SD Specifications
Part 2

File System Specification

Version 3.00

April 16, 2009

SD Group
Panasonic Corporation
SanDisk Corporation
Toshiba Corporation

Technical Committee
SD Card Association

CONFIDENTIAL

Revision History

Date	Version	Changes compared to previous issue
March 22, 2000	1.00	Base version initial release.
April 15, 2001	1.01	- One notation is added - The description of System ID field is modified - The description of Reserved field in the Extended FDC Descriptor is modified - The description of Reserved field in the Directory Entry is modified - Some computations are added in Annex B - Typo fixes and some clarification notes
May 9, 2006	2.00	- File System Specification V1.01 Supplemental Note is merged into base specification - New file system definition for High Capacity SD Memory Card, whose capacity is over 2GB and up to 32GB, is added - LFN option for FAT12/16 is added - Timestamp option for FAT12/16 is added - Typo fixes and some clarification notes
April 16, 2009	3.00	- File System Specification V2.00 Supplemental Note is merged into base specification - New file system definition for Extended Capacity SD Memory Card, whose capacity is over 32GB and up to 2TB, is added - Typo fixes and some clarification notes

Conditions for publication

Publisher:
SD Card Association
2400 Camino Ramon, Suite 375
San Ramon, CA 94583 USA
Telephone: +1 (925) 275-6615,
Fax: +1 (925) 886-4870
E-mail: office@sdcard.org

Conventions Used in This Document

Naming Conventions

- Some terms are capitalized to distinguish their definition from their common English meaning. Words not capitalized have their common English meaning.

Numbers and Number Bases

- Hexadecimal numbers are written with a lower case “h” suffix, e.g., FFFFh and 80h.
- Binary numbers are written with a lower case “b” suffix (e.g., 10b).
- Binary numbers larger than four digits are written with a space dividing each group of four digits, as in 1000 0101 0010b.
- All other numbers are decimal.

Key Words

- May: Indicates flexibility of choice with no implied recommendation or requirement.
- Shall: Indicates a mandatory requirement. Designers shall implement such mandatory requirements to ensure interchangeability and to claim conformance with the specification.
- Should: Indicates a strong recommendation but not a mandatory requirement. Designers should give strong consideration to such recommendations, but there is still a choice in implementation.

Application Notes

Some sections of this document provide guidance to the host implementers as follows:

Application Note: This is an example of an application note.

Table of Contents

Table of Figures

Table of Tables

1. Overview

This part specifies the file system of SD Memory Card (Secure Digital Memory Card). It manages the data recorded in SD Memory Card as files, and it enables the data exchange between the hosts supporting SD Memory Card. The card to which the file system in this specification is applied shall comply with "Part1. PHYSICAL LAYER SPECIFICATION" of SD specifications.

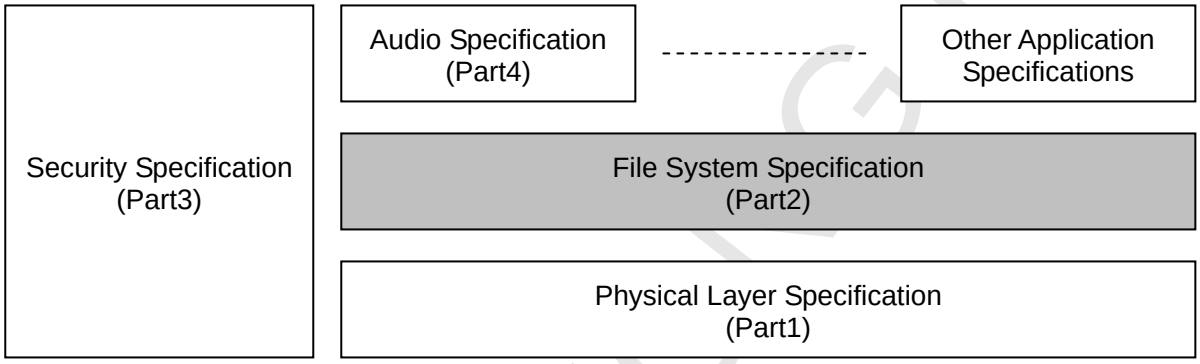


Figure 1-1 : SD Memory Card Document Structure

The SD Memory Card has two recordable areas. One is Data Area that user can access without mutual authentication. The other is Protected Area that user can access after mutual authentication. These two areas have file system independently with each other. This part specifies the file system for Data Area. And the one for Protected Area is specified in "Part3. SECURITY SPECIFICATION" of SD specifications.

This specification specifies some file systems. The type of the file system to be used shall be uniquely decided with Card Capacity as follows. Here, Card Capacity means the total size of Data Area and Protected Area size.

Card Capacity	Card Type	File System Type for Data Area
~2,048MB	Standard Capacity SD Memory Card	FAT12 / FAT16
2,088.5MB(*) ~32,768MB	High Capacity SD Memory Card	FAT32
32,896MB(*) ~2,048GB	Extended Capacity SD Memory Card	exFAT

*) See NOTE described in this section.

Table 1-1 : File System Type

That is, all Standard Capacity SD Memory Cards whose capacity is 2048MB or less shall use FAT12 / FAT16 file system, and never use the other file system. Similarly, all High Capacity SD Memory Cards shall use FAT32 file system, and never use the other file system. And all Extended Capacity SD Memory Cards shall use exFAT file system, and never use the other file system. This includes the prohibition of partial format of SD Memory Card. For example, 8GB High Capacity SD Memory Card should not be formatted as 2GB card with FAT12 / FAT16 file system. In this case, whole area of 8GB should be formatted with FAT32 file system.

This specification consists of several chapters. Chapter 2 describes the main features of this file system. Chapter 3 specifies FAT12 / FAT16 file system. Chapter 4 specifies FAT32 file system. Chapter 5 specifies exFAT file system. Appendix follows these chapters and it describes some normative references, definitions, and recommendations.

NOTE:

1. **The Part 1 Physical Layer Specification Version 3.00 and Part 2 File System Specification Version 3.00 allow Standard Capacity SD Memory Cards to have capacity up to and including 2GB, High Capacity SD Memory Cards to have capacity up to and including 32GB, and Extended Capacity SD Memory Cards to have capacity up to and including 2TB. SD Memory Cards with a capacity greater than 2TB are not specified within this specification, however these higher than 2TB capacities might be addressed in future version/releases of Part 1 and Part 2 Specifications.**
2. **Hosts that can access (read and/or write) High Capacity SD Memory Cards shall also be able to access Standard Capacity SD Memory Cards. And hosts that can access (read and/or write) Extended Capacity SD Memory Cards shall also be able to access Standard Capacity SD Memory Cards and High Capacity SD Memory Cards.**
3. **Hosts that can access (read and/or write) Extended Capacity SD Memory Cards shall support exFAT file system.**
4. **The High Capacity SD Memory Card covered by this specification shall comply with "Part1. PHYSICAL LAYER SPECIFICATION Version 3.00" or the later version. And the High Capacity SD Memory Card supports capacity 2,088.5MB (2,088.5 × 1,024 × 1,024 bytes) or more and is limited to 32,768MB (32,768 × 1,024 × 1,024 bytes). In order to avoid the confusion caused by the border capacity, the concrete value of the minimum capacity of the High Capacity SD Memory Card shall be 2,088.5MB (2,088.5 × 1,024 × 1,024 bytes). In this case, the Protected Area size is 32MB (32 × 1,024 × 1,024 bytes) and the Data Area size is 2,056.5MB (2,056.5 × 1,024 × 1,024 bytes). And the card whose capacity is more than 2,048MB (2,048 × 1,024 × 1,024 bytes) and less than 2,088.5MB (2,088.5 × 1,024 × 1,024 bytes) is not defined by this version of the specification.**
   Similarly, the Extended Capacity SD Memory Card covered by this specification shall comply with "Part 1. PHYSICAL LAYER SPECIFICATION Version 3.00" or the later version. And the Extended Capacity SD Memory Card supports capacity 32,896MB (32,896 × 1,024 × 1,024 bytes) or more and is limited to 2TB (2 × 1,024 × 1,024 × 1,024 × 1,024 bytes). In order to avoid the confusion caused by the border capacity, the concrete value of the minimum capacity of the Extended Capacity SD Memory Card shall be 32,896MB (32,896 × 1,024 × 1,024 bytes). In this case, the Protected Area size is 128MB (128 × 1,024 × 1,024 bytes) and the Data Area size is 32,768MB (32,768 × 1,024 × 1,024 bytes). And the card whose capacity is more than 32,768MB (32,768 × 1,024 × 1,024 bytes) and less than 32,896MB (32,896 × 1,024 × 1,024 bytes) is not defined by this version of the specification.

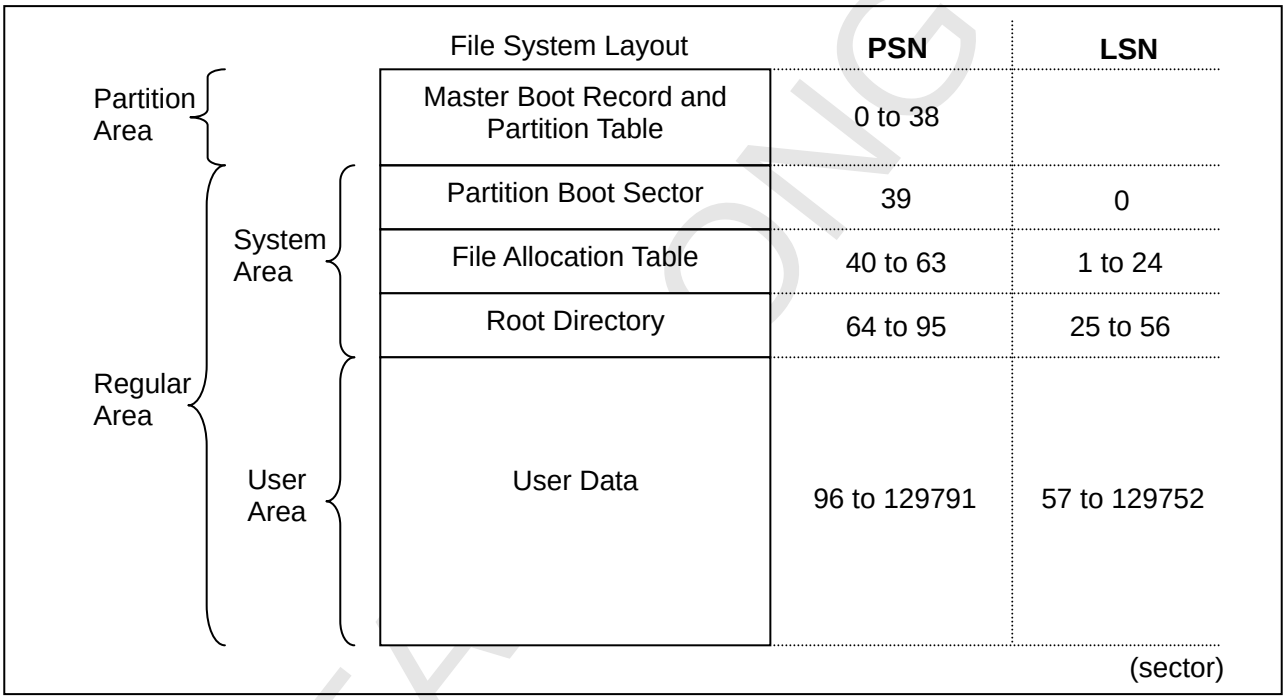
2. Features

- **Compatibility with FAT File System**
  - **Standard Capacity SD Memory Card complies with ISO/IEC 9293 (FAT12 / FAT16).**
  - **High Capacity SD Memory Card complies with FAT32 File System.**
  - **Extended Capacity SD Memory Card complies with exFAT File System.**
- **CHS parameter recommendation**
- **Cluster size recommendation**
- **Boundary Unit recommendation for User Data area alignment**
- **Long File Name support (Optional for FAT12/FAT16/FAT32. exFAT supports Long File Name by default.)**

3. FAT12/FAT16 File System

3.1. Volume Structure

The volume structure of the Standard Capacity SD Memory Card, whose capacity is 2GB or less, is specified in this section. It defines the logical structure of the Data Area. For the identification of the Data Area as a partition, the first sector has Master Boot Record and Partition Table. And the Standard Capacity SD Memory Card uses the FAT file system (ISO/IEC 9293) and supports both FAT12 and FAT16 as the file system type.



PSN : Physical Sector Number

LSN : Logical Sector Number

Figure 3-1 : Example of Volume Structure for Data Area

3.1.1. Arrangement of the Data Area

3.1.1.1. Physical Address

Each sector shall be identified by a Physical Address comprising the parameters of SD Memory Card's own.

3.1.1.2. Physical Sector Number

Each sector on a volume shall be identified by a Physical Sector Number. There shall be a one-to-one correspondence between Physical Address and Physical Sector Number. The Physical Sector Numbers shall be assigned in an ascending sequence, beginning with 0.

3.1.1.3. Logical Sector Number

Each sector on a partition shall be identified by a Logical Sector Number. The first sector of the partition shall be assigned 0 as Logical Sector Number. There shall be a one-to-one correspondence between Physical Sector Number.

3.1.1.4. Partition Area and Regular Area

The space on Data Area shall be divided into two parts: Partition Area and Regular Area. And the Regular Area shall be divided into System Area and User Area.

The Partition Area shall occupy sectors with the Physical Sector Numbers 0 to *NOM-1*, where *NOM* is the number of sectors in the Master Boot Record and Partition Table.

The Regular Area is a partition of the volume, and divided into System Area and User Area.

The System Area shall occupy sectors with the Physical Sector Numbers *NOM* to *NOM+SSA*-1, where *SSA* is the number of sectors in the System Area. The System Area shall contain Descriptors that specify the recording format of the Regular Area. No part of any file shall be contained in the System Area.

The User Area shall occupy sectors with the Physical Sector Numbers starting with *NOM+SSA*. The User Area shall contain files and directories, and be recorded user data.

3.1.2. Arrangement of the User Area

3.1.2.1. Clusters

The User Area shall be organized into units of allocation called clusters. Each cluster shall consist of the same number of sectors. Each cluster shall be identified by a unique Cluster Number. Cluster Numbers shall be assigned integer number starting with 2.

3.1.2.2. Status of Clusters

A status shall be assigned to each cluster, and shall be one of the following:

- allocated to a file
  The cluster is already allocated.

- available for allocation
  The cluster is prepared for allocate.

- defective
  The cluster is defective. This cluster cannot be allocated.

The status of each cluster shall be identified according to ISO/IEC 9293.

3.1.3. Arrangement of the Partition Area

The first sector of the Data Area has a Master Boot Record that includes executable codes and Partition Table that includes the information to identify the partition.

BP	Length (bytes)	Field Name	Contents
0	446	Master Boot Record	Not Restricted
446	16	Partition Table (partition1)	Refer to Table 3-2
462	16	Partition Table (partition2)	All 00h
478	16	Partition Table (partition3)	All 00h
494	16	Partition Table (partition4)	All 00h
510	2	Signature Word	55h, AAh

Table 3-1 : Master Boot Record and Partition Table

(BP 0 to 445) Master Boot Record
The content of this field is not specified by this specification.

(BP 446 to 461) Partition Table (partition1)
This field shall specify the information of first partition in the volume. This partition means Regular Area that user can access without mutual authentication. It shall be recorded according to Table 3-2.

(BP 462 to 477) Partition Table (partition2)
This field shall be recorded as ZEROs, as a volume shall consist of single Regular Area.

(BP 478 to 493) Partition Table (partition3)
This field shall be recorded as ZEROs, as a volume shall consist of single Regular Area.

(BP 494 to 509) Partition Table (partition4)
This field shall be recorded as ZEROs, as a volume shall consist of single Regular Area.

(BP 510 and 511) Signature Word
This field shall be recorded as 55h (BP 510) and AAh (BP 511).

BP	Length (bytes)	Field Name	Contents
0	1	Boot Indicator	00h or 80h
1	1	Starting Head	Numeric Value
2	2	Starting Sector / Starting Cylinder	Numeric Value
4	1	System ID	01h or 04h or 06h
5	1	Ending Head	Numeric Value
6	2	Ending Sector / Ending Cylinder	Numeric Value
8	4	Relative Sector	Numeric Value
12	4	Total Sector	Numeric Value

Table 3-2 : Partition Table

(BP 0) Boot Indicator
This field shall be recorded as 80h if SD Memory Card is used for boot. Otherwise, this field shall be recorded as 00h.

(BP 1) Starting Head
This field shall specify the starting head of the partition.

(BP 2 and 3) Starting Sector / Starting Cylinder
This field shall specify the starting sector and cylinder of the partition. 6 bits (Bit 0 to Bit 5 in BP 2) in this field shall be used for starting sector. 10 bits (Bit 6 and Bit 7 in BP 2, Bit 0 to Bit 7 in BP 3) in this field shall be used for starting cylinder.

(BP 4) System ID
This field shall be determined only by partition length regardless of file system types (FAT12/FAT16). It shall be recorded as 01h if the partition size is less than 32680 sectors. And it shall be recorded as 04h if the one is less than 65536 sectors. Otherwise, it shall be recorded as 06h.

(BP 5) Ending Head
This field shall specify the ending head of the partition.

(BP 6 and 7) Ending Sector / Ending Cylinder
This field shall specify the ending sector and cylinder of the partition. 6 bits (Bit 0 to Bit 5 in BP 6) in this field shall be used for ending sector. 10 bits (Bit 6 and Bit 7 in BP 6, Bit 0 to Bit 7 in BP 7) in this field shall be used for ending cylinder.

(BP 8 to 11) Relative Sector
This field shall specify the number of sectors existing before the starting sector of this partition.

(BP 12 to 15) Total Sector
This field shall specify the number of sectors on the partition.

3.1.4. Arrangement of the System Area

3.1.4.1. System Area

The System Area shall contain the Partition Boot Sector, the Root Directory and the File Allocation Table (FAT) recorded twice.

