exFAT and SafeexFAT Test Suite User Guide

Version 1.20

For use with exFAT and SafeexFAT Test Suite versions 1.12 and above

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1 System Overview

This chapter contains the fundamental information for this module.

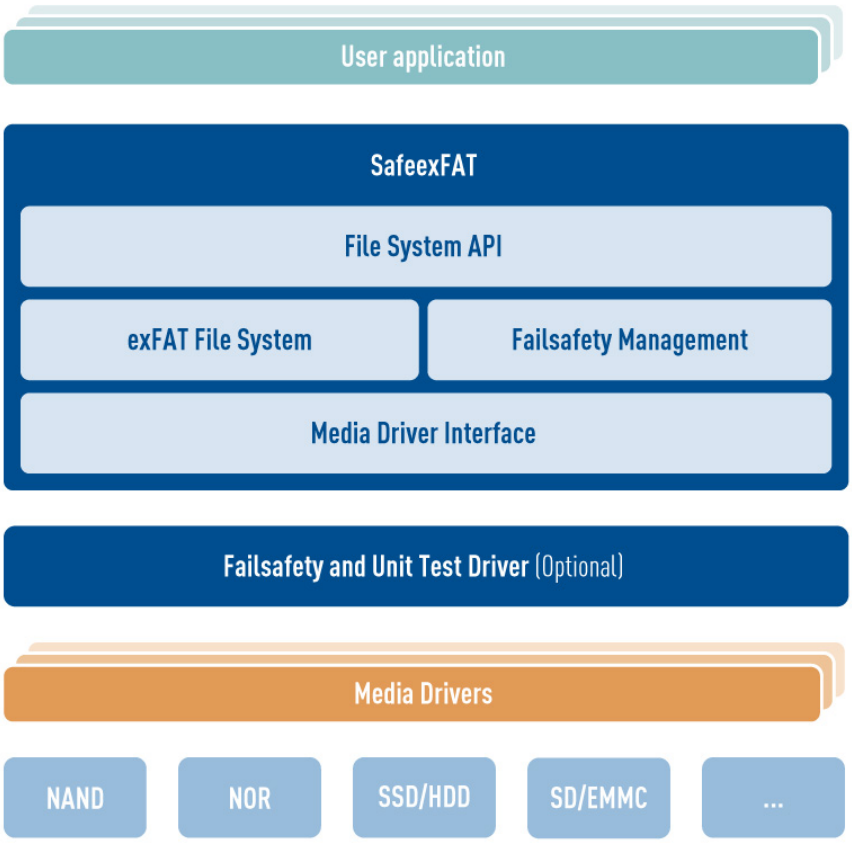
The component sections are as follows:

- Introduction – describes the main elements of the module.
- How Testing Works – describes the role of the unit test driver.
- Feature Check – summarizes the main features of the module as bullet points.
- Packages and Documents – the *Packages* section lists the packages that you need in order to use this module. The *Documents* section lists the relevant user guides.
- Change History – lists the earlier versions of this manual, giving the software version that each manual describes.

1.1 Introduction

This guide is for those who want to test an HCC Embedded exFAT/SafeexFAT file system. SafeexFat was designed with integration and target verification in mind and you can use this comprehensive test suite to prove that the product behaves correctly when integrated with your product.

This diagram shows the system architecture.



The **Fail-safety and Unit Test Driver** is used with the target MCU to test that the file system is fail-safe. This driver is used to inject errors at the media driver level. Once testing has shown that the file system is fail-safe, this module can be removed before the file system goes live.

This test suite allows you to test two types of function, described below.

Standard File System Functions

The standard file system functions include the following:

- File and directory creation and deletion.
- File reading and writing.
- Checking of file content.
- Handling of "a", "a+", "w", and "w+" files.
- Concurrent access with "r" files.
- Volume formatting.
- Recovery from power failure.
- Finding and seeking.
- File listing.
- File and directory renaming and moving.
- File and directory attributes.
- File positions.
- File truncation.
- File ranges.
- Files with no FAT chain.
- Timestamps.
- Appending to files.
- Write-protection.
- Upcase tables.
- Error handling.
- SafeexFAT repair function.

Fail-safe functions

Safety is achieved by using internal logs, which are also written to the media. These log files contain all the information required to recover the last good state of the file system after reset or power failure occurs.

