("\nUnable to open RAM disk device");
    _task_block();
}

/* Install MFS: */
error_code = _io_mfs_install(dev_handle1, "MFS1:", 0);
if ((error_code != MFS_NO_ERROR) &&
    (error_code != MFS_NOT_A_DOS_DISK)) {
    printf("FATAL error while initializing: \n");
    _mqx_exit(1);
} else {
    printf("Initialized MFS1%s\n");
}
```

### 3.3 `_io_mfs_uninstall`

Uninstall MFS.

#### Synopsis

```
uint32_t _io_mfs_uninstall(  
    /*[IN] String that identifies the device driver */  
    /* to uninstall. Must be identical to the string */  
    /* that was used to install the MFS device driver */  
    char *      identifier)
```

#### Description

This function uninstalls the MFS device driver and frees the memory allocated for it. Before you call the function, you must close the MFS device driver by calling **fclose()**.

#### Return Codes

Returns a **uint32\_t** error code.

- **MFS\_INVALID\_PARAMETER**  
— The identifier passed to the function is invalid.
- **MFS\_SHARING\_VIOLATION**  
— There are files still open on the device, or the MFS device is still open.

#### Example

```
error_code = _io_mfs_uninstall("MFS1:");
```

## 3.4 `_io_part_mgr_install`

Installs the partition manager device driver.

### Synopsis

```
int32_t _io_part_mgr_install(
    /*[IN] Handle of the device on which to install */
    /* the partition manager */
    int dev_fd,
    /*[IN] New name of the partition manager device */
    char * identifier,
    /*[IN] Size of sectors in bytes on the lower level device */
    uint32_t sector_size)
```

### Description

This function initializes the partition manager device driver and allocates the memory for its internal structures.

The first parameter is the handle acquired by opening the lower-level device driver using **open()** (for example, `dev_fd = open("flashdisk",0)`).

The second parameter is the identifier, under which the partition manager is to be installed.

The third parameter is the sector size of the disk. If you specify zero, the partition manager queries the disk for the sector size. If the query fails, the partition manager uses a default sector size, as defined by `PMGR_DEFAULT_SECTOR_SIZE`. The default is 512 bytes.

### Errors

- `PMGR_INSUF_MEMORY`  
— Partition manager could not allocate memory for its internal data.

### Example

Install the partition manager as "PM:" and let it determine the sector size.

```
error_code = _io_part_mgr_install(dev_fd, "PM:", 0);
```

Obtain the handle to the partition manager without selecting a particular partition, . with access to the whole underlying device.

```
pm_fd = open("PM1:",0);
```

Obtain the handle to the partition manager with the first partition selected, i.e., the read/write access is limited to the first partition.

```
part_fd = open("PM1:1",0);
```

## 3.5 `_io_part_mgr_uninstall`

Uninstalls the partition manager.

### Synopsis

```
int32_t _io_part_mgr_uninstall(  
    /*[IN] Identifier string of the device */  
    char * identifier)
```

### Description

You must close the partition manager before you uninstall it. The first parameter is the same identifier that is used with `_io_part_mgr_install()`. All handles associated with a given partition manager have to be closed prior to calling the function. Otherwise, the function fails.

### Errors

- `IO_EOF`
  - Incorrect *identifier*.
- `IO_ERROR_DEVICE_BUSY`
  - There are still open handles associated with the partition manager instance.

### Example

```
error_code = _io_part_mgr_uninstall("PM:");
```

## 3.6 close

Closes the device or file.

### Synopsis

```
int close(
    /* [IN] File descriptor to close */
    int fd)
```

### Description

This function frees the memory allocated for the given *file descriptor* (which was returned when the application called **open()** on a file). It also updates the date, time, and size of the file on the disk.

When the application no longer needs to use the device driver, it can close the device driver and uninstall it. The function **close()** is used to close the device driver if the device driver *file descriptor* is passed as a parameter. The function fails if any files are still open on the device.

### Return Codes for MFS

- *IO\_EOF*  
— *file\_ptr* was invalid.
- *MFS\_SHARING\_VIOLATION*  
— Files are open on the device.

### Example: MFS

See **open()**.

### Example: Partition Manager Device Driver

```
pmgr_fd = open("PM:", NULL);
...
...
/* End of application. */
close(pmgr_fd);
_io_part_mgr_uninstall("PM:");
```

## 3.7 open

Opens the device or file.

### Synopsis

```
int open(
    /*[IN] Name of the device or file to open      */
    /* Must be identical to the name that was used */
    /* to install the device driver */
    char * name_ptr,
    /*[IN] Open flags*/
    int flags)
```

### Description

This function opens the specified device driver for MFS or the partition manager. You must install the device driver before you call the function. Opening the device returns a *file descriptor* for the device that can be used in input/output control commands (see [Section 3.8, “ioctl”](#)).

The first time **open()** is called on the device driver, it opens the device driver. Each subsequent call is used to open a file. This means that you must first call **open()** with the device name (just once to open the device), and then every other call will be to open a file. Each of these other calls should include the device name, along with a specific flag on the device.

Opening a file returns a *file descriptor* for that file. This is used to read and write to the file. Standard read(), write() and lseek() functions are then used for reading and writing data from/to the file.

### NOTE

Note: If standard library functions are compiled in then it is possible to use stream API to work with files: fopen() , fclose(), fread(), fwrite(), fseek() and it is also possible to use formatted IO, e.g., fprintf().

To open a file, you must pass the name of the device followed by the name of the file. To open the file *data.txt* in the current directory:

```
To open the file March2000results.data in the MFS1:\data\march directory:
fd = open("MFS1:\data\march\March2000results.data", O_RDWR);
```

The following table lists the supported open mode flags and their meanings. Multiple flags may be combined by using bitwise OR:

Flag	Description
O_RDONLY	File must be opened in read only mode.
O_WRONLY	File must be opened in write only mode
O_RDWR	File must be opened in read/write mode
O_CREAT	File must be created if it does not exist
O_EXCL	If used with O_CREAT and if the file already exists, the open operation fails
O_TRUNC	Truncates the file when the file is opened for writing
O_APPEND	Opens the file in append mode - seeking to the end of the file is done atomically prior to each write operation

## Returns

Returns a file descriptor of the file or device on success.

Returns -1 on failure and sets errno to the error code.

## Example: MFS

Open the MFS device driver and open a file on the device.