3.1.4.2. Partition Boot Sector

The first sector of the System Area shall contain the Partition Boot Sector including the FDC Descriptor. The FDC Descriptor shall contain the parameters for the partition.

3.1.4.3. File Allocation Table (FAT)

The FAT shall contain a Format Identifier and some entries, each of which indicates cluster of the User Area. These entries shall be numbered consecutively starting with 2 and the Entry Number shall be equal to the Cluster Number of the corresponding cluster.

Each entry in the FAT shall indicate the status of the corresponding cluster. The FAT entries shall be used to identify the set of clusters that are allocated to each file.

3.1.4.4. Root Directory

The Root Directory shall be recorded in the System Area following the second occurrence of the FAT.

3.2. File Structure

3.2.1. Partition Boot Sector

There is a Partition Boot Sector at the head of a partition and it contains an FDC Descriptor or an Extended FDC Descriptor. The FDC Descriptor and the Extended FDC Descriptor are compliant to ISO/IEC 9293. The Extended FDC is used for the default.

BP	Length (bytes)	Field Name	Contents
0	3	Jump Command	bytes
3	8	Creating System Identifier	a-characters
11	2	Sector Size	Numeric Value
13	1	Sectors per Cluster	Numeric Value
14	2	Reserved Sector Count	Numeric Value
16	1	Number of FATs	Numeric Value
17	2	Number of Root-directory Entries	Numeric Value
19	2	Total Sectors	Numeric Value
21	1	Medium Identifier	F8h
22	2	Sectors per FAT	Numeric Value
24	2	Sectors per Track	Numeric Value
26	2	Number of Sides	Numeric Value
28	2	(Reserved for future standardization)	0000h
30	480	(Reserved for system use)	Not Restricted
510	2	Signature Word	55h, AAh

Table 3-3 : FDC Descriptor

BP	Length (bytes)	Field Name	Contents
0	3	Jump Command	bytes
3	8	Creating System Identifier	a-characters
11	2	Sector Size	Numeric Value
13	1	Sectors per Cluster	Numeric Value
14	2	Reserved Sector Count	Numeric Value
16	1	Number of FATs	Numeric Value
17	2	Number of Root-directory Entries	Numeric Value
19	2	Total Sectors	Numeric Value
21	1	Medium Identifier	F8h
22	2	Sectors per FAT	Numeric Value
24	2	Sectors per Track	Numeric Value
26	2	Number of Sides	Numeric Value
28	4	Number of Hidden Sectors	Numeric Value
32	4	Total Sectors	Numeric Value
36	1	Physical Disk Number	80h
37	1	Reserved	00h
38	1	Extended Boot Record Signature	29h
39	4	Volume ID Number	Numeric Value
43	11	Volume Label	d-characters
54	8	File System Type	d-characters
62	448	(Reserved for system use)	Not Restricted
510	2	Signature Word	55h, AAh

Table 3-4 : Extended FDC Descriptor

(BP 0 to 2) Jump Command
This field shall specify the jump command to the boot program. It shall be recorded as EBh (BP 0), XXh (BP 1) and 90h (BP 2), or E9h (BP 0), XXh (BP 1) and XXh (BP 2). XXh means that the value is not specified in this specification.

(BP 3 to 10) Creating System Identifier
This field shall specify identification for the system. This field shall be recorded using a-characters and according to ISO/IEC 9293 9.

(BP 11 and 12) Sector Size
This field shall specify the size of a sector in bytes. It shall be recorded as the number 512.

(BP 13) Sectors per Cluster
This field shall specify the number of sectors per cluster. It shall be recorded the following number: 1, 2, 4, 8, 16, 32 or 64. The Cluster Size shall be determined taking the erase block size of physical layer into account. This field should be recorded complying with the recommendation of this specification. Detailed explanations for the recommendation are described in Appendix C.1.3.

(BP 14 and 15) Reserved Sector Count
This field shall specify the number of sectors reserved for system use. It shall be recorded as the number 1.

(BP 16) Number of FATs
This field shall specify the number of FATs. It shall be recorded as the number 2.

(BP 17 and 18) Number of Root-directory Entries
This field shall specify the number of entries in the Root Directory. It shall be recorded as the number 512.

(BP 19 and 20) Total Sectors
This field shall specify the number of sectors on the partition. It shall be recorded according to ISO/IEC 9293 9.

(BP 21) Medium Identifier
This field shall be recorded as F8h for this specification.

(BP 22 and 23) Sectors per FAT
This field shall specify the number of sectors that shall be occupied by each FAT. It shall be recorded according to ISO/IEC 9293 9.

(BP 24 and 25) Sectors per Track
This field shall specify the number of sectors in each track. This parameter depends on the SD Memory Card's parameter. It shall be recorded according to ISO/IEC 9293 9. This field should be recorded complying with the recommendation of this specification. Detailed explanations for the recommendation are described in Appendix C.1.2.

(BP 26 and 27) Number of Sides
This field shall specify the number of sides that can be recorded. This parameter depends on the SD Memory Card's parameter. It shall be recorded according to ISO/IEC 9293 9. This field should be recorded complying with the recommendation of this specification. Detailed explanations for the recommendation are described in Appendix C.1.2.

(BP 28 and 29) Field reserved for future standardization
This field shall be reserved for future standardization. It shall contain only ZEROs.

(BP 30 to 509) Field reserved for system use
This field shall be reserved for system use. It shall not be specified in this specification.

(BP 510 and 511) Signature Word
This field shall be recorded as 55h (BP 510) and AAh (BP 511).

(Extended FDC Descriptor BP 28 to 31) Number of Hidden Sectors
This field shall specify the number of sectors existing before the starting sector of this partition.

(Extended FDC Descriptor BP 32 to 35) Total Sectors
This field shall specify the number of sectors on the partition if the field in BP 19 and 20 is recorded as ZEROs. It shall be recorded according to ISO/IEC 9293 9.

(Extended FDC Descriptor BP 36) Physical Disk Number
This field shall specify the BIOS physical disk number. This field shall be recorded as 80h.

(Extended FDC Descriptor BP 37) Reserved
This field shall be reserved for future standardization. It shall be recorded as ZEROs. It shall be recorded according to ISO/IEC 9293 9. However, since a value other than 00h may be set on other devices, 00h shall not be expected at the time of operation.

(Extended FDC Descriptor BP 38) Extended Boot Record Signature

This field shall be used to identify the descriptor type in the Extended FDC Descriptor when either BP 19 or BP 20 is not recorded as ZEROs. This field shall be recorded as 29h.

(Extended FDC Descriptor BP 39 to 42) Volume ID Number
This field shall specify the volume identification number. It shall be recorded according to ISO/IEC 9293 9.

(Extended FDC Descriptor BP 43 to 53) Volume Label
This field shall specify the volume label. It shall be recorded according to ISO/IEC 9293 9.

(Extended FDC Descriptor BP 54 to 61) File System Type
This field shall specify the type of the file system. It shall be recorded according to ISO/IEC 9293 9.

(Extended FDC Descriptor BP 62 to 509) Field reserved for system use
This field shall be reserved for system use. It shall not be specified in this specification.

(Extended FDC Descriptor BP 510 and 511) Signature Word
This field shall be recorded as 55h (BP 510) and AAh (BP 511).

3.2.2. File Allocation Table

The File Allocation Table supports both the 12-bit FAT and the 16-bit FAT. The FAT structure is compliant to ISO/IEC 9293. The FAT type shall be determined by the number of clusters that depends on the parameter from the physical layer. If the cluster number is less than 4085, FAT12 shall be used. Otherwise, FAT16 shall be used. The first byte of the FAT shall specify the format identifier and be recorded F8h. In case of FAT12, the byte 2 and 3 shall be recorded as FFh each. In case of FAT16, the byte 2, 3 and 4 shall be recorded as FFh each. The sectors of the FAT may include unused area, because the number of clusters shall determine the FAT size in byte. This unused area shall be recorded as ZEROs.

FAT Entry Value		Contents
FAT12	FAT16	
000h	0000h	Indicates that the corresponding cluster is not in use and may be allocated to a file or a directory.
002h to MAX	0002h to MAX	Indicates that the corresponding cluster is already allocated. The value of the entry is the cluster number of the next cluster following this corresponding cluster. Max shall be the Maximum Cluster Number.
MAX+1 to FF6h	MAX+1 to FFF6h	Shall be reserved for future standardization and shall not be used.
FF7h	FFF7h	Indicates that the corresponding cluster has a defective cluster.
FF8h to FFFh	FFF8h to FFFFh	The corresponding cluster is already allocated, and it is the final cluster of the file.

Table 3-5 : FAT Entry Value

3.2.3. File Directories

3.2.3.1. Characteristics

A Directory is a Descriptor that shall contain a set of Directory entries each of which identifies a file, a Volume Label, another Directory or is unused. The maximum number of Directory entries in a Directory excluding root directory is 65536.
The Short File Name entry storing file name as 8.3 format shall be supported as mandatory. And the character code permitted by the ISO/IEC 9293 can be used for this type of Directory entry.

Moreover, hosts can also support Long File Name (LFN) entry as optional. If host doesn't support Long File Name, it may ignore Long File Name entries, and refers to only the file name of 8.3 format that is stored with the LFN.

NOTE: The Long File Name feature is described in Appendix C.3.

3.2.3.2. Directory Entry Types

Directory entries shall contain descriptive information about the files recorded on the partition. There are some types of these entries as below:

- File Entry
  A File Entry shall specify information of a file.

- Volume Label Entry
  A Volume Label Entry shall specify the volume label of the partition.

- Sub-directory Pointer Entry
  A Sub-directory Pointer Entry shall specify information of a directory.

- Sub-directory Identifier Entry
  A Sub-directory Identifier Entry shall identify a file as a Sub-directory.

- Sub-directory Parent Pointer Entry
  A Sub-directory Parent Pointer Entry shall specify information of its parent directory.

- Not-currently-in-use Entry
  A Not-currently-in-use Entry shall specify the entry is not used and able to allocate.

- Never-used Entry
  A Never-used Entry shall specify the end of the directory. It shall not appear before any other type of Directory entry.

These entries shall be recorded according to ISO/IEC 9293 11.

3.2.3.3. General Definition of Directory Entry Fields

The following table indicates the structure of the Directory entry field.

BP	Length (bytes)	Field Name	Contents
0	8	Name	Depends on entry type
8	3	Name Extension	d-characters
11	1	Attributes	8 bits
12	10	Reserved Field	bytes
22	2	Time Recorded	Numeric Value
24	2	Date Recorded	Numeric Value
26	2	Starting Cluster Number	Numeric Value
28	4	File Length	Numeric Value

Table 3-6 : Directory Entry Field

(BP 0 to 7) Name
The content and the description of this field shall depend on the entry type. It shall be recorded according to ISO/IEC 9293 11.

(BP 8 to 10) Name Extension
The content and the description of this field shall depend on the entry type. The content of this field shall be d-characters. It shall be recorded according to ISO/IEC 9293 11.

(BP 11) Attributes
This field shall specify the attributes of the entry. It shall be recorded according to ISO/IEC 9293 11.

(BP 12 to 21) Reserved Field
The content of this field shall depend on the entry type. It should be recorded as ZEROs by default. However, some timestamps (Created Time Tenth, Created Time, Created Date, and Last Access Date) can be stored in this field as optional. Detailed explanations of these timestamps are described in the section “4.2.4.2. Directory Entry Fields”. If the host doesn’t support these timestamps, 00h shall not be expected at the time of operation.

(BP 22 and 23) Time Recorded
This field shall contain a 16-bit integer representing a time. It shall be recorded according to ISO/IEC 9293 11.

(BP 24 and 25) Date Recorded
This field shall contain a 16-bit integer representing a date. It shall be recorded according to ISO/IEC 9293 11.

(BP 26 and 27) Starting Cluster Number
The content of this field shall depend on the entry type. It shall be recorded according to ISO/IEC 9293 11.

(BP 28 to 31) File Length
The content of this field shall depend on the entry type. It shall be recorded according to ISO/IEC 9293 11.

3.2.3.4. User Area

The User Area shall be organized into clusters. Each cluster has a Cluster Number respectively. The first cluster in the User Area is corresponding to Cluster Number 2.

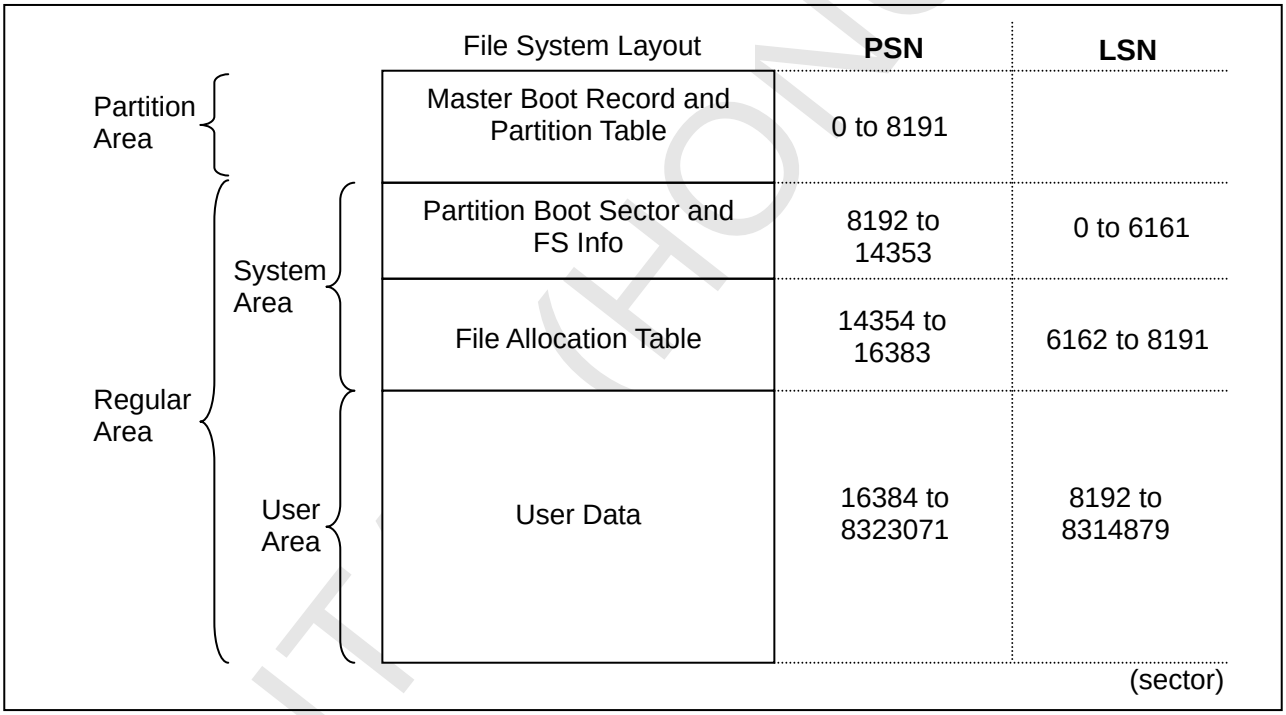
Although it is available to read/write by the sector, it is necessary to transact reading/writing with the unit whose minimum size is the same as that of the recommended reading/writing at the physical layer. Other than that, there are no special restrictions for the SD Memory Card file system.

4. FAT32 File System

4.1. Volume Structure

The volume structure of the High Capacity SD Memory Card is specified in this section. For the identification of the Data Area as a partition, Master Boot Record and Partition Table exist in the first sector of the card as well as the Standard Capacity SD Memory Card. The FAT32 file system shall be applied to the High Capacity SD Memory Card.

NOTE: FAT32 Specification described in this section includes portions of Microsoft FAT Specification, the copyright of which is owned by Microsoft but licensed to SD Card Association.



PSN : Physical Sector Number

LSN : Logical Sector Number

Figure 4-1 : Example of Volume Structure for Data Area

4.1.1. Arrangement of the Data Area

The arrangement of the Data Area for High Capacity SD Memory Card is the same one with the arrangement for the Standard Capacity SD Memory Card.
That is, this type of the card has the concept of Physical Address, Physical Sector Number and Logical Sector Number, and Data Area is divided into the Partition Area and the Regular Area too.

The detailed explanation is described in the section “3.1.1. Arrangement of the Data Area”.

4.1.2. Arrangement of the User Area

The arrangement of the User Area for High Capacity SD Memory Card is the same one with the arrangement for the Standard Capacity SD Memory Card.

That is, the User Area shall be organized into units of Cluster, and there are three statuses for Cluster.

The detailed explanation is described in the section “3.1.2. Arrangement of the User Area”.

4.1.3. Arrangement of the Partition Area

The first sector of the Data Area has a Master Boot Record that includes executable codes and Partition Table that includes the information to identify the partition as well as the Standard Capacity SD Memory Card.

BP	Length (bytes)	Field Name	Contents
0	446	Master Boot Record	Not Restricted
446	16	Partition Table (partition1)	Refer to Table 4-2
462	16	Partition Table (partition2)	All 00h
478	16	Partition Table (partition3)	All 00h
494	16	Partition Table (partition4)	All 00h
510	2	Signature Word	55h, AAh

Table 4-1 : Master Boot Record and Partition Table

(BP 0 to 445) Master Boot Record
The content of this field is not specified by this specification.

(BP 446 to 461) Partition Table (partition1)
This field shall specify the information of first partition in the volume. This partition means Regular Area that user can access without mutual authentication. It shall be recorded according to Table 4-2.

(BP 462 to 477) Partition Table (partition2)
This field shall be recorded as ZEROs, as a volume shall consist of single Regular Area.

(BP 478 to 493) Partition Table (partition3)
This field shall be recorded as ZEROs, as a volume shall consist of single Regular Area.

(BP 494 to 509) Partition Table (partition4)
This field shall be recorded as ZEROs, as a volume shall consist of single Regular Area.