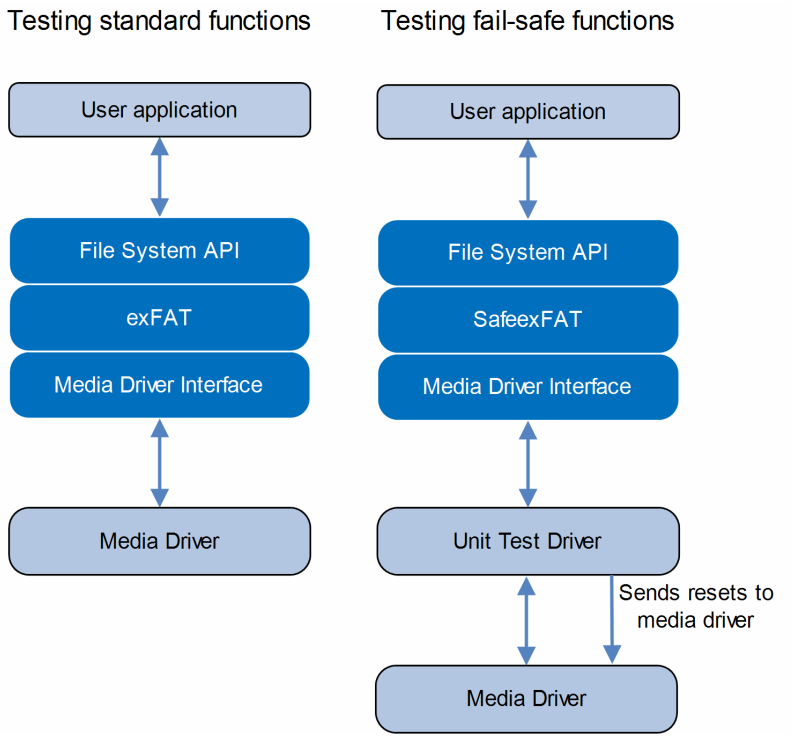
SafeexFAT has been implemented for the following functions and all of these can be tested as shown below.

Function	Notes
exfat_open()	In modes a, a+, w, w+, and r+.
exfat_write()	In mode "r+" **exfat_write()** copies the whole cluster when overwriting existing data. This way existing data is kept until **exfat_close()**/**exfat_flush()** is called. This copy can be optimized to reduce the amount of copied data.
exfat_seek()	When seeking beyond file size in a file opened in all the modes above.
exfat_flush()	Tested in a file opened in all the modes above.
exfat_close()	Tested in a file opened in all the modes above.
exfat_ftruncate()	Tested in a file opened in all the modes above.
exfat_mkdir()	
exfat_rmdir()	
exfat_remove()	
exfat_remove_content()	If this call is interrupted, the file is removed, but some cluste rs may not be cleared.
exfat_rename()	
exfat_move()	

1.2 How Testing Works

Testing the Standard Functions

The standard test suite of functions exercises the file system using the target media driver and media. This is the setup shown in the left-hand side of this diagram:



Testing SafeexFAT Functions

This is the setup shown in the right-hand side of the above diagram.

The Unit Test Driver

To test the fail-safe features of the system, the unit test driver is installed between the real media driver and the SafeexFAT file system. It is used to inject faults into the media operations for writing and reading. Normally write requests are forwarded to the real media driver but, to simulate a power failure, a reset is issued by the test media driver at a specific moment.

In short, the test driver helps simulate error conditions so that the correct behavior can be checked. The same test media driver is used for Windows and Linux systems.

How the Unit Test Driver Works

To test the safe functions listed earlier, a simulated reset is implemented. The file system uses the unit test driver to write and read from the media.

A counter in the unit test driver counts sector writes. After a pre-defined sector write count is reached, the test driver jumps from the sector write function to a previously specified reset point and leaves the media in

an inconsistent state. This reset can happen at any time: during log file writing, log file extending, writing the user's file content, updating directory entries, etc.

After a reset the test function:

1. Detects the reset event, initializes the file system using **exfat_init()**, and initializes the volume using **exfat_initvolume()**, as though this was a power-up.
2. It repairs the file system and checks that files are in the expected condition: exists, does not exist, having the correct FAT chain or content.

The same test is repeated with increasing write counts until the simulated software reset does not occur. If the test finally runs without resetting, it means that all possible write errors have been tried.

Note that:

- The test runs longer when the cluster size is larger, because more sector writes are needed. Therefore more repeats are necessary.
- Resources are deliberately not released during reset, therefore these tests need many more mutexes than the other ones.
- To run the SafeexFAT tests, Visual Studio and the Windows 32 or Linux OS Abstraction Layer (OAL) are needed.

1.3 Feature Check

The main features of the module are the following:

- Provides a full test capability for HCC Embedded's exFAT and SafeexFAT file systems.
- Conforms to the HCC Advanced Embedded Framework.
- Designed for integration with both RTOS and non-RTOS based systems.
- Conforms to the HCC Coding Standard.

1.4 Packages and Documents

Packages

This table lists the packages that need to be used with this module:

Package	Description
hcc_base_doc	This contains the two guides that will help you get started.
fs_exfat_test	The exFAT and SafeexFAT test suite package.
psp_template_base	The Platform Support Package (PSP) base package.
media_drv_test	This is needed to run media failure tests.

Documents

For an overview of HCC file systems and guidance on choosing a file system, see Product Information on the main HCC website.

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 exFAT and SafeexFAT File System User Guide

This document describes the main packages.

HCC exFAT and SafeexFAT Test Suite User Guide

This is this document.

1.5 Change History

This section describes past changes to this manual.

- To download this manual see File System PDFs.
- For the history of changes made to the package code itself, see History: fs_exfat_test.

The current version of this manual is 1.20.

