SafeFLASH File System User's Guide

Version 3.40

For use with SafeFLASH File System versions 4.15 and above

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1 System Overview

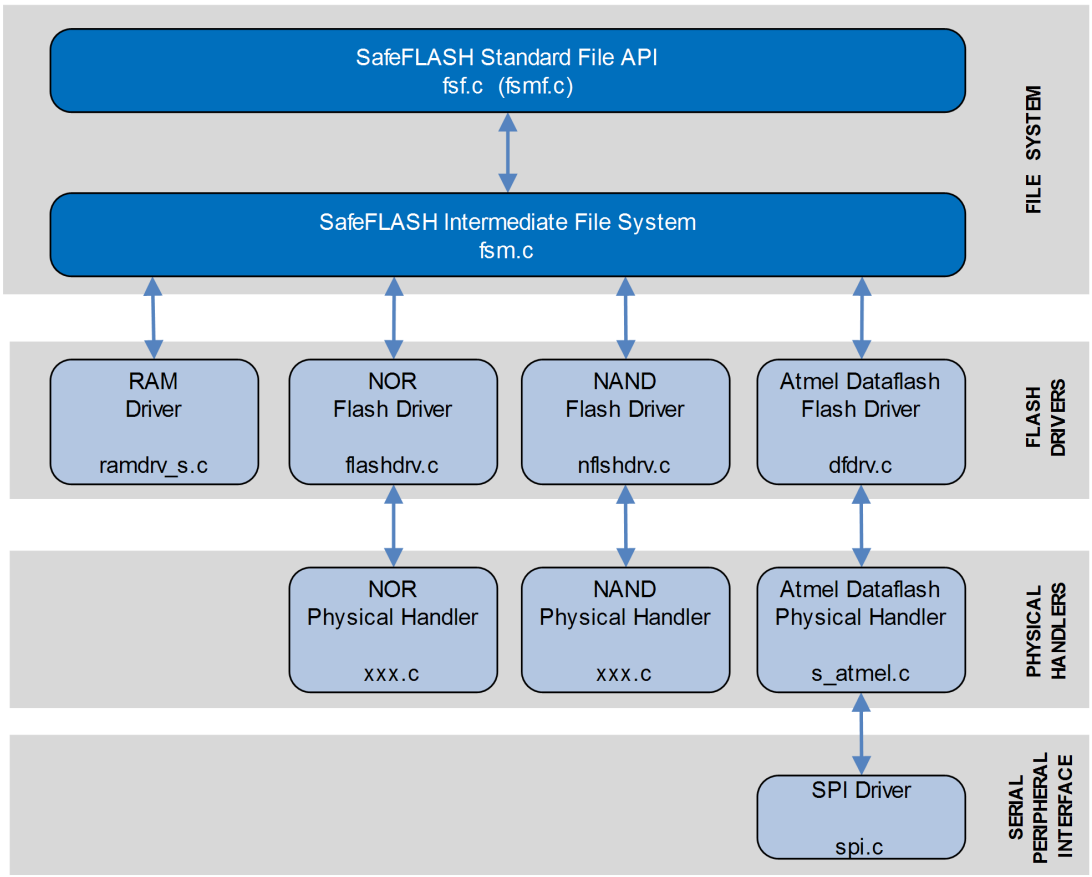
1.1 Introduction

This guide is for those who want to implement a file system in any combination of RAM, NOR flash, NAND flash, and Atmel® DataFlash.

The SafeFLASH file system driver is highly portable without compromising excellent performance. In short, SafeFLASH:

- is a package of source code designed for flash file system development in embedded systems.
- is a high performance truly fail-safe file system that can be used with all NOR and NAND flash, and any media that can simulate a block-structured array.
- supports dynamic and static wear leveling and provides a highly efficient solution for products in which data integrity is critical.

The following diagram illustrates the structure of the SafeFLASH file system:



This diagram shows:

- The Standard API and intermediate layer. The file **fsmf.c** is the Standard API multi-thread wrapper.

- The drivers – the basic device architecture includes a high level driver for each general media type. These drivers share some common properties. The driver handles issues of FAT maintenance, wear leveling, and so on.
- A physical device handler below the driver (except for the RAM driver) performs the translation between the driver and the physical flash hardware. Separate manuals detail the implementation of physical handlers for NOR flash, NAND flash, and Atmel® DataFlash.

Generally only the physical handler needs to be modified when the hardware configuration changes (for example, a different chip type, the number of devices in parallel, and so on). HCC Embedded provides a range of physical handlers to make the porting process as simple as possible.

Note:

- HCC Embedded offers hardware and firmware development consultancy to assist developers with the implementation of flash file systems.
- The SafeFLASH file system was previously known as EFFS-STD. All references to STD in the code are historical and refer to the file system’s original name.

1.2 Feature Check

The main features of the system are the following:

- It conforms to the HCC Advanced Embedded Framework.
- It can be used with or without an RTOS.
- The code size is just 17 - 20KB.
- RAM usage depends on the configuration and flash type. HCC provides a tool for calculating this number.
- It provides fail safety.
- ANSI ‘C’.
- It supports long filenames.
- It supports Unicode 16 names.
- It supports multiple open files.
- It supports multiple users of open files.
- It supports multiple volumes.
- It handles media errors.
- It supports CRC on files (this is optional).
- A test suite is provided.
- It offers high relative performance.
- It has a cache option.
- It supports zero copy.
- It supports static wear leveling.
- It supports dynamic wear leveling.
- It is reentrant.
- Common API (CAPI) support.

- Secure delete option (NOR flash only).

NOR Flash Support

- Supports all NOR flash types.
- Easy porting for all known device types.
- Sample driver available with porting description.

Atmel® DataFlash Support

- Supports all devices.
- Manages the 10K writes/sector limitation.
- Fail-safe implementation of the DataFlash interface.

NAND Flash Support

- Supports all NAND flash types.
- Error Correction Codes (ECC) algorithm.
- Easy porting for all known device types.
- Sample driver with porting description.
- MCU/NAND controller support.

Note: SafeFLASH does not support removable media and is not recommended for arrays of flash greater than 4GB. For removable media and very large arrays, we recommend using the HCC FAT or SafeFAT system, with HCC SafeFTL where NAND flash is required.

1.3 Packages and Documents

Packages

The following table lists the packages that need to be used with this module, and also optional modules which may interact with this module, depending on your particular system's design:

Package	Description
hcc_base_doc	This contains the two guides that will help you get started.
fs_safe	SafeFLASH base package.
media_drv_base	The Media Driver base package that provides the base for all media drivers that attach to the file system.
media_drv_ram	The RAM Media Driver package, used for creating a RAM drive.
fs_safe_ram	SafeFLASH package for RAM.
fs_safe_nor	SafeFLASH package for NOR flash.
fs_safe_nand	SafeFLASH package for NAND flash.
fs_safe_df	SafeFLASH package for Atmel® DataFlash.

Documents

Readers should note the points in the HCC Documentation Guidelines on the HCC documentation website.

HCC Firmware Quick Start Guide

This document describes how to install packages provided by HCC in the target development environment. Also follow the *Quick Start Guide* when HCC provides package updates.

HCC Source Tree Guide

This document describes the HCC source tree. It gives an overview of the system to make clear the logic behind its organization.

HCC SafeFLASH File System User's Guide

This is this document.

Other HCC SafeFLASH Guides

These describe how to use SafeFLASH with the various drivers/physical handlers:

- *HCC SafeFLASH (RAM) User's Guide* – documents the SafeFLASH RAM driver.
- *HCC SafeFLASH (NAND) User's Guide* – documents the SafeFLASH NAND setup.
- *HCC SafeFLASH (NOR) User's Guide* – documents the SafeFLASH NOR setup.
- *HCC SafeFLASH (Atmel® DataFlash) User's Guide* – documents the SafeFLASH Atmel® DataFlash setup.

1.4 Change History

This section includes recent changes to this product. For a complete list of all changes, refer to the file **src /history/safe-flash/safe-flash.txt** in the distribution package.

Version	Changes
4.15	Discardable sectors are collected in a dedicated buffer to speed up **_fg_flush()**, which is called after most of the file system operations. The size of this buffer is set by the new FS_DISCARD_BUF_SIZE configuration option.
4.14	Fixed Keil RTX compatibility issue: mutex was released before being deleted.
4.13	Fixed problem that meant write tests failed if there was not enough space. The code now checks for free space before writing.
4.12	File can now be opened in "r" mode again, even if it is already open in "a" or "a+" mode.

2 Source File List

This section lists all the files included in the file system. These files follow HCC Embedded's standard source tree system, described in the *HCC Source Tree Guide*. All references to file pathnames refer to locations within this standard source tree, not within the package you initially receive.

> **Note:** Do not modify any files except the configuration file.

2.1 API Interface

The following files in the directory **src/api** must be included by any application using the system. They include all that is required to access the system. For details of the API functions, see Application Programming Interface.

File	Description
fsf.c	API for the module.
api_fs_err.h	Error code definitions.

2.2 Configuration File

The file **src/config/config_safe.h** contains all the configurable parameters of the system. Configure these as required. For details of these options, see Configuration Options.

2.3 Version File

The file **src/version/ver_safe.h** contains the version number of this module. This version number is checked by all modules that use this module to ensure system consistency over upgrades.

2.4 SafeFLASH System

The following files are in the directory **src/safe-flash/common**. **These files should only be modified by HCC.**

File	Description
fsf.c	SafeFLASH Standard API code.
fsf.h	SafeFLASH Standard API header.
fsm.c	SafeFLASH intermediate layer code.
fsm.h	SafeFLASH intermediate layer header.
fsmf.c	SafeFLASH Standard API multi-thread wrapper code.
fsmf.h	SafeFLASH Standard API multi-thread wrapper header.
fstaticw.c	Static wear leveling code.
fstaticw.h	Static wear leveling header.
port_s.h	Header file for port functions.

2.5 Test Files

The following files are in the directory **src/safe-flash/test**. Use these files to exercise your file system.

FIle	Description
test_s.c	Source of test program used to exercise the file system.
test_s.h	Header file for test program.
testdrv_s.c	Source of test program used to exercise a flash driver.
testdrv_s.h	Header file for flash driver test program.
testport_ram_s.c	Sample port file for running test applications.

3 Configuration Options

Set the SafeFLASH configuration options in the file **src/config/config_safe.h**. This section lists the available configuration options and their default values.

FS_MAXDENAME

This is the maximum size of a name in a base directory entry. SafeFLASH supports filenames of almost unlimited length. A filename is built from a chain of small fragments taken from the descriptor block, consisting of one FS_MAXDENAME entry that may have FS_MAXLFN size entries chained to it. The maximum file name length is limited by the FS+MAXLNAME definition:

- FS_MAXLFN – if a filename is longer than FS_MAXDENAME (the default is 13), an additional FS_MAXLFN (the default is 11) byte block is allocated to store the longer name. These additional blocks are added by the file system automatically.
- FS_MAXLNAME – sets the maximum allowed name length. By default this is set to FS_MAXDENAME+4*FS_MAXLFN (57 bytes). You may increase/decrease this by multiples of FS_MAXLFN bytes; just change the FS_MAXLFN multiplier in the FS_MAXLNAME definition. This sets the number of these structures that may be used for a single name.