```
char buffer[100] = "This a test file";
char buffer2[100];
/* Open the MFS device driver: */
mfs_fd = open("MFS1:", 0);
if (mfs_fd < 0) {
    printf("Error opening the MFS device driver!");
    _mqx_exit(1);
}
/* Open file on disk in the current directory and write to it: */
fd = open("MFS1:myfile.txt", O_RDWR | O_CREAT);
write(fd, buffer, strlen(buffer));
read(fd, buffer2, strlen(buffer));

/* Close the file: */
error_code = close(fd_ptr);

/* Open other files, create directories, and so on. */

/* The application has done all it needs. */
/* Close the MFS device driver and uninstall it: */
error_code = close(mfs_fd);
if (!error_code) {
    error_code = _io_mfs_uninstall("MFS1:");
} else if (error_code == MFS_SHARING VIOLATION) {
    printf("There are open files on the device. Call close on their
        handles before attempting to fclose the device driver");
}
```

### Example: Partition Manager Device Driver

The example shows how to directly open the first partition on the drive. It assumes that the partition manager is already installed.

```
pmgr_fd = open("PM: 1", O_RDWR);
```

## 3.8 ioctl

Issues a control command.

### Synopsis

```
int ioctl(
    /*[IN] Stream to perform the operation on */
    int fd,
    /*[IN] I/O control command */
    unsigned long int request,
    /*[IN] I/O control-command parameters */
    ...)
```

### Description

The first parameter is a *file descriptor*, returned by calling **open()** for the device driver, which can either be the handle of a specific file, or the handle of the device driver itself. It varies depending on which command is used. Further parameters are specific to particular IOCTL requests and they are typically pointers to memory locations for passing parameters and results.

#### CAUTION

The parameters passed to `ioctl` function vary with the IOCTL request. You must ensure that the `ioctl` call is used correctly for the specified control command.

### 3.8.1 Input/Output Control Commands for MFS

Together with the MQX input/output control commands, MFS also includes the following input/output control commands.

#### 3.8.1.1 IO\_IOCTL\_BAD\_CLUSTERS

This command gets the number of bad clusters on the drive.

```
result = ioctl(mfs_fd,
    IO_IOCTL_BAD_CLUSTERS,
    (uint32_t *) &bad_clusters);
```

The parameter *mfs\_fd\_ptr* is the *FILE\_PTR* returned when **fopen()** was called on the MFS device driver. The *mfs\_fd\_ptr* must correspond to the disk, on which the bad clusters are to be counted. The third parameter is a pointer to the unsigned 32 bit word where the number of bad clusters is stored.

#### 3.8.1.2 IO\_IOCTL\_CHANGE\_CURRENT\_DIR

This command changes the current directory.

```
error_code = ioctl(mfs_fd,
    IO_IOCTL_CHANGE_CURRENT_DIR,
    (char *) pathname);
```

If *pathname* begins with a directory separator, it is assumed that *pathname* represents the complete directory name. If *pathname* does not begin with a directory separator, *pathname* is assumed to be relative to the current directory. The third parameter is a *char \** (to a directory name) cast to a *uint32\_t \**.

The directory path must exist for the change to succeed.

### Errors

- *MFS\_INVALID\_LENGTH\_IN\_DISK\_OPERATION*  
— Path name is too long. The full path name, including the filename, cannot be any longer than 260 characters.

### Example

```
char pathname = "\\docs";
error_code = ioctl(mfs_fd, IO_IOCTL_CHANGE_CURRENT_DIR,
                  pathname);
```

#### 3.8.1.3 IO\_IOCTL\_CREATE\_SUBDIR

This command creates a subdirectory in the current directory.

```
error_code = ioctl(mfs_fd,
                  IO_IOCTL_CREATE_SUBDIR,
                  "\\temp\\newdir");
```

A path name can be specified to create the subdirectory in a different directory. The parameter *mfs\_fd* is the *file descriptor* returned when **open()** was called on the MFS device driver corresponding to the disk on which to operate. The third parameter is a *char \** (to a directory name) cast to a *uint32\_t \**

All directories in the path, except the last one, must exist. The last directory in the path must not exist as either a directory or a file.

### Errors

- *MFS\_CANNOT\_CREATE\_DIRECTORY*  
— There was an error creating the subdirectory.

#### 3.8.1.4 IO\_IOCTL\_DEFAULT\_FORMAT

This command formats the drive by using default parameters.

```
error_code = ioctl(mfs_fd,
                  IO_IOCTL_DEFAULT_FORMAT,
                  NULL);
```

The command deletes all files and subdirectories on the drive. The parameter *mfs\_fd\_ptr* is the *FILE\_PTR* returned when **fopen()** was called on the MFS device driver, which corresponds to the disk on which to operate. The default parameters are:

- *PHYSICAL\_DRIVE* = 0x80
- *MEDIA\_DESCRIPTOR* = 0xf8
- *BYTES\_PER\_SECTOR* = device sector size
- *SECTORS\_PER\_TRACK* = 0x00
- *NUMBER\_OF\_HEADS* = 0x00
- *NUMBER\_OF\_SECTORS* = number of device sectors - RESERVED\_SECTORS

- *HIDDEN\_SECTORS* = 0
- *RESERVED\_SECTORS* = 1 if *NUMBER\_OF\_SECTORS* < 2097152, 32 otherwise

### Errors

- *MFS\_SHARING\_VIOLATION*  
— Some files are open on the drive.

### Example

```
error_code = ioctl(mfs_fd, IO_IOCTL_FORMAT, NULL);
```

#### 3.8.1.5 IO\_IOCTL\_DELETE\_FILE

This command deletes a file on the disk. Wildcard characters are not valid in the filename.