Manual version	Date	Software version	Reason for change
1.20	2019-10-02	1.12	Added configuration options EXFAT_TEST_SAFE_LOG_WRITE_NEG, EXFAT_TEST_SAFE_LOG_FTRUNCATE_NEG and EXFAT_TEST_SAFE_LOG_FTRUNC_BELOW_ACTUAL_FSIZE
1.10	2019-09-16	1.11	Added many configuration options. Added functions to API: **exfat_do_test2()**, **exfat_test_readsector()**, and **exfat_test_readmultiplesector()**. Added EXFAT_TEST_ERR_INVALID_DRIVE_INDEX to *Return Codes*.
1.00	2019-08-29	1.09	First version.

2 Source File List

This section lists and describes all the source code files included in the 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 Header File

The file **src/api/api_exfat_test.h** must be included by any application using the system. It includes all that is required to access the system. The use of these API functions is defined in Running Tests. **This file should only be modified by HCC**.

2.2 Configuration File

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

2.3 Source Code

These files are in the directory **src/exfat/test**. **These files should only be modified by HCC**.

File	Description
exfat_test.c and **.h**	Basic test functions.
exfat_test_dev.c and **.h**	Development test functions.
exfat_test_dev_safe.c and **.h**	SafeexFAT development test functions.
exfat_test_dev_safe_log.c and **.h**	SafeexFAT log test functions.
exfat_test_dir.c and **.h**	Directory test functions.
exfat_test_file.c and **.h**	File test functions.
exfat_test_media.c and **.h**	Media driver test functions.
exfat_test_task.c and **.h**	Task test functions.
exfat_test_upcase.c and **.h**	Upcase table test functions.

2.4 Version File

The file **src/version/ver_exfat_test.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.

2.5 Platform Support Package (PSP) Files

These files provide functions and elements the core code may need to use, depending on the hardware. Modify these files as required for your hardware.

Note:

- These are PSP implementations for the specific microcontroller and board; you may need to modify these to work with a different microcontroller and/or development board; see PSP Porting for details.
- In the package these files are offset to avoid overwriting an existing implementation. Copy them to the root **hcc** directory for use.

The following files are in the directory **src/psp/target/exfat**:

File	Description
psp_exfat_test.c	PSP source code.
psp_exfat_test.h	PSP header file.

The PSP also has a version file, **ver_psp_exfat_test.h**.

3 Configuration Options

Set the following exFAT Test Suite configuration options in the file **config_exfat_test.h**. To disable a test whose default is 1, just set its option to 0.

EXFAT_TEST_VERBOSE

Set this to 1 for fully detailed test output. The default is 0.

EXFAT_TEST_PRINTF_CAPITAL_S_SUPPORTED

There are two options:

- 0: only **psp_printf("%s", ascii_str)** is supported (ASCII).
- 1: **psp_printf("%S", utf32_str)** UTF-32 and ASCII are supported. This is the default.

EXFAT_TEST_PRINTF_LLI_SUPPORTED

There are two options:

- 0: only **psp_printf("%i", int32_t)** is supported.
- 1: **psp_printf("%lli", int64_t)** is supported as well as the above **int32_t** option. This is the default.

EXFAT_TEST_ALWAYS_FORMAT

There are two options:

- 0: only format the media if it is not formatted, or the file system is not exFAT. This is the default.
- 1: always format the media at the start of a test. **WARNING: all data will be lost!**

EXFAT_TEST_VOLUME_LABEL

Keep the default of 1 to test **exfat_setlabel()** and **exfat_getlabel()**.

EXFAT_TEST_CREATE_TEST_FILES

Keep the default of 1 to create the test files that the following two options need.

> **Note:** The following two options only apply if EXFAT_TEST_CREATE_TEST_FILES (above) is set.

EXFAT_TEST_CHDIR_GETCWD

Keep the default of 1 to test **exfat_chdir()** with absolute and relative paths.

EXFAT_TEST_READ_FILES

Keep the default of 1 to test reading of files.

EXFAT_TEST_WRITE_FILES

Keep the default of 1 to enable the file writing (mode "w") test.

EXFAT_TEST_DIR

Keep the default of 1 to test **exfat_mkdir()** and **exfat_rmdir()**.

EXFAT_TEST_REMOVE

Keep the default of 1 to test **exfat_remove()**.

> **Note:** The following option only applies if EXFAT_ENABLE_REMOVE_CONTENT (in the main file system package) is set.

EXFAT_TEST_REMOVE_CONTENT

Keep the default of 1 to test **exfat_remove_content()**.

EXFAT_TEST_TRUNCATE

Keep the default of 1 to test **exfat_truncate()** and **exfat_ftruncate/exfat_seteof()**.

EXFAT_TEST_APPEND

Keep the default of 1 to enable the file append test (mode "a"/"a+").

EXFAT_TEST_ATTR

Keep the default of 1 to test **exfat_setattr()** and **exfat_getattr()**.

EXFAT_TEST_RANGE

Keep the default of 1 to test file read, write, and seek with special range values.

EXFAT_TEST_SEEK_BEYOND

Keep the default of 1 to test **exfat_seek()** seeking beyond the file size.

EXFAT_TEST_SEEK_BEYOND_NOWRITE

Keep the default of 1 to test **exfat_seek()** seeking beyond the file size with NOWRITE.

EXFAT_TEST_DIR_OPEN

Keep the default of 1 to test directory opening.