Long filenames use memory from the descriptor blocks in the file system. The system uses an efficient algorithm for allocating additional blocks in units of FS_MAXLFN. The use of long filenames reduces the number of file and directory entries that can be stored.

FS_CAPI_USED

If you are using FAT in the same system as SafeFLASH, you can use the Common API (CAPI) to provide a common API for accessing both systems. To do this, set FS_CAPI_USED to 1. If you are using SafeFLASH on its own, do not change this setting from the default zero.

FS_SAFE_CASE_SENSITIVE

By default SafeFLASH uses case insensitive names. To enable case sensitive names, set this to 1.

FS_MAXVOLUME

The maximum number of volumes. The default is 2. Set this value to the maximum volume number used. If only a RAM drive is used, set the value to 1; if you use a RAM drive and NOR flash, set it to 2, and so on. Volume letters are assigned by passing a parameter in the **f_mountdrive()** function.

SafeFLASH supports multiple volumes. Each volume must have its own driver routine, which normally has its own physical handler (except for the RAM drive).

FS_MAXTASK

The maximum number of tasks. The default is 1.

FS_MAXPATHNAME

The maximum length of a path. The default is 256.

FS_CURRDRIVE

This sets the current drive at startup. The default is zero. A value of -1 means there's no default current drive.

HCC_16BIT_CHAR, TI_COMPRESS

Some TI DSP devices (for example, C2000 and C5000) require special handling by the file system because of their unique architecture. For these devices, modify these two parameters as follows:

- HCC_16BIT_CHAR – enable this if the target controller has a char type that is 16 bits wide.
- TI_COMPRESS – this option allows more highly optimized storage of data in the file system. If this is enabled and the file is opened with the special mode for this, only the lower half (8 bits) is stored for all data written by the file system, and all data read out of the file system is stored in the lower 8 bits of the chars in the buffer.

To use the TI_COMPRESS option, add a "c" to the open mode after the "r", "w" or "a". For example:

```
f_open("test", rc+);
f_open("test", wc);
```

If TI_COMPRESS is set and the "c" is not included in the open mode, the file data is handled normally.

> **Note:** When using devices in which the pointer wraps at 64KB word boundaries, special effort is needed to allocate memory for the system in a way that this can work. Please contact support@hcc-embedded.com to discuss this further.

CRCONFILES

To handle all files with a CRC, enable this (by default it is disabled). When it is enabled, each time a file is stored the CRC is stored, and each time a file is opened its CRC is verified.

> **Note:** Enabling this option has a major effect on system performance.

F_FILE_CHANGED_EVENT

Set this to 1 enable Change Event Notification when a file state changes. By default it is zero.

USE_TASK_SEPARATED_CWD

If this is set to 1, every task has its own current working directory. This is the default and is consistent with older versions of the system.

If it is set to zero, there is one current working directory per volume. If any task changes it, it is changed for all tasks accessing that volume.

HCC_UNICODE

To enable the use of the Unicode 16 API functions, set this to 1. These functions are prefixed with "f_w", for example **f_wopen()** instead of **f_open()**.

FS_SEPARATORCHAR

This defines the file separator character. By default this is a slash ("/"). Set this to '\\' to use backslash as the pathname separator character.

FSF_MOST_FREE_ALLOC

Set this to 1, the default, to use Free Block Allocation. This allocates the block that has the most free sectors.

The alternative algorithm for allocating file system blocks just finds a block with a single available sector.

FS_DISCARD_BUF_SIZE

The size of the FS_VOLUMEINFO.discard_buf that holds the indexes of discardable sectors. The default is 16.

Using a larger value may speed up small operations performed on large files on large volumes.

4 System Features

4.1 Other Media Types

The SafeFLASH system design is based on the concept of a storage device with a logical block arrangement. Because of this, any device that can emulate a logical block arrangement can be used as a storage medium. However, note that:

- SafeFLASH does not support removable media.
- SafeFLASH is not recommended for arrays of flash greater than 4GB.
- For removable media and very large arrays, we recommend using the HCC FAT or SafeFAT system.

4.2 Power Fail Safety

The SafeFLASH file system is entirely safe against power failure. The system may be stopped at any point, then restarted, without data being lost; the previously completed state of the file system is restored.

When a file is closed, its data are automatically flushed from the file system. Until this closure takes place, the file is preserved. You may also use the **f_flush()** function to write the current state of the file to the medium, thus updating its fail-safe state.

4.3 Multiple Open Files in a Volume

SafeFLASH allows multiple files to be opened simultaneously on a volume, or on different volumes. Within each driver (**ramdrv_s.c**, **flashdrv.c**, **nflshdrv.c** and **dfdrv.c**) there is a MAXFILE definition that determines the number of files that can be opened simultaneously on that volume at any particular time.

For each opened file, an array must be allocated that contains a sector size buffer. Therefore, increasing MAXFILE for a particular volume increases the RAM required by the system.

4.4 Wildcards

Wildcard characters can be used to find files or directories. Wildcard characters can be used only as parameters for the **f_findfirst()** function; these are then re-used when **f_findnext()** is called. The valid wildcard characters are:

Wildcard	Description
*	Matches any string.
?	Matches any single character.
"*"	Matches a string up to the end of file or the first ".", or from the first "." to the end of file. So "*.*" is required to access all files or directories in the target directory.

Note: If you want to perform a logical operation such as **f_delete(".")**:

1. Call **f_findfirst()/f_findnext()** repeatedly.
2. When each name is returned in the F_FIND structure, use that as a parameter for **f_delete()**.

4.5 Static Wear Leveling

Flash devices are usually manufactured to a specification that includes a guaranteed number of write-erase cycles that can be performed on each block before it may develop a fault. Because of this, it is important to use the blocks in a device "evenly" to maximize the device lifetime.

SafeFLASH uses a process called **dynamic wear leveling** to allocate the least-used blocks from those available. However, in systems where there are large areas of static data (for example, the executable binary for the system), the areas may be written only once. This leaves a relatively small section of the device to handle the much more heavily used files.

To counter this, a process called **static wear leveling** is used. When the **fs_staticwear()** function is called, it searches for blocks that have been used much less than the most used blocks in the system. If the difference between their usage rates is greater than a defined threshold (FS_STATIC_DISTANCE), the two blocks are exchanged.

To use static wear leveling, you must include the files **fstaticw.c** and **fstaticw.h** in your project. The header file should include the following two defines:

Define	Description
FS_STATIC_DISTANCE	This specifies the minimum difference between a heavily used block and a lightly used block before a static swap is allowed. Do not set this number so small that it causes unnecessary swapping. A reasonable figure is between 1% and 10% of the guaranteed erase/write cycles of the target chip.
FS_STATIC_PERIOD	This specifies how often this function will actually attempt to perform a swap. To reduce unnecessary checking of the system, you may use this to reduce the number of times that **fs_staticwear()** is executed. If you always know that the system will be idle when **fs_staticwear()** is called, you may set this to 1 so that it is always executed; for example, if you make just a few calls to **fs_staticwear()** at start-up. If **fs_staticwear()** is called at every available opportunity, you may want to execute it less frequently.

While the static wear leveling function executes, the file system is not accessible. The length of time it takes depends on the specification of the target chips being used, in particular the time required to erase a block and the time required to copy one block to another.

BlockCopy

For static wear leveling to function, an additional **BlockCopy** driver function must also be provided. See the appropriate driver documents (for NOR flash or NAND flash) for information on implementing this function for your target media. It is important to provide a highly optimized version of **BlockCopy**, preferably by using special copy functions that are specific to the target chip, in order to achieve the best system performance and least system disruption.

Do I need static wear-leveling?

In many cases it is an unnecessary overhead. To assess its importance, look at how your product is to be used and consider the specifications of your target devices. Many devices have up to one million guaranteed erase/write cycles per block and in many applications this number will not be reached in the lifetime of the product.

When should I perform static wear-leveling?

Because wear leveling involves swapping blocks in the file system, all access is excluded for the duration of the process. Thus, if your device has time-critical features, it is preferable to perform static wear leveling during idle moments. For effective management of the system, call the function regularly during idle time.

5 Getting Started

To start your development as efficiently as possible, take the following steps:

1. Build the file system using the API (**fsf.c, fsmf.c**), the intermediate file system (**fsm.c**), and the RAM driver (**ramdrv_s.c** from the **fs_safe_ram** package), including the relevant header files. In this way you can build a file system that runs in RAM with little or no dependency on your hardware platform.
2. Build a test program to exercise this file system and check how it works in RAM. All build and integration issues can thus be addressed before worrying about specific flash devices.
3. Now add the next volume to the system, depending on your requirements.

For a NOR drive:	For a DataFlash drive:	For a NAND drive:
Add **flashdrv.c** from the **fs_safe_nor** package to the build.	Add **dfdrv.c** from the **fs_safe_df** package to the build.	Add **nflshdrv.c** from the **fs_safe_nand** package to the build.

4. Now add a physical device driver to the build.

For NOR chips:	For DataFlash chips:	For NAND chips:
Read the *HCC SafeFLASH File System (NOR) User's Guide* carefully. Using the available sample drivers as a basis, create a driver that meets your specific needs.	Read the *HCC SafeFLASH File System (Atmel® DataFlash) User's Guide* carefully. Using the available sample drivers as a basis, create a driver that meets your specific needs.	Read the *HCC SafeFLASH File System (NAND) User's Guide* carefully. Using the available sample drivers as a basis, create a driver that meets your specific needs.

5. Add new volumes by repeating steps 3 and 4.

6 Application Programming Interface

This section documents the Application Programming Interface (API). It includes all the functions that are available to an application program.

6.1 Module Management

f_init

Use this function to initialize the file system. Call it once at start-up.

Data areas for the file system to use are allocated at compile time, based on the settings for each volume in the configuration file **src/config/config_safe.h**.

Format

```
int f_init ( void )
```

Arguments

Argument
None.

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example:

```
void main()
{
    f_init(); /* Initialize file system */
        .
        .
        .
}
```

6.2 File System API

This section describes all the Application Programmer Interface (API) functions available, apart from Unicode functions. It is split into functions for general, volume, directory, and file management, also file access.

General Management

f_enterFS

Use this function to create resources for the calling task in the file system and allocate a current working directory for that task.

Note:

- If the target system allows multiple tasks to use the file system, this function must be called by a task before it uses any other file API functions.
- Correct operation of this function also requires that **oal_get_task_id()** in the OS Abstraction Layer (OAL) has been ported to give a unique identifier for each task.

f_releaseFS() must be called to release the task from the file system and free the allocated resource. If the system is a single task-based system, this function must also be called after **f_init()** is called.

Format

```
int f_enterFS ( void )
```

Arguments

Argument
None.