```
error_code = ioctl(mfs_fd,
    IO_IOCTL_DELETE_FILE,
    "filename");
```

The *mfs\_fd* is the *file descriptor* returned from **open()** that opened the MFS device. The third parameter points to a filename which can include a path (for example *\backup\oldfiles\myfile.txt*). Long filenames and long path names are supported. The file must reside on the drive that corresponds to *mfd\_fd*.

Any currently open handles to this file become invalid, that is, subsequent file operations using a file handle of a deleted file result in an error.

### Errors

- *MFS\_OPERATION\_NOT\_ALLOWED*

#### 3.8.1.6 IO\_IOCTL\_FAT\_CACHE\_OFF

Obsolete. MFS does not use dedicated FAT buffers anymore.

#### 3.8.1.7 IO\_IOCTL\_FAT\_CACHE\_ON

Obsolete. MFS does not use dedicated FAT buffers anymore.

### 3.8.1.8 IO\_IOCTL\_FIND\_FIRST\_FILE, IO\_IOCTL\_FIND\_NEXT\_FILE

The `IO_IOCTL_FIND_FIRST_FILE` command searches for a file on the disk.

The parameter `mfs_fd_ptr` is the `FILE_PTR` returned when `fopen()` was called on the MFS device driver. The third parameter is a pointer to the `MFS_SEARCH_PARAM` structure. See structure definitions for details.

If a file is found, use the input/output control command, `IO_IOCTL_FIND_NEXT_FILE`, to keep searching for more files which match the same criteria. The third parameter for the `IO_IOCTL_FIND_NEXT_FILE` is a pointer to the `MFS_SEARCH_DATA` structure used in the `IO_IOCTL_FIND_FIRST_FILE` command. The filename can include wildcard search characters.

When searching for files, the file path search string that is passed in the `MFS_SEARCH_PARAM` structure is used. Therefore, it must not be freed or changed if you plan to subsequently use `IO_IOCTL_FIND_NEXT_FILE`.

The search criteria for the attribute field of the `MFS_SEARCH_PARAM` structure is defined in the following table:

Attribute:	Return these types of entries:
<code>MFS_SEARCH_NORMAL</code>	Non-hidden non-system files and directories
<code>MFS_SEARCH_READ_ONLY</code>	Read only files and directories
<code>MFS_SEARCH_HIDDEN</code>	Hidden files and directories
<code>MFS_SEARCH_SYSTEM</code>	System files and directories
<code>MFS_SEARCH_VOLUME</code>	Volume label only
<code>MFS_SEARCH_SUBDIR</code>	Non-hidden non-system directories
<code>MFS_SEARCH_ARCHIVE</code>	Archive files and directories
<code>MFS_SEARCH_EXCLUSIVE</code>	Match exactly all remaining attributes
<code>MFS_SEARCH_ANY</code>	All files and directories
<code>MFS_SEARCH_LFN</code>	Extract long filename

The search bit mask can be a combination of all search attributes. The evaluation of the bit mask is done in the following order:

1. If mask includes `MFS_SEARCH_ANY`, then all disk entries match.
2. If mask includes `MFS_SEARCH_VOLUME`, then only the volume label entry matches.
3. If mask includes `MFS_SEARCH_EXCLUSIVE`, then there must be an exact match of the remaining attributes.
4. If mask is `MFS_SEARCH_NORMAL`, then all non-system, non-hidden files and directories, match.
5. If mask is `MFS_SEARCH_SUBDIR`, then all non-system, non-hidden directories, match.
6. Otherwise mask must be subset of disk entry attributes to produce a match.

The search results are written into the *MFS\_SEARCH\_DATA* structure addressed by the *SEARCH\_DATA\_PTR* member of the *MFS\_SEARCH\_PARAM* structure. Results of the repetitive execution of the *IO\_IOCTL\_FIND\_NEXT* command overwrite the previous results.

### ***MFS\_SEARCH\_DATA Fields***

#### **ATTRIBUTE**

File entry attribute byte.

#### **TIME**

File entry time, as described in *IO\_IOCTL\_GET\_DATE\_TIME*.

#### **DATE**

File entry date, as described in *IO\_IOCTL\_GET\_DATE\_TIME*.

#### **FILE\_SIZE**

Size of the file in bytes.

#### **NAME[24]**

The short name of the file in the format *filename.filetype* as a null terminated string in the UTF-8 encoding. In addition, when the *MFS\_SEARCH\_LFN* attribute is set, the long filename is extracted to the caller allocated buffer specified by the *LFN\_BUF* and *LFN\_BUF\_LEN* of the *MFS\_SEARCH\_PARAM* structure. The long filename is stored as a null-terminated string in the UTF-8 encoding. If the buffer is not sufficient length, the long filename is not extracted.

#### **Errors**

- *MFS\_INVALID\_MEMORY\_BLOCK\_ADDRESS*  
— The *MFS\_SEARCH\_DATA\_PTR* in the *MFS\_SEARCH\_PARAM* is invalid.

#### **Example**

```
List all files and subdirectories in a directory.
MFS_SEARCH_DATA      search_data;
MFS_SEARCH_PARAM      search;
char                  filepath = ".*.";

search.ATTRIBUTE = MFS_SEARCH_ANY;
search.WILDCARD = filepath;
search.SEARCH_DATA_PTR = &search_data;

error_code = ioctl(mfs_fd, IO_IOCTL_FIND_FIRST_FILE,
                  &search);
while (error_code == MFS_NO_ERROR) {
    printf ("%12.12s %6lu %02lu-%02lu-%04lu %02lu:%02lu:%02lu\n",
            search_data.NAME, search_data.FILE_SIZE,
            (uint32_t)(search_data.DATE & MFS_MASK_MONTH) >>
            MFS_SHIFT_MONTH,
            (uint32_t)(search_data.DATE & MFS_MASK_DAY) >>
            MFS_SHIFT_DAY,
```

```

        (uint32_t)((search_data.DATE & MFS_MASK_YEAR) >>
        MFS_SHIFT_YEAR) + 1980,
        (uint32_t)(search_data.TIME & MFS_MASK_HOURS) >>
        MFS_SHIFT_HOURS,
        (uint32_t)(search_data.TIME & MFS_MASK_MINUTES) >>
        MFS_SHIFT_MINUTES,
        (uint32_t)(search_data.TIME & MFS_MASK_SECONDS) << 1);

    error_code = ioctl(mfs_fd, IO_IOCTL_FIND_NEXT_FILE,
        &search_data);
}

```

### 3.8.1.9 IO\_IOCTL\_FLUSH\_FAT

Obsolete. MFS does not use dedicated FAT buffers anymore.

### 3.8.1.10 IO\_IOCTL\_FORMAT

This command formats the drive according to the given specifications.

```

error_code = ioctl(mfs_fd,
    IO_IOCTL_FORMAT,
    &format_struct);

```

The command deletes all files and subdirectories on the drive. The parameter *mfs\_fd\_ptr* is the *FILE\_PTR* returned when **fopen()** was called on the MFS device driver, which corresponds to the disk on which to operate. The third parameter is a pointer to the *MFS\_IOCTL\_FORMAT\_PARAM* structure. The only field in the *MFS\_IOCTL\_FORMAT\_PARAM* structure that must be initialized is the *FORMAT\_PTR* field. See the structure descriptions for details.

#### Errors

- *MFS\_SHARING\_VIOLATION*  
— Some files are open on the drive.

#### Example

```

MFS_IOCTL_FORMAT_PARAM    format_struct;
MFS_FORMAT_DATA MFS_format =
{
    /* PHYSICAL_DRIVE; */    PHYSICAL_DRIVE,
    /* MEDIA_DESCRIPTOR; */    MEDIA_DESC,
    /* BYTES_PER_SECTOR; */    BYTES_PER_SECT,
    /* SECTORS_PER_TRACK; */    SECTS_PER_TRACK,
    /* NUMBER_OF_HEADS; */    NUM_OF_HEADS,
    /* NUMBER_OF_SECTORS; */    1000, /* depends on drive */
    /* HIDDEN_SECTORS; */    HIDDEN_SECTS,
    /* RESERVED_SECTORS; */    RESERVED_SECTS
};
format_struct.FORMAT_PTR = &MFS_format;
error_code = ioctl(mfs_fd, IO_IOCTL_FORMAT,
    &format_struct);

```

### 3.8.1.11 IO\_IOCTL\_FORMAT\_TEST

This command formats the drive and counts the bad clusters on a disk.