EXFAT_TEST_LONG_FILENAME

Keep the default of 1 to test long filenames.

EXFAT_TEST_LONG_PATH

Keep the default of 1 to test long pathnames.

EXFAT_TEST_OPEN_MODE

Keep the default of 1 to enable the open mode test.

EXFAT_TEST_MULTI_FILE

Keep the default of 1 to enable the multiple file test.

EXFAT_TEST_INIT_VOLUME

Keep the default of 1 to test **exfat_initvolume()**.

> **Note:** The following two options only apply if EXFAT_MAX_TASK_COUNT (in the main file system package) > 1.

EXFAT_TEST_ENTER_TASK

Keep the default of 1 to enable the task entry test.

EXFAT_TEST_TASK

Keep the default of 1 to enable the task test.

EXFAT_TEST_INVALID_FILE_NAME

Keep the default of 1 to enable the test of invalid file names.

EXFAT_TEST_INVALID_DIR_NAME

Keep the default of 1 to enable the test of invalid directory names.

EXFAT_TEST_OPEN_NEG

Keep the default of 1 to test file handling functions with invalid arguments.

EXFAT_TEST_DIR_NEG

Keep the default of 1 to test directory handling functions with invalid arguments.

EXFAT_TEST_REWIND_DIR

Keep the default of 1 to test the directory directory rewind function.

EXFAT_TEST_DIR_DEPTH

Keep the default of 1 to test **exfat_chdir()** to the maximum directory depth.

EXFAT_TEST_WRITE_PROTECTED

Keep the default of 1 to test the write-protected state of media. The function **media_drv_test()** is needed to run this test.

EXFAT_TEST_MEDIA_ERROR

Keep the default of 1 to test media error of media. The function **media_drv_test()** is needed to run this test.

EXFAT_TEST_FORMAT

Keep the default of 1 to test the format when the media has zero or low sectors.

EXFAT_TEST_PUTC_GETC

Keep the default of 1 to test the **exfat_getc()** and **exfat_putc()** functions.

EXFAT_TEST_DIR_ENTRY

Keep the default of 1 to test the creation and deletion of directory entries.

EXFAT_TEST_REWIND

Keep the default of 1 to test the rewind function.

EXFAT_TEST_MEDIA_STATUS

Keep the default of 1 to test the missing and changed media states (the **media_drv_test** package is needed to run this test).

EXFAT_TEST_MEDIA_FLUSH

Keep the default of 1 to test the IOCTL flush (the **media_drv_test** package is needed to run this test).

EXFAT_TEST_INVALID_VOLUME

Keep the default of 1 to test functions with a non-existing volume index.

EXFAT_TEST_SEEK_NEG

Keep the default of 1 to test the error handling of **exfat_seek()**.

EXFAT_TEST_BOOTSECTOR_ERRORS

Keep the default of 1 to test the boot sector (the **media_drv_test** package is needed to run this test).

EXFAT_TEST_BITMAP_DIR_ENTRY_ERROR

Keep the default of 1 to test the allocation bitmap's entry (the **media_drv_test** package is needed to run this test).

EXFAT_TEST_UPCASE_DIR_ENTRY_ERROR

Keep the default of 1 to test errors in the upcase table's entry (the **media_drv_test** package is needed to run this test).

EXFAT_TEST_FILE_DIR_ENTRY_ERROR

Keep the default of 1 to test errors in a file's entry (the **media_drv_test** package is needed to run this test).

EXFAT_TEST_PARTITION_TABLE_ERROR

Keep the default of 1 to test error of FAT. The **media_drv_test** package and a disk image with a partition table (MBR) are needed to run this test.

EXFAT_TEST_FAT_ERROR

Keep the default of 1 to test FAT errors (the **media_drv_test** package is needed to run this test).

EXFAT_TEST_LABEL_DIR_ENTRY_ERROR

Keep the default of 1 to test errors in a label's entry (the **media_drv_test** package is needed to run this test).

EXFAT_TEST_INVALID_FILE_CUR_POS

Keep the default of 1 to test handling of an invalid current position.

EXFAT_TEST_DIR_CLUSTER

Keep the default of 1 to test **exfat_mkdir()** when the directory's cluster is full.

EXFAT_TEST_DIRENTRY_UPDATE_ERROR

Keep the default of 1 to test handling of directory entry errors (the **media_drv_test** package is needed to run this test).

EXFAT_TEST_STREAM_EXT_DIR_ENTRY_ERROR

Keep the default of 1 to test errors in the stream ext. directory entry (the **media_drv_test** package is needed to run this test).

EXFAT_TEST_FILEDATALENGTH_ERROR_WITH_NOFATCHAIN

Keep the default of 1 to test a file's DataLength error when NoFatChain=1.

EXFAT_TEST_DIR_WITH_BAD_ENTRY_FILE

Keep the default of 1 to test a file with a bad directory entry. This needs a special file to be present on the media.

EXFAT_TEST_INIT_VOLUME_WITH_INV_CACHE

Keep the default of 1 to test **exfat_initvolume()** with an invalid cache configuration.

EXFAT_TEST_INIT_NEG

Keep the default of 1 to test mutex resource errors (needs OAL with fault injection).