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void main()
{
    f_init();     /* Initialize file system */
    f_enterFS();  /* Allow current (only) task to access file system */
        .
        .
}
```

f_releaseFS

Use this function to release a previously assigned unique task ID.

This function must be called if a given task is to be killed.

Format

```
void f_releaseFS ( void )
```

Arguments

Argument
None.

Return values

Return value
None.

Example

```
void task_destructor()
{
    f_releaseFS();  /* Release current task ID */
    .
    .
    .
}
```

f_getlasterror

Use this function to return the last error code.

The last error code is cleared/changed when any API function is called.

Format

```
int f_getlasterror ( )
```

Arguments

Argument
None.

Return values

Return value	Description
Error code	The last error code.

Example

```
int myopen()
{
    F_FILE *file;
    file = f_open( "nofile.tst", "rb" );
    if (!file)
    {
        int rc = f_getlasterror();
        printf ( "f_open failed, errorcode:%d\n", rc );
        return rc;
    }
    return F_NO_ERROR;
}
```

f_getversion

Use this function to retrieve file system version information.

Format

```
char * f_getversion ( void )
```

Arguments

Argument
None.

Return values

Return value	Description
char *	A pointer to a null-terminated ASCII string.

Example

```
void display_fs_version( void )
{
    printf( "File system version: %s", f_getversion() );
}
```

fs_staticwear

Use this function to even the wear of blocks that are rarely used.

See Static Wear Leveling for information about when and how to use this function.

Format

```
int fs_staticwear ( int drvnum )
```

Arguments

Argument	Description	Type
drvnum	The number of the drive (0='A', 1='B', and so on).	int

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void idle( void )
{
    int ret;
    /* Try static wear on Drive A */
    ret = fs_staticwear(0);
    if (!ret)
    {
        printf( "Static wear done\n" );
    }
    Else
    {
        printf( "Error in static wear!\n", ret );
    }
}
```

Volume Management

Note: The API functions **f_chdrive()**, **f_getdrive()**, **f_get_drive_count()**, **f_get_drive_list()**, **f_mountdrive()** and **f_unmountdrive()** refer to drives by name because this is the convention, but the names are really references to volumes.

f_mountdrive

Use this function to mount and map a new drive. Call it with the following parameters:

drivenum

The number of the drive to be mounted, where 0 is drive 'A', 1 is drive 'B', and so on. The maximum value of **drivenum** is set in FS_MAXVOLUME-1 in **fsm.h**.

buffer

A pointer for a buffer area to be used by the generic driver. Its size depends on the specific devices and configuration used.

- For a RAM drive allocate a buffer of the size required for the whole RAM file system, as shown in the example below.
- For a NOR drive call the generic NOR flash function **fs_getmem_flashdrive()** with a pointer to the **get-physical()** function of the specific physical chip driver to be mounted (for example, **fs_phy_nor_29lvxxx()**). This function calculates and returns the amount of memory that must be allocated for the physical driver. The caller must then allocate the memory and pass its pointer and size to **f_mountdrive()**. See the example code below.
- For a NAND drive call the generic NAND flash function **fs_getmem_nandflashdrive()** with a pointer to the **get-physical()** function of the specific physical chip driver to be mounted (for example, **fs_phy_nand_K9F2816X0C()**). This function calculates and returns the amount of memory that must be allocated for the physical driver. The caller must then allocate this amount of memory and pass its pointer and size to **f_mountdrive()**. See the example code below.

buffsize

The size of the allocated buffer that is passed to the mount function.

mountfunc

A pointer to the generic mount function for the specific media type. **mountfunc()** is a driver function that describes which drive needs to be mounted. This calls the physical driver function to be associated with it. Standard examples are:

- **fs_mount_ramdrive()** – to use a drive as a RAM drive.
- **fs_mount_flashdrive()** – to use a drive as a NOR flash drive.
- **fs_mount_nandflashdrive()** – to use a drive as a NAND flash drive.

phyfunc

A pointer to a physical driver function for the desired device that is called by the generic mount function to get information about how to use the device. For a RAM drive this function is NULL. Standard examples are:

- **fs_phy_nor_sim()** – for PC emulation of NOR physical.
- **fs_phy_nor_29lvxxx()** – for AMD flash.
- **fs_phy_nand_sim()** – for PC emulation of NAND physical.
- **fs_phy_nand_ K9F2816X0C()** – for Samsung NAND flash.

Format

```
int f_mountdrive (
    int           drivenum,
    void *        buffer,
    long          buffsize,
    FS_DRVMOUNT   mountfunc,
    FS_PHYGETID   phyfunc )
```

Arguments

Argument	Description	Type
drivenum	The drive number (0='A', 1='B', and so on).	int
buffer	The buffer pointer to be used by the file system.	void *
buffsize	The size of the buffer.	long
mountfunc	The mount function for the selected drive type.	FS_DRVMOUNT
phyfunc	The physical driver for the specific chip type.	FS_PHYGETID

Return values

Return value	Description
FS_VOL_OK	Drive successfully mounted.
FS_VOL_NOTMOUNT	Drive not mounted.
FS_VOL_NOTFORMATTED	Drive is mounted but is not formatted.
FS_VOL_NOMEMORY	Not enough memory, drive is not mounted.
FS_VOL_NOMORE	No more drives available (FS_MAXVOLUME).
FS_VOL_DRVERROR	Mount driver error, not mounted.

Example

```
/* This example shows how to mount Ramdrive, FLASH drive and NANDFLASH drive    */
char p0buffer[0x100000]; /* 1M */
void main( void )
{
    char *p1buffer, *p2buffer;
    long memsize;
    f_init();
    f_enterFS();
    /* Drive A will be RAM drive */
    f_mountdrive( 0, p0buffer, sizeof( p0buffer ), fs_mount_ramdrive, 0 );
    memsize = fs_getmem_flashdrive( fs_phy_nor_29lvxxx );
    if (!memsize)
    {
        /* Flash is not identified */
    }
    p1buffer = (char*)malloc( memsize );
    if (!p1buffer)
    {
        /* Not enough memory to allocate */
    }
    /* Drive B will be NOR flash drive with AMD physical driver */
    f_mountdrive( 1, p1buffer, memsize, fs_mount_flashdrive, fs_phy_nor_29lvxxx );
    memsize = fs_getmem_nandflashdrive( fs_phy_nand_K9F2816X0C );
    if (!memsize)
    {
        /* NAND flash is not identified, */
    }
    p2buffer = (char*)malloc( memsize );
    if (!p2buffer)
    {
        /* Not enough memory to allocate */
    }
    /* Drive C will be NAND flash drive with Samsung physical driver */
    f_mountdrive( 2, p2buffer, memsize, fs_mount_nandflashdrive, fs_phy_nand_K9F2816X0C );
}
```

f_unmountdrive

Use this function to unmount an existing volume.

Any open files on the media are marked as closed so that subsequent API accesses to a previously opened file handle return with an error.

This function works independently of the status of the hardware.

Format

```
int f_unmountdrive ( int drivenum )
```

Arguments

Argument	Description	Type
drivenum	The drive number (0='A', 1='B', and so on).	int

Return values

Return value	Description
F_NO_ERROR	Drive successfully deleted.
Else	See Error Codes.

Example

```
void mydelfs( int num )
{
    int ret;
    /* Unmounts volume 1 */
    if (f_unmountdrive (num))
        printf( "Unable to unmount volume %d", num );
            .
            .
            .
}
```

f_chdrive

Use this function to change to a new current drive.

In non-multitasking and multitasking systems, you must call **f_chdrive()** if you need relative path access. In a multitasking system, and in a non-multitasking system after **f_initvolume()**, every **f_enterFS()** must be followed by an **f_chdrive()** function call. In a multitasking system every task has its own current drive.

Format

```
int f_chdrive ( int drivenum )
```

Arguments

Argument	Description	Type
drivenum	The drive number to change to (0='A', 1='B', and so on).	int

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example:

```
void myfunc( void )
{
        .
        .
    f_chdrive( 0 );     /* Select drive A */
        .
        .
}
```

f_getdrive

Use this function to get the current drive number.

Format

```
int f_getdrive ( void )
```

Arguments

Argument
None.

Return values

Return value	Description
Current drive	The drive number (0='A', 1='B', and so on).
Else	See Error Codes.

Example

```
void myfunc( void )
{
    int currentdrive;
        .
    currentdrive = f_getdrive();
        .
        .
}
```

f_checkvolume

Use this function to check the status of a drive that has been initialized.

Format

```
int f_checkvolume ( int drivenum )
```

Arguments

Argument	Description	Type
drivenum	The drive number (0='A', 1='B', and so on).	int

Return values

Return value	Description
F_NO_ERROR	The drive is working.
Else	There is an error on the drive; for example, a card is missing. See Error Codes.

Example

```
void mychkfs( int num )
{
        int ret;
        /* Checking volume */
        if (f_checkvolume( num ))
        {
            printf( "Volume %d is not usable! Error %d", num, ret );
        }
        else
        {
            printf( "Volume %d is working, no error", num );
        }
            .
            .
}
```

f_format

Use this function to format the specified drive.

All data on the drive are destroyed, except the wear-leveling information on a FLASH device.

Format

```
int f_format ( int drivenum )
```

Arguments

Arguments	Description	Type
drivenum	The drive number (0='A', 1='B', and so on).	int

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
char buffer[0x30000];
void myinitfs( void )
{
    int ret;
    f_init();
    f_enterFS();
    /* Drive A will be NOR flash drive */
    ret = f_mountdrive( 0, buffer, sizeof(buffer), fs_mount_flashdrive, fs_phy_nor_29lvxxx );
    if (ret == FS_VOL_OK) return;   /* Initialized */
    if (ret == FS_VOL_NOTFORMATTED)
    {
        ret = f_format(0);   /* Format drive A */
        if (ret == F_ERR_NOTERR) return;   /* Formatted */
    }
initializationfailed:
}
```

f_get_drive_count

Use this function to get the number of drives currently available to the user.

Format

```
int f_get_drive_count ( void )
```

Arguments

Argument
None.

Return values

Return value	Description
num	The number of active volumes.

Example

```
void mygetvols( void )
{
    printf( "There are %d active drives\n", f_get_drive_count() );
            .
            .
}
```

f_get_drive_list

Use this function to get a list of drives currently available to the user.

Format

```
int f_get_drive_list ( int * buffer )
```

Arguments

Argument	Description	Type
buffer	Where to write the list.	int *

Return values

Return value	Description
number	The number of active volumes.

Example

```
void mygetvols( void )
{
    int i, j;
    int buffer[F_MAXVOLUME];
    i = f_get_drive_list(buffer);
    if (!i) printf ( "No active drive found\n" );
    for (j=0; j<i; j++)
    {
        printf ( "Drive %d is active\n", buffer[j] );
    }
}
```

f_getlabel

Use this function to return the label as a function value.

Format

```
int f_getlabel (
    int      drivenum,
    char *   pLabel,
    long     len )
```

Arguments

Argument	Description	Type
drivenum	The drive number (0='A', 1='B', and so on).	int
pLabel	Where to copy the label to. This should be able to hold an 11 character string.	char *
len	The length of the storage area.	long

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void getlabel( void )
{
    char label[12];
    int result;
    result = f_getlabel( f_getdrive(), label, 12 );
    if (result)
        printf( "Error on Drive!" );
    else
        printf( "Drive is %s", label );
}
```

f_setlabel

Use this function to set a volume label.

The volume label should be an ASCII string with a maximum length of 11 characters. Non-printable characters are padded out as space characters.