(BP 510 and 511) Signature Word
This field shall be recorded as 55h (BP 510) and AAh (BP 511).

BP	Length (bytes)	Field Name	Contents
0	1	Boot Indicator	00h or 80h
1	1	Starting Head	Numeric Value
2	2	Starting Sector / Starting Cylinder	Numeric Value
4	1	System ID	0Bh or 0Ch
5	1	Ending Head	Numeric Value
6	2	Ending Sector / Ending Cylinder	Numeric Value
8	4	Relative Sector	Numeric Value
12	4	Total Sector	Numeric Value

Table 4-2 : Partition Table

(BP 0) Boot Indicator
This field shall be recorded as 80h if SD Memory Card is used for boot. Otherwise, this field shall be recorded as 00h.

(BP 1) Starting Head
This field shall specify the starting head of the partition. If the starting location of the partition exceeds 8032.5MB (8,422,686,720Bytes), this field shall be recorded as FEh.

(BP 2 and 3) Starting Sector / Starting Cylinder
This field shall specify the starting sector and cylinder of the partition. 6 bits (Bit 0 to Bit 5 in BP 2) in this field shall be used for starting sector. 10 bits (Bit 6 and Bit 7 in BP 2, Bit 0 to Bit 7 in BP 3) in this field shall be used for starting cylinder. If the starting location of the partition exceeds 8032.5MB (8,422,686,720Bytes), this field shall be recorded as FFFFh.

(BP 4) System ID
This field shall be recorded as 0Bh if the ending location of the partition is less than 8032.5MB (8,422,686,720Bytes). Otherwise, this field shall be recorded as 0Ch.

(BP 5) Ending Head
This field shall specify the ending head of the partition. If the ending location of the partition exceeds 8032.5MB (8,422,686,720Bytes), this field shall be recorded as FEh.

(BP 6 and 7) Ending Sector / Ending Cylinder
This field shall specify the ending sector and cylinder of the partition. 6 bits (Bit 0 to Bit 5 in BP 6) in this field shall be used for ending sector. 10 bits (Bit 6 and Bit 7 in BP 6, Bit 0 to Bit 7 in BP 7) in this field shall be used for ending cylinder. If the ending location of the partition exceeds 8032.5MB (8,422,686,720Bytes), this field shall be recorded as FFFFh.

(BP 8 to 11) Relative Sector
This field shall specify the number of sectors existing before the starting sector of this partition. The starting sector of the partition should be aligned to the Boundary Unit specified in Appendix C.2. Detailed explanations for the alignment are described in Appendix C.2.

(BP 12 to 15) Total Sector
This field shall specify the number of sectors on the partition.

4.1.4. Arrangement of the System Area

4.1.4.1. System Area

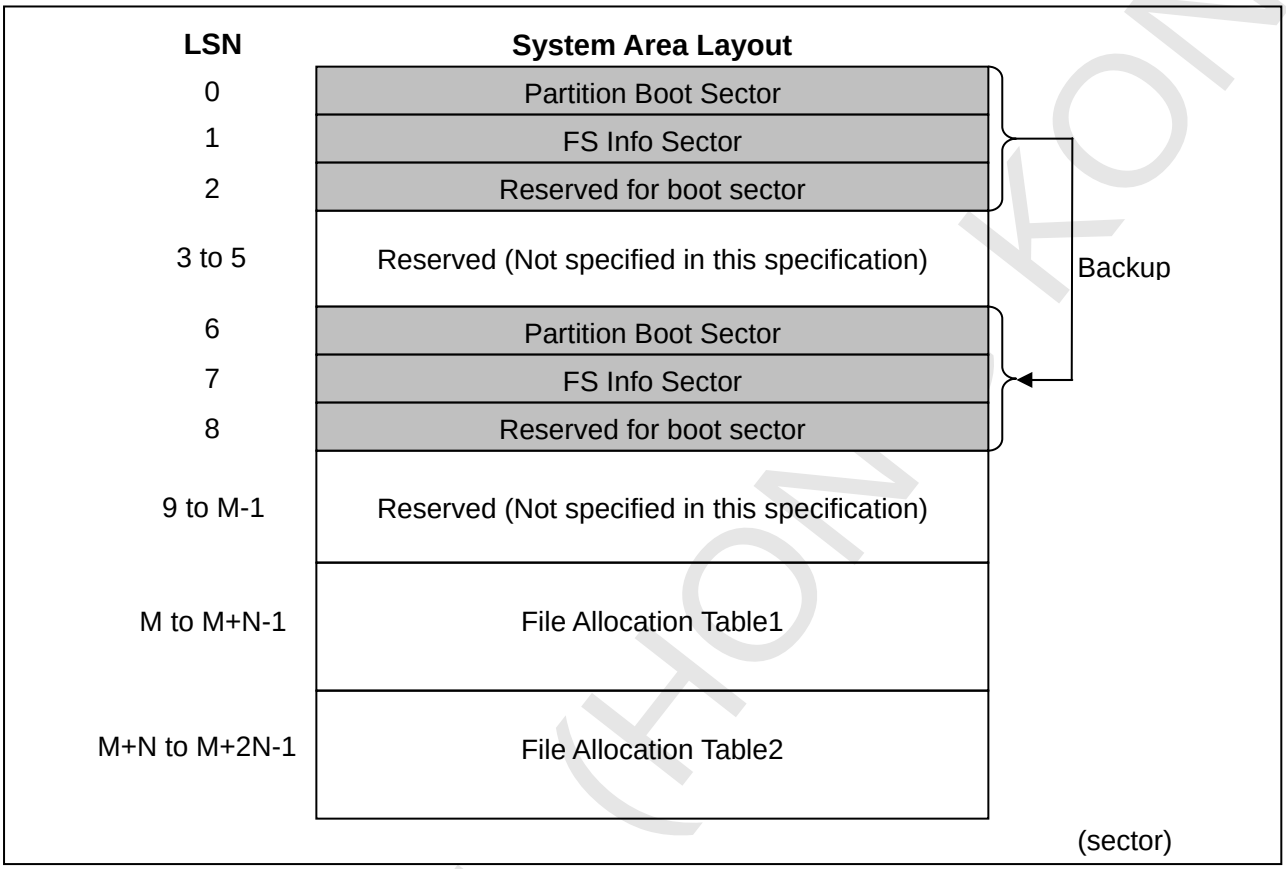
The System Area shall contain the Partition Boot Sector, the FS Info Sector and the File Allocation Table (FAT). These sectors shall be recorded twice on the card for the sake of backup. FAT32 has no reserved area for Root Directory. It shall be located in the User Data Area like the other directories.

4.1.4.2. Partition Boot Sector and FS Info Sector

The first sector of the System Area shall contain the Partition Boot Sector. It shall contain the parameters for the partition like cluster size, partition size, etc.
The second sector of the System Area shall contain the FS Info Sector. It shall contain the additional information like free cluster count, next free cluster, etc.
The third sector of the System Area shall be reserved for boot sectors. This sector has the signature word. That is, 55h shall be recorded in BP 510, and AAh shall be recorded in BP 511. The other bytes in this third sector shall be reserved for system use and they shall not be specified in this specification.

The size of this area shall be recorded in the Reserved Sector Count field in the Partition Boot Sector. In this specification, the size should be used for the alignment of User Data area. For more details, see Appendix C.2.

All 3 sectors described above shall be recorded twice on the card. They shall be recorded in the Logical Sector Number (LSN) 0 to 2 and 6 to 8 as follows.



M : The number of reserved sector count
N : The number of sectors per FAT

Figure 4-2 : System Area Layout

4.1.4.3. File Allocation Table (FAT)

The FAT shall contain a Format Identifier and some entries, each of which indicates cluster of the User Area. These entries shall be numbered consecutively starting with 2 and the Entry Number shall be equal to the Cluster Number of the corresponding cluster.

Each entry in the FAT shall indicate the status of the corresponding cluster. The FAT entries shall be used to identify the set of clusters that are allocated to each file.

4.2. File Structure

4.2.1. Partition Boot Sector

There is a Partition Boot Sector at the head of a partition. For FAT32 file system, some fields are extended from Extended FDC Descriptor of ISO/IEC 9293. Partition Boot Sector shall be recorded twice as described before.

BP	Length (bytes)	Field Name	Contents
0	3	Jump Command	bytes
3	8	Creating System Identifier	bytes
11	2	Sector Size	Numeric Value
13	1	Sectors per Cluster	Numeric Value
14	2	Reserved Sector Count	Numeric Value
16	1	Number of FATs	Numeric Value
17	2	Number of Root-directory Entries	Numeric Value
19	2	Total Sectors	Numeric Value
21	1	Medium Identifier	F8h
22	2	Sectors per FAT	Numeric Value
24	2	Sectors per Track	Numeric Value
26	2	Number of Sides	Numeric Value
28	4	Number of Hidden Sectors	Numeric Value
32	4	Total Sectors	Numeric Value
36	4	Sectors per FAT for FAT32	Numeric Value
40	2	Extension Flag	Numeric Value
42	2	FS Version	0000h
44	4	Root Cluster	Numeric Value
48	2	FS Info	Numeric Value
50	2	Backup Boot Sector	Numeric Value
52	12	Reserved	All 00h
64	1	Physical Disk Number	80h
65	1	Reserved	00h
66	1	Extended Boot Record Signature	29h
67	4	Volume ID Number	Numeric Value
71	11	Volume Label	bytes
82	8	File System Type	bytes
90	420	(Reserved for system use)	Not Restricted
510	2	Signature Word	55h, AAh

Table 4-3 : Partition Boot Sector

(BP 0 to 2) Jump Command
This field shall specify the jump command to the boot program. It shall be recorded as EBh (BP 0), XXh (BP 1) and 90h (BP 2), or E9h (BP 0), XXh (BP 1) and XXh (BP 2). XXh means that the value is not specified in this specification.

(BP 3 to 10) Creating System Identifier
This field shall specify identification for the system.

(BP 11 and 12) Sector Size
This field shall specify the size of a sector in bytes. It shall be recorded as the number 512.

(BP 13) Sectors per Cluster
This field shall specify the number of sectors per cluster. It shall be recorded the following number: 1, 2, 4, 8, 16, 32 or 64. The Cluster Size shall be determined taking the erase block size of physical layer into account. This field should be recorded complying with the recommendation of this specification. Detailed explanations for the recommendation are described in Appendix C.2.3.

(BP 14 and 15) Reserved Sector Count
This field shall specify the number of sectors reserved for system use. This field should be used for the alignment of User Data area. Detailed explanations for the alignment are described in Appendix C.2.

(BP 16) Number of FATs
This field shall specify the number of FATs. It shall be recorded as the number 2.

(BP 17 and 18) Number of Root-directory Entries
This field shall specify the number of entries in the Root Directory for FAT12 / FAT16 file system. FAT32 file system shall not use this field and it shall be recorded as the number 0.

(BP 19 and 20) Total Sectors
This field shall specify the number of sectors on the partition whose size is 65535 sectors or less. FAT32 file system shall not use this field and it shall be recorded as the number 0.

(BP 21) Medium Identifier
This field shall be recorded as F8h for this specification.

(BP 22 and 23) Sectors per FAT
This field shall specify the number of sectors that shall be occupied by each FAT for FAT12 / FAT16 file system. FAT32 file system shall not use this field and it shall be recorded as the number 0.

(BP 24 and 25) Sectors per Track
This field shall specify the number of sectors in each track. This parameter depends on the SD Memory Card's parameter. This field should be recorded complying with the recommendation of this specification. Detailed explanations for the recommendation are described in Appendix C.2.2.

(BP 26 and 27) Number of Sides
This field shall specify the number of sides that can be recorded. This parameter depends on the SD Memory Card's parameter. This field should be recorded complying with the recommendation of this specification. Detailed explanations for the recommendation are described in Appendix C.2.2.

(BP 28 to 31) Number of Hidden Sectors
This field shall specify the number of sectors existing before the starting sector of this partition. The starting sector of the partition should be aligned to the Boundary Unit specified in Appendix C.2. Detailed explanations for the alignment are described in Appendix C.2.

(BP 32 to 35) Total Sectors
This field shall specify the number of sectors on the partition if the field in BP 19 and 20 is recorded as ZEROs. FAT32 file system shall not use BP 19 and 20. Therefore, this field shall not be ZEROs.

(BP 36 to 39) Sectors per FAT for FAT32
This field shall specify the number of sectors that shall be occupied by each FAT for FAT32 file system.

(BP 40 and 41) Extension Flag
This field shall specify the status of FAT mirroring.

Bits 0 to 3 : These bits shall specify zero-based number of active FAT. These bits are valid only if mirroring is disabled.
Bits 4 to 6 : Reserved.
Bits 7 : 0 means the FAT is mirrored at runtime into all FATs.
1 means only one FAT is active; it is the one referenced in bits 0 to 3.
Bits 8 to 15 : Reserved.

(BP 42 and 43) FS Version
This field shall specify the version number of FAT32 file system. High byte is major revision number. Low byte is minor revision number. This field shall be recorded as 0000h which shows the version 0:0.

(BP 44 to 47) Root Cluster
This field shall specify the cluster number of the first cluster of the root directory. This value should be 2 or the first usable (not defective) cluster available thereafter.

(BP 48 and 49) FS Info
This field shall specify the sector number of the area where FS Info Sector structure is recorded in. Here, the sector number means the offset from the head sector of the System Area. That is, the sector number 0 means the location of the head sector of the System Area.
This field shall be recorded as the sector number 1. It shows FS Info Sector shall be located in the second sector of the System Area.

(BP 50 and 51) Backup Boot Sector
This field shall specify the starting sector number of the area where the copy of the boot sectors is recorded in. Here, the sector number means the offset from the head sector of the System Area. That is, the sector number 0 means the location of the head sector of the System Area.
This field shall be recorded as the sector number 6. It shows the copy of the boot sectors shall be recorded in the area starting the seventh sector of the System Area.

(BP 52 to 63) Reserved
This field shall be reserved for future standardization. It shall be recorded as ZEROs. However, since a value other than 00h may be set on other devices, 00h shall not be expected at the time of operation.

(BP 64) Physical Disk Number
This field shall specify the BIOS physical disk number. This field shall be recorded as 80h.

(BP 65) Reserved
This field shall be reserved for future standardization. It shall be recorded as ZEROs. However, since a value other than 00h may be set on other devices, 00h shall not be expected at the time of operation.

(BP 66) Extended Boot Record Signature
This field shall be used to identify this structure. This field shall be recorded as 29h.

(BP 67 to 70) Volume ID Number
This field shall specify the volume identification number.

(BP 71 to 81) Volume Label
This field shall specify the volume label.

(BP 82 to 89) File System Type
This field shall specify the type of the file system. This field shall be recorded as “FAT32 ”. 20h shall be recorded in the last 3 bytes.

(BP 90 to 509) Field reserved for system use
This field shall be reserved for system use. It shall not be specified in this specification.

(BP 510 and 511) Signature Word
This field shall be recorded as 55h (BP 510) and AAh (BP 511).

4.2.2. FS Info Sector

There is a FS Info Sector in the next sector of the Partition Boot Sector. This structure doesn't exist on the FAT12 / FAT16 volume. FS Info Sector shall be recorded twice as described before.

BP	Length (bytes)	Field Name	Contents
0	4	Lead Signature	52h, 52h, 61h, 41h
4	480	Reserved	All 00h
484	4	Structure Signature	72h, 72h, 41h, 61h
488	4	Free Cluster Count	Numeric Value
492	4	Next Free Cluster	Numeric Value
496	12	Reserved	All 00h
508	4	Trail Signature	00h, 00h, 55h, AAh

Table 4-4 : FS Info Sector

(BP 0 to 3) Lead Signature
This field shall be used to validate the beginning of the FS Info Sector. It shall be recorded as 52h (BP 0), 52h (BP 1), 61h (BP 2) and 41h (BP 3).

(BP 4 to 483) Reserved
This field shall be reserved for future standardization. It shall be recorded as ZEROs. However, since a value other than 00h may be set on other devices, 00h shall not be expected at the time of operation.

(BP 484 to 487) Structure Signature
This field shall be used as an additional signature validating the integrity of the FS Info Sector. It shall be recorded as 72h (BP 484), 72h (BP 485), 41h (BP 486) and 61h (BP 487).

(BP 488 to 491) Free Cluster Count
This field shall contain the last known free cluster count on the volume. The value FFFFFFFFh indicates the free count is not known. The contents of this field shall be validated at volume mount (and subsequently maintained in memory by the file system driver implementation). It is recommended that this field contain an accurate count of the number of free clusters at volume dismount (during controlled dismount/shutdown).

(BP 492 to 495) Next Free Cluster
This field shall contain the cluster number of the first available (free) cluster on the volume. The value FFFFFFFFh indicates that there exists no information about the first available (free) cluster. The contents of this field shall be validated at volume mount. It is recommended that this field be appropriately updated at volume dismount (during controlled dismount/shutdown).

(BP 496 to 507) Reserved
This field shall be reserved for future standardization. It shall be recorded as ZEROs. However, since a value other than 00h may be set on other devices, 00h shall not be expected at the time of operation.

(BP 508 to 511) Trail Signature
This field shall be used to validate the integrity of the data in the FS Info Sector. It shall be recorded as 00h (BP 508), 00h (BP 509), 55h (BP 510) and AAh (BP 511).

4.2.3. File Allocation Table

The File Allocation Table consists of 32-bit FAT Entries. Each FAT Entry value is described in the following table. The high 4 bits of a FAT32 FAT Entry are reserved. All FAT implementations shall preserve the current value of the high 4 bits when modifying any FAT32 FAT entry except during volume initialization (formatting) when the entire FAT table shall be set to 0. And no FAT32 volume should ever be configured containing cluster numbers available for allocation >= FFFFFF7h.