EXFAT_TEST_STREAM_ENTRY_UPDATE_ERROR

Keep the default of 1 to test an erroneous stream ext. directory entry (**media_drv_test** is needed to run this test).

EXFAT_TEST_DIR_SIZE_NEG

Keep the default of 1 to test a directory full of files (needs directories and files on media).

EXFAT_TEST_FREEENTRY_AT_CLUSTERBEGINING

Keep the default of 1 to test a directory which has a free entry at the cluster boundary (needs directories and files on media).

EXFAT_TEST_DIRENTRY_DISABLE_ERROR

Keep the default of 1 to test error of stream ext. directory entry (**media_drv_test** is needed to run this test).

EXFAT_TEST_NOFATCHAIN

Set this to 1 to enable the No FAT Chain test. The **/nofatchain/** directory contains prepared files that are used to run this test.

EXFAT_TEST_TIMESTAMP

Keep the default of 1 to test setting/getting timestamps. This tests **exfat_gettimestamp()** and **exfat_settimestamp()**.

EXFAT_TEST_UPCASE_RND

Keep the default of 1 to test a randomly-generated UpCase table.

EXFAT_TEST_UPCASE

Keep the default of 1 to test non case-sensitive behavior.

EXFAT_TEST_ZERO_LENGTH

Set this to 1 to test opening a zero length file in "r+" mode. The default is 0.

EXFAT_TEST_REOPEN

Keep the default of 1 to test opening the same file several times simultaneously.

EXFAT_TEST_RENAME

Keep the default of 1 to test file and directory renaming. This tests **exfat_rename()**.

EXFAT_TEST_MOVE

Keep the default of 1 to test file and directory moving. This tests **exfat_move()**.

Note:

- The following option only applies if both EXFAT_TEST_CREATE_TEST_FILES and EXFAT_TEST_READ_FILES are set.
- Setting EXFAT_TEST_WRITE_FULL can make the test run very slowly.

EXFAT_TEST_WRITE_FULL

Keep the default of 1 to test writing to full media.

EXFAT_TEST_LIST_FILES

This only applies if EXFAT_TEST_CREATE_TEST_FILES (see above) is set. Set this to 1 to test **exfat_opendir()**, **exfat_readdir()**, and **exfat_closedir()**. The default is 0.

Note:

- The following SAFE tests (options starting **EXFAT_TEST_SAFE_**) are only available if EXFAT_ENABLE_SAFE is set to 1.
- These tests need a lot of mutex resources for reset simulation.
- These can only be enabled when Visual Studio and Win32 OAL or Linux OAL are used.

EXFAT_TEST_SAFE_FILE_APPEND

Keep the default of 1 to test file handling of append mode ("a"). **This writes to the media until it is full, so can be very slow.**

EXFAT_TEST_SAFE_FILE_OVERWRITE

Keep the default of 1 to test file handling of overwrite mode ("r+").

EXFAT_TEST_SAFE_FILE_OVERWRITE_NO_WERR

Keep the default of 1 to test file handling of overwrite mode ("r+") without write error simulation.

EXFAT_TEST_SAFE_REPAIR

Keep the default of 1 to test **exfat_repair()** and the repair-needed state.

EXFAT_TEST_SAFE_DIR

Keep the default of 1 to test directory handling.

EXFAT_TEST_SAFE_LOG_RANGE

Keep the default of 1 to test log file writing/reading.

EXFAT_TEST_SAFE_LOG_ERROR

Keep the default of 1 to enable the write error test of log file writing.

EXFAT_TEST_SAFE_LOG_ENTRY

Keep the default of 1 to test log entry reading/writing.

EXFAT_TEST_SAFE_REMOVE

Keep the default of 1 to test fail-safe **exfat_remove()**.

EXFAT_TEST_SAFE_MKDIR

Keep the default of 1 to test fail-safe **exfat_mkdir()** and **exfat_rmdir()**.

EXFAT_TEST_SAFE_RMDIR

Keep the default of 1 to test fail-safe **exfat_rmdir()**.

EXFAT_TEST_SAFE_RENAME

Keep the default of 1 to test fail-safe **exfat_rename()**.

EXFAT_TEST_SAFE_MOVE

Keep the default of 1 to test fail-safe **exfat_move()**.

EXFAT_TEST_SAFE_TRUNCATE

Keep the default of 1 to test **exfat_truncate()** and **exfat_ftruncate/exfat_seteof()**.

EXFAT_TEST_SAFE_TRUNCATE_EXT

Keep the default of 1 to test **safe exfat_truncate()** when extending file size.

EXFAT_TEST_SAFE_LOG_INIT_ERROR

Keep the default of 1 to test log initialization.

EXFAT_TEST_SAFE_DIR_FAT_CHAIN

Keep the default of 1 to test exfat_check_fat_chain.

EXFAT_TEST_MKDIR_WRITE_ERROR

Keep the default of 1 to test mkdir with different write errors.

EXFAT_TEST_SAFE_SETLABEL

Keep the default of 1 to test safe **exfat_setlabel()**.

EXFAT_TEST_SAFE_SETTIMESTAMP

Keep the default of 1 to test safe **exfat_settimestamp()**.