Format

```
int f_setlabel (
    int             drivenum,
    const char *    pLabel )
```

Arguments

Argument	Description	Type
drivenum	The drive number (0='A', 1='B', and so on).	int
pLabel	A pointer to the null-terminated string to use.	char *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void setlabel( void )
{
    int result = f_setlabel( f_getdrive(), "DRIVE 1" );
    if (result)
        printf( "Error on drive!" );
}
```

f_get_oem

Use this function to return the OEM name in the disk boot record.

Format

```
int f_get_oem (
    int      drivenum,
    char *   str,
    long     len )
```

Arguments

Argument	Description	Type
drivenum	The drive number (0='A', 1='B', and so on).	int
str	A pointer to the location to copy the label to. This should be able to hold an eight character string.	char *
len	The length of the storage area.	long

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void get_disk_oem( void )
{
    char oem_name[9];
    int result;
    oem_name[8] = 0;  /* Zero-terminate the string */
    result = f_get_oem( f_getdrive(), oem_name, 8 );
    if (result)
        printf( "Error on drive!" );
    else
        printf( "Drive OEM is %s", oem_name );
}
```

f_getfreespace

Use this function to fill a structure with information about the drive space usage: total space, free space, used space, and bad (damaged) size.

Note:

- If a drive is greater than 4GB, also read the high elements of the returned structure (for example, pspace.total_high) to get the upper 32 bits of each number.
- The first call to this function after a drive is mounted may take some time, depending on the size and format of the medium being used. After the initial call, changes to the volume are counted; the function then returns immediately with the data.

Format

```
int f_getfreespace (
    int         drivenum,
    F_SPACE *   pspace )
```

Arguments

Argument	Description	Type
drivenum	The drive number (0='A', 1='B', and so on).	int
pspace	A pointer to an F_SPACE structure.	F_SPACE *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void info( void )
{
    F_SPACE space;
    int ret;
    /* Get free space on current drive */
    int ret = f_getfreespace( f_getdrive(), &space );
    if (!ret)
    {
        printf( "There are:\
        %d bytes total,\
        %d bytes free,\
        %d bytes used,\
        %d bytes bad.",\
        space.total, space.free, space.used, space.bad );
    }
    else
    {
        printf( "\nError %d reading drive\n", ret );
    }
}
```

Directory Management

f_mkdir

Use this function to create a new directory.

Format

```
int f_mkdir ( const char * dirname )
```

Arguments

Argument	Description	Type
dirname	The name of the new directory to create.	char *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
        .
        .
    f_mkdir( "subfolder" );  /* Creating directories */
    f_mkdir( "subfolder/sub1" );
    f_mkdir( "subfolder/sub2" );
    f_mkdir( "a:/subfolder/sub3" );
        .
        .
}
```

f_chdir

Use this function to change the current working directory.

Every relative path starts from this directory. In a multitasking system every task has its own current working directory.

Format

```
int f_chdir ( const char * dirname )
```

Arguments

Argument	Description	Type
dirname	A null-terminated string with the name of the directory to change to.	char *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
        .
        .
    f_mkdir( "subfolder" );
    f_chdir( "subfolder" );         /* Change directory */
    f_mkdir( "sub2" );
    f_chdir( ".." );                /* Go up one directory level */
    f_chdir( "subfolder/sub2" );    /* Go into directory sub2 */
        .
        .
}
```

f_rmdir

Use this function to remove a directory.

The function returns an error code if:

- The target directory is not empty.
- The directory is read-only.

Format

```
int f_rmdir ( const char * dirname )
```

Arguments

Argument	Description	Type
dirname	The name of the directory to remove.	char *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
        .
        .
    f_mkdir( "subfolder" );      /* Create directories */
    f_mkdir( "subfolder/sub1" );
        .
        . /* Do some work */
        .
    f_rmdir( "subfolder/sub1" ); /* Remove directories */
    f_rmdir( "subfolder" );
        .
        .
}
```

f_getcwd

Use this function to get the current working directory on the current drive.

Format

```
int f_getcwd (
    char *   buffer,
    int      maxlen )
```

Arguments

Argument	Description	Type
buffer	Where to store the current working directory string.	char *
maxlen	The length of the buffer.	int

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
#define BUFFLEN F_MAXPATH + F_MAXNAME
void myfunc( void )
{
    char buffer[BUFFLEN];
    if (!f_getcwd( buffer, BUFFLEN ))
    {
        printf ( "Current directory is %s", buffer );
    }
    else
    {
        printf ( "Drive error!" )
    }
}
```

f_getdcwd

Use this function to get the current working directory on the selected drive.

Format

```
int f_getdcwd (
    int      drivenum,
    char *   buffer,
    int      maxlen )
```

Arguments

Argument	Description	Type
drivenum	The drive number (0='A', 1='B', and so on).	int
buffer	Where to store the current working directory string.	char *
maxlen	The length of the buffer.	int

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
#define BUFFLEN F_MAXPATH + F_MAXNAME
void myfunc( long drivenum )
{
    char buffer[BUFFLEN];
    if (!f_getdcwd( drivenum, buffer, BUFFLEN ))
    {
        printf( "Current directory is %s", buffer );
        printf( "on drive %c", drivenum+'A' );
    }
    else
    {
        printf( "Drive error!" )
    }
}
```

File Access

f_open

Use this function to open a file. The following opening modes are allowed:

Mode	Description
"r"	Open existing file for reading. The stream is positioned at the beginning of the file.
"r+"	Open existing file for reading and writing. The stream is positioned at the beginning of the file.
"w"	Truncate file to zero length or create file for writing. The stream is positioned at the beginning of the file.
"w+"	Open a file for reading and writing. The file is created if it does not exist; otherwise it is truncated. The stream is positioned at the beginning of the file.
"a"	Open for appending (writing to end of file). The file is created if it does not exist. The stream is positioned at the end of the file.
"a+"	Open for reading and appending (writing to end of file). The file is created if it does not exist. The stream is positioned at the end of the file.

Note the following:

- The same file can be opened multiple times in “r” mode.
- A file can only be opened once at a time in a mode which gives write access (that is, in “r+, “w”, “w+” , “a” or “a+” mode).
- The same file can be opened multiple times in “r” mode and at the same time once in one of the “r+, “a” or “a+” modes which give write access.
- If a file is opened in “w” or “w+” mode, a lock mechanism prevents it being opened in any other mode. This prevents opening of the file for reading and writing at the same time.

Note: There is no text mode. The system assumes that all files are in binary mode only.

Format

```
F_FILE * f_open (
    const char *   filename,
    const char *   mode )
```

Arguments

Argument	Description	Type
filename	The file to be opened.	char *
mode	The opening mode (see above).	char *

Return values

Return value	Description
F_FILE *	A pointer to the handle of the opened file.
NULL	If the pointer is null, the file could not be opened.

Example

```
void myfunc( void )
{
    F_FILE *file;
    char c;
    file = f_open( "myfile.bin", "r" );
    if (!file)
    {
        printf( "File cannot be opened!" );
        return;
    }
    f_read( &c, 1, 1, file );   /* Read one byte */
    printf( "'%c' is read from file", c );
    f_close( file );
}
```

f_close

Use this function to close a previously opened file.

Format

```
int f_close ( F_FILE * filehandle )
```

Arguments

Argument	Description	Type
filehandle	The file handle.	F_FILE *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
    F_FILE *file;
    char *string = "ABC";
    file = f_open( "myfile.bin", "w" );
    if (!file)
    {
        printf( "File cannot be opened!" );
        return;
    }
    f_write( string, 3, 1, file );  /* Write 3 bytes */
    if (!f_close( file ))
    {
        printf( "File stored" );
    }
    else
    {
        printf( "File close error!" );
    }
}
```

f_flush

Use this function to flush an opened file to a storage medium.

This is logically equivalent to performing a close and open on a file to ensure the data changed before the flush is committed to the medium.

Format

```
int f_flush ( F_FILE * filehandle )
```

Arguments

Argument	Description	Type
filehandle	The file handle.	F_FILE *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myflush( void )
{
    F_FILE *file;
    char *string = "ABC";
    file = f_open( "myfile.bin", "w" );
    if (!file)
    {
        printf ( "File cannot be opened!" );
        return;
    }
    f_write( string, 3, 1, file );  /* Write 3 bytes */
    f_flush( file );  /* Commit data written */
        .
        .
}
```

f_read

Use this function to read bytes from the current position in the target file.

The file must be opened with “r”, "r+", "w+" or "a+".

Format

```
long f_read (
    void *      buf,
    long        size,
    long        size_st,
    F_FILE *    filehandle )
```

Arguments

Argument	Description	Type
buf	The buffer to store the data in.	void *
size	The size of the items to read.	long
size_st	The number of items to read.	long
filehandle	The file handle.	F_FILE *

Return values

Return value	Description
The number of items successfully read.	If this does not equal the number of items requested, call **f_getlasterror()** to determine the cause.

Example

```
void myread( void )
{
    F_FILE *file = f_open( filename, "r" );
    long size = f_filelength( filename );
    if (!file)
    {
        printf ( "%s cannot be opened!", filename );
        return 1;
    }
    if (f_read( buffer, 1, size, file )!= size)
    {
        printf( "Some items not read! Error:%d", f_getlasterror() );
    }
    f_close( file );
    return 0;
}
```

f_write

Use this function to write data into a file at the current position.

The file must be opened with "r+", “w”, “w+”, "a+" or “a”. The file pointer is moved forward by the number of bytes successfully written.

> **Note:** Data is NOT permanently stored to the media until either an **f_flush()** or **f_close ()** has been executed on the file.

Format

```
long f_write (
    const void *    buf,
    long            size,
    long            size_st,
    F_FILE *        filehandle )
```

Arguments

Argument	Description	Type
buf	A pointer to the data to write.	void *
size	The size of the items to write.	long
size_st	The number of items to write.	long
filehandle	The file handle.	F_FILE *

Return values

Return value	Description
The number of items successfully written.	If this does not equal the number of items requested, call **f_getlasterror()** to determine the cause.

Example

```
void myfunc( void )
{
    F_FILE *file;
    char *string = "ABC";
    file = f_open( "myfile.bin", "w" );
    if (!file)
    {
        printf( "File cannot be opened!" );
        return;
    }
    if (f_write( string, 1, 3, file )!= 3)  /* Write 3 bytes */
    {
        printf( "Some items not written! Error:%d", f_getlasterror() );
    }
    f_close( file );
}
```

f_getc

Use this function to read a character from the current position in the open target file.

Format

```
int f_getc ( F_FILE * filehandle )
```

Arguments

Argument	Description	Type
filehandle	The file handle.	F_FILE *

Return values

Return value	Description
-1	Read failed.
value	The character read from the file.

Example

```
int myreadfunc( char *filename, char *buffer, long buffsize )
{
    F_FILE *file = f_open( filename, "r" );
    while (buffsize--)
    {
        int ch;
        if ((ch = f_getc( file )) == -1)
            break;
        *buffer++ = ch;
        buffsize--;
    }
    f_close( file );
    return 0;
}
```

f_putc

Use this function to write a character to the specified open file at the current file position. The current file position is incremented.

Format

```
int f_putc (
    char        ch,
    F_FILE *    filehandle )
```

Arguments

Argument	Description	Type
ch	The character to write.	char
filehandle	The file handle.	F_FILE *

Return values

Return value	Description
-1	Write failed.
value	The successfully written character.

Example

```
void myfunc( char *filename, long num )
{
    F_FILE *file = f_open( filename, "w" );
    while (num--)
    {
        int ch = 'A';
        if (ch != (f_putc( ch ))
        {
            printf( "f_putc error!" );
            break;
        }
    }
    f_close( file );
    return 0;
}
```

f_eof

Use this function to check whether the current position in the open target file is the end of file (EOF).