FAT Entry Value (FAT32)	Contents
0000000h	Indicates that the corresponding cluster is not in use and may be allocated to a file or a directory.
0000002h to MAX	Indicates that the corresponding cluster is already allocated. The value of the entry is the cluster number of the next cluster following this corresponding cluster. Max shall be the Maximum Cluster Number.
MAX+1 to FFFFFF6h	Shall be reserved for future standardization and shall not be used.
FFFFFF7h	Indicates that the corresponding cluster has a defective cluster.
FFFFFF8h to FFFFFFFh	The corresponding cluster is already allocated, and it is the final cluster of the file. This entry value is called EOC mark (End Of Clusterchain).

Table 4-5 : FAT Entry Value

The first two entries (8 bytes) in the FAT are reserved. These 8 bytes of the FAT shall be recorded as F8h (BP 0), FFh (BP 1), FFh (BP 2), 0Fh (BP 3), FFh (BP 4), FFh (BP 5), FFh (BP 6) and 0Fh (BP 7). However, the file system driver may use the specific two bits of BP 7 for dirty volume flags as follows.

Bit 3 (Clean Shutdown Bit) :

If bit is 1, the volume is “clean”. The volume can be mounted for access.

If bit is 0, the volume is “dirty” indicating that a FAT file system driver was unable to dismount the volume properly (during a prior mount operation). The volume contents should be scanned for any damage to file system metadata.

Bit 2 (Hard Error Bit) :

If bit is 1, no disk read/write errors were encountered.

If bit is 0, the file system driver implementation encountered a disk I/O error on the volume the last time it was mounted, which is an indicator that some sectors may have gone bad. The volume contents should be scanned with a disk repair utility that does surface analysis on it looking for new bad sectors.

The sectors of the FAT may include unused area, because the number of clusters shall determine the FAT size in byte. This unused area shall be recorded as ZEROs.

4.2.4. File Directories

4.2.4.1. Characteristics

A Directory is a Descriptor that shall contain a set of Directory entries each of which identifies a file, a Volume Label, another Directory or is unused. The maximum number of Directory entries in a Directory including root directory is 65536.
The format of the file name for the Directory entries shall support 8.3 format as mandatory. And hosts can also support Long File Name (LFN) as optional. If host doesn't support Long File Name, it may ignore Long File Name entries, and refers to only the file name of 8.3 format that is stored with the LFN.

NOTE: The Long File Name feature is described in Appendix C.3.

As described in the previous section, on FAT12 and FAT16 volumes, the root directory shall immediately follow the last file allocation table. And the size is a fixed size in sectors calculated from the Number of Root-directory Entries value stored in Partition Boot Sector.

On volumes formatted FAT32, the root directory can be of variable size. The location of the first cluster of the root directory on the FAT32 volume is stored in the Root Cluster field of Partition Boot Sector. Only the root directory can contain a Volume Label Entry. There is no name for the root directory (on most operating system implementations, the implied name "\" is used). Further, the root directory does not have any associated date/time stamps. Lastly, the root directory does not contain either the dot and dotdot entries.

4.2.4.2. Directory Entry Fields

The following table indicates the structure of the Directory entry field.

BP	Length (bytes)	Field Name	Contents
0	11	Name and Name Extension	bytes
11	1	Attributes	8 bits
12	1	Reserved for NT	byte
13	1	Created Time Tenth	Numeric Value
14	2	Created Time	Numeric Value
16	2	Created Date	Numeric Value
18	2	Last Access Date	Numeric Value
20	2	Starting Cluster Number High	Numeric Value
22	2	Time Recorded	Numeric Value
24	2	Date Recorded	Numeric Value
26	2	Starting Cluster Number Low	Numeric Value
28	4	File Length	Numeric Value

Table 4-6 : Directory Entry Field

(BP 0 to 10) Name and Name Extension

This field shall contain the 11 character ("short") name of the file or sub-directory described by the corresponding entry containing the field. This field is logically comprised of two components:

- The 8-character man part of the name
- The 3-character extension

Each of the above two components are "trailing space padded" if required (using value: 20h).

Note the following:

1. An implied '.' character separates the main part of the name from the extension. The "." separator character is never stored in this field.
2. If the first byte in this field is E5h, it indicates the directory entry is free (available). However, E5h is a valid KANJI lead byte value for the character set used in Japan. For KANJI character set based names, the value 05h is stored in this byte - if required - to represent E5h. If the FAT file system implementation reads this byte as 05h and if the character set used is KANJI, it shall perform the appropriate substitution in memory prior to returning the name to the application.
3. If the first byte in this field is 00h, it also indicates the directory entry is free (available). However, 00h set in the first byte in this field is an additional indicator that all directory entries following the current free entry are also free.
4. The first byte in this field cannot equal 20h (in other words, names cannot start with a space character).
5. All names in the directory shall be unique.

Restrictions on characters comprising the name

- Lower case characters are not allowed
- Illegal values for characters in the name are as follows:
  - Values less than 20h (except for the special case of 05h in the first byte in this field described earlier)
  - 22h, 2Ah, 2Bh, 2Ch, 2Eh, 2Fh, 3Ah, 3Bh, 3Ch, 3Dh, 3Eh, 3Fh, 5Bh, 5Ch, 5Dh, and 7Ch

(BP 11) Attributes
This field shall specify the attributes of the entry.

Name	Value	Content
ATTR_READ_ONLY	01h	The file cannot be modified – all modification requests shall fail with an appropriate error code value.
ATTR_HIDDEN	02h	The corresponding file or sub-directory shall not be listed unless a request is issued by the user/application explicitly requesting inclusion of “hidden files”.
ATTR_SYSTEM	04h	The corresponding file is tagged as a component of the operating system. It shall not be listed unless a request is issued by the user/application explicitly requesting inclusion of “system files”.
ATTR_VOLUME_ID	08h	The corresponding entry contains the volume label. Starting Cluster Number High field and Starting Cluster Number Low field shall always be 0 for the corresponding entry (representing the volume label) since no clusters can be allocated for this entry. Only the root directory can contain one entry with this attribute. No sub-directory shall contain an entry of this type. Entries representing long file names are exceptions to these rules.
ATTR_DIRECTORY	10h	The corresponding entry represents a directory (a child or sub-directory to the containing directory). File Length field for the corresponding entry shall always be 0 (even though clusters may have been allocated for the directory).
ATTR_ARCHIVE	20h	This attribute shall be set when the file is created, renamed, or modified. The presence of this attribute indicates that properties of the associated file have been modified. Backup utilities can utilize this information to determine the set of files that need to be backed up to ensure protection in case of media and other failure conditions.

Table 4-7 : Attributes

The upper two bits of the attribute byte are reserved and should always be set to 0 when a file is created and never modified or looked at after that.

When a new directory is created, the file system implementation shall ensure the following:

- The ATTR_DIRECTORY bit shall set in its Attributes field
- The File Length field shall be set to 0
- At least one cluster shall be allocated – the contents of the Starting Cluster Number Low field and

Starting Cluster Number High field shall refer to the first allocated cluster number

- If only a single cluster is allocated, the corresponding file allocation table entry shall indicate end-of-file condition
- The contents of the allocated cluster(s) shall be initialized to 0
- Except for the root directory, each directory shall contain the following two entries at the beginning of the directory:

  - The first directory entry shall have a directory name set to "."

    This dot entry refers to the current directory. Rules listed above for the Attributes field and File Length field shall be followed. Since the dot entry refers to the current directory (the one containing the dot entry), the contents of the Starting Cluster Number Low field and Starting Cluster Number High field shall be the same as that of the current directory. All date and time fields shall be set to the same value as that for the containing directory.

  - The second directory entry shall have the directory name set to ".."

    This dotdot entry refers to the parent of the current directory. Rules listed above for the Attributes field and File Length field shall be followed. Since the dotdot entry refers to the parent of the current directory (the one containing the dotdot entry), the contents of the Starting Cluster Number Low field and Starting Cluster Number High field shall be the same as that of the parent of the current directory. If the parent of the current directory is the root directory, the Starting Cluster Number Low field and Starting Cluster Number High field contents shall be set to 0. All date and time fields shall be set to the same value as that for the containing directory.

(BP 12) Reserved for NT
This field shall be reserved. This field shall be set to 0.

(BP 13) Created Time Tenth
This field shall specify the component of the file creation time. This field actually contains a count of tenths of a second. The valid value range is 0-199 inclusive. If this field is not supported, it should be set to 0 on file create and ignored on other file operations.

(BP 14 and 15) Created Time
This field shall specify the file creation time. The detailed format is described in the following section. If this field is not supported, it should be set to 0 on file create and ignored on other file operations.

(BP 16 and 17) Created Date
This field shall specify the file creation date. The detailed format is described in the following section. If this field is not supported, it should be set to 0 on file create and ignored on other file operations.

(BP 18 and 19) Last Access Date
This field shall specify the last access date. Last access is defined as a read or write operation performed on the file/directory described by this entry. This field shall be updated on file modification (write operation) and the date value shall be equal to Date Recorded field. The detailed format is described in the following section. If this field is not supported, it should be set to 0 on file create and ignored on other file operations.

(BP 20 and 21) Starting Cluster Number High
This field shall specify the high word of first data cluster number for file/directory described by this entry.

(BP 22 and 23) Time Recorded

This field shall specify the last modification (write) time. This field shall be equal to Created Time field at file creation. The detailed format is described in the following section. This field shall be supported by all hosts.

(BP 24 and 25) Date Recorded
This field shall specify the last modification (write) date. This field shall be equal to Created Date field at file creation. The detailed format is described in the following section. This field shall be supported by all hosts.

(BP 26 and 27) Starting Cluster Number Low
This field shall specify the low word of first data cluster number for file/directory described by this entry.

(BP 28 to 31) File Length
This field shall specify the 32-bit quantity containing size in bytes of file/directory described by this entry.

4.2.4.3. Date and Time Formats

The date and time formats in the directory entry are as follows.

(Date Format)
Contents of the date related field in the directory entry shall be in the following format:

- Bit positions 0 through 4 represent the day of the month (valid range: 1..31 inclusive)
- Bit positions 5 through 8 represent the month of the year (1 = January, 12 = December, valid range: 1..12 inclusive)
- Bit positions 9 through 15 are the count of years from 1980 (valid range: 0..127 inclusive allowing representation of years 1980 through 2107)

(Time Format)
Directory entry timestamps are 16-bit values with a granularity of 2 seconds. Contents of the timerelated field in the directory entry shall be in the following format:

- Bit positions 0 through 4 contain elapsed seconds – as a count of 2-second increments (valid range: 0..29 inclusive allowing representation of 0 through 58 seconds)
- Bit positions 5 through 10 represent number of minutes (valid range: 0..59 inclusive)
- Bit positions 11 through 15 represent hours (valid range: 0..23 inclusive)

The valid time range is from Midnight 00:00:00 to 23:59:58.

4.2.4.4. Difference from the FAT12 / FAT16 File Directories

File directories of FAT32 file system are similar to FAT12 / FAT16 file system (ISO/IEC 9293), however there are some differences. The main differences between them are as follows:

- For FAT32, the root directory isn't located in the special location, and it can be of variable size and is a cluster chain, just like any other directory is.
- The following fields in the directory entry are added : Reserved for NT, Created Time Tenth, Created Time, Created Date, Last Access Date, and Starting Cluster Number High

4.2.4.5. User Area

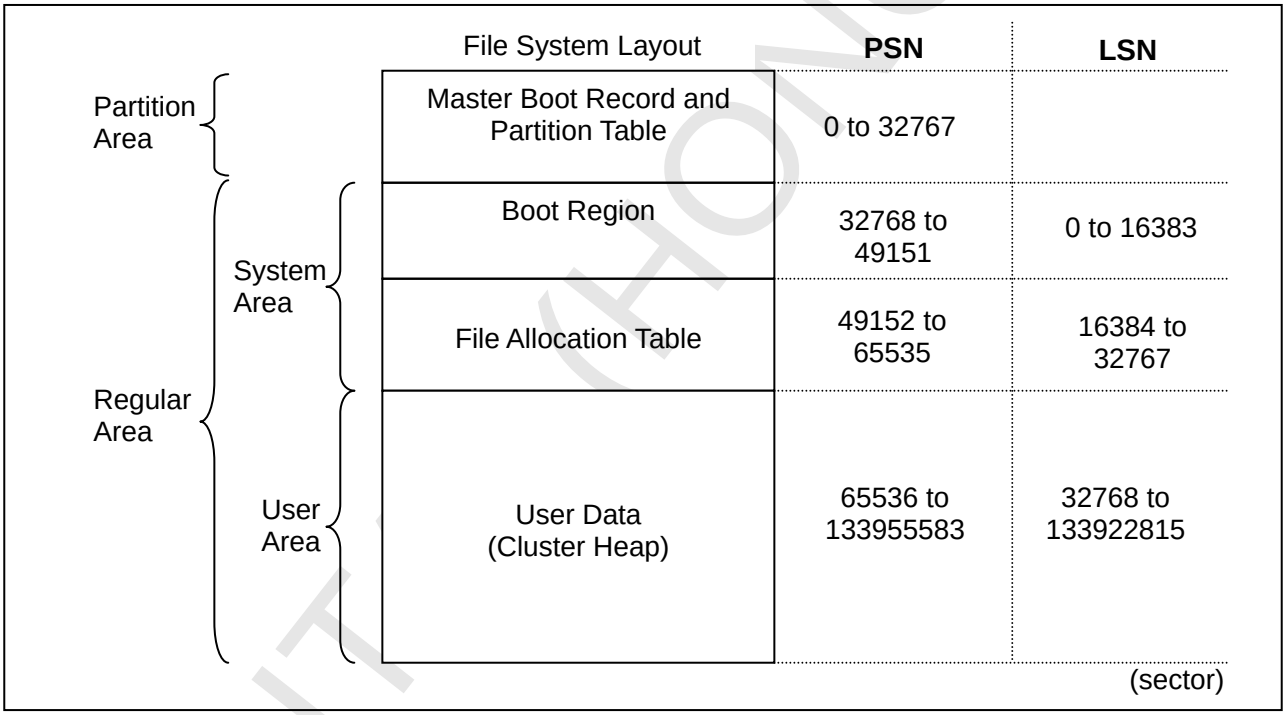
The User Area shall consist of some clusters. Each cluster has a Cluster Number respectively. The first cluster in the User Area is corresponding to Cluster Number 2.
Although it is available to read/write by the sector, it is recommended to transact reading/writing with the unit whose minimum size is the same as that of the recommended reading/writing at the physical layer. Other than that, there are no special restrictions for the SD Memory Card file system.

5. exFAT File System

5.1. Volume Structure

The volume structure of the Extended Capacity SD Memory Card is specified in this section. For the identification of the Data Area as a partition, Master Boot Record and Partition Table exist in the first sector of the card as well as the Standard Capacity SD Memory Card. The exFAT file system shall be applied to the Extended Capacity SD Memory Card.

NOTE: exFAT Specification described in this section includes portions of "exFAT Revision 1.00 File System Basic Specification", the copyright of which is owned by Microsoft but licensed to SD Card Association.



PSN : Physical Sector Number
LSN : Logical Sector Number

Figure 5-1 : Example of Volume Structure for Data Area

5.1.1. Arrangement of the Data Area

The arrangement of the Data Area for Extended Capacity SD Memory Card is the same one with the arrangement for the Standard Capacity SD Memory Card.
That is, this type of the card has the concept of Physical Address, Physical Sector Number and Logical Sector Number, and Data Area is divided into the Partition Area and the Regular Area too.

The detailed explanation is described in the section "3.1.1. Arrangement of the Data Area".

5.1.2. Arrangement of the User Area

The arrangement of the User Area for Extended Capacity SD Memory Card is the same one with the arrangement for the Standard Capacity SD Memory Card.

That is, the User Area shall be organized into units of Cluster, and there are three statuses for Cluster.

The detailed explanation is described in the section “3.1.2. Arrangement of the User Area”.

Moreover, in the exFAT Specification, this area is called as “Cluster Heap”. Therefore, this section may use the words “Cluster Heap” instead of the words “User Data Area”. Note that these are the same meaning.

5.1.3. Arrangement of the Partition Area

The first sector of the Data Area has a Master Boot Record that includes executable codes and Partition Table that includes the information to identify the partition as well as the Standard Capacity SD Memory Card.

BP	Length (bytes)	Field Name	Contents
0	446	Master Boot Record	Not Restricted
446	16	Partition Table (partition1)	Refer to Table 5-2
462	16	Partition Table (partition2)	All 00h
478	16	Partition Table (partition3)	All 00h
494	16	Partition Table (partition4)	All 00h
510	2	Signature Word	55h, AAh

Table 5-1 : Master Boot Record and Partition Table

(BP 0 to 445) Master Boot Record
The content of this field is not specified by this specification.

(BP 446 to 461) Partition Table (partition1)
This field shall specify the information of first partition in the volume. This partition means Regular Area that user can access without mutual authentication. It shall be recorded according to Table 5-2.

(BP 462 to 477) Partition Table (partition2)
This field shall be recorded as ZEROs, as a volume shall consist of single Regular Area.

(BP 478 to 493) Partition Table (partition3)
This field shall be recorded as ZEROs, as a volume shall consist of single Regular Area.

(BP 494 to 509) Partition Table (partition4)
This field shall be recorded as ZEROs, as a volume shall consist of single Regular Area.

(BP 510 and 511) Signature Word
This field shall be recorded as 55h (BP 510) and AAh (BP 511).

BP	Length (bytes)	Field Name	Contents
0	1	Boot Indicator	00h or 80h
1	1	Starting Head	Numeric Value
2	2	Starting Sector / Starting Cylinder	Numeric Value
4	1	System ID	07h
5	1	Ending Head	FEh
6	2	Ending Sector / Ending Cylinder	FFFFh
8	4	Relative Sector	Numeric Value
12	4	Total Sector	Numeric Value

Table 5-2 : Partition Table

(BP 0) Boot Indicator
This field shall be recorded as 80h if SD Memory Card is used for boot. Otherwise, this field shall be recorded as 00h.