EXFAT_TEST_SAFE_SETATTR

Keep the default of 1 to test **safe exfat_setattr()**.

EXFAT_TEST_SAFE_LOG_INIT_WITH_WPROTECT

Keep the default of 1 to test $$SAFE$$ creation when the media is write-protected.

EXFAT_TEST_SAFE_LOG_OPEN_WITH_DIR

Keep the default of 1 to test log opening with a test directory existing in $$SAFE$$.

EXFAT_TEST_SAFE_LOG_ENTRY_PART_MISSING

Keep the default of 1 to test log read with log directory entry second part missing.

EXFAT_TEST_SAFE_LOG_SEEK_NEG

Keep the default of 1 to test log seek with error values.

EXFAT_TEST_SAFE_LOG_REWIND

Keep the default of 1 to test log rewinding.

EXFAT_TEST_SAFE_LOG_SEEK_BEYOND

Keep the default of 1 to test log seek by seeking beyond its file size.

EXFAT_TEST_SAFE_LOG_REMOVE_NEG

Keep the default of 1 to test log removal with a directory entry error.

EXFAT_TEST_SAFE_LOG_WRITE_NEG

Keep the default of 1 to test log write with an invalid open mode.

EXFAT_TEST_SAFE_LOG_FTRUNCATE_NEG

Keep the default of 1 to test log **ftruncate()** with an invalid open mode.

EXFAT_TEST_SAFE_LOG_FTRUNC_BELOW_ACTUAL_FSIZE

Keep the default of 1 to test log **ftruncate()** with a setting smaller than the real file size.

EXFAT_TEST_BUFFER_SIZE

The size of the statically allocated buffer for reading and writing files.

The default is `( 2 * 1024 * 1024 )`.

EXFAT_TEST_FILE_COUNT

The number of test files used. The default is 256 and the minimum is 16.

EXFAT_TEST_WRITE_FILE_COUNT

The number of test files written. This only applies if EXFAT_TEST_WRITE_FILES (see above) is set. The default is 256 and the minimum is 1.

EXFAT_TEST_TASK1_STACK_SIZE

The stack size for the test task. The default is `( 2 * 1024 * 1024 )`.

4 Running Tests

This section shows how to run a test by using the API function **exfat_do_test()**. It also explains the return codes that running the test suite may produce.

4.1 exfat_do_test

Use this function to run the full test suite on a volume.

Format

```
t_exfat_ret exfat_do_test (
    t_exfat_drive   drivenum,
    F_DRIVERINIT    driver_init,
    uint32_t        driver_param )
```

Arguments

Argument	Type	Description
drivenum	The ID of the volume to test.	t_exfat_drive
driver_init	The media driver's **F_DRIVERINIT()** function.	F_DRIVERINIT
driver_param	This can optionally be used to pass information to the low level driver. Its use is driver-dependent. When the **xxx_initfunc()** of the driver is called, this parameter is passed to the driver. One use for this is to specify which device associated with the specified driver will be initialized.	uint32_t

Return Values

Return value	Description
EXFAT_NO_ERROR	Successful execution; all tests worked as expected.
Else	See Test Return Codes.

4.2 exfat_do_test2

Use this function to run the full test suite on two volumes.

Format

```
t_exfat_ret exfat_do_test (
    t_exfat_drive   drivenum,
    F_DRIVERINIT    driver_init,
    uint32_t        driver_param,
    t_exfat_drive   drivenum2,
    F_DRIVERINIT    driver_init2,
    uint32_t        driver_param2 )
```

Arguments

Argument	Type	Description
drivenum	The ID of the volume to test.	t_exfat_drive
driver_init	The media driver's **F_DRIVERINIT()** function, used to allocate and initialize a new driver.	F_DRIVERINIT
driver_param	This can optionally be used to pass information to the low level driver. Its use is driver-dependent. When the **xxx_initfunc()** of the driver is called, this parameter is passed to the driver. One use for this is to specify which device associated with the specified driver will be initialized.	uint32_t
drivenum2	The ID of the second volume to test.	t_exfat_drive
driver_init2	The media driver's **F_DRIVERINIT()** function, used to allocate and initialize a second driver.	F_DRIVERINIT
driver_param2	Use this is to specify which device associated with the second driver to initialize.	uint32_t

Return Values

Return value	Description
EXFAT_NO_ERROR	Successful execution; all tests worked as expected.
Else	See Test Return Codes.

4.3 exfat_test_readsector

This function alters the content of *p_buffer* according to fault injection.

> **Note:** Do not call this function. It is called by **media_drv_test**.
>
> Registered this function by using **drvtest_register_read_sector_cb()**.

Format

```
int exfat_test_readsector (
    uint8_t         drvidx,
    uint8_t *       p_buffer,
    unsigned long   sector )
```

Arguments

Argument	Type	Description
drvidx	The drive's index.	uint8_t
p_buffer	The buffer to alter.	uint8_t *
sector	The sector's index.	unsigned long

Return Values

Return value	Description
MDRIVER_TEST_NO_ERROR	Successful execution; the function changed the buffer's content.
MDRIVER_TEST_ERROR	The function did not change the buffer's content.