Format

```
int f_eof ( F_FILE * filehandle )
```

Arguments

Argument	Description	Type
filehandle	The file handle.	F_FILE *

Return values

Return value	Description
F_NO_ERROR	Not at the end of the file.
Else	At the end of file, or an error occurred; see Error Codes.

Example

```
int myreadfunc( char *filename, char *buffer, long buffsize )
{
    F_FILE *file = f_open( filename, "r" );
    while (!f_eof())
    {
        if (!buffsize) break;
        buffsize--;
        f_read( buffer++, 1, 1, file );
    }
    f_close( file );
    return 0;
}
```

f_seteof

Use this function to move the end of file (EOF) to the current file pointer.

All data after the new EOF position are lost.

Format

```
int f_seteof ( F_FILE * filehandle )
```

Arguments

Argument	Description	Type
filehandle	The file handle.	F_FILE *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
int mytruncatefunc( char *filename, int position )
{
    F_FILE *file = f_open( filename, "r+" );
    f_seek( file, position, SEEK_SET );
    if (f_seteof( file ))
        printf( "Truncate failed!\n" );
    f_close( file );
    return 0;
}
```

f_tell

Use this function to obtain the current read/write position in the open target file.

Format

```
long f_tell ( F_FILE * filehandle )
```

Arguments

Argument	Description	Type
filehandle	The file handle.	F_FILE *

Return values

Return value	Description
filepos	The current read or write file position.

Example

```
int myreadfunc( char *filename, char *buffer, long buffsize )
{
    F_FILE *file = f_open( filename, "r" );
    printf( "Current position %d", f_tell( file) );  /* Position 0 */
    f_read( buffer, 1, 1, file );  /* Read one byte */
    printf( "Current position %d", f_tell( file) );  /* Position 1 */
    f_read( buffer, 1, 1, file );  /* Read one byte */
    printf( "Current position %d", f_tell( file) );  /* Position 2 */
    f_close( file );
    return 0;
}
```

f_seek

Use this function to move the stream position in the target file. The file must be open.

The *whence* parameter is one of the following:

- F_SEEK_CUR – current position of file pointer.
- F_SEEK_END – end of file.
- F_SEEK_SET – start of file.

The offset position is relative to *whence.*

Format

```
long f_seek (
    F_FILE *   filehandle,
    long       offset,
    long       whence )
```

Arguments

Argument	Description	Type
filehandle	The file handle.	F_FILE *
offset	The byte position relative to *whence.*	long
whence	Where to calculate the *offset* from.	long

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
int myreadfunc( char *filename, char *buffer, long buffsize )
{
    F_FILE *file = f_open( filename, "r" );
    f_read( buffer, 1, 1, file );  /* Read the first byte */
    f_seek( file, 0, SEEK_SET );
    f_read( buffer, 1, 1, file );  /* Read the same byte */
    f_seek( file, -1, SEEK_END );
    f_read( buffer, 1, 1, file );  /* Read the last byte */
    f_close( file );
    return 0;
}
```

f_rewind

Use this function to set the file position in the open target file to the start of the file.

Format

```
int f_rewind ( F_FILE * filehandle )
```

Arguments

Argument	Description	Type
filehandle	The file handle.	F_FILE *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
    char buffer[4];
    char buffer2[4];
    F_FILE *file = f_open( "myfile.bin", "r" );
    if (file)
    {
        f_read( buffer, 4, 1, file );
        f_rewind( file );  /* Rewind file pointer */
        f_read( buffer2, 4, 1, file );  /* Read from beginning */
        f_close( file );
    }
    return 0;
}
```

f_truncate

Use this function to open a file for writing and truncate it to the specified length.

A file can only be truncated to a size less than or equal to its current size.

Format

```
F_FILE * f_truncate (
    const char *    filename,
    unsigned long   length )
```

Arguments

Argument	Description	Type
filename	The file to open.	char *
length	The new length of the file.	unsigned long

Return values

Return value	Description
F_FILE *	A pointer to the handle of the opened file.
NULL	If the pointer is null, the file could not be opened.

Example

```
int mytruncatefunc( char *filename, unsigned long length )
{
    F_FILE *file = f_truncate( filename, length );
    if (!file)
    {
        printf( "File opening error!" );
    }
    else
    {
        printf( "File %s truncated to %d bytes", filename, length );
        f_close( file );
    }
    return 0;
}
```

f_ftruncate

Use this function to truncate a file which is open for writing to a specified length.

A file can only be truncated to a size less than or equal to its current size.

Format

```
int f_ftruncate (
    F_FILE *        filehandle,
    unsigned long   length )
```

Arguments

Argument	Description	Type
filehandle	The file handle of the open file.	F_FILE *
length	The new length of the file.	unsigned long

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
int mytruncatefunc( F_FILE *file, unsigned long length )
{
    int ret = f_ftruncate( filename, length );
    if (ret)
    {
        printf( "Error:%d\n", ret );
    }
    else
    {
        printf( "File is truncated to %d bytes", length );
    }
    return ret;
}
```

File Management

f_delete

Use this function to delete a file.

> **Note:** A read-only or open file cannot be deleted.

Format

```
int f_delete ( const char * filename )
```

Arguments

Argument	Description	Type
filename	A null-terminated string with the name of the file, with or without its path.	char *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
        .
        .
    f_delete( "oldfile.txt" );
    f_delete( "A:/subdir/oldfile.txt" );
        .
        .
}
```

f_findfirst

Use this function to find the first file or subdirectory in a specified directory.

First call **f_findfirst()** and then, if the file is found, get the next file with **f_findnext ()**. Files with the system attribute set are ignored.

Note: If this is called with "*.*" and it is not the root directory, then:

- the first entry found is ".", the current directory.
- the second entry found is “..”, the parent directory.

Format

```
int f_findfirst (
    const char *   filename,
    F_FIND *       find )
```

Arguments

Argument	Description	Type
filename	The name of the file to find.	char *
find	Where to store the file information.	F_FIND *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void mydir( void )
{
    F_FIND find;
    if (!f_findfirst( "A:/subdir/*.*", &find ))
    {
        do
        {
            printf( "filename:%s", find.filename );
            if (find.attr&F_ATTR_DIR)
            {
                printf( " directory\n" );
            }
            else
            {
                printf( " size %d\n", find.filesize );
            }
        } while (!f_findnext( &find ));
    }
}
```

f_findnext

Use this function to find the next file or subdirectory in a specified directory after a previous call to **f_findfirst ()** or **f_findnext()**.

First call **f_findfirst ()** and then, if a file is found, get the rest of the matching files by repeated calls to **f_findnext()**. Files with the system attribute set will be ignored.

> **Note:** If this is called with "*.*" and it is not the root directory, then:
>
> - the first file found is ".", the current directory.
> - the second file found is “..”, the parent directory.

Format

```
int f_findnext ( F_FIND * find )
```

Arguments

Argument	Description	Type
find	File information (created by calling **f_findfirst()**).	F_FIND *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void mydir( void )
{
    F_FIND find;
    if (!f_findfirst( "A:/subdir/*.*", &find ))
    {
        do
        {
            printf( "filename:%s", find.filename );
            if (find.attr&F_ATTR_DIR)
            {
                printf( " directory\n" );
            }
            else
            {
                printf( " size %d\n", find.filesize );
            }
        } while (!f_findnext( &find ));
    }
}
```

f_move

Use this function to move a file or directory.The original file or directory is lost.

The source and target must be in the same volume. A file can be moved only if it is not open. A directory can be moved only if there are no open files in it.

A file or directory can be moved, irrespective of its attribute settings; the attribute settings are moved with it.

Format

```
int f_move (
    const char *   filename,
    const char *   newname )
```

Arguments

Argument	Description	Type
filename	The file or directory name, with or without its path.	char *
newname	The new name of the file or directory, with or without its path.	char *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
        .
        .
    f_move( "oldfile.txt", "newfile.txt" );
    f_move( "A:/subdir/oldfile.txt", "A:/newdir/oldfile.txt" );
        .
        .
}
```

f_rename

Use this function to rename a file or directory.

If a file or directory is read-only it cannot be renamed. If a file is open it cannot be renamed.

Format

```
int f_rename (
    const char *   filename,
    const char *   newname )
```

Arguments

Argument	Description	Type
filename	The file or directory name, with or without its path.	char *
newname	The new name of the file or directory.	char *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
        .
        .
    f_rename( "oldfile.txt", "newfile.txt" );
    f_rename( "A:/subdir/oldfile.txt", "newfile.txt" );
        .
        .
}
```

f_getpermission

Use this function to retrieve the file or directory permission field associated with a file.

Every file and directory in the file system has an associated 32 bit field, known as the permission setting. Except for the top six bits, you can program this field as required. You could, for example, use it to create a user access system. The first six bits are reserved for use by the system, as follows:

```
#define FSSEC_ATTR_ARC (0x20UL << (31-6))
#define FSSEC_ATTR_DIR (0x10UL << (31-6))
#define FSSEC_ATTR_VOLUME (0x08UL << (31-6))
#define FSSEC_ATTR_SYSTEM (0x04UL << (31-6))
#define FSSEC_ATTR_HIDDEN (0x02UL << (31-6))
#define FSSEC_ATTR_READONLY (0x01UL << (31-6))
```

Format

```
int f_getpermission (
    const char *      filename,
    unsigned long *   psecure )
```

Arguments

Argument	Description	Type
filename	The name of the file.	char *
psecure	Where to store the permission field.	unsigned long *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
    unsigned long secure;
    if (!f_getpermission( "subfolder", &secure ))
    {
        printf( "Permission is: %d", secure );
    }
    else
    {
        printf( "Permission cannot be retrieved!" );
    }
}
```

f_setpermission

Use this function to set the file or directory permission field associated with a file.

Every file/directory in the file system has an associated 32 bit field, known as the permission setting. Except for the top six bits, this field is freely programmable by the user and could, for instance, be used to create a user access system. The first six bits are reserved for use by the system, as follows:

```
#define FSSEC_ATTR_ARC (0x20UL << (31-6))
#define FSSEC_ATTR_DIR (0x10UL << (31-6))
#define FSSEC_ATTR_VOLUME (0x08UL << (31-6))
#define FSSEC_ATTR_SYSTEM (0x04UL << (31-6))
#define FSSEC_ATTR_HIDDEN (0x02UL << (31-6))
#define FSSEC_ATTR_READONLY (0x01UL << (31-6))
```

Format

```
int f_setpermission (
    const char *    filename,
    unsigned long   secure )
```

Arguments

Argument	Description	Type
filename	The name of the file.	char *
secure	A 32 bit number to associate with the filename.	unsigned long

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
    f_mkdir( "subfolder" );     /* Create directory */
    f_setpermission( "subfolder", 0x00FF0000 );
}
```

f_gettimedate

Use this function to get time and date information from a file or directory.

This field is automatically set by the system when a file or directory is created, and when a file is closed.

Date and Time Formats

The date and time fields are two 16 bit fields associated with each file/directory. If FAT compatibility is required, these must use the standard type definitions for time and date given below. If FAT compatibility is not required, you can use these fields as you require. See PSP Porting for information on porting.

The required format for the date for PC compatibility is a short integer ‘d’ (16 bit), such that:

Argument	Valid values	Format
Day	0-31	(d & 0x001F)
Month	1-12	((d & 0x01E0) >> 5)
Years since 1980	0-119	((d & 0xFE00) >> 9)

The required format for the time for PC compatibility is a short integer ‘t’ (16 bit), such that:

Argument	Valid values	Format
Two second increments	0-30	(t & 0x001F)
Minute	0-59	((t & 0x07E0) >> 5)
Hour	0-23	((t & 0xF800) >> 11)

Format

```
int f_gettimedate (
    const char *       filename,
    unsigned short *   pctime,
    unsigned short *   pcdate )
```

Arguments

Argument	Description	Type
filename	The target file.	char *
pctime	Where to store the creation time.	unsigned short *
pcdate	Where to store the creation date.	unsigned short *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
    unsigned short t, d, sec, min, hour;
    unsigned short day, month, year;
    if (!f_gettimedate( "subfolder", &t, &d ))
    {
        sec = (t & F_CTIME_SEC_MASK);
        min = ((t & F_CTIME_MIN_MASK) >> F_CTIME_MIN_SHIFT);
        hour = ((t & F_CTIME_HOUR_MASK) >> F_CTIME_HOUR_SHIFT);
        day = (d & F_CDATE_DAY_MASK);
        month = ((d & F_CDATE_MONTH_MASK) >> F_CDATE_MONTH_SHIFT);
        year = 1980 + ((d & F_CDATE_YEAR_MASK) >> F_CDATE_YEAR_SHIFT);
        printf( "Time: %d:%d:%d", hour, min, sec );
        printf( "Date: %d.%d.%d", year, month, day );
    }
    else
    {
        printf( "File time cannot be retrieved!" );
    }
}
```

f_settimedate

Use this function to set the time and date on a file or on a directory.