```
error_code = ioctl(mfs_fd,
                  IO_IOCTL_FORMAT_TEST,
                  &format_struct);
```

The parameter *mfs\_fd\_ptr* is the *FILE\_PTR* returned when **fopen()** was called on the MFS device driver, which corresponds to the device on which to operate. The third parameter is a pointer to the *MFS\_IOCTL\_FORMAT\_PARAM* structure cast to the *uint32\_t \**. Both fields of the *MFS\_IOCTL\_FORMAT\_PARAM* structure must be initialized (*FORMAT\_PTR* and *COUNT\_PTR*). See structure descriptions for details.

#### Errors

- MFS\_SHARING\_VIOLATION  
— Files are open on the drive.

#### Example

```
uint32_t          bad_cluster_count;
MFS_IOCTL_FORMAT_PARAM format_struct;
MFS_FORMAT_DATA   MFS_format =
{
    /* PHYSICAL_DRIVE; */    PHYSICAL_DRIVE,
    /* MEDIA_DESCRIPTOR; */ MEDIA_DESC,
    /* BYTES_PER_SECTOR; */  BYTES_PER_SECT,
    /* SECTORS_PER_TRACK; */ SECTS_PER_TRACK,
    /* NUMBER_OF_HEADS; */  NUM_OF_HEADS,
    /* NUMBER_OF_SECTORS; */ 1000, /* depends on disk */
    /* HIDDEN_SECTORS; */    HIDDEN_SECTS,
    /* RESERVED_SECTORS; */  RESERVED_SECTS
};
format_struct.FORMAT_PTR = &MFS_format;
format_struct.COUNT_PTR = &bad_cluster_count;
error_code = ioctl(mfs_fd_ptr, IO_IOCTL_FORMAT,
                  (uint32_t *) &format_struct);

if (!error_code)
    printf("The count of bad clusters is: %d\n", bad_cluster_count);
```

### 3.8.1.12 IO\_IOCTL\_FREE\_SPACE, IO\_IOCTL\_FREE\_CLUSTERS

This command gets the count of free space on the disk in bytes or in clusters.

```
result = ioctl(mfs_fd_ptr,
              IO_IOCTL_FREE_SPACE,
              &space_64);
```

The parameter *mfs\_fd\_ptr* is the *FILE\_PTR* returned when **fopen()** was called on the MFS device driver. It should correspond to the disk on which the free space is to be calculated. The third parameter is a pointer to *uint64\_t* which is filled with 64-bit value representing free space in bytes.

Alternatively, a combination of `IO_IOCTL_FREE_CLUSTERS` and `IO_IOCTL_GET_CLUSTER_SIZE` may be used to determine the free space size of the drive in bytes by using long (64-bit) arithmetic.

### 3.8.1.13 IO\_IOCTL\_GET\_CLUSTER\_SIZE

This command gets the size of clusters in bytes.

```
result = ioctl(mfs_fd,
               IO_IOCTL_GET_CLUSTER_SIZE,
               &cluster_size);
```

The parameter `mfs_fd` is the *file descriptor* returned when `open()` was called on the MFS device driver. It should correspond to the disk for which the cluster size should be returned. The third parameter is a pointer to a `uint32_t *` to pre-allocated space in which to store the cluster size.

### 3.8.1.14 IO\_IOCTL\_GET\_CURRENT\_DIR

This command gets the path name of the current directory on the MFS device.

```
error_code = ioctl(mfs_fd,
                  IO_IOCTL_GET_CURRENT_DIR,
                  pathname);
```

The drive and drive separator are not included in the filename (for example, "d:" is not returned). The parameter `mfs_fd` is the *file descriptor* returned when `open()` was called on the MFS device driver corresponding to the disk on which to operate. The third parameter is a `char *`, pointer to the allocated space in which to store the current directory.

#### Example

```
char pathname[261];
error_code = ioctl(mfs_fd, IO_IOCTL_GET_CURRENT_DIR,
                  pathname);
printf("The current directory is: %s\n", pathname);
```

### 3.8.1.15 IO\_IOCTL\_GET\_DATE\_TIME

This command gets the current date and time associated with the file.

```
error_code = ioctl(fd,
                  IO_IOCTL_GET_DATE_TIME,
                  &date);
```

The first parameter is the *file descriptor* of the file for which the date or time is to be retrieved. The third parameter is a pointer to a **MFS\_DATE\_TIME\_PARAM** structure. Both fields of the structure must be filled in. See structure definitions for details.

The bits of the date and time words are defined as follows:

Time word		Date word	
Bits	Meaning	Bits	Meaning

4 – 0	0 – 29, 2 second increments		4 – 0	1 – 31 days
10 – 5	0 – 59 minutes		8 – 5	1 – 12 month
15 – 11	0 – 23 hours		15 – 9	0 – 119 year (1980 – 2099)

### Example

```

uint32_t          error_code;
uint16_t          date_word, time_word;
MFS_DATE_TIME_PARAM date;

date.DATE_PTR = &date_word;
date.TIME_PTR = &time_word;

error_code = ioctl(fd, IO_IOCTL_GET_DATE_TIME,
                  &date);
if (!error_code )
printf ("%02lu-%02lu-%04lu  %02lu:%02lu:%02lu \n",
        (uint32_t)(date_word & MFS_MASK_MONTH) >> MFS_SHIFT_MONTH,
        (uint32_t)(date_word & MFS_MASK_DAY) >> MFS_SHIFT_DAY,
        (uint32_t)((date_word & MFS_MASK_YEAR) >> MFS_SHIFT_YEAR)
        + 1980,
        (uint32_t)(time_word.TIME & MFS_MASK_HOURS) >>
        MFS_SHIFT_HOURS,
        (uint32_t)(time_word.TIME & MFS_MASK_MINUTES) >>
        MFS_SHIFT_MINUTES,
        (uint32_t)(time_word.TIME & MFS_MASK_SECONDS) << 1);

```

#### 3.8.1.16 IO\_IOCTL\_GET\_DEVICE\_HANDLE

This command gets the handle of the low-level device which this instance of the file system is operating on.