4.4 exfat_test_readmultiplesector

This function alters the content of *p_buffer* according to fault injection.

> **Note:** Do not call this function. It is called by **media_drv_test**.
>
> Registered this function by using **drvtest_register_read_multiple_sector_cb()**.

Format

```
int exfat_test_readmultiplesector (
    uint8_t         drvidx,
    uint8_t *       p_buffer,
    unsigned long   sector,
    int             cnt )
```

Arguments

Argument	Type	Description
drvidx	The drive's index.	uint8_t
p_buffer	The buffer to alter.	uint8_t *
sector	The sector's index.	unsigned long
cnt	The number of sectors in *p_buffer*.	int

Return Values

Return value	Description
MDRIVER_TEST_NO_ERROR	Successful execution; the function changed the buffer's content.
MDRIVER_TEST_ERROR	The function did not change the buffer's content.

4.5 Test Return Codes

The table below lists all the error codes that may be generated by running the test suite.

Errors are reported with the relevant file name and the line number in that file.

Error	Value	Meaning
EXFAT_TEST_ERR_NEGATIVE	1000	EXFAT_ERR_NO_ERROR was returned, but it is a faulty error code.
EXFAT_TEST_ERR_WRONG_OFFSET	1001	The offset is incorrect.
EXFAT_TEST_ERR_WRONG_STATUS	1002	The file status is incorrect.
EXFAT_TEST_ERR_INTERNAL_ERROR	1003	Internal error.
EXFAT_TEST_ERR_READ_ERROR	1004	Read error.
EXFAT_TEST_ERR_WRITE_ERROR	1005	Write error.
EXFAT_TEST_ERR_FILE_CONTENT_MISMATCH	1006	File content is incorrect.
EXFAT_TEST_ERR_FILE_SIZE_MISMATCH	1007	File size is incorrect.
EXFAT_TEST_ERR_CHECKSUM_MISMATCH	1008	Checksum is incorrect.
EXFAT_TEST_ERR_CWD_MISMATCH	1009	Current working directory is incorrect.
EXFAT_TEST_ERR_BUFFER_SIZE_TOO_SMALL	1010	Buffer size is insufficient.
EXFAT_TEST_ERR_LABEL_MISMATCH	1011	Label is incorrect.
EXFAT_TEST_ERR_WRONG_ATTRIBUTE	1012	File or directory's attribute is incorrect.
EXFAT_TEST_ERR_TIMESTAMP_MISMATCH	1013	Timestamp is incorrect.
EXFAT_TEST_ERR_LONG_FILENAME_RW_MISMATCH	1014	Error reading/writing long filename.
EXFAT_TEST_ERR_LONG_FILEPATH_RW_MISMATCH	1015	Error reading/writing long file pathname.
EXFAT_TEST_ERR_TASK	1016	Task error.
EXFAT_TEST_ERR_EXCEEDS_PATH_LENGTH_LIMIT	1017	Pathname is too long.
EXFAT_TEST_ERR_SPACE_MISMATCH	1018	The used space obtained is not the expected amount.
EXFAT_TEST_ERR_DIR_READ_FILENAME_MISMATCH	1019	Directory contains unexpected file or directory.

Error	Value	Meaning
EXFAT_TEST_ERR_MULTIFILE_RW_MISMATCH	1020	The amount of data read does not match the amount of data written.
EXFAT_TEST_ERR_INITVOLUME_RW_MISMATCH	1021	After initializing the volume, the amount of data read does not match the amount of data written.
EXFAT_TEST_ERR_DIRECTORY_ERROR	1022	Directory does not have 'DIR' attribute.
EXFAT_TEST_ERR_FAULT_INJECTION	1023	Cannot inject error using test media driver.
EXFAT_TEST_ERR_PUTC_GETC_RW_MISMATCH	1024	**exfat_getc()**/**exfat_putc()** mismatch.
EXFAT_TEST_ERR_VOLUME_INFO	1025	Volume information error.
EXFAT_TEST_ERR_FILE_POS_MISMATCH	1026	File position error.
EXFAT_TEST_ERR_CLUSTER_CHAIN_MISMATCH	1027	Cluster chain mismatch.
EXFAT_TEST_ERR_INVALID_DRIVE_INDEX	1028	Drive index is invalid.

5 Integration

This section describes all aspects of the file system that require integration with your target project.

This includes porting and configuration of external resources.

5.1 OS Abstraction Layer

The module uses the OS Abstraction Layer (OAL) that allows it to run seamlessly with a wide variety of RTOSes, or without an RTOS.