Date and Time Formats

The date and time fields are two 16 bit fields associated with each file/directory. If FAT compatibility is required, these must use the standard type definitions for time and date given below. If FAT compatibility is not required, you can use these fields as you require. See PSP Porting for information on porting.

The required format for the date for PC compatibility is a short integer ‘d’ (16 bit), such that:

Argument	Valid values	Format
Day	0-31	(d & 0x001F)
Month	1-12	((d & 0x01E0) >> 5)
Years since 1980	0-119	((d & 0xFE00) >> 9)

The required format for the time for PC compatibility is a short integer ‘t’ (16 bit), such that:

Argument	Valid values	Format
Two second increments	0-30	(t & 0x001F)
Minute	0-59	((t & 0x07E0) >> 5)
Hour	0-23	((t & 0xF800) >> 11)

Format

```
int f_settimedate (
    const char *     filename,
    unsigned short   ctime,
    unsigned short   cdate )
```

Arguments

Argument	Description	Type
filename	The file or directory.	char *
ctime	The creation time of the file or directory.	unsigned short
cdate	The creation date of the file or directory.	unsigned short

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
    unsigned short ctime, cdate;
    ctime = (15 << 11) + (30 << 5) + (22 >> 1);      /* 15:30:22 */
    cdate = ((2002 - 1980) << 9) + (11 << 5) + (3);  /* 2002.11.03. */
    f_mkdir( "subfolder" );  /* Create directory */
    f_settimedate( "subfolder", ctime, cdate );
}
```

f_fstat

Use this function to get information about a file by using the file handle.

This function retrieves information by filling the F_STAT structure passed to it. It sets the file size, creation time/date, last access date, modified time/date, and the drive number where the file is located.

Format

```
int f_fstat (
    F_FILE *    p_filehandle,
    F_STAT *    p_stat )
```

Arguments

Argument	Description	Type
p_filehandle	The file handle.	F_FILE *
p_stat	A pointer to the F_STAT structure to be filled.	F_STAT *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc ( void )
{
    F_FILE *file;
    F_STAT stat;
    int ret;
    file = f_open( filename, "r" );
    if ( file != NULL )
    {
        ret = f_fstat( file, &stat );
        if ( ret == F_NO_ERROR )
        {
            printf( "filesize:%d\r\n", stat.filesize );
        }
        else
        {
            printf( "f_fstat error: %d.\r\n", ret );
        }
        f_close( file );
    }
    else
    {
        printf( "%s cannot be opened!\r\n", filename );
    }
}
```

f_stat

Use this function to get information about a file.

This function retrieves information by filling the F_STAT structure passed to it. It sets file size, creation time /date, last access date, modified time/date, and the drive number where the file is located.

> **Note:** This function can also return with the opened file's current size when **f_findopensize()** is allowed to search through all open file descriptors for its modified size. If this feature is disabled then **f_findopensize()** always returns zero.

Format

```
int f_stat (
    const char *    filename,
    F_STAT *        stat )
```

Arguments

Argument	Description	Type
filename	The name of the file.	char *
stat	A pointer to the F_STAT structure to be filled.	F_STAT *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
    F_STAT stat;
    if (f_stat( "myfile.txt", &stat ))
    {
        printf( "Error!" );
        return;
    }
    printf( "filesize:%d", stat.filesize );
}
```

f_filelength

Use this function to get the length of a file.

> **Note:** This function can also return with the opened file's size when **f_findopensize()** is allowed to search for it. If **f_findopensize()** always returns with zero, this feature is disabled.

Format

```
long f_filelength ( const char * filename )
```

Arguments

Argument	Description	Type
filename	The file name, with or without the path.	char *

Return values

Return value	Description
filelength	The length of the file.
-1	The requested file does not exist or has an error; check the last error.

Example

```
int myreadfunc( char *filename, char *buffer, long buffsize )
{
    F_FILE *file = f_open( filename, "r" );
    long size = f_filelength( filename );
    if (!file)
    {
        printf( "%s cannot be opened!", filename );
        return 1;
    }
    if (size > buffsize)
    {
        printf( "Not enough memory!" );
        return 2;
    }
    f_read( buffer, size, 1, file );
    f_close( file );
    return 0;
}
```

6.3 File System Unicode API

This section describes all the API Unicode functions available with the SafeFLASH file system. It is split into functions for directory management, file access and file management.

Unicode-Specific File System Functions

To enable Unicode API calls in the SafeFLASH file system, enable HCC_UNICODE in the **src/config /config_safe.h** file. This makes the functions in this section, as well as their standard API equivalents, available for use.

All functions are exactly the same as their standard API counterparts, except that all character string parameters are changed to “wide character” (wchar) strings.

Character and wide character definition with W_CHAR

W_CHAR is defined as **char** if Unicode is disabled and as **wchar** if it is enabled. Therefore W_CHAR is used in structures where the element could be used in either type of system.

Unicode Directory Management

f_wmkdir

Use this function to create a new directory with a Unicode 16 name.

Format

```
int f_wmkdir ( const W_CHAR * dirname )
```

Arguments

Argument	Description	Type
dirname	The Unicode 16 name of the directory to create.	W_CHAR *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc( void )
{
        .
        .
    f_wmkdir( "subfolder" );    /* Create directories */
    f_wmkdir( "subfolder/sub1" );
    f_wmkdir( "subfolder/sub2" );
    f_wmkdir( "a:/subfolder/sub3" );
        .
        .
}
```

f_wchdir

Use this function to change the current working directory (that has a Unicode 16 name).

Format

```
int f_wchdir ( const W_CHAR * dirname )
```

Arguments

Argument	Description	Type
dirname	The Unicode 16 name of the directory to change to.	W_CHAR *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc( void )
{
        .
        .
    f_wmkdir( "subfolder" );
    f_wchdir( "subfolder" );        /* Change directory */
    f_wmkdir( "sub2" );
    f_wchdir( ".." );                /* Go upward */
    f_wchdir( "subfolder/sub2" );    /* Go into directory sub2 */
        .
        .
}
```

f_wrmdir

Use this function to remove a directory with a Unicode 16 name.

The directory must be empty, otherwise an error code is returned and it is not removed.

Format

```
int f_wrmdir ( const W_CHAR * dirname )
```

Arguments

Argument	Description	Type
dirname	The Unicode 16 name of the directory to remove.	W_CHAR *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc( void )
{
        .
        .
    f_wmkdir( "subfolder" );       /* Create directory */
    f_wmkdir( "subfolder/sub1" );  /* Create directory */
        .
        . /* Do some work */
        .
    f_wrmdir( "subfolder/sub1" ); /* Remove directory */
    f_wrmdir( "subfolder" );      /* Remove directory */
        .
        .
}
```

f_wgetcwd

Use this function to get the current working directory on the current drive.

Format

```
int f_wgetcwd (
    W_CHAR *   buffer,
    int        maxlen )
```

Arguments

Argument	Description	Type
buffer	Where to store the current working directory string.	W_CHAR *
maxlen	The length of the buffer.	int

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc( int drivenum )
{
    W_CHAR buffer[F_MAXPATH];
    if (!f_wgetdcwd( drivenum, buffer, F_MAXPATH ))
    {
        wprintf( "Current directory is %s", buffer );
        wprintf( "on drive %c", drivenum + 'A' );
    }
    else
    {
        wprintf( "Drive error!" );
    }
}
```

f_wgetdcwd

Use this function to get the current working directory on the selected drive.

Format

```
int f_wgetdcwd (
    int         drivenum,
    W_CHAR *    buffer,
    int         maxlen )
```

Arguments

Argument	Description	Type
drivenum	The drive number (0='A', 1='B', and so on).	int
buffer	Where to store the current working directory string.	W_CHAR *
maxlen	The length of the buffer.	int

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc( int drivenum )
{
    W_CHAR buffer[F_MAXPATH];
    if (!f_wgetdcwd( drivenum, buffer, F_MAXPATH ))
    {
        wprintf( "Current directory is %s", buffer );
        wprintf( "on drive %c", drivenum + 'A' );
    }
    else
    {
        wprintf( "Drive error!" );
    }
}
```

Unicode File Access

f_wopen

Use this function to open a file with a Unicode 16 filename. The following opening modes are allowed:

Modes	Description
"r"	Open an existing file for reading. The stream is positioned to the beginning of the file.
"r+"	Open an existing file for reading and writing. The stream is positioned to the beginning of the file.
"w"	Truncate file to zero length or create file for writing. The stream is positioned to the beginning of the file.
"w+"	Open for reading and writing. The file is created if it does not exist; otherwise it is truncated. The stream is positioned to the beginning of the file.
"a"	Open for appending (writing at end of file). The file is created if it does not exist. The stream is positioned to the end of the file.
"a+"	Open for reading and appending (writing at end of file). The file is created if it does not exist. The stream is positioned to the end of the file.

Note the following:

- The same file can be opened multiple times in “r” mode.
- A file can only be opened once at a time in a mode which gives write access (that is, in “r+, “w”, “w+” , “a” or “a+” mode).
- The same file can be opened multiple times in “r” mode and at the same time once in one of the “r+, “a” or “a+” modes which give write access.
- If a file is opened in “w” or “w+” mode, a lock mechanism prevents it being opened in any other mode. This prevents opening of the file for reading and writing at the same time.

Note: There is no text mode. The system assumes all files to be accessed in binary mode only.

Format

```
F_FILE * f_wopen (
    const W_CHAR *   filename,
    const char *     mode )
```

Arguments

Argument	Description	Type
filename	The Unicode 16 name of the file.	W_CHAR *
mode	The opening mode (see above).	char *

Return values

Return value	Description
F_FILE *	A pointer to the handle of the opened file.
NULL	If the pointer is null, the file could not be opened.