(BP 1) Starting Head
This field shall specify the starting head of the partition. If the starting location of the partition exceeds 8032.5MB (8,422,686,720Bytes), this field shall be recorded as FEh.

(BP 2 and 3) Starting Sector / Starting Cylinder
This field shall specify the starting sector and cylinder of the partition. 6 bits (Bit 0 to Bit 5 in BP 2) in this field shall be used for starting sector. 10 bits (Bit 6 and Bit 7 in BP 2, Bit 0 to Bit 7 in BP 3) in this field shall be used for starting cylinder. If the starting location of the partition exceeds 8032.5MB (8,422,686,720Bytes), this field shall be recorded as FFFFh.

(BP 4) System ID
This field shall be recorded as 07h.

(BP 5) Ending Head
This field shall specify the ending head of the partition. However, in case of the Extended Capacity SD Memory Card, this field shall not be used for the recognition of the ending location. This field shall be recorded as FEh.

(BP 6 and 7) Ending Sector / Ending Cylinder
This field shall specify the ending sector and cylinder of the partition. 6 bits (Bit 0 to Bit 5 in BP 6) in this field shall be used for ending sector. 10 bits (Bit 6 and Bit 7 in BP 6, Bit 0 to Bit 7 in BP 7) in this field shall be used for ending cylinder. However, in case of the Extended Capacity SD Memory Card, this field shall not be used for the recognition of the ending location. This field shall be recorded as FFFFh.

(BP 8 to 11) Relative Sector
This field shall specify the number of sectors existing before the starting sector of this partition. The starting sector of the partition should be aligned to the Boundary Unit specified in Appendix C.5. Detailed explanations for the alignment are described in Appendix C.5.

(BP 12 to 15) Total Sector
This field shall specify the number of sectors on the partition.

5.1.4. Arrangement of the System Area

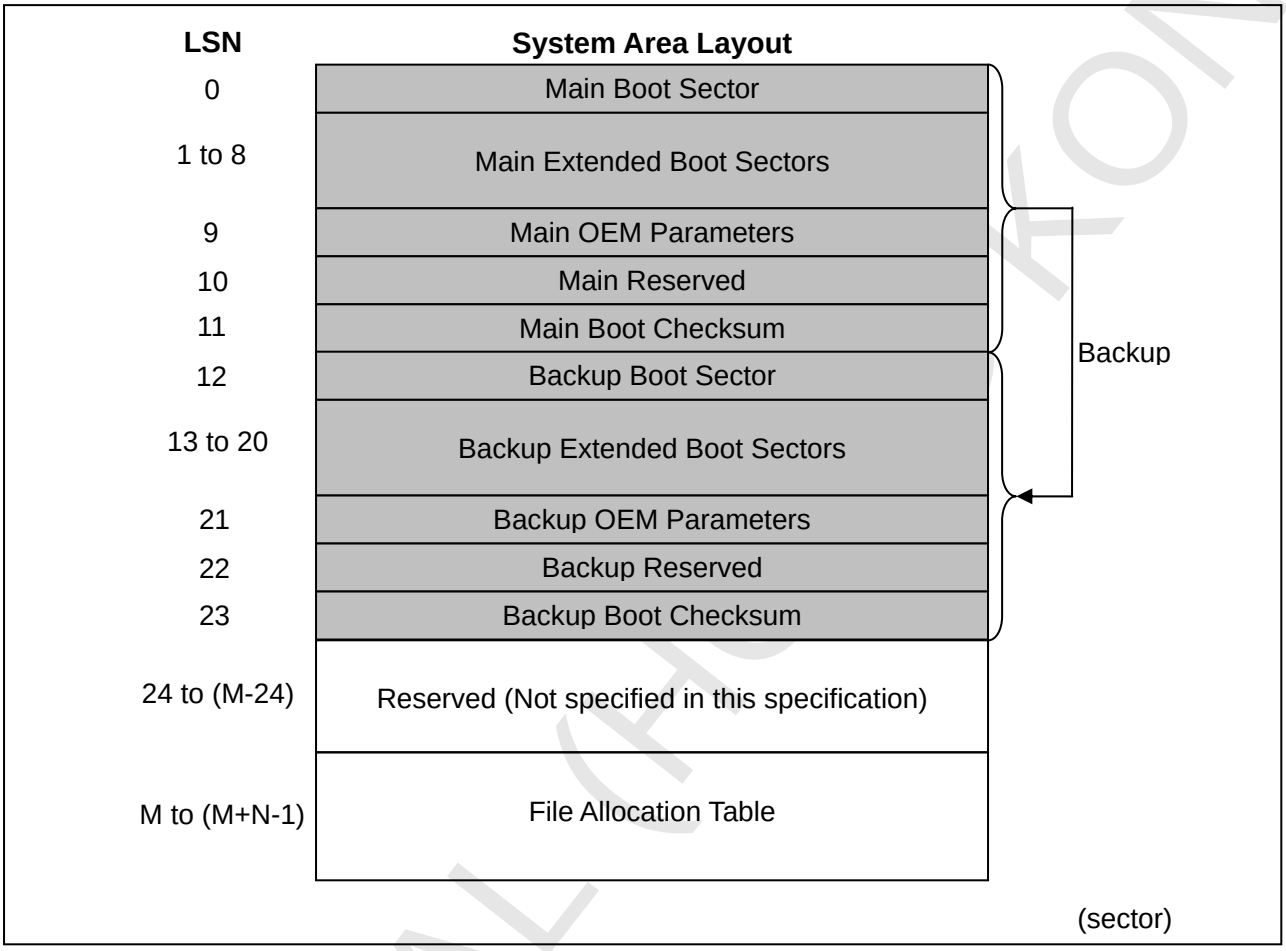
5.1.4.1. System Area

The System Area shall contain two Boot Regions (Main Boot region and Backup Boot region) and the File Allocation Table (FAT). The Backup Boot region is a backup of the Main Boot region. It aids recovery of the exFAT volume in the advent of the Main Boot region being in an inconsistent state. Except under infrequent circumstances, such as updating boot-strapping instructions, implementations should not modify the contents of the Backup Boot region.

5.1.4.2. Main and Backup Boot Region

Both Boot Regions consist from 12 sectors each. The first sector shall contain the Boot Sector. It shall contain the parameters for the partition like cluster size, partition size, etc.
From the second sector to the ninth sector shall contain the Extended Boot Sectors. It may contain the boot-strapping instructions.
The tenth sector shall contain the OEM Parameters. It may contain manufacturer-specific information.
The eleventh sector shall be reserved. This sector shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.
The twelfth sector shall contain the Boot Checksum. It shall contain a repeating pattern of the four-byte checksum of the contents of all other sectors in Boot Region.

These 24 sectors shall be recorded in the first 24 sectors of the partition as follows.



M : The number of FatOffset
N : The number of FatLength

Figure 5-2 : System Area Layout

5.1.4.3. File Allocation Table (FAT)

The FAT shall contain a Format Identifier and some entries, each of which indicates cluster of the Cluster Heap. These entries shall be numbered consecutively starting with 2 and the Entry Number shall be equal to the Cluster Number of the corresponding cluster.

In an exFAT volume, a FAT maintains only the cluster chain information and an Allocation Bitmap maintains the record of the allocation state of all clusters. This is a significant difference from exFAT's predecessors (FAT12, FAT16, and FAT32), in which a FAT maintained both the cluster chain information and the record of the allocation state of all clusters.

5.2. File Structure

5.2.1. Main and Backup Boot Sector

The Main Boot Sector contains code for boot-strapping from an exFAT volume and fundamental exFAT parameters which describe the volume structure. BIOS, MBR, or other boot-strapping agents may inspect this sector and may load and execute any boot-strapping instructions contained therein.

The Backup Boot Sector is a backup of the Main Boot Sector and has the same structure (see Table 5-3). The Backup Boot Sector may aid recovery operations; however, implementations shall treat the contents of the VolumeFlags and PercentInUse fields as stale.

Prior to using the contents of either the Main or Backup Boot Sector, implementations shall verify their contents by validating their respective Boot Checksum and ensuring all their fields are within their valid value range.

While the initial format operation will initialize the contents of both the Main and Backup Boot Sectors, implementations may update these sectors (and shall also update their respective Boot Checksum) as needed. However, implementations may update either the VolumeFlags or PercentInUse fields without updating their respective Boot Checksum (the checksum specifically excludes these two fields).

BP	Length (bytes)	Field Name	Contents
0	3	JumpBoot	EBh, 76h, 90h
3	8	FileSystemName	“EXFAT “
11	53	MustBeZero	All 00h
64	8	PartitionOffset	Numeric Value
72	8	VolumeLength	Numeric Value
80	4	FatOffset	Numeric Value
84	4	FatLength	Numeric Value
88	4	ClusterHeapOffset	Numeric Value
92	4	ClusterCount	Numeric Value
96	4	FirstClusterOfRootDirectory	Numeric Value
100	4	VolumeSerialNumber	Numeric Value
104	2	FileSystemRevision	Numeric Value
106	2	VolumeFlags	Numeric Value
108	1	BytesPerSectorShift	Numeric Value
109	1	SectorsPerClusterShift	Numeric Value
110	1	NumberOfFats	Numeric Value
111	1	DriveSelect	80h
112	1	PercentInUse	Numeric Value
113	7	Reserved	All 00h
120	390	BootCode	Not Restricted
510	2	BootSignature	55h, AAh

Table 5-3 : Main and Backup Boot Sector

(BP 0 to 2) JumpBoot

This field shall specify the jump instruction for CPUs common in personal computers, which, when executed, “jumps” the CPU to execute the boot-strapping instructions in the BootCode field. It shall be recorded as EBh (BP 0), 76h (BP 1) and 90h (BP 2).

(BP 3 to 10) FileSystemName
This field shall specify the name of the file system on the volume. It shall be recorded as, in ASCII characters, “EXFAT ”, which includes three trailing white spaces.

(BP 11 to 63) MustBeZero
This field directly corresponds with the range of bytes the packed Partition Boot Sector consumes on FAT12/16/32 volumes. It shall be recorded as ZEROs, which helps to prevent FAT12/16/32 implementations from mistakenly mounting an exFAT volume.

(BP 64 to 71) PartitionOffset
This field shall specify the number of sectors existing before the starting sector of this partition. The starting sector of the partition should be aligned to the Boundary Unit specified in Appendix C.5. Detailed explanations for the alignment are described in Appendix C.5.

(BP 72 to 79) VolumeLength
This field shall specify the number of sectors on the partition.

(BP 80 to 83) FatOffset
This field shall specify the volume-relative sector offset of the First FAT. That is, this field shall specify the number of sectors existing from the Main Boot Sector to the First FAT. This field enables implementations to align the First FAT to the characteristics of the card. The starting sector of the First FAT should be aligned complying with the alignment rule described in this specification. Detailed explanations for the alignment are described in Appendix C.5.

(BP 84 to 87) FatLength
This field shall specify the length, in sectors, of each FAT table (the volume may contain up to two FATs). This field may contain a value in excess of its lower bound (the minimum FAT size which ensures each FAT has sufficient space for describing all the clusters in the Cluster Heap) to enable the Second FAT, if present, to also be aligned to the characteristics of the underlying storage media. The contents of space which exceeds what the FAT itself requires, if any, are undefined. The FAT size should be the half size of the Boundary Unit in order to comply with the alignment rule described in this specification. Detailed explanations for the alignment are described in Appendix C.5.

(BP 88 to 91) ClusterHeapOffset
This field shall specify the volume-relative sector offset of the Cluster Heap. That is, this field shall specify the number of sectors existing from the Main Boot Sector to the starting sector of the Cluster Heap. This field enables implementations to align the Cluster Heap to the characteristics of the card. The starting sector of the Cluster Heap should be aligned to the Boundary Unit specified in Appendix C.5. Detailed explanations for the alignment are described in Appendix C.5.

(BP 92 to 95) ClusterCount
This field shall specify the number of clusters the Cluster Heap contains.

(BP 96 to 99) FirstClusterOfRootDirectory
This field shall specify the cluster index of the first cluster of the root directory. Implementations should make every effort to place the first cluster of the root directory in the first non-bad cluster after the clusters the Allocation Bitmap and Up-case Table consume.

(BP 100 to 103) VolumeSerialNumber
This field shall specify a unique serial number. This assists implementations to distinguish among different exFAT volumes. Implementations should generate the serial number by combining the date and time of formatting the exFAT volume. The mechanism for combining date and time to form a serial number is implementation-specific.

(BP 104 and 105) FileSystemRevision
This field shall specify the major and minor revision numbers of the exFAT structures on the given volume. The high-order byte is the major revision number and the low-order byte is the minor revision number. For example, if the high-order byte contains the value 01h and if the low-order byte contains the value 05h, then the FileSystemRevision field describes the revision number 1.05. Likewise, if the high-order byte contains the value 0Ah and if the low-order byte contains the value 0Fh, then the FileSystemRevision field describes the revision number 10.15. The maximum value of each byte is 63h. This means the maximum revision numbers are 99.99.

This field shall be recorded as 00h (BP 104) and 01h (BP 105). This describes the revision number 1.00. Implementations of this specification should mount any exFAT volume with major revision number 1 and shall not mount any exFAT volume with any other major revision number. Implementations shall honor the minor revision number and shall not perform operations or create any file system structures not described in the given minor revision number's corresponding specification.

(BP 106 and 107) VolumeFlags
This field shall be used to contain flags which indicate the status of various file system structures on the exFAT volume (see Table 5-4). Implementations shall not include this field when computing its respective Main Boot or Backup Boot region checksum. When referring to the Backup Boot Sector, implementations shall treat this field as stale.

Field Name	Offset(bit)	Size(bits)	Comments
ActiveFat	0	1	This field describes which FAT and Allocation Bitmap are active.
VolumeDirty	1	1	This field describes whether the volume is dirty or not.
MediaFailure	2	1	This field describes whether an implementation has discovered media failures or not.
ClearToZero	3	1	This field does not have significant meaning in this specification.
Reserved	4	12	This field is reserved.

Table 5-4 : VolumeFlags

(ActiveFat)
This field shall describe which FAT and Allocation Bitmap are active (and implementations shall use), as follows:

- 0, which means the First FAT and First Allocation Bitmap are active
- 1, which means the Second FAT and Second Allocation Bitmap are active and is possible only when the NumberOfFats field contains the value 2

Implementations shall consider the inactive FAT and Allocation Bitmap as stale.

(VolumeDirty)
This field shall describe whether the volume is dirty or not, as follows:

- 0, which means the volume is probably in a consistent state
- 1, which means the volume is probably in an inconsistent state

Implementations should set the value of this field to 1 upon encountering file system metadata

inconsistencies which they do not resolve. If, upon mounting a volume, the value of this field is 1, only implementations which resolve file system metadata inconsistencies may clear the value of this field to 0. Such implementations shall only clear the value of this field to 0 after ensuring the file system is in a consistent state.
If, upon mounting a volume, the value of this field is 0, implementations should set this field to 1 before updating file system metadata and clear this field to 0 afterwards, similar to the recommended write ordering Section 5.2.9.1 describes.

(MediaFailure)
This field shall describe whether an implementation has discovered media failures or not, as follows:

- 0, which means the hosting media has not reported failures or any known failures are already recorded in the FAT as “bad” clusters
- 1, which means the hosting media has reported failures (i.e. has failed read or write operations)

An implementation should set this field to 1 when:
1. The hosting media fails access attempts to any region in the volume
2. The implementation has exhausted access retry algorithms, if any

If, upon mounting a volume, the value of this field is 1, implementations which scan the entire volume for media failures and record all failures as “bad” clusters in the FAT (or otherwise resolve media failures) may clear the value of this field to 0.

(ClearToZero)
This field shall not have significant meaning in this specification. The valid values for this field are:

- 0, which does not have any particular meaning
- 1, which means implementations shall clear this field to 0 prior to modifying any file system structures, directories, or files

(Reserved)
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 108) BytesPerSectorShift
This field shall specify the bytes per sector expressed as log2(N), where N is the number of bytes per sector. For example, for 512 bytes per sector, the value of this field is 9. This field shall be recorded as the number 9.

(BP 109) SectorsPerClusterShift
This field shall specify the sectors per cluster expressed as log2(N), where N is the number of sectors per cluster. For example, for 8 sectors per cluster, the value of this field is 3. The valid range of this field shall be from 0 to 16. This means the minimum cluster size is 512 bytes and the maximum cluster size is 32MB. And the cluster size shall be determined taking the erase block size of physical layer into account. This field should be recorded complying with the recommendation of this specification. Detailed explanations for the recommendation are described in Appendix C.5.

(BP 110) NumberOfFats
This field shall specify the number of FATs and Allocation Bitmaps the volume contains. It shall be recorded as the number 1 or 2. However, 1 should be used by default. If this field is recorded as the number 2, the inactive FAT and Allocation Bitmap shall be ignored by the host which supports only one FAT.

(BP 111) DriveSelect
This field shall specify the extended INT 13h drive number, which aids boot-strapping from this volume using extended INT 13h on personal computers. It shall be recorded as 80h.

(BP 112) PercentInUse
This field shall specify the percentage of clusters in the Cluster Heap which are allocated. The valid range of values for this field is:

- Between 0 and 100 inclusively, which is the percentage of allocated clusters in the Cluster Heap, rounded down to the nearest integer
- Exactly FFh, which indicates the percentage of allocated clusters in the Cluster Heap is not available

Implementations shall change the value of this field to reflect changes in the allocation of clusters in the Cluster Heap or shall change it to FFh. Implementations shall not include this field when computing its respective Main Boot or Backup Boot region checksum. When referring to the Backup Boot Sector, implementations shall treat this field as stale.