The test suite uses the following OAL components:

OAL Resource	Number required
Tasks	1
Mutexes	0 (but the Safe tests do require mutexes)
Events	2

5.2 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 module makes use of the following standard PSP functions:

Function	Package	Element	Description
psp_getrand()	psp_base	psp_rand	Generates a random number. This is used for the volume serial number.
psp_memcmp()	psp_base	psp_string	Compares two blocks of memory.
psp_memset()	psp_base	psp_string	Sets the specified area of memory to the defined value.
psp_printf()	psp_base	psp_stdio	Prints a string.
psp_snprintf()	psp_base	psp_stdio	Sends formatted output to compose a string holding the same text that would be printed if *format* was used on **psp_printf()**. Instead of being printed, the content is stored as a *C string* in a buffer.
psp_strncmp()	psp_base	psp_string	Compares two strings of defined length.
psp_strncpy()	psp_base	psp_string	Copies one string of defined length to another.
psp_w16csncat()	psp_base	psp_string	Concatenates a source string to the end of a destination string.
psp_w16csnchr()	psp_base	psp_string	Counts characters in a UTF-16 string buffer.
psp_w16csncmp()	psp_base	psp_string	Compares two strings, returning 0 when they match, otherwise -1 or 1.
psp_w16csncpy()	psp_base	psp_string	Copies a source string to the destination string, overwriting existing content.
psp_w16csnlen()	psp_base	psp_string	Returns the length of a UTF-16 string.

The module makes use of the following PSP functions. These are described in the following sections, as is the callback they use:

Function	Description
psp_exfat_test_set_error()	Sets error flags. This enables error injecting at the media driver level.
psp_exfat_test_clear_error()	Clears error flags; disables error injecting at the media driver level.
psp_exfat_test_set_write_error_counter()	Sets the write error counter which is decreased after every write. If this is zero, write operations are not executed, but no error is reported.
psp_exfat_test_reset_driver()	Resets the driver to the state it would be in after a power-on reset.

The module makes use of the following standard PSP macros:

Macro	Package	Element	Description
PSP_RD_BE16	psp_base	psp_endianness	Reads a 16 bit value stored as big-endian from a memory location.
PSP_RD_LE16	psp_base	psp_endianness	Reads a 16 bit value stored as little-endian from a memory location.
PSP_RD_BE32	psp_base	psp_endianness	Reads a 32 bit value stored as big-endian from a memory location.
PSP_RD_LE32	psp_base	psp_endianness	Reads a 32 bit value stored as little-endian from a memory location.
PSP_WR_BE16	psp_base	psp_endianness	Writes a 16 bit value to be stored as big-endian to a memory location.
PSP_WR_LE16	psp_base	psp_endianness	Writes a 16 bit value to be stored as little-endian to a memory location.
PSP_WR_BE32	psp_base	psp_endianness	Writes a 32 bit value to be stored as big-endian to a memory location.

Unicode string literals

The HCC_UTF macro is used to create UTF-16 string literals. This macro is used in the code examples.

- ISO C99 or older compilers generate a UTF-16 string when the capital letter 'L' prefix is used, for example `L"myfile.bin"`.
- ISO C11 or newer compilers generate a 16-bit Unicode string when the lower case letter 'u' is used, example `u"myfile.bin"`.

t_exfat_test_cb

The PSP provides this callback which is used by the PSP functions in this section.

Format

```
typedef void ( * t_exfat_test_cb ) ( void )
```

psp_exfat_test_set_error

The PSP provides this function to set error flags. This enables error injecting at the media driver level.

Format

```
t_exfat_ret psp_exfat_test_set_error (
    t_exfat_drive   drivenum,
    uint64_t        error_flags )
```

Arguments

Argument	Description	Type
drivenum	The drive (0='A', 1='B', and so on).	t_exfat_drive
error_flags	The error flags; the errors to inject.	uint64_t

Return values

Return value	Description
EXFAT_NO_ERROR	Successful execution.
EXFAT_TEST_ERR_FAULT_INJECTION	Operation failed.

psp_exfat_test_clear_error

The PSP provides this function to clear the error flags. This disables error injecting at the media driver level.

Format

```
t_exfat_ret psp_exfat_test_clear_error (
    t_exfat_drive   drivenum,
    uint64_t        error_flags )
```

Arguments

Argument	Description	Type
drivenum	The drive (0='A', 1='B', and so on).	t_exfat_drive
error_flags	The error flags; the errors to clear.	uint64_t

Return values

Return value	Description
EXFAT_NO_ERROR	Successful execution.
EXFAT_TEST_ERR_FAULT_INJECTION	Operation failed.

psp_exfat_test_reset_driver

The PSP provides this function to reset the driver to the state it would be in after a power-on reset.

Format

```
t_exfat_ret psp_exfat_test_reset_driver ( t_exfat_drive drivenum )
```

Arguments

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

Return values

Return value	Description
EXFAT_NO_ERROR	Successful execution.
EXFAT_TEST_ERR_FAULT_INJECTION	Operation failed.

psp_exfat_test_set_write_error_counter

The PSP provides this function to set the write error counter that is decreased after every write. (If this is zero, write operations are not executed, but no error is reported.)

Format

```
t_exfat_ret psp_exfat_test_set_write_error_counter (
    t_exfat_drive     drivenum,
    uint32_t          write_error_counter,
    t_exfat_test_cb   p_write_error_cb )
```

Arguments

Argument	Description	Type
drivenum	The drive (0='A', 1='B', and so on).	t_exfat_drive
write_error_counter	The number of sector writes that is allowed. This is decreased after every write.	uint32_t
p_write_errorcb	A pointer to the callback.	t_exfat_test_cb

Return values

Return value	Description
EXFAT_NO_ERROR	Successful execution.
EXFAT_TEST_ERR_FAULT_INJECTION	Operation failed.