```

result = ioctl(mfs_fd,
               IO_IOCTL_GET_DEVICE_HANDLE,
               &handle);

```

The parameter *mfs\_fd* is the *file descriptor* returned when **open()** was called on the MFS device driver. The third parameter is a pointer to a *int* which points to pre-allocated space in which to store the device handle.

#### 3.8.1.17 IO\_IOCTL\_GET\_FAT\_CACHE\_MODE, IO\_IOCTL\_SET\_FAT\_CACHE\_MODE

Obsolete. MFS does not use dedicated FAT buffers anymore.

#### 3.8.1.18 IO\_IOCTL\_GET\_FILE\_ATTR, IO\_IOCTL\_SET\_FILE\_ATTR

These commands get or set the attributes of the file on disk.

```

error_code = ioctl(mfs_fd,
                  IO_IOCTL_GET_FILE_ATTR,

```

```

        &attr);
error_code = ioctl(mfs_fd,
    IO_IOCTL_SET_FILE_ATTR,
    &attr);

```

An application cannot set the volume or directory bits of the attribute **char**. The first parameter is the *file descriptor* of the MFS device driver that corresponds to the disk on which the file whose attributes are to be read or written is located. The third parameter is a pointer to a **MFS\_FILE\_ATTR\_PARAM** structure. Both fields of the structure must be filled in. See the structure definitions for details.

### Example

```

MFS_FILE_ATTR_PARAM attr;
uint32_t error_code;
char      filepath = "\\temp\\myfile.txt";
unsigned char attribute;

attr.ATTRIBUTE_PTR = &attribute;
attr.PATHNAME = filepath;

/* Get the attribute: */
error_code = ioctl(mfs_fd, IO_IOCTL_GET_FILE_ATTR,
    &attr);

if (error_code == MFS_NO_ERROR) {
    printf ("Attributes of %s: %s%s%s%s%s%s\n",
        filepath,
        (attribute & MFS_ATTR_READ_ONLY) ? "R/O ":"",
        (attribute & MFS_ATTR_HIDDEN_FILE) ? "HID ":"",
        (attribute & MFS_ATTR_SYSTEM_FILE) ? "SYS ":"",
        (attribute & MFS_ATTR_VOLUME_NAME) ? "VOL ":"",
        (attribute & MFS_ATTR_DIR_NAME) ? "DIR ":"",
        (attribute & MFS_ATTR_ARCHIVE) ? "ARC ":"");
}
/* Set file's attributes: */
if (!error_code) {
    attribute = MFS_ATTR_READ_ONLY | MFS_ATTR_HIDDEN_FILE;
    error_code = ioctl(mfs_fd, IO_IOCTL_SET_FILE_ATTR,
        &attr);
}

```

### 3.8.1.19 IO\_IOCTL\_GET\_LFN

This command gets the long filename where the path name is in 8.3 representation.

```

error_code = ioctl(mfs_fd,
    IO_IOCTL_GET_LFN,
    &lfn_struct);

```

The first parameter is the *file descriptor* of the MFS device driver that corresponds to the disk on which the operation is to take place. The third parameter is the *char \** to the path name of the of file which we want the long filename of.

### Example

```

MFS_GET_LFN_STRUCT    lfn_struct;
char                  lfn[FILENAME_SIZE + 1];
char                  filepath = "\\temp\\longfi~1.txt";
uint32_t              error_code;

lfn_struct.PATHNAME = filepath;
lfn_struct.LONG_FILENAME = lfn;

error_code = ioctl(mfs_fd, IO_IOCTL_GET_LFN,
                  &lfn_struct);

if (!error_code) {
    printf("%s\n", lfn);
}

```

### 3.8.1.20 IO\_IOCTL\_GET\_VOLUME

This command gets the volume label.

```

error_code = ioctl(mfs_fd,
                  IO_IOCTL_GET_VOLUME,
                  label);

```

The first parameter is the *file descriptor* of the MFS device driver that corresponds to the disk on which the operation is to take place. The third parameter is a **char \*** to an allocated space with 12 free bytes in which the volume label will be written.

#### Example

```

charlabel[12];
error_code = ioctl(mfs_fd, IO_IOCTL_GET_VOLUME,
                  label);
if (!error_code) {
    printf("The volume label is: %d\n", label);

    /* Now set the volume label */
    strcpy(label, "newlabel");
    error_code = ioctl(mfs_fd, IO_IOCTL_SET_VOLUME,
                      label);
}

```

### 3.8.1.21 IO\_IOCTL\_GET\_WRITE\_CACHE\_MODE, IO\_IOCTL\_SET\_WRITE\_CACHE\_MODE

This command gets or sets the current mode of the data and directory caches.

```

result = ioctl(mfs_fd,
              IO_IOCTL_GET_WRITE_CACHE_MODE,
              &mode);

```

The parameter *mfs\_fd\_ptr* is the *file descriptor* returned when **open()** was called on the MFS device driver. The third parameter is a *\_mfs\_cache\_policy* pointer which points to a pre-allocated space in which to store (when using get) or obtain (when using set) the mode of the write caches.

### 3.8.1.22 IO\_IOCTL\_LAST\_CLUSTER

This command gets the number of clusters on a drive.

```
result = ioctl(mfs_fd,
               IO_IOCTL_LAST_CLUSTER,
               (uint32_t *) &last_cluster);
```

The parameter *mfs\_fd* is the *file descriptor* returned when **open()** was called on the MFS device driver. The third parameter is a pointer to the 32 bit word where the number of the last cluster is stored.

### 3.8.1.23 IO\_IOCTL\_REMOVE\_SUBDIR

This command removes a the subdirectory in the current directory.

```
error_code = ioctl(mfs_fd,
                   IO_IOCTL_REMOVE_SUBDIR,
                   "\\temp\\deldir");
```

A path name can be specified to remove the subdirectory in a different directory. The subdirectory must be empty and cannot be the current directory or the root directory. The parameter *mfs\_fd* is the *file descriptor* returned when **open()** was called on the MFS device driver corresponding to the disk on which to operate. The third parameter is the *char \** (to a directory name).

#### Errors

- *MFS\_ATTEMPT\_TO\_REMOVE\_CURRENT\_DIR*  
— The directory specified is the current directory. No changes took place.

### 3.8.1.24 IO\_IOCTL\_RENAME\_FILE

This command renames a file or moves a file if path names are specified.