Example

```
void myfunc( void )
{
    F_FILE *file;
    char c;
    file = f_wopen( "myfile.bin", "r" );
    if (!file)
    {
        wprintf( "File cannot be opened!" );
        return;
    }
    f_read( &c, 1, 1, file );  /* Read one byte */
    wprintf( "'%c' is read from file", c );
    f_close( file );
}
```

f_wtruncate

Use this function to open an existing file for writing and truncate it to the specified length.

If the length is greater than the length of the existing file, the file is padded with zeroes to the truncated length.

Format

```
F_FILE * f_wtruncate (
    const W_CHAR *   filename,
    unsigned long    length )
```

Arguments

Argument	Description	Type
filename	The file to open.	W_CHAR *
length	The new length of the file.	unsigned long

Return values

Return value	Description
F_FILE *	A pointer to the handle of the opened file.
NULL	If the pointer is null, the file could not be opened.

Example

```
int mywtruncatefunc( W_CHAR *filename, unsigned long length )
{
    F_FILE *file = f_wtruncate( filename, length );
    if (!file)
        wprintf( "File not found!" );
    else
    {
        wprintf( "File %s truncated to %d bytes", filename, length );
        f_close( file );
    }
    return 0;
}
```

Unicode File Management

f_wdelete

Use this function to delete a file with a Unicode 16 name.

Format

```
int f_wdelete ( const W_CHAR * filename )
```

Arguments

Argument	Description	Type
filename	The Unicode 16 name of the file to delete, with or without its path.	W_CHAR *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc( void )
{
        .
        .
    f_wdelete( "oldfile.txt" );
    f_wdelete( "A:/subdir/oldfile.txt" );
        .
        .
}
```

f_wmove

Use this function to move a file or directory with a Unicode 16 name.

The source and target must be in the same volume. The original file or directory is lost.

Format

```
int f_wmove (
    const W_CHAR *   filename,
    const W_CHAR *   newname )
```

Arguments

Argument	Description	Type
filename	The Unicode 16 name of the file or directory, with or without the path.	W_CHAR *
newname	The new Unicode 16 name of the file or directory.	W_CHAR *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc( void )
{
        .
        .
    f_wmove( "oldfile.txt", "newfile.txt" );
    f_wmove( "A:/subdir/oldfile.txt", "A:/newdir/oldfile.txt" );
        .
        .
}
```

f_wfilelength

Use this function to obtain the length of a file with a Unicode 16 name.

Format

```
long f_wfilelength ( W_CHAR * filename )
```

Arguments

Argument	Description	Type
filename	The Unicode 16 file name, with or without the path.	W_CHAR *

Return values

Return value	Description
filelength	The length of the file.
-1	The requested file does not exist or has an error ; check the last error.

Example

```
 int myreadfunc( W_CHAR *filename, char *buffer, long buffsize )
{
    F_FILE *file = f_wopen( filename, "r" );
    long size = f_wfilelength( filename );
    if (!file)
    {
        wprintf( "%s Cannot be opened!", filename );
        return 1;
    }
    if (size > buffsize)
    {
        wprintf( "Not enough memory!" );
        return 2;
    }
    f_read( buffer, size, 1, file );
    f_close( file );
    return 0;
}
```

f_wfindfirst

Use this function to find the first Unicode 16 file or subdirectory in the specified directory.

First call **f_wfindfirst()** then, if a file is found, get the next file with **f_wfindnext()**.

Format

```
int f_wfindfirst (
    const W_CHAR *   filename,
    F_WFIND *        find )
```

Arguments

Argument	Description	Type
filename	The Unicode 16 name of the file or subdirectory to find.	W_CHAR *
find	Where to store the file information.	F_WFIND *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void mydir( void )
{
    F_WFIND find;
    if (!f_wfindfirst( "A:/subdir/*.*", &find ))
    {
        do
        {
            wprintf( "filename:%s", find.filename );
            if (find.attr&F_ATTR_DIR)
            {
                wprintf( " directory\n" );
            }
            else
            {
                wprintf( " size %d\n", find.len );
            }
        } while (!f_wfindnext( &find ));
    }
}
```

f_wfindnext

Use this function to find the next Unicode 16 file or subdirectory in a specified directory after a previous call to **f_wfindfirst()** or **f_wfindnext()** .

First call **f_wfindfirst ()** then, if a file is found, get the rest of the matching files by repeated calls to **f_wfindnext()**.

Format

```
int f_wfindnext ( F_WFIND * find )
```

Arguments

Argument	Description	Type
find	The Find structure (from **f_wfindfirst()**).	F_WFIND *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void mydir( void )
{
    F_WFIND find;
    if (!f_wfindfirst( "A:/subdir/*.*", &find ))
    {
        do
        {
            wprintf( "filename:%s", find.filename );
               if (find.attr&F_ATTR_DIR)
            {
                wprintf( " directory\n" );
            }
            else
            {
                wprintf( " size %d\n", find.len );
            }
        } while (!f_wfindnext( &find ));
    }
}
```

f_wrename

Use this function to rename a file or directory with a Unicode 16 name.

Format

```
int f_rename (
    const W_CHAR *   filename,
    const W_CHAR *   newname )
```

Arguments

Argument	Description	Type
filename	The Unicode 16 name of the file or directory, with or without the path.	W_CHAR *
newname	The new Unicode 16 name of the file or directory.	W_CHAR *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc( void )
{
        .
        .
    f_wrename( "oldfile.txt", "newfile.txt" );
    f_wrename( "A:/dir/oldfile.txt", "newfile.txt" );
        .
        .
}
```

f_wgetpermission

Use this function to retrieve the file or directory permission field associated with a file with a Unicode 16 name.

Every file/directory in the file system has an associated 32 bit field, known as the permission setting. Except for the top 6 bits, this field is freely programmable by the developer and can, for example, be used to create a user access system. The first six bits are reserved for use by the system, as follows:

```
#define FSSEC_ATTR_ARC (0x20UL << (31-6))
#define FSSEC_ATTR_DIR (0x10UL << (31-6))
#define FSSEC_ATTR_VOLUME (0x08UL << (31-6))
#define FSSEC_ATTR_SYSTEM (0x04UL << (31-6))
#define FSSEC_ATTR_HIDDEN (0x02UL << (31-6))
#define FSSEC_ATTR_READONLY (0x01UL << (31-6))
```

Format

```
int f_getpermission (
    const W_CHAR *    filename,
    unsigned long *   psecure )
```

Arguments

Argument	Description	Type
filename	The Unicode 16 name of the file.	W_CHAR *
psecure	Where to store the permission field.	unsigned long *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc( void )
{
    unsigned long secure;
    if (!f_wgetpermission( "subfolder", &secure ))
    {
        wprintf( "Permission is: %d", secure );
    }
    else
    {
        wprintf( "Permission cannot be retrieved!" );
    }
}
```

f_wsetpermission

Use this function to set the file or directory permission field associated with a file with a Unicode 16 name.

Every file/directory in the file system has an associated 32 bit field, known as the permission setting. Except for the top six bits, this field is freely programmable by the developer and can, for example, be used to create a user access system. The first six bits are reserved for use by the system, as follows:

```
#define FSSEC_ATTR_ARC (0x20UL << (31-6))
#define FSSEC_ATTR_ARC (0x20UL << (31-6))
#define FSSEC_ATTR_DIR (0x10UL << (31-6))
#define FSSEC_ATTR_VOLUME (0x08UL << (31-6))
#define FSSEC_ATTR_SYSTEM (0x04UL << (31-6))
#define FSSEC_ATTR_HIDDEN (0x02UL << (31-6))
#define FSSEC_ATTR_READONLY (0x01UL << (31-6))
```

Format

```
int f_wsetpermission (
    const W_CHAR *   filename,
    unsigned long    secure )
```

Arguments

Argument	Description	Type
filename	The Unicode 16 name of the file.	W_CHAR *
secure	The 32 bit number to associate with *filename*.	unsigned long

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
void myfunc( void )
{
    f_mkdir( "subfolder" );     /* Create directory */
    f_wsetpermission( "subfolder", 0x00FF0000 );
}
```

f_wgettimedate

Use this function to get time and date information for a file or directory with a Unicode 16 name.

This field is automatically set by the system when a file or directory is created, and when a file is closed.

Date and Time Formats

The date and time fields are two 16 bit fields associated with each file/directory. If FAT compatibility is required, these must use the standard type definitions for time and date given below. If FAT compatibility is not required, you can use these fields as you require. See PSP Porting for information on porting.

The required format for the date for PC compatibility is a short integer ‘d’ (16 bit), such that:

Argument	Valid values	Format
Day	0-31	(d & 0x001F)
Month	1-12	((d & 0x01E0) >> 5)
Years since 1980	0-119	((d & 0xFE00) >> 9)

The required format for the time for PC compatibility is a short integer ‘t’ (16 bit), such that:

Argument	Valid values	Format
Two second increments	0-30	(t & 0x001F)
Minute	0-59	((t & 0x07E0) >> 5)
Hour	0-23	((t & 0xF800) >> 11)

Format

```
int f_wgettimedate (
    const W_CHAR *     filename,
    unsigned short *   pctime,
    unsigned short *   pcdate )
```

Arguments

Argument	Description	Type
filename	The Unicode 16 name of the file or directory.	W_CHAR *
pctime	Where to store the time.	unsigned short *
pcdate	Where to store the date.	unsigned short *

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc( void )
{
    unsigned short t,d;
    if (!f_wgettimedate( "subfolder", &t, &d ))
    {
        unsigned short sec = (t & 0x001F) << 1;
        unsigned short minute = ((t & 0x07E0) >> 5);
        unsigned short hour = ((t & 0x0F800) >> 11);
        unsigned short day = (d & 0x001F);
        unsigned short month = ((d & 0x01E0) >> 5);
        unsigned short year = 1980 + ((d & 0xFE00) >> 9);
        wprintf( "Time: %d:%d:%d", hour, minute, sec );
        wprintf( "Date: %d.%d.%d", year, month, day );
    }
    else
    {
        wprintf( "File time cannot retrieved!" );
    }
}
```

f_wsettimedate

Use this function to set the time and date on a file or directory with a Unicode 16 name.

Date and Time Formats

The date and time fields are two 16 bit fields associated with each file/directory. If FAT compatibility is required, these must use the standard type definitions for time and date given below. If FAT compatibility is not required, you can use these fields as you require. See PSP Porting for information on porting.

The required format for the date for PC compatibility is a short integer ‘d’ (16 bit), such that:

Argument	Valid values	Format
Day	0-31	(d & 0x001F)
Month	1-12	((d & 0x01E0) >> 5)
Years since 1980	0-119	((d & 0xFE00) >> 9)

The required format for the time for PC compatibility is a short integer ‘t’ (16 bit), such that:

Argument	Valid values	Format
Two second increments	0-30	(t & 0x001F)
Minute	0-59	((t & 0x07E0) >> 5)
Hour	0-23	((t & 0xF800) >> 11)

Format

```
int f_settimedate (
    const W_CHAR *   filename,
    unsigned short   ctime,
    unsigned short   cdate )
```

Arguments

Argument	Description	Type
filename	The Unicode 16 name of the file or directory.	W_CHAR *
ctime	The creation time of the file or directory.	unsigned short
cdate	The creation date of the file or directory.	unsigned short

Return values

Return value	Description
F_NO_ERROR	Successful execution.
Else	See Error Codes.