(BP 113 to 119) Reserved
This field shall be reserved for future standardization. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 120 to 509) BootCode
This field shall be used to contain boot-strapping instructions. Implementations may populate this field with the CPU instructions necessary for boot-strapping a computer system. Implementations which don't provide boot-strapping instructions shall initialize each byte in this field to F4h as part of their format operation.

(BP 510 and 511) BootSignature
This field shall describe whether the intent of given sector is for it to be a Boot Sector or not. It shall be recorded as 55h (BP 510) and AAh (BP 511). Any other value in this field invalidates its respective Boot Sector. Implementations should verify the contents of this field prior to depending on any other field in its respective Boot Sector.

5.2.2. Main and Backup Extended Boot Sectors

Each sector of the Main Extended Boot Sectors has the same structure; however, each sector may hold distinct boot-strapping instructions (see Table 5-5). Boot-strapping agents, such as the boot-strapping instructions in the Main Boot Sector, alternate BIOS implementations, or an embedded system's firmware, may load these sectors and execute the instructions they contain.

The Backup Extended Boot Sectors is a backup of the Main Extended Boot Sectors and has the same structure (see Table 5-5).

Prior to executing the instructions of either the Main or Backup Extended Boot Sectors, implementations should verify their contents by ensuring each sector's ExtendedBootSignature field contains its prescribed value.

While the initial format operation will initialize the contents of both the Main and Backup Extended Boot Sectors, implementations may update these sectors (and shall also update their respective Boot Checksum) as needed.

BP	Length (bytes)	Field Name	Contents
0	508	ExtendedBootCode	Not Restricted
508	4	ExtendedBootSignature	00h, 00h, 55h, AAh

Table 5-5 : Main and Backup Extended Boot Sectors

(BP 0 to 507) ExtendedBootCode

This field shall be used to contain boot-strapping instructions. Implementations may populate this field with the CPU instructions necessary for boot-strapping a computer system. Implementations which don't provide boot-strapping instructions shall initialize each byte in this field to 00h as part of their format operation.

(BP 508 to 511) ExtendedBootSignature

This filed shall describe whether the intent of given sector is for it to be an Extended Boot Sector or not. It shall be recorded as 00h (BP 508), 00h (BP 509), 55h (BP 510) and AAh (BP 511). Any other value in this field invalidates its respective Main or Backup Extended Boot Sector. Implementations should verify the contents of this field prior to depending on any other field in its respective Extended Boot Sector.

5.2.3. Main and Backup OEM Parameters

The Main OEM Parameters contains ten parameters structures which contain manufacturer-specific information (see Table 5-6). Each of the ten parameters structures derives from the Generic Parameters template (see Section 5.2.3.2). Manufacturers may derive their own custom parameters structures from the Generic Parameters template. This specification itself defines two parameters structures: Null Parameters (see Section 5.2.3.3) and Flash Parameters (see Section 5.2.3.4).

The Backup OEM Parameters is a backup of the Main OEM Parameters and has the same structure (see Table 5-6).

Prior to using the contents of either the Main or Backup OEM Parameters, implementations shall verify their contents by validating their respective Boot Checksum.

Manufacturers should populate the Main and Backup OEM Parameters with their own custom parameters structures, if any, and any other parameter structures. Subsequent format operations shall preserve the contents of the Main and Backup OEM Parameters.

Implementations may update the Main and Backup OEM Parameters as needed (and shall also update their respective Boot Checksum).

BP	Length (bytes)	Field Name	Contents
0	48	Parameters[0]	Generic Parameters Template
:	:	:	:
432	48	Parameters[9]	Generic Parameters Template
480	32	Reserved	All 00h

Table 5-6 : Main and Backup OEM Parameters

5.2.3.1. Parameters[0] … Parameters[9]

Each Parameters field in this array contains a parameters structure, which derives from the Generic Parameters template (see Section 5.2.3.2). Any unused Parameters field shall be described as containing a Null Parameters structure (see Section 5.2.3.3).

5.2.3.2. Generic Parameters Template

The Generic Parameters template provides the base definition of a parameters structure (see Table 5-7). All parameters structures derive from this template.

BP	Length (bytes)	Field Name	Contents
0	16	ParametersGuid	GUID
16	32	CustomDefined	Not Restricted

Table 5-7 : Generic Parameters Template

(BP 0 to 15) ParametersGuid

This field shall describe a GUID, which determines the layout of the remainder of the given parameters structure. All possible values for this field are valid.

(BP 16 to 31) CustomDefined

The content of this field shall be defined by the structures which derive from this template.

5.2.3.3. Null Parameters

The Null Parameters structure derives from the Generic Parameters template (see Section 5.2.3.2) and describes an unused Parameters field (see Table 5-8). When creating or updating the OEM Parameters structure, implementations shall populate unused Parameters fields with the Null Parameters structure. Also, when creating or updating the OEM Parameters structure, implementations should consolidate Null Parameters structures at the end of the array, thereby leaving all other Parameters structures at the beginning of the OEM Parameters structure.

BP	Length (bytes)	Field Name	Contents
0	16	ParametersGuid	GUID
16	32	Reserved	All 00h

Table 5-8 : Null Parameters

(BP 0 to 15) ParametersGuid
This field shall conform to the definition the Generic Parameters template provides (see Section 5.2.3.2). This field shall be recorded, in GUID notation, as {00000000-0000-0000-0000-000000000000}.

(BP 16 to 47) Reserved
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

5.2.3.4. Flash Parameters

The Flash Parameter structure derives from the Generic Parameters template (see Section 5.2.3.2) and contains parameters of flash media (see Table 5-9). Card manufacturers should set this structure in the OEM Parameters area (preferably the Parameters[0] field).

Note: This structure is used for the Cluster Heap alignment described in this specification. Therefore, this structure may not store the actual flash parameters of the card.

BP	Length (bytes)	Field Name	Contents
0	16	ParametersGuid	GUID
16	4	EraseBlockSize	Numeric Value
20	4	PageSize	00000000h
24	4	SpareSectors	00000000h
28	4	RandomAccessTime	00000000h
32	4	ProgrammingTime	00000000h
36	4	ReadCycle	00000000h
40	4	WriteCycle	00000000h
44	4	Reserved	All 00h

Table 5-9 : Flash Parameters

The value 0 indicates the field is actually meaningless (implementations shall ignore the given field).

(BP 0 to 15) ParametersGuid
This field shall conform to the definition the Generic Parameters template provides (see Section 5.2.3.2). This field shall be recorded, in GUID notation, as {0A0C7E46-3399-4021-90C8-FA6D389C4BA2}.

(BP 16 to 19) EraseBlockSize

Basically, this field describes the size, in bytes, of the flash media's erase block. However, the half of the Boundary Unit size, in bytes, shall be stored in this field. For example, if the Boundary Unit size is 16MB, this field shall be recorded as the number 8,388,608.

(BP 20 to 23) PageSize
Basically, this field describes the size, in bytes of the flash media's page. However, this field shall be recorded as the number 0.

(BP 24 to 27) SpareSectors
Basically, this field describes the number of sectors the flash media has available for its internal sparing operations. However, this field shall be recorded as the number 0.

(BP 28 to 31) RandomAccessTime
Basically, this field describes the flash media's average random access time, in nanoseconds. However, this field shall be recorded as the number 0.

(BP 32 to 35) ProgrammingTime
Basically, this field describes the flash media's average programming time, in nanoseconds. However, this field shall be recorded as the number 0.

(BP 36 to 39) ReadCycle
Basically, this field describes the flash media's average read cycle time, in nanoseconds. However, this field shall be recorded as the number 0.

(BP 40 to 43) WriteCycle
Basically, this field describes the average write cycle time, in nanoseconds. However, this field shall be recorded as the number 0.

(BP 44 to 47) Reserved
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

5.2.4. Main and Backup Boot Checksum

The Main and Backup Boot Checksum contain a repeating pattern of the four-byte checksum of the contents of all other sectors in their respective Boot regions. The checksum calculation does not include the VolumeFlags and PercentInUse fields in their respective Boot Sector. The repeating pattern of the four-byte checksum fills its respective Boot Checksum from the beginning to the end of the sector.

Prior to using the contents of any of the other sectors in either the Main or Backup Boot regions, implementations shall verify their contents by validating their respective Boot Checksum.

While the initial format operation will populate both the Main and Backup Boot Checksums with the repeating checksum pattern, implementations shall update these sectors as the contents of the other sectors in their respective Boot regions change.

The below algorithm describes the logic used to generate the checksum value:

```
UInt32 BootChecksum
(
     UCHAR *    Sectors, // points to an in-memory copy of the 11 sectors
     USHORT     BytesPerSector
)
{
     UInt32     NumberOfBytes = (UInt32)BytesPerSector * 11;
     UInt32     Checksum = 0;
     UInt32     Index;

     for (Index = 0; Index < NumberOfBytes; Index++)
     {
          if ((Index == 106) || (Index == 107) || (Index == 112))
          {
               continue;
          }
          Checksum =
           ((Checksum&1) ? 0x80000000 : 0) + (Checksum>>1) + (UInt32)Sectors[Index];
     }

     return Checksum;
}
```

5.2.5. File Allocation Table

In a legacy FAT volume (FAT12, FAT16, and FAT32), the File Allocation Table maintained both the cluster chain information and the record of the allocation state of all clusters. However, in an exFAT volume, the File Allocation Table maintains only the cluster chain information and an Allocation Bitmap maintains the record of the allocation state of all clusters. This is a significant difference between them.

The File Allocation Table consists of 32-bit FAT Entries. Each FAT Entry value is described in the following table.

FAT Entry Value (exFAT)	Contents
00000000h	Indicates that the corresponding cluster is not in use and may be allocated to a file or a directory.
00000002h to ClusterCount+1	Indicates that the corresponding cluster is already allocated. The value of the entry is the cluster number of the next cluster following this corresponding cluster.
ClusterCount+2 to FFFFFFF6h	Shall be reserved for future standardization and shall not be used.
FFFFFFF7h	Indicates that the corresponding cluster has a defective cluster.
FFFFFFF8h to FFFFFFFEh	Shall be reserved for future standardization and shall not be used.
FFFFFFFFh	The corresponding cluster is already allocated, and it is the final cluster of the file.

Table 5-10 : FAT Entry Value

The first two entries (8 bytes) in the FAT are reserved. These 8 bytes of the FAT shall be recorded as F8h (BP 0), FFh (BP 1), FFh (BP 2), FFh (BP 3), FFh (BP 4), FFh (BP 5), FFh (BP 6) and FFh (BP 7).

The sectors of the FAT may include unused area after the all available FAT Entries. The contents of this field are undefined.

5.2.6. Cluster Heap

The Cluster Heap shall consist of some clusters. Each consecutive series of sectors describes one cluster, as the SectorsPerClusterShift field defines. Importantly, the first cluster of the Cluster Heap is corresponding to Cluster Number 2.

In an exFAT volume, an Allocation Bitmap maintains the record of the allocation state of all clusters. This is a significant difference from exFAT's predecessors (FAT12, FAT16, and FAT32), in which a FAT maintained a record of the allocation state of all clusters in the Cluster Heap.

5.2.7. Directory Structure

5.2.7.1. Generic DirectoryEntry Template

The Generic DirectoryEntry template provides the base definition for directory entries (see Table 5-11). The ability to interpret the Generic DirectoryEntry template is mandatory.

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	19	CustomDefined	Not Restricted
20	4	FirstCluster	Numeric Value
24	8	DataLength	Numeric Value

Table 5-11 : Generic DirectoryEntry Template

(BP 0) EntryType

This field shall have three modes of usage which the value of the field defines (see list below).

- 00h, which is an end-of-directory marker and the following conditions apply:
  - All other fields in the given DirectoryEntry are actually reserved
  - All subsequent directory entries in the given directory also are end-of-directory markers
  - End-of-directory markers are only valid outside directory entry sets
  - Implementations may overwrite end-of-directory markers as necessary

- Between 01h and 7Fh inclusively, which is an unused-directory-entry marker and the following conditions apply:
  - All other fields in the given DirectoryEntry are actually undefined
  - Unused directory entries are only valid outside of directory entry sets
  - Implementations may overwrite unused directory entries as necessary
  - This range of values corresponds to the InUse field containing the value 0

- Between 81h and FFh inclusively, which is a regular directory entry and the following conditions apply:
  - The contents of the EntryType field (see Table 5-12) determine the layout of the remainder of the DirectoryEntry structure
  - This range of values, and only this range of values, are valid inside a directory entry set
  - This range of values directly corresponds to the InUse field containing the value 1

To prevent modifications to the InUse field erroneously resulting in an end-of-directory marker, the value 80h is invalid.

Field Name	Offset(bit)	Size(bits)	Comments
TypeCode	0	5	This field partially describes the specific type of the given directory entry.
TypeImportance	5	1	This field describes the importance of the given directory entry.
TypeCategory	6	1	This field describes the category of the given directory entry.
InUse	7	1	This field describes whether the given directory entry in use or not.

Table 5-12 : Generic EntryType

(TypeCode)
This field shall partially describe the specific type of the given directory entry. This field, plus the TypeImportance and TypeCategory fields uniquely identify the type of the given directory entry. All possible values of this field are valid, unless the TypeImportance and TypeCategory fields both contain the value 0; in that case, the value 0 is invalid for this field.

(TypeImportance)
This field shall describe the importance of the given directory entry. The valid values for this field are:

- 0, which means the given directory entry is critical
- 1, which means the given directory entry is benign

(TypeCategory)
This field shall describe the category of the given directory entry. The valid values for this field are:

- 0, which means the given directory entry is primary
- 1, which means the given directory entry is secondary

(InUse)
This field shall describe whether the given directory entry in use or not. The valid values for this field are:

- 0, which means the given directory entry is not in use; this means the given structure actually is an unused directory entry
- 1, which means the given directory entry is in use; this means the given structure is a regular directory entry

(BP 1 to 19) CustomDefined
The content of this field shall be defined by the structures which derive from this template.

(BP 20 to 23) FirstCluster
This field shall contain the index of the first cluster of an allocation in the Cluster Heap associated with the given directory entry. If no cluster allocation exists, this field shall be recorded as the number 0.
Structures which derive from this template may redefine both the FirstCluster and DataLength fields, if a cluster allocation is not compatible with the derivative structure.

(BP 24 to 31) DataLength
This field shall describe the size, in bytes, of the data the associated cluster allocation contains. If the

FirstCluster field contains the value 0, this field shall be recorded as the number 0.
Structures which derive from this template may redefine both the FirstCluster and DataLength fields, if a cluster allocation is not possible for the derivative structure.

5.2.7.2. Generic Primary DirectoryEntry Template

The first directory entry in a directory entry set is a primary directory entry. All subsequent directory entries, if any, in the directory entry set are secondary directory entries (see Section 5.2.7.3). The ability to interpret the Generic Primary DirectoryEntry template is mandatory.
All primary directory entry structures derive from the Generic Primary DirectoryEntry template (see Table 5-13), which derives from the Generic DirectoryEntry template (see Section 5.2.7.1).

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	SecondaryCount	Numeric Value
2	2	SetChecksum	Numeric Value
4	2	GeneralPrimaryFlags	Numeric Value
6	14	CustomDefined	Not Restricted
20	4	FirstCluster	Numeric Value
24	8	DataLength	Numeric Value

Table 5-13 : Generic Primary DirectoryEntry Template

(BP 0) EntryType
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1).

(TypeCode)
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1).

(TypeImportance)
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1).

- **Critical Primary Directory Entries**
  Critical primary directory entries shall contain information which is critical to the proper management of an exFAT volume. Only the root directory shall contain critical primary directory entries (File directory entries are an exception, see Section 5.2.8.4).
  The definition of critical primary directory entries correlates to the major exFAT revision number. Implementations shall support all critical primary directory entries and shall only record the critical primary directory entry structures this specification defines.

- **Benign Primary Directory Entries**
  Benign primary directory entries shall contain additional information which may be useful for managing an exFAT volume. Any directory may contain benign primary directory entries.
  The definition of benign primary directory entries correlates to the minor exFAT revision number. Support for any benign primary directory entry this specification, or any subsequent specification, defines is optional. An unrecognized benign primary directory entry renders the entire directory entry set as unrecognized (beyond the definition of the applicable directory entry templates).

(TypeCategory)
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1). This field shall be recorded as 0.

(InUse)
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1).

(BP 1) SecondaryCount
This field shall describe the number of secondary directory entries which immediately follow the given primary directory entry. These secondary directory entries, along with the given primary directory entry, comprise the directory entry set. If this field is recorded as 0, it means this primary directory entry is the only entry in the directory entry set. The maximum value of this field is 255.
Critical primary directory entry structures which derive from this template may redefine both the SecondaryCount and SetChecksum fields.

(BP 2 and 3) SetChecksum
This field shall contain the checksum of all directory entries in the given directory entry set. However, the checksum excludes this field. Implementations shall verify the contents of this field are valid prior to using any other directory entry in the given directory entry set.
Critical primary directory entry structures which derive from this template may redefine both the SecondaryCount and SetChecksum fields.

The below algorithm describes the logic used to generate the checksum value:

```
UInt16 EntrySetChecksum
(
     UCHAR *    Entries, // points to an in-memory copy of the directory entry set
     UCHAR      SecondaryCount
)
{
     UInt16     NumberOfBytes = ((UInt16)SecondaryCount + 1) * 32;
     UInt16     Checksum = 0;
     UInt16     Index;

     for (Index = 0; Index < NumberOfBytes; Index++)
     {
          if ((Index == 2) || (Index == 3))
          {
               continue;
          }
          Checksum =
           ((Checksum&1) ? 0x8000 : 0) + (Checksum>>1) + (UInt16)Entries[Index];
     }

     return Checksum;
}
```

(BP 4 and 5) GeneralPrimaryFlags
This field shall contain flags (see Table 5-14). Critical primary directory entry structures which derive from this template may redefine this field.