```
error_code = ioctl(mfs_fd,
                   IO_IOCTL_RENAME_FILE,
                   &rename_struct);
```

No wildcard characters are allowed in the path names. The parameter *mfs\_fd* is the *file descriptor* returned, when **open()** was called on the MFS device driver corresponding to the drive on which to operate. The third parameter is a pointer to the *MFS\_RENAME\_PARAM* structure. Both fields in this structure must be filled out. See structure definitions for details.

A file is moved if the directory paths are different and the file names are the same. A file is renamed if the directory paths are the same and the file names are different.

A directory can be renamed, but cannot be moved.

#### Example

```
MFS_RENAME_PARAM  rename_struct;
char               oldpath[PATHNAME_SIZE + 1],
                  newpath[PATHNAME_SIZE + 1];
uint32_t           error_code;

rename_struct.OLD_PATHNAME = oldpath;
```

```

rename_struct.NEW_PATHNAME = newpath;

/* Rename a file: */
strcpy(oldpath, "myfile.txt");
strcpy(newpath, "myfile.bak");
error_code = ioctl(mfs_fd, IO_IOCTL_RENAME_FILE,
                  &rename_struct);

/* Move the file: */
if (!error_code) {
    strcpy(oldpath, "myfile.bak");
    strcpy(newpath, "\\temp\\temp.tmp");
    error_code = ioctl(mfs_fd, IO_IOCTL_RENAME_FILE,
                    &rename_struct);
}

```

### 3.8.1.25 IO\_IOCTL\_SET\_DATE\_TIME

This command sets the time and date of an open file.

```

error_code = ioctl(fd,
                  IO_IOCTL_SET_DATE_TIME,
                  &date);

```

The first parameter is the *file descriptor* of the file for which to set the date. The third parameter is a pointer to the *MFS\_DATE\_TIME\_PARAM* structure. Both fields of the structure must be filled in. See the structure definitions for more information.

#### Example

See *IO\_IOCTL\_GET\_DATE\_TIME* for details.

```

MFS_DATE_TIME_PARAM  date_time;
uint32_t              error_code;
uint16_t              date_word, time_word;

date.DATE_PTR = &date_word;
date.TIME_PTR = &time_word;

error_code = ioctl(fd, IO_IOCTL_GET_DATE_TIME,
                  &date);

```

### 3.8.1.26 IO\_IOCTL\_SET\_VOLUME

This command sets the volume label.

```

error_code = ioctl(mfs_fd,
                  IO_IOCTL_SET_VOLUME,
                  label);

```

The first parameter is the *file descriptor* of the MFS device driver that corresponds to the disk on which the operation is to take place. The third parameter is the *char \** to the new volume name to be set with a maximum of 11 characters.

### 3.8.1.27 IO\_IOCTL\_TEST\_UNUSED\_CLUSTERS

This command tests the unused clusters on the drive for bad clusters.

```
error_code = ioctl(mfs_fd,
                  IO_IOCTL_TEST_UNUSED_CLUSTERS,
                  &count_of_unused_clusters);
```

The parameter *mfs\_fd* is the *file descriptor* returned when **open()** was called on the MFS device driver corresponding to the drive, on which to test the unused clusters. The third parameter is the *uint32\_t* \* to a variable, in which the count of bad clusters is stored. The bad clusters are marked in the file allocation table so that they will not be used to store data.

### 3.8.1.28 IO\_IOCTL\_WRITE\_CACHE\_ON, IO\_IOCTL\_WRITE\_CACHE\_OFF

Deprecated: use *IO\_IOCTL\_SET\_WRITE\_CACHE\_MODE*.

## 3.8.2 Input/Output Control Commands for the Partition Manager Device Driver

In addition to the MQX input/output control commands, the partition manager device driver includes the following.

### 3.8.2.1 IO\_IOCTL\_CLEAR\_PARTITION

This command removes a partition from the disk.

The third **ioctl()** parameter is a pointer to the *uint32\_t* variable and contains the number of the partition to remove. This IOCTL call is valid only if no partition is currently selected, i.e., the handle allows for access to the whole underlying device.

#### Example

Remove the third partition from the disk.

```
uint32_t    part_num;
part_num = 3;
error_code = ioctl(pmgr_fd, IO_IOCTL_CLEAR_PARTITION,
                  &part_num);
```

### 3.8.2.2 IO\_IOCTL\_GET\_PARTITION

This command gets partition information to the disk.

The third **ioctl()** parameter is the *PMGR\_PART\_INFO\_STRUCT* pointer. The only field in the structure that must be filled in is the *SLOT* field. It must contain a value between zero and four and represents the partition number for which information is requested. If the *SLOT* field is zero then information about currently selected partition is retrieved. The other fields are overwritten with the retrieved data. *HEADS*, *CYLINDERS*, and *SECTORS* are set to zero, because such information cannot be retrieved from the disk.

### 3.8.2.3 IO\_IOCTL\_SET\_PARTITION

This command sets partition information to the disk.

The third **ioctl()** parameter is the *PMGR\_PART\_INFO\_STRUCT* pointer.

```
typedef struct pmgr_part_info_struct
{
    /* Partition slot (1 to 4) */
    unsigned char SLOT;
    /* Heads per Cylinder */
    unsigned char HEADS;
    /* Sectors per head */
    unsigned char SECTORS;
    /* Cylinders on the device */
    uint16_t CYLINDERS;
    /* Partition type (0 not used, 1 FAT 12 bit, 4 FAT 16 bit, */
    /* 5 extended, 6 huge - DOS 4.0+, other = unknown OS) */
    unsigned char TYPE;
    /* Start sector for partition, relative to beginning of disk */
    uint32_t START_SECTOR;
    /* Partition length in sectors */
    uint32_t LENGTH;
} PMGR_PART_INFO_STRUCT, * PMGR_PART_INFO_STRUCT_PTR;
```

The *SLOT* field must be filled in with the partition number to set.

The *HEADS*, *SECTORS*, and *CYLINDERS* fields are optional. They represent data that the partition manager uses to write the partition, but the data is used only by MS-DOS operating systems. Because Microsoft Windows operating system does not use the fields on the disk, fill in the fields only if the disk is to be used with the MS-DOS operating system.

The *TYPE* field must be set to one of the following. Types that are marked with + are recommended when you create a partition.

+	PMGR_PARTITION_FAT_12_BIT	
	PMGR_PARTITION_FAT_16_BIT	Old FAT16 (MS-DOS 3.3 and previous )
	PMGR_PARTITION_HUGE	Modern FAT16 (MS-DOS 3.3 and later)
	PMGR_PARTITION_FAT32	Normal FAT32
+	PMGR_PARTITION_FAT32_LBA	FAT32 with LBA
+	PMGR_PARTITION_HUGE_LBA	FAT16 with LBA

The *START\_SECTOR* field must be filled in. It is the physical sector on the device where the partition should start. For the first partition, is it generally sector 32 (for FAT32) or sector one (for FAT16 and FAT12). For partitions other than the first, it is the next sector after the end of the previous partition. You can leave unused sectors between partition, but they amount to wasted space.

The *LENGTH* field must be filled in. It contains the length in sectors of the new partition that is to be created.

This IOCTL call is valid only if no partition is currently selected, i.e., the handle allows for access to the whole underlying device and there is only a single open handle to the partition manager instance. This is to prevent possible inconsistency of data if more than one handle to the partition manager exists.

The partition manager checks validity of the partition table before writing it to the device. It is thus impossible to create a partition which overlaps another partition. Partitions which would collide with the new one have to be removed first.

### Example

Create two partitions on a disk. The example assumes that the partition manager is installed and open.