Example

```
 void myfunc(void)
{
    unsigned short ctime;
    unsigned short cdate;
    ctime = (15 << 11) + (30 << 5) + (23 >> 1);        /* 15:30:22 */
    cdate = ((2002 - 1980) << 9) + (11 << 5) + (3);    /* 2002.11.03. */
    f_wmkdir( "subfolder" );     /* Create directory */
    f_wsettimedate( "subfolder", ctime, cdate );
}
```

6.4 Error Codes

The table below lists all the error codes that may be generated by API calls to HCC's file systems. Please note that some error codes are not used by every file system.

The header file to include for this list is **src/api/api_fs_err.h**.

Error	Value	Meaning
F_NO_ERROR	0	Successful execution.
F_ERR_INVALIDDRIVE	1	The specified drive does not exist.
F_ERR_NOTFORMATTED	2	The specified volume has not been formatted.
F_ERR_INVALIDDIR	3	The specified directory is invalid.
F_ERR_INVALIDNAME	4	The specified file name is invalid.
F_ERR_NOTFOUND	5	The file or directory could not be found.
F_ERR_DUPLICATED	6	The file or directory already exists.
F_ERR_NOMOREENTRY	7	The volume is full.
F_ERR_NOTOPEN	8	The file access function requires the file to be open.
F_ERR_EOF	9	End of file.
F_ERR_RESERVED	10	Not used.
F_ERR_NOTUSEABLE	11	Invalid parameters for **f_seek()**.
F_ERR_LOCKED	12	The file has already been opened for writing/appending.
F_ERR_ACCESSDENIED	13	The necessary physical read and/or write functions are not present for this volume.
F_ERR_NOTEMPTY	14	The directory to be moved or deleted is not empty.
F_ERR_INITFUNC	15	No init function is available for a driver, or the function generates an error.
F_ERR_CARDREMOVED	16	The card has been removed.
F_ERR_ONDRIVE	17	Non-recoverable error on drive.
F_ERR_INVALIDSECTOR	18	A sector has developed an error.
F_ERR_READ	19	Error reading the volume.
F_ERR_WRITE	20	Error writing file to volume.
F_ERR_INVALIDMEDIA	21	Media not recognized.

Error	Value	Meaning
F_ERR_BUSY	22	The caller could not obtain the semaphore within the expiry time.
F_ERR_WRITEPROTECT	23	The physical medium is write protected.
F_ERR_INVFATTYPE	24	The type of FAT is not recognized.
F_ERR_MEDIATOOSMALL	25	Media is too small for the format type requested.
F_ERR_MEDIATOOLARGE	26	Media is too large for the format type requested.
F_ERR_NOTSUPPSECTORSIZE	27	The sector size is not supported. The only supported sector size is 512 bytes.
F_ERR_UNKNOWN	28	An unspecified error has occurred.
F_ERR_DRVALREADYMNT	29	The drive is already mounted.
F_ERR_TOOLONGNAME	30	The name is too long.
F_ERR_NOTFORREAD	31	Not for read.
F_ERR_DELFUNC	32	The delete drive driver function failed.
F_ERR_ALLOCATION	33	**psp_malloc()** failed to allocate the required memory.
F_ERR_INVALIDPOS	34	An invalid position is selected.
F_ERR_NOMORETASK	35	All task entries are exhausted.
F_ERR_NOTAVAILABLE	36	The called function is not supported by the target volume.
F_ERR_TASKNOTFOUND	37	The caller’s task identifier was not registered. This is normally because **f_enterFS()** has not been called.
F_ERR_UNUSABLE	38	The file system has become unusable. This is normally a result of excessive error rates on the underlying media.
F_ERR_CRCERROR	39	A CRC error has been detected on the file.
F_ERR_CARDCHANGED	40	The card that was being accessed has been replaced with a different card.

6.5 Types and Definitions

W_CHAR: Character and Wide Character Definition

W_CHAR is defined to *char* if Unicode is disabled and to *wchar* if it is enabled. Therefore *W_CHAR* is used in structures where the element could be used in either type of system.

F_FILE: File Handle

This is the file handle, used as a reference for accessing files.

The handle is obtained when a file is opened and released when it is closed.

F_FIND

The *F_FIND* structure takes this form:

Element	Type	Description
attr	char	The attribute setting of the file.
filename [F_MAXPATHNAME]	char	The long file name.
ctime	unsigned short	The creation time.
cdate	unsigned short	The creation date.
filesize	unsigned long	The length of the file.
secure	unsigned long	The secure setting.
findfsname	FS_NAME	The Find properties.
findpos	unsigned short	The Find position.

F_WFIND

The *F_WFIND* structure takes this form:

Element	Type	Description
attr	char	The attribute setting of the file.
filename [F_MAXPATHNAME]	W_CHAR	The long file name.
ctime	unsigned short	The creation time.
cdate	unsigned short	The creation date.
filesize	unsigned long	The length of the file.
secure	unsigned long	The secure setting.
findfsname	FS_NAME	The Find properties.
findpos	unsigned short	The Find position.

F_STAT Structure

The *F_STAT* structure takes this form:

Element	Type	Description
filesize	unsigned long	The size of the file.
createdate	unsigned short	The creation date.
createtime	unsigned short	The creation time.
secure	unsigned long	
drivenum	int	The number of the volume.

F_SPACE

The *F_SPACE* structure takes this form:

Element	Type	Description
total	unsigned long	The total size in bytes of the disk.
free	unsigned long	The number of free bytes on the disk.
used	unsigned long	The number of used bytes on the disk.
bad	unsigned long	The number of bad bytes on the disk.

7 Testing the System

Two test suites are provided for exercising the file system and the flash drivers, and ensuring that all are working correctly.

Both test programs require the functions defined and implemented (as samples) in **testport_ram_s.c**. Port these functions to your system. Refer to the comments and simple code for reference.

7.1 File System Test

This program exercises most of the functionality of the file system, including file read/write/append/seek/file content, directories and file manipulation functions.

To use the test program:

1. Include **test_s.c** and **test_s.h** in your test project.
2. Call the following to execute the test code:

```
void f_dotest( void )
```

7.2 Flash Driver Test

This code tests your ported flash driver in isolation, to ensure that it is ported correctly and is stable.

To use this test program:

1. Include **testdrv_s.c** and **testdrv_s.h** in your test project.
2. Configure the options in **testdrv_s.c** listed below.
3. Call the following to execute the test code:

```
void f_dotestdrv ( FS_PHYGETID phyfunc )
```

Note: Errors in the execution of this test indicate that there is an error in the implementation of the driver. Contact support@hcc-embedded.com if you need further advice.

Configuration Options in testdrv_s.c

Check and set the following #DEFINE values in the file before running a test.

DESCSIZE

The descriptor size; set this according to your driver. The default is NOR_DESCSIZE.

SECTORSIZE

The sector size; set this according to your driver. The default is NOR_SECTORSIZE.

NANDFLASH

Set this if NAND flash is used, otherwise keep the default of zero.

> **Note:** You can use SKIP_MASK, SKIP_LO and SKIP_HI to skip some blocks during testing, speeding up the test. Higher bits of block numbers are masked off by SKIP_MASK and the result is checked if it is in the range between SKIP_LO and SKIP_HI.

SKIP_MASK

Keep SKIP_MASK at the default of zero to perform a complete test. It masks the higher bits of block numbers.

SKIP_LO

The default is 3.

SKIP_HI

The default is (SKIP_MASK - 4).

8 Integration

This section describes all aspects of the SafeFLASH module that require integration with your target project. This includes porting and configuration of external resources.

8.1 Requirements

The SafeFLASH system is designed to be as open and portable as possible. No assumptions are made about the functionality or behavior of the underlying operating system.

For SafeFLASH to work at its best, perform the porting work outlined below. This is a very straightforward task for an experienced engineer.

Stack Requirements

SafeFLASH file system functions are always called in the context of the calling thread or task. Naturally the functions require stack space and you should allow for this in applications that call file system functions. Typically calls to the file system use <2KB of stack.

Timeouts

Flash devices are normally controlled by hardware control signals. As a result there is no explicit need for any timeouts to control exception conditions. However, some operations on flash devices are relatively slow and it is often worthwhile to schedule other operations while waiting for them to complete. For example, a NOR flash erase typically takes two seconds and a NAND flash erase takes two milliseconds.

- For NOR flash in the **29lvxxx.c** sample driver, the **DataPoll()** function is used to check for the completion of operations. This routine can be modified to force scheduling of the system, or to use the host system's event generation mechanism so that other operations can be performed while waiting.
- For NAND flash in the K9F2816X0C sample driver, the **nandwaitrb()** function is used to check for the completion of operations. This routine can be modified to force scheduling of the system, or to use the host system's event generation mechanism so that other operations can be performed while waiting.

Memory Allocation

Some larger buffers are required by SafeFLASH to handle FATs in RAM, and also to buffer write processes.

A call is made to each driver to get the specific size of memory required for that drive. It is then up to you to allocate this memory from the system.

Buffer sizes depend on the particular chips being used and their configurations. For further information, see the descriptions of the **f_mountdrive()** and **fs_getmem_xxx()** functions in the relevant driver manuals.

8.2 OS Abstraction Layer

All HCC modules use the OS Abstraction Layer that allows the module to run seamlessly with a wide variety of RTOSes, or without an RTOS.

This module uses the following OAL components:

OAL resource	Number required
Tasks	0
Mutexes	1 per volume plus 1 Each volume needs protecting by a mutex mechanism to ensure that file access is safe.
Events	0

Note: If the Common API (CAPI) is used (that is, FS_CAPI_USED is defined in the file **config_safe.h**), the above mutex functions are replaced by the equivalent functions from the CAPI. See the *HCC File System Common API User's Guide* for details.

Within the standard API there is no support for the current working directory to be maintained on a per-caller basis. By default, the system provides a single **cwd** that can be changed by any user. The **cwd** is maintained on a per-volume basis, or on a per-task basis if multitasking is implemented.

For a multitasking system, do the following:

1. Set F_MAXTASK to the maximum number of tasks that can simultaneously maintain access to the file system. This effectively creates a table of **cwd**s for each task.
2. Use the OAL's **oal_task_get_id()** function to get a unique identifier for the calling task.
3. Ensure that any task using the file system calls **f_enterFS()** before any other API calls; this ensures that the calling task is registered.
4. Ensure that for any application that has finished using the file system, or is terminated, **f_releaseFS()** is called with the task's unique identifier. This frees that table entry for use by other applications.

Once these steps are implemented, each caller is logged as it acquires the mutex, and a current working directory is associated with it.

Note: If the CAPI is used, **oal_task_get_id()** is replaced by the equivalent function from the CAPI. See the *HCC File System Common API User's Guide* for further information.

8.3 PSP Porting

The Platform Support Package (PSP) is designed to hold all platform-specific functionality, either because it relies on specific features of a target system, or because this provides the most efficient or flexible solution for the developer.

The SafeFLASH module makes use of the following standard PSP function:

Function	Package	Element	Description
psp_getcurrenttimedate()	psp_base	psp_rtc	Gets the current time and date.

Note: If the Common API (CAPI) is used (that is, F_CAPI_USED is defined in **config_safe.h**) then **psp_getcurrenttimedate()** is replaced by the equivalent function from the CAPI. See the *HCC File System Common API User's Guide* for further information.