Field Name	Offset(bit)	Size(bits)	Comments
AllocationPossible	0	1	This field describes whether or not an allocation in the Cluster Heap is possible for the given directory entry.
NoFatChain	1	1	This field describes whether or not the active FAT describes the given allocation's cluster chain.
CustomDefined	2	14	The content of this field shall be defined by the structures which derive from this template.

Table 5-14 : GeneralPrimaryFlags

(AllocationPossible)
This field shall describe whether or not an allocation in the Cluster Heap is possible for the given directory entry. The valid values for this field are:

- 0, which means an associated allocation of clusters is not possible and the FirstCluster and DataLength fields are actually undefined (structures which derive from this template may redefine those fields)
- 1, which means an associated allocation of clusters is possible and the FirstCluster and DataLength fields are as defined

(NoFatChain)
This field shall indicate whether or not the active FAT describes the given allocation's cluster chain. The valid values for this field are:

- 0, which means the corresponding FAT entries for the allocation's cluster chain are valid and implementations shall interpret them; if the AllocationPossible field contains the value 0, or if the AllocationPossible field contains the value 1 and the FirstCluster field contains the value 0, then this field's only valid value is 0
- 1, which means the associated allocation is one contiguous series of clusters; the corresponding FAT entries for the clusters are invalid and implementations shall not interpret them; implementations may use the following equation to calculate the size of the associated allocation:

$$\text{DataLength} / (2^{\text{SectorsPerClusterShift}} * 2^{\text{BytesPerSectorShift}}) \text{ rounded up to the nearest integer}$$

If critical primary directory entry structures which derive from this template redefine the GeneralPrimaryFlags field, then the corresponding FAT entries for any associated allocation's cluster chain are valid.

(CustomDefined)
The content of this flags shall be defined by the structures which derive from this template.

(BP 6 to 19) CustomDefined
The content of this field shall be defined by the structures which derive from this template.

(BP 20 to 23) FirstCluster
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1). Critical primary directory entry structures which derive from this template may redefine the FirstCluster and DataLength fields. Other structures which derive from this template may redefine the

FirstCluster and DataLength fields only if the AllocationPossible field contains the value 0.

(BP 24 to 31) DataLength
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1). Critical primary directory entry structures which derive from this template may redefine the FirstCluster and DataLength fields. Other structures which derive from this template may redefine the FirstCluster and DataLength fields only if the AllocationPossible field contains the value 0.

5.2.7.3. Generic Secondary DirectoryEntry Template

The central purpose of secondary directory entries is to provide additional information about a directory entry set. The ability to interpret the Generic Secondary DirectoryEntry template is mandatory.
The definition of both critical and benign secondary directory entries correlates to the minor exFAT revision number. Support for any critical or benign secondary directory entry this specification, or subsequent specifications, defines is optional.
All secondary directory entry structures derive from the Generic Secondary DirectoryEntry template (see Table 5-15), which derives from the Generic DirectoryEntry template (see Section 5.2.7.1).

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	GeneralSecondaryFlags	8bits
2	18	CustomDefined	Not Restricted
20	4	FirstCluster	Numeric Value
24	8	DataLength	Numeric Value

Table 5-15 : Generic Secondary DirectoryEntry Template

(BP 0) EntryType
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1).

(TypeCode)
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1).

(TypeImportance)
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1).

- **Critical Secondary Directory Entries**
  Critical secondary directory entries shall contain information which is critical to the proper management of its containing directory entry set. While support for any specific critical secondary directory entry is optional, an unrecognized critical directory entry renders the entire directory entry set as unrecognized (beyond the definition of the applicable directory entry templates).
  However, if a directory entry set contains at least one critical secondary directory entry which an implementation does not recognize, then the implementation shall at most interpret the templates of the directory entries in the directory entry set and not the data any allocation associated with any directory entry in the directory entry set contains (File directory entries are an exception, see Section 5.2.8.4).

- **Benign Secondary Directory Entries**
  Benign secondary directory entries shall contain additional information which may be

useful for managing its containing directory entry set. Support for any specific benign secondary directory entry is optional. Unrecognized benign secondary directory entries do not render the entire directory entry set as unrecognized.
Implementations may ignore any benign secondary entry it does not recognize.

(TypeCategory)
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1). This field shall be recorded as 1.

(InUse)
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1).

(BP 1) GeneralSecondaryFlags
This field shall contain flags (see Table 5-16).

Field Name	Offset(bit)	Size(bits)	Comments
AllocationPossible	0	1	This field describes whether or not an allocation in the Cluster Heap is possible for the given directory entry.
NoFatChain	1	1	This field describes whether or not the active FAT describes the given allocation's cluster chain.
CustomDefined	2	6	The content of this field shall be defined by the structures which derive from this template.

Table 5-16 : GeneralSecondaryFlags

(AllocationPossible)
This field shall have the same definition as the similarly-named field in the Generic Primary DirectoryEntry template (see Section 5.2.7.2).

(NoFatChain)
This field shall have the same definition as the similarly-named field in the Generic Primary DirectoryEntry template (see Section 5.2.7.2).

(CustomDefined)
The content of this field shall be defined by the structures which derive from this template.

(BP 2 to 19) CustomDefined
The content of this field shall be defined by the structures which derive from this template.

(BP 20 to 23) FirstCluster
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1).

(BP 24 to 31) DataLength
This field shall conform to the definition the Generic DirectoryEntry template provides (see Section 5.2.7.1).

5.2.8. Directory Entry Definitions

Revision 1.00 of the exFAT file system defines the following directory entries:

- Critical primary
  - Allocation Bitmap
  - Up-case Table
  - Volume Label
  - File
- Benign primary
  - Volume GUID
  - TexFAT Padding
  - Windows CE Access Control Table
- Critical secondary
  - Stream Extension
  - File Name
  - Windows CE Access Control
- Benign secondary
  - Vendor Extension
    - Continuous Information Manage
  - Vendor Allocation
    - Continuous Information

5.2.8.1. Allocation Bitmap Directory Entry

In the exFAT file system, a FAT does not describe allocation state of clusters; rather, an Allocation Bitmap does. Allocation Bitmaps exist in the Cluster Heap and have corresponding critical primary directory entries in the root directory (see Table 5-17).

The NumberOfFats field determines the number of valid Allocation Bitmap directory entries in the root directory. If the NumberOfFats field contains the value 1, then the only valid number of Allocation Bitmap directory entries is 1. Further, the one Allocation Bitmap directory entry is only valid if it describes the First Allocation Bitmap. If the NumberOfFats field contains the value 2, then the only valid number of Allocation Bitmap directory entries is 2. Further, the two Allocation Bitmap directory entries are only valid if one describes the First Allocation Bitmap and the other describes the Second Allocation Bitmap.

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	BitmapFlags	8bits
2	18	Reserved	All 00h
20	4	FirstCluster	Numeric Value
24	8	DataLength	Numeric Value

Table 5-17 : Allocation Bitmap DirectoryEntry

(BP 0) EntryType

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 81h.

(TypeCode)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 1.

(TypeImportance)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(TypeCategory)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(InUse)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 1.

(BP 1) BitmapFlags
This field shall contain flags (see Table 5-18).

Field Name	Offset(bit)	Size(bits)	Comments
BitmapIdentifier	0	1	This field describes whether or not an allocation in the Cluster Heap is possible for the given directory entry.
Reserved	1	7	This field is reserved.

Table 5-18 : BitmapFlags

(BitmapIdentifier)
This field shall indicate which Allocation Bitmap the given directory entry describes. Implementations shall use the First Allocation Bitmap in conjunction with the First FAT and shall use the Second Allocation Bitmap in conjunction with the Second FAT. The ActiveFat field describes which FAT and Allocation Bitmap are active. The valid values for this field are:

- 0, which means the given directory entry describes the First Allocation Bitmap
- 1, which means the given directory entry describes the Second Allocation Bitmap and is possible only when NumberOfFats contains the value 2

(Reserved)
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 2 to 19) Reserved
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 20 to 23) FirstCluster
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2).
This field shall contain the index of the first cluster of the cluster chain, as the FAT describes, which hosts the Allocation Bitmap.

(BP 24 to 31) DataLength
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2).

[Allocation Bitmap]
An Allocation Bitmap records the allocation state of the clusters in the Cluster Heap. Each bit in an Allocation Bitmap indicates whether its corresponding cluster is available for allocation or not.

An Allocation Bitmap represents clusters from lowest to highest index (see Table 5-19). For historical reasons, the first cluster has index 2. Note: the first bit in the bitmap is the lowest-order bit of the first byte.

Field Name	Offset(bit)	Size(bits)	Comments
BitmapEntry[2]	0	1	This field corresponds to the first cluster in the Cluster Heap.
:	:	:	:
BitmapEntry[ClusterCount+1]	ClusterCount -1	1	This field corresponds to the last cluster in the Cluster Heap.
Reserved	ClusterCount	(DataLength * 8) - ClusterCount	This field, if any, shall be reserved.

Table 5-19 : Allocation Bitmap

Each BitmapEntry field in this array represents a cluster in the Cluster Heap. BitmapEntry[2] represents the first cluster in the Cluster Heap and BitmapEntry[ClusterCount+1] represents the last cluster in the Cluster Heap. The valid values for these fields are:

- 0, which describes the corresponding cluster as available for allocation
- 1, which describes the corresponding cluster as not available for allocation (a cluster allocation may already consume the corresponding cluster or the active FAT may describe the corresponding cluster as bad)

5.2.8.2. Up-case Table Directory Entry

The Up-case Table defines the conversion from lower-case to upper-case characters. This is important due to the File Name directory entry (see Section 5.2.8.9) using Unicode characters and the exFAT file system being case insensitive and case preserving. The Up-case Table exists in the Cluster Heap and has a corresponding critical primary directory entry in the root directory (see Table 5-20). The valid number of Up-case Table directory entries is 1.
Due to the relationship between the Up-case Table and file names, implementations should not modify the Up-case Table, except as a result of format operations.

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	3	Reserved1	All 00h
4	4	TableChecksum	Numeric Value
8	12	Reserved2	All 00h
20	4	FirstCluster	Numeric Value
24	8	DataLength	Numeric Value

Table 5-20 : Up-case Table DirectoryEntry

(BP 0) EntryType
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 82h.

(TypeCode)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see

Section 5.2.7.2). This field shall be recorded as 2.

(TypeImportance)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(TypeCategory)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(InUse)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 1.

(BP 1 to 3) Reserved1
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 4 and 7) TableChecksum
This field shall contain the checksum of the Up-case Table (which the FirstCluster and DataLength fields describe). Implementations shall verify the contents of this field are valid prior to using the Up-case Table.

The below algorithm describes the logic used to generate the checksum value:

```
UInt32 TableChecksum
(
     UCHAR *    Table, // points to an in-memory copy of the up-case table
     UInt64     DataLength
)
{
     UInt32     Checksum = 0;
     UInt64     Index;

     for (Index = 0; Index < DataLength; Index++)
     {
          Checksum =
           ((Checksum&1) ? 0x80000000 : 0) + (Checksum>>1) + (UInt32)Table[Index];
     }

     return Checksum;
}
```

(BP 8 to 19) Reserved2
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 20 to 23) FirstCluster
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2).
This field shall contain the index of the first cluster of the cluster chain, as the FAT describes, which hosts the Up-case Table.

(BP 24 to 31) DataLength
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2).

[Up-case Table]

The Up-case Table is a series of Unicode character mappings. A character mapping consists of a 2-byte field, with the index of the field in the Up-case Table representing the Unicode character to be up-cased, and the 2-byte field representing the up-cased Unicode character.

The first 128 Unicode characters have mandatory mappings (see Table 5-21). An Up-case Table which has any other character mapping for any of the first 128 Unicode characters is invalid.

Implementations which only support characters from the mandatory mapping range may ignore the mappings of the rest of the Up-case Table. Such implementations shall only use characters from the mandatory mapping range when creating or renaming files (via the File Name directory entry, see Section 5.2.8.9). When up-casing existing file names, such implementations shall not up-case characters from the non-mandatory mapping range, but shall leave them intact in the resulting up-cased file name (this is a partial up-casing). When comparing file names, such implementations shall treat file names which differ from the name under comparison only by Unicode characters from the non-mandatory mapping range as equivalent. While such file names are only potentially equivalent, such implementations cannot ensure the fully up-cased file name does not collide with the name under comparison.

Table Index	Table Entries							
	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7
0000h	0000h	0001h	0002h	0003h	0004h	0005h	0006h	0007h
0008h	0008h	0009h	000Ah	000Bh	000Ch	000Dh	000Eh	000Fh
0010h	0010h	0011h	0012h	0013h	0014h	0015h	0016h	0017h
0018h	0018h	0019h	001Ah	001Bh	001Ch	001Dh	001Eh	001Fh
0020h	0020h	0021h	0022h	0023h	0024h	0025h	0026h	0027h
0028h	0028h	0029h	002Ah	002Bh	002Ch	002Dh	002Eh	002Fh
0030h	0030h	0031h	0032h	0033h	0034h	0035h	0036h	0037h
0038h	0038h	0039h	003Ah	003Bh	003Ch	003Dh	003Eh	003Fh
0040h	0040h	0041h	0042h	0043h	0044h	0045h	0046h	0047h
0048h	0048h	0049h	004Ah	004Bh	004Ch	004Dh	004Eh	004Fh
0050h	0050h	0051h	0052h	0053h	0054h	0055h	0056h	0057h
0058h	0058h	0059h	005Ah	005Bh	005Ch	005Dh	005Eh	005Fh
0060h	0060h	**0041h**	**0042h**	**0043h**	**0044h**	**0045h**	**0046h**	**0047h**
0068h	**0048h**	**0049h**	**004Ah**	**004Bh**	**004Ch**	**004Dh**	**004Eh**	**004Fh**
0070h	**0050h**	**0051h**	**0052h**	**0053h**	**0054h**	**0055h**	**0056h**	**0057h**
0078h	**0058h**	**0059h**	**005Ah**	007Bh	007Ch	007Dh	007Eh	007Fh

Table 5-21 : Mandatory First 128 Up-case Table Entries

Upon formatting a volume, implementations may generate the Up-case Table in a compressed format using identity-mapping compression, since a large portion of the Unicode character space has no concept of case (which means the “lower-case” and “upper-case” characters are equivalent). Implementations compress the Up-case Table by representing a series of identity mappings with the value FFFFh followed with the number of identity mappings.

For example, an implementation may represent the first 100 (64h) character mappings with the following eight entries of a compressed Up-case Table:

FFFFh, 0061h, 0041h, 0042h, 0043h

The first two entries indicate the first 97 (61h) characters (from 0000h to 0060h) have identity mappings. The subsequent characters, 0061h through 0063h, map to characters 0041h through 0043h, respectively.

The ability to provide a compressed Up-case Table upon formatting a volume is optional. However, the ability to interpret both an uncompressed and a compressed Up-case Table is mandatory. The value of the TableChecksum field is always of how an up-case table exists on the volume, which may be either compressed or uncompressed format.

5.2.8.2.1. Recommended Up-case Table

When formatting a volume, implementations should record the recommended up-case table in compressed format (see Table 5-22), for which the value of the TableChecksum field is E619D30Dh.

Table Index	Table Entries							
	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7
0000h	0000h	0001h	0002h	0003h	0004h	0005h	0006h	0007h
0008h	0008h	0009h	000Ah	000Bh	000Ch	000Dh	000Eh	000Fh
0010h	0010h	0011h	0012h	0013h	0014h	0015h	0016h	0017h
0018h	0018h	0019h	001Ah	001Bh	001Ch	001Dh	001Eh	001Fh
0020h	0020h	0021h	0022h	0023h	0024h	0025h	0026h	0027h
0028h	0028h	0029h	002Ah	002Bh	002Ch	002Dh	002Eh	002Fh
0030h	0030h	0031h	0032h	0033h	0034h	0035h	0036h	0037h
0038h	0038h	0039h	003Ah	003Bh	003Ch	003Dh	003Eh	003Fh
0040h	0040h	0041h	0042h	0043h	0044h	0045h	0046h	0047h
0048h	0048h	0049h	004Ah	004Bh	004Ch	004Dh	004Eh	004Fh
0050h	0050h	0051h	0052h	0053h	0054h	0055h	0056h	0057h
0058h	0058h	0059h	005Ah	005Bh	005Ch	005Dh	005Eh	005Fh
0060h	0060h	0041h	0042h	0043h	0044h	0045h	0046h	0047h
0068h	0048h	0049h	004Ah	004Bh	004Ch	004Dh	004Eh	004Fh
0070h	0050h	0051h	0052h	0053h	0054h	0055h	0056h	0057h
0078h	0058h	0059h	005Ah	007Bh	007Ch	007Dh	007Eh	007Fh
0080h	0080h	0081h	0082h	0083h	0084h	0085h	0086h	0087h
0088h	0088h	0089h	008Ah	008Bh	008Ch	008Dh	008Eh	008Fh
0090h	0090h	0091h	0092h	0093h	0094h	0095h	0096h	0097h
0098h	0098h	0099h	009Ah	009Bh	009Ch	009Dh	009Eh	009Fh
00A0h	00A0h	00A1h	00A2h	00A3h	00A4h	00A5h	00A6h	00A7h
00A8h	00A8h	00A9h	00AAh	00ABh	00ACh	00ADh	00AEh	00AFh
00B0h	00B0h	00B1h	00B2h	00B3h	00B4h	00B5h	00B6h	00B7h
00B8h	00B8h	00B9h	00BAh	00BBh	00BCh	00BDh	00BEh	00BFh
00C0h	00C0h	00C1h	00C2h	00C3h	00C4h	00C5h	00C6h	00C7h
00C8h	00C8h	00C9h	00CAh	00CBh	00CCh	00CDh	00CEh	00CFh
00D0h	00D0h	00D1h	00D2h	00D3h	00D4h	00D5h	00D6h	00D7h
00D8h	00D8h	00D9h	00DAh	00DBh	00DCh	00DDh	00DEh	00DFh
00E0h	00C0h	00C1h	00C2h	00C3h	00C4h	00C5h	00C6h	00C7h
00E8h	00C8h	00C9h	00CAh	00CBh	00CCh	00CDh	00CEh	00CFh
00F0h	00D0h	00D1h	00D2h	00D3h	00D4h	00D5h	00D6h	00F7h
00F8h	00D8h	00D9h	00DAh	00DBh	00DCh	00DDh	00DEh	0178h
0100h	0100h	0100h	0102h	0102h	0104h	0104h	0106h	0106h
0108h	0108h	0108h	010Ah	010Ah	010Ch	010Ch	010Eh	010Eh
0110h	0110h	0110h	0112h	0112h	0114h	0114h	0116h	0116h
0118h	0118h	0118h	011Ah	011Ah	011Ch	011Ch	011Eh	011Eh
0120h	0120h	0120h	0122h	0122h	0124h	0124h	0126h	0126h
0128h	0128h	0128h	012Ah	012Ah	012Ch	012Ch	012Eh	012Eh
0130h	0130h	0131h	0132h	0132h	0134h	0134h	0136h	0136h