```
PMGR_PART_INFO_STRUCT    part_info;

/* Create a 42-Megabyte partition: */
part_info.SLOT = 1;
part_info.TYPE = PMGR_PARTITION_HUGE_LBA;
part_info.START_SECTOR = 32;
part_info.LENGTH = 84432;

error_code = ioctl(pm_fd, IO_IOCTL_SET_PARTITION,
                  &part_info);
if ( error_code ) {
    printf("\nError creating partition %d!\n Error code: %d",
        1, error_code);
    _mqx_exit(1);
}/* Endif */

/* Create a 5-Megabyte partition: */
part_info.SLOT = 2;
part_info.TYPE = PMGR_PARTITION_FAT_12_BIT;
part_info.START_SECTOR = 84464;
part_info.LENGTH = 10000;

error_code = ioctl(pm_fd, IO_IOCTL_SET_PARTITION,
                  &part_info);

if ( error_code ) {
    printf("\nError creating partition %d!\n Error code: %d",
        2, error_code);
    _mqx_exit(1);
}/* Endif */
```

### 3.8.2.4 IO\_IOCTL\_USE\_PARTITION

This command directly sets partition parameters to use with the handle.

The third **ioctl()** parameter is the *PMGR\_PART\_INFO\_STRUCT* pointer.

The information passed to this IOCTL call directly sets partition information associated with the handle without touching the underlying device. This provides with possibility to restrict access through the handle to certain part of the underlying device even for media without partition table in the first sector, i.e., the device may be partitioned in software.

Seek to the beginning of the just defined partition is performed when this IOCTL gets executed.

### 3.8.2.5 IO\_IOCTL\_SEL\_PART

This command selects partition to use with the handle.

The third **ioctl()** parameter points to *uint32\_t* number which has to be between zero and four and represents the number of partition to select. If zero is specified no partition will be selected, i.e., whole device will be accessible through the handle.

It is not possible to directly select another partition if there is a partition already selected. Partition has to be deselected first, i.e., *IO\_IOCTL\_SEL\_PART* has to be executed with pointer to zero as third parameter.

Seek to the beginning of the just selected partition or the device is performed when this IOCTL gets executed.

### 3.8.2.6 IO\_IOCTL\_VAL\_PART

This command validates partition table and checks partition type.

The third **ioctl()** parameter may be either *NULL* or pointer to *uint32\_t* number which has to be between zero and four.

The IOCTL call checks partition table for validity. Then, it optionally checks type of partition whether it matches one of the FAT partition types. If the third parameter is pointer to zero only the partition table validity check is performed. If the third parameter is *NULL*, the type check is performed on a currently selected partition.

The IOCTL call with non-*NULL* third parameter is valid only if no partition is selected, i.e., the whole device is accessible through the handle.

If the partition type is checked and does not match any of the FAT partition types, *PMGR\_UNKNOWN\_PARTITION* is returned which indicates that the partition is valid but does not match any of the FAT types.

## 3.8.3 Return Codes for MFS

- *MFS\_ACCESS\_DENIED*  
— Application attempted to modify a read-only file or a system file.
- *MFS\_ALREADY\_ASSIGNED*
- *MFS\_ATTEMPT\_TO\_REMOVE\_CURRENT\_DIR*
- *MFS\_BAD\_DISK\_UNIT*  
— Operation on a file failed because that file is corrupted.
- *MFS\_BAD\_LFN\_ENTRY*  
— MFS failed to find a complete long file name within two clusters.
- *MFS\_CANNOT\_CREATE\_DIRECTORY*

- MFS was unable to create the requested long directory name, usually because an invalid (illegal) directory name was specified.
- *MFS\_DISK\_FULL*
  - Disk is full.
- *MFS\_DISK\_IS\_WRITE\_PROTECTED*
  - Disk is write protected and could not be written to.
- *MFS\_EOF*
  - End of the file has been reached during a read. This is not a failure; it is only a warning.
- *MFS\_ERROR\_INVALID\_DRIVE\_HANDLE*
  - The MFS *FILE\_PTR* was invalid.
- *MFS\_ERROR\_INVALID\_FILE\_HANDLE*
  - The MFS *FILE\_PTR* was invalid.
- *MFS\_ERROR\_UNKNOWN\_FS\_VERSION*
  - The drive contains an advanced FAT32 version. The MFS FAT32 version is not compatible. (There is currently only one FAT32 version, but this could change in the future.)
- *MFS\_FAILED\_TO\_DELETE\_LFN*
  - MFS failed to completely delete a long file name. This results when MFS cannot locate all of the long file name entries associated with a file.
- *MFS\_FILE\_EXISTS*
  - File already exists with the specified name.
- *MFS\_FILE\_NOT\_FOUND*
  - File specified does not exist.
- *MFS\_INSUFFICIENT\_MEMORY*
  - MFS memory allocation failed. (MQX RTOS is out of memory or it has a corrupted memory pool.)
- *MFS\_INVALID\_CLUSTER\_NUMBER*
  - A cluster number was detected that exceeds the maximum number of clusters on the drive (or partition). This may be a result of a corrupted directory entry.
- *MFS\_INVALID\_DEVICE*
  - The underlying block mode driver does not support the block size command, or the block size is not legal (neither one of 512, 1024, 2048, or 4096 bytes).
- *MFS\_INVALID\_FUNCTION\_CODE*
  - Not currently used.
- *MFS\_INVALID\_HANDLE*
  - One of the fields in a given *FILE\_PTR* structure was invalid.
- *MFS\_INVALID\_LENGTH\_IN\_DISK\_OPERATION*
  - Requested directory exceeds maximum in change-directory operation.
- *MFS\_INVALID\_MEMORY\_BLOCK\_ADDRESS*
  - *SEARCH\_DATA\_PTR* is NULL on find-first or fine-next file operation.

- *MFS\_INVALID\_PARAMETER*
  - One or more of the parameters passed to `_io_ioctl()` is invalid.
- *MFS\_LOST\_CHAIN*
  - This is not a critical error. It means there is a lost cluster chain which results in some wasted space. Operations on the drive continue normally.
- *MFS\_NO\_ERROR*
  - Function call was successful.
- *MFS\_NOT\_A\_DOS\_DISK*
  - Disk is not formatted at FAT12, FAT16, or FAT32 file system.
- *MFS\_NOT\_INITIALIZED*
  - Not currently returned.
- *MFSOPERATION\_NOT\_ALLOWED*
  - Returned when attempting a write operation when MFS is built in read-only mode, or a format operation when MFS is built without format functionality, or an attempt to rename a file to the same name.
- *MFS\_PATH\_NOT\_FOUND*
  - Path name specified does not exist.
- *MFS\_READ\_FAULT*
  - An error occurred reading from the disk.
- *MFS\_ROOT\_DIR\_FULL*
  - Root directory on the drive has no more free entries for new files.
- *MFS\_SECTOR\_NOT\_FOUND*
  - An error occurred while writing to the disk. The drive was formatted with incorrect parameters, or the partition table specified incorrect values.
- *MFS\_SHARING\_VIOLATION*
  - Produced by one of:
    - An attempt to close or format a drive that currently has files open.
    - An attempt to open a file to write that is already opened.
- *MFS\_WRITE\_FAULT*
  - An error occurred while writing to the disk.

### 3.8.4 Return Codes for the Partition Manager Device Driver

- *PMGR\_INVALID\_PARTITION*
  - The specified partition slot does not describe a valid partition.
- *PMGR\_INSUF\_MEMORY*
  - Attempt to allocate memory failed. MQX RTOS is out of memory or it has a corrupt memory pool.

### 3.8.5 Other Error Codes

An error was returned from the lower-level device driver.

## Chapter 4 Reference: Data Types

### 4.1 In This Chapter

Alphabetically sorted data-type descriptions for MFS.

### 4.2 `_mfs_cache_policy`

```
typedef enum {  
    MFS_WRITE_THROUGH_CACHE=0,    // No write caching (only read caching)  
    MFS_MIXED_MODE_CACHE=1,       // Write Caching allowed on file write only  
    MFS_WRITE_BACK_CACHE=2        // Write Caching fully enabled  
} _mfs_cache_policy;
```

## 4.3 MFS\_DATE\_TIME\_PARAM

```
typedef struct mfs_date_time_param
{
    uint16_t * DATE_PTR;
    uint16_t * TIME_PTR;
} MFS_DATE_TIME_PARAM, * MFS_DATE_TIME_PARAM_PTR;
```

A pointer to the structure is used in *IO\_IOCTL\_GET\_DATE\_TIME* and *IO\_IOCTL\_SET\_DATE\_TIME* commands.

The first field is the *uint16\_t \** to *uint16\_t* variable in which the date is to be stored (for get) or read from (for set). The second field is the *uint16\_t \** to *uint16\_t* variable, in which the time is to be stored (for get) or read from (for set). See the **ioctl** description for details.

## 4.4 MFS\_FILE\_ATTR\_PARAM

```
typedef struct mfs_file_attr_param
{
    char *    PATHNAME;
    /* Path name and filename of the file */
    unsigned char *  ATTRIBUTE_PTR;
    /* pointer to the attribute variable */
} MFS_FILE_ATTR_PARAM, * MFS_FILE_ATTR_PARAM_PTR;
```

A pointer to the structure is used in *IO\_IOCTL\_GET\_FILE\_ATTR* and *IO\_IOCTL\_SET\_FILE\_ATTR* commands.

The first field is the *char \** to the path name and filename of the file for which you want to get or set the attribute. The second field is the *unsigned char \** to the *char* variable in which the attribute is read from (for set), or in which the attribute is stored (for get).

## 4.5 MFS\_GET\_LFN\_STRUCT

```
typedef struct mfs_get_lfn_struct
{
    char *    PATHNAME;
    /* Path name of the 8.3 name */
    char *    LONG_FILENAME;
    /* pointer to memory block in which to store the long name */
} MFS_GET_LFN_STRUCT, * MFS_GET_LFN_STRUCT_PTR;
```

A pointer to this structure is used in *IO\_IOCTL\_GET\_LFN* commands.

The first field is the *char \** to the path name or file name of the file that we want to get the long file name of. The second field is the *char \** to pre-allocated space in which to store the long file name of the requested file.

## 4.6 MFS\_IOCTL\_FORMAT\_PARAM

```
typedef struct mfs_ioctl_format
{
    MFS_FORMAT_DATA_PTR  FORMAT_PTR; /* Points to format data */
    uint32_t *           COUNT_PTR;  /* Count the bad clusters */
} MFS_IOCTL_FORMAT_PARAM, * MFS_IOCTL_FORMAT_PARAM_PTR;
```

A pointer to the structure is used in calls to *IO\_IOCTL\_FORMAT* and *IO\_IOCTL\_FORMAT\_TEST* commands.

The first field is a pointer to the *MFS\_FORMAT\_DATA* structure, which is explained at the beginning of this document. The second field is used only for the *IO\_IOCTL\_FORMAT\_TEST* command. It is a pointer to the *uint32\_t* variable in which the count of bad clusters is stored.

## 4.7 MFS\_RENAME\_PARAM

```
typedef struct mfs_rename_param
{
    char *                OLD_PATHNAME;
    char *                NEW_PATHNAME;
} MFS_RENAME_PARAM, * MFS_RENAME_PARAM_PTR;
```

A pointer to the structure used in *IO\_IOCTL\_RENAME\_FILE* commands.

The first field is the *char \** to a string that contains the path name and file name of the file to move or rename. The second field is the *char \** to the new path name or filename.

## 4.8 MFS\_SEARCH\_PARAM

```
typedef struct mfs_search_param
{
    uint32_t          ATTRIBUTE;
    char              *WILDCARD;
    char              *LFN_BUF;
    uint32_t          LFN_BUF_LEN;
    MFS_SEARCH_DATA_PTR
} MFS_SEARCH_PARAM, * MFS_SEARCH_PARAM_PTR;
```

A pointer to the structure is used in *IO\_IOCTL\_FIND\_FIRST\_FILE* commands.

- a) The attribute field `unsigned char` contains the search attributes specifying types of directory entries which are retrieved during the search. The `WILDCARD` field contains a path and a specific filename or the wildcard mask. It can include wildcard characters. The `LFN_BUF` and `LFN_BUF_LEN` specify an address and length of the optional caller-allocated buffer to retrieve long filenames of the directory entities found. The `SEARCH_DATA_PTR` is a pointer to the caller-allocated `SEARCH_DATA` structure to return the retrieved data. See the *IO\_IOCTL\_FIND\_FIRST\_FILE*, *IO\_IOCTL\_FIND\_NEXT\_FILE* command explanation for details.