Table Index	Table Entries							
	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7
0138h	0138h	0139h	0139h	013Bh	013Bh	013Dh	013Dh	013Fh
0140h	013Fh	0141h	0141h	0143h	0143h	0145h	0145h	0147h
0148h	0147h	0149h	014Ah	014Ah	014Ch	014Ch	014Eh	014Eh
0150h	0150h	0150h	0152h	0152h	0154h	0154h	0156h	0156h
0158h	0158h	0158h	015Ah	015Ah	015Ch	015Ch	015Eh	015Eh
0160h	0160h	0160h	0162h	0162h	0164h	0164h	0166h	0166h
0168h	0168h	0168h	016Ah	016Ah	016Ch	016Ch	016Eh	016Eh
0170h	0170h	0170h	0172h	0172h	0174h	0174h	0176h	0176h
0178h	0178h	0179h	0179h	017Bh	017Bh	017Dh	017Dh	017Fh
0180h	0243h	0181h	0182h	0182h	0184h	0184h	0186h	0187h
0188h	0187h	0189h	018Ah	018Bh	018Bh	018Dh	018Eh	018Fh
0190h	0190h	0191h	0191h	0193h	0194h	01F6h	0196h	0197h
0198h	0198h	0198h	023Dh	019Bh	019Ch	019Dh	0220h	019Fh
01A0h	01A0h	01A0h	01A2h	01A2h	01A4h	01A4h	01A6h	01A7h
01A8h	01A7h	01A9h	01AAh	01ABh	01ACh	01ACh	01AEh	01AFh
01B0h	01AFh	01B1h	01B2h	01B3h	01B3h	01B5h	01B5h	01B7h
01B8h	01B8h	01B8h	01BAh	01BBh	01BCh	01BCh	01BEh	01F7h
01C0h	01C0h	01C1h	01C2h	01C3h	01C4h	01C5h	01C4h	01C7h
01C8h	01C8h	01C7h	01CAh	01CBh	01CAh	01CDh	01CDh	01CFh
01D0h	01CFh	01D1h	01D1h	01D3h	01D3h	01D5h	01D5h	01D7h
01D8h	01D7h	01D9h	01D9h	01DBh	01DBh	018Eh	01DEh	01DEh
01E0h	01E0h	01E0h	01E2h	01E2h	01E4h	01E4h	01E6h	01E6h
01E8h	01E8h	01E8h	01EAh	01EAh	01ECh	01ECh	01EEh	01EEh
01F0h	01F0h	01F1h	01F2h	01F1h	01F4h	01F4h	01F6h	01F7h
01F8h	01F8h	01F8h	01FAh	01FAh	01FCh	01FCh	01FEh	01FEh
0200h	0200h	0200h	0202h	0202h	0204h	0204h	0206h	0206h
0208h	0208h	0208h	020Ah	020Ah	020Ch	020Ch	020Eh	020Eh
0210h	0210h	0210h	0212h	0212h	0214h	0214h	0216h	0216h
0218h	0218h	0218h	021Ah	021Ah	021Ch	021Ch	021Eh	021Eh
0220h	0220h	0221h	0222h	0222h	0224h	0224h	0226h	0226h
0228h	0228h	0228h	022Ah	022Ah	022Ch	022Ch	022Eh	022Eh
0230h	0230h	0230h	0232h	0232h	0234h	0235h	0236h	0237h
0238h	0238h	0239h	2C65h	023Bh	023Bh	023Dh	2C66h	023Fh
0240h	0240h	0241h	0241h	0243h	0244h	0245h	0246h	0246h
0248h	0248h	0248h	024Ah	024Ah	024Ch	024Ch	024Eh	024Eh
0250h	0250h	0251h	0252h	0181h	0186h	0255h	0189h	018Ah
0258h	0258h	018Fh	025Ah	0190h	025Ch	025Dh	025Eh	025Fh
0260h	0193h	0261h	0262h	0194h	0264h	0265h	0266h	0267h
0268h	0197h	0196h	026Ah	2C62h	026Ch	026Dh	026Eh	019Ch
0270h	0270h	0271h	019Dh	0273h	0274h	019Fh	0276h	0277h
0278h	0278h	0279h	027Ah	027Bh	027Ch	2C64h	027Eh	027Fh
0280h	01A6h	0281h	0282h	01A9h	0284h	0285h	0286h	0287h
0288h	01AEh	0244h	01B1h	01B2h	0245h	028Dh	028Eh	028Fh
0290h	0290h	0291h	01B7h	0293h	0294h	0295h	0296h	0297h
0298h	0298h	0299h	029Ah	029Bh	029Ch	029Dh	029Eh	029Fh

Table Index	Table Entries							
	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7
02A0h	02A0h	02A1h	02A2h	02A3h	02A4h	02A5h	02A6h	02A7h
02A8h	02A8h	02A9h	02AAh	02ABh	02ACh	02ADh	02AEh	02AFh
02B0h	02B0h	02B1h	02B2h	02B3h	02B4h	02B5h	02B6h	02B7h
02B8h	02B8h	02B9h	02BAh	02BBh	02BCh	02BDh	02BEh	02BFh
02C0h	02C0h	02C1h	02C2h	02C3h	02C4h	02C5h	02C6h	02C7h
02C8h	02C8h	02C9h	02CAh	02CBh	02CCh	02CDh	02CEh	02CFh
02D0h	02D0h	02D1h	02D2h	02D3h	02D4h	02D5h	02D6h	02D7h
02D8h	02D8h	02D9h	02DAh	02DBh	02DCh	02DDh	02DEh	02DFh
02E0h	02E0h	02E1h	02E2h	02E3h	02E4h	02E5h	02E6h	02E7h
02E8h	02E8h	02E9h	02EAh	02EBh	02ECh	02EDh	02EEh	02EFh
02F0h	02F0h	02F1h	02F2h	02F3h	02F4h	02F5h	02F6h	02F7h
02F8h	02F8h	02F9h	02FAh	02FBh	02FCh	02FDh	02FEh	02FFh
0300h	0300h	0301h	0302h	0303h	0304h	0305h	0306h	0307h
0308h	0308h	0309h	030Ah	030Bh	030Ch	030Dh	030Eh	030Fh
0310h	0310h	0311h	0312h	0313h	0314h	0315h	0316h	0317h
0318h	0318h	0319h	031Ah	031Bh	031Ch	031Dh	031Eh	031Fh
0320h	0320h	0321h	0322h	0323h	0324h	0325h	0326h	0327h
0328h	0328h	0329h	032Ah	032Bh	032Ch	032Dh	032Eh	032Fh
0330h	0330h	0331h	0332h	0333h	0334h	0335h	0336h	0337h
0338h	0338h	0339h	033Ah	033Bh	033Ch	033Dh	033Eh	033Fh
0340h	0340h	0341h	0342h	0343h	0344h	0345h	0346h	0347h
0348h	0348h	0349h	034Ah	034Bh	034Ch	034Dh	034Eh	034Fh
0350h	0350h	0351h	0352h	0353h	0354h	0355h	0356h	0357h
0358h	0358h	0359h	035Ah	035Bh	035Ch	035Dh	035Eh	035Fh
0360h	0360h	0361h	0362h	0363h	0364h	0365h	0366h	0367h
0368h	0368h	0369h	036Ah	036Bh	036Ch	036Dh	036Eh	036Fh
0370h	0370h	0371h	0372h	0373h	0374h	0375h	0376h	0377h
0378h	0378h	0379h	037Ah	03FDh	03FEh	03FFh	037Eh	037Fh
0380h	0380h	0381h	0382h	0383h	0384h	0385h	0386h	0387h
0388h	0388h	0389h	038Ah	038Bh	038Ch	038Dh	038Eh	038Fh
0390h	0390h	0391h	0392h	0393h	0394h	0395h	0396h	0397h
0398h	0398h	0399h	039Ah	039Bh	039Ch	039Dh	039Eh	039Fh
03A0h	03A0h	03A1h	03A2h	03A3h	03A4h	03A5h	03A6h	03A7h
03A8h	03A8h	03A9h	03AAh	03ABh	0386h	0388h	0389h	038Ah
03B0h	03B0h	0391h	0392h	0393h	0394h	0395h	0396h	0397h
03B8h	0398h	0399h	039Ah	039Bh	039Ch	039Dh	039Eh	039Fh
03C0h	03A0h	03A1h	03A3h	03A3h	03A4h	03A5h	03A6h	03A7h
03C8h	03A8h	03A9h	03AAh	03ABh	038Ch	038Eh	038Fh	03CFh
03D0h	03D0h	03D1h	03D2h	03D3h	03D4h	03D5h	03D6h	03D7h
03D8h	03D8h	03D8h	03DAh	03DAh	03DCh	03DCh	03DEh	03DEh
03E0h	03E0h	03E0h	03E2h	03E2h	03E4h	03E4h	03E6h	03E6h
03E8h	03E8h	03E8h	03EAh	03EAh	03ECh	03ECh	03EEh	03EEh
03F0h	03F0h	03F1h	03F9h	03F3h	03F4h	03F5h	03F6h	03F7h
03F8h	03F7h	03F9h	03FAh	03FAh	03FCh	03FDh	03FEh	03FFh
0400h	0400h	0401h	0402h	0403h	0404h	0405h	0406h	0407h

Table Index	Table Entries							
	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7
0408h	0408h	0409h	040Ah	040Bh	040Ch	040Dh	040Eh	040Fh
0410h	0410h	0411h	0412h	0413h	0414h	0415h	0416h	0417h
0418h	0418h	0419h	041Ah	041Bh	041Ch	041Dh	041Eh	041Fh
0420h	0420h	0421h	0422h	0423h	0424h	0425h	0426h	0427h
0428h	0428h	0429h	042Ah	042Bh	042Ch	042Dh	042Eh	042Fh
0430h	0410h	0411h	0412h	0413h	0414h	0415h	0416h	0417h
0438h	0418h	0419h	041Ah	041Bh	041Ch	041Dh	041Eh	041Fh
0440h	0420h	0421h	0422h	0423h	0424h	0425h	0426h	0427h
0448h	0428h	0429h	042Ah	042Bh	042Ch	042Dh	042Eh	042Fh
0450h	0400h	0401h	0402h	0403h	0404h	0405h	0406h	0407h
0458h	0408h	0409h	040Ah	040Bh	040Ch	040Dh	040Eh	040Fh
0460h	0460h	0460h	0462h	0462h	0464h	0464h	0466h	0466h
0468h	0468h	0468h	046Ah	046Ah	046Ch	046Ch	046Eh	046Eh
0470h	0470h	0470h	0472h	0472h	0474h	0474h	0476h	0476h
0478h	0478h	0478h	047Ah	047Ah	047Ch	047Ch	047Eh	047Eh
0480h	0480h	0480h	0482h	0483h	0484h	0485h	0486h	0487h
0488h	0488h	0489h	048Ah	048Ah	048Ch	048Ch	048Eh	048Eh
0490h	0490h	0490h	0492h	0492h	0494h	0494h	0496h	0496h
0498h	0498h	0498h	049Ah	049Ah	049Ch	049Ch	049Eh	049Eh
04A0h	04A0h	04A0h	04A2h	04A2h	04A4h	04A4h	04A6h	04A6h
04A8h	04A8h	04A8h	04AAh	04AAh	04ACh	04ACh	04AEh	04AEh
04B0h	04B0h	04B0h	04B2h	04B2h	04B4h	04B4h	04B6h	04B6h
04B8h	04B8h	04B8h	04BAh	04BAh	04BCh	04BCh	04BEh	04BEh
04C0h	04C0h	04C1h	04C1h	04C3h	04C3h	04C5h	04C5h	04C7h
04C8h	04C7h	04C9h	04C9h	04CBh	04CBh	04CDh	04CDh	04C0h
04D0h	04D0h	04D0h	04D2h	04D2h	04D4h	04D4h	04D6h	04D6h
04D8h	04D8h	04D8h	04DAh	04DAh	04DCh	04DCh	04DEh	04DEh
04E0h	04E0h	04E0h	04E2h	04E2h	04E4h	04E4h	04E6h	04E6h
04E8h	04E8h	04E8h	04EAh	04EAh	04ECh	04ECh	04EEh	04EEh
04F0h	04F0h	04F0h	04F2h	04F2h	04F4h	04F4h	04F6h	04F6h
04F8h	04F8h	04F8h	04FAh	04FAh	04FCh	04FCh	04FEh	04FEh
0500h	0500h	0500h	0502h	0502h	0504h	0504h	0506h	0506h
0508h	0508h	0508h	050Ah	050Ah	050Ch	050Ch	050Eh	050Eh
0510h	0510h	0510h	0512h	0512h	0514h	0515h	0516h	0517h
0518h	0518h	0519h	051Ah	051Bh	051Ch	051Dh	051Eh	051Fh
0520h	0520h	0521h	0522h	0523h	0524h	0525h	0526h	0527h
0528h	0528h	0529h	052Ah	052Bh	052Ch	052Dh	052Eh	052Fh
0530h	0530h	0531h	0532h	0533h	0534h	0535h	0536h	0537h
0538h	0538h	0539h	053Ah	053Bh	053Ch	053Dh	053Eh	053Fh
0540h	0540h	0541h	0542h	0543h	0544h	0545h	0546h	0547h
0548h	0548h	0549h	054Ah	054Bh	054Ch	054Dh	054Eh	054Fh
0550h	0550h	0551h	0552h	0553h	0554h	0555h	0556h	0557h
0558h	0558h	0559h	055Ah	055Bh	055Ch	055Dh	055Eh	055Fh
0560h	0560h	0531h	0532h	0533h	0534h	0535h	0536h	0537h
0568h	0538h	0539h	053Ah	053Bh	053Ch	053Dh	053Eh	053Fh

Table Index	Table Entries							
	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7
0570h	0540h	0541h	0542h	0543h	0544h	0545h	0546h	0547h
0578h	0548h	0549h	054Ah	054Bh	054Ch	054Dh	054Eh	054Fh
0580h	0550h	0551h	0552h	0553h	0554h	0555h	0556h	FFFFh
0588h	17F6h	2C63h	1D7Eh	1D7Fh	1D80h	1D81h	1D82h	1D83h
0590h	1D84h	1D85h	1D86h	1D87h	1D88h	1D89h	1D8Ah	1D8Bh
0598h	1D8Ch	1D8Dh	1D8Eh	1D8Fh	1D90h	1D91h	1D92h	1D93h
05A0h	1D94h	1D95h	1D96h	1D97h	1D98h	1D99h	1D9Ah	1D9Bh
05A8h	1D9Ch	1D9Dh	1D9Eh	1D9Fh	1DA0h	1DA1h	1DA2h	1DA3h
05B0h	1DA4h	1DA5h	1DA6h	1DA7h	1DA8h	1DA9h	1DAAh	1DABh
05B8h	1DACh	1DADh	1DAEh	1DAFh	1DB0h	1DB1h	1DB2h	1DB3h
05C0h	1DB4h	1DB5h	1DB6h	1DB7h	1DB8h	1DB9h	1DBAh	1DBBh
05C8h	1DBCh	1DBDh	1DBEh	1DBFh	1DC0h	1DC1h	1DC2h	1DC3h
05D0h	1DC4h	1DC5h	1DC6h	1DC7h	1DC8h	1DC9h	1DCAh	1DCBh
05D8h	1DCCh	1DCDh	1DCEh	1DCFh	1DD0h	1DD1h	1DD2h	1DD3h
05E0h	1DD4h	1DD5h	1DD6h	1DD7h	1DD8h	1DD9h	1DDAh	1DDBh
05E8h	1DDCh	1DDDh	1DDEh	1DDFh	1DE0h	1DE1h	1DE2h	1DE3h
05F0h	1DE4h	1DE5h	1DE6h	1DE7h	1DE8h	1DE9h	1DEAh	1DEBh
05F8h	1DECh	1DEDh	1DEEh	1DEFh	1DF0h	1DF1h	1DF2h	1DF3h
0600h	1DF4h	1DF5h	1DF6h	1DF7h	1DF8h	1DF9h	1DFAh	1DFBh
0608h	1DFCh	1DFDh	1DFEh	1DFFh	1E00h	1E00h	1E02h	1E02h
0610h	1E04h	1E04h	1E06h	1E06h	1E08h	1E08h	1E0Ah	1E0Ah
0618h	1E0Ch	1E0Ch	1E0Eh	1E0Eh	1E10h	1E10h	1E12h	1E12h
0620h	1E14h	1E14h	1E16h	1E16h	1E18h	1E18h	1E1Ah	1E1Ah
0628h	1E1Ch	1E1Ch	1E1Eh	1E1Eh	1E20h	1E20h	1E22h	1E22h
0630h	1E24h	1E24h	1E26h	1E26h	1E28h	1E28h	1E2Ah	1E2Ah
0638h	1E2Ch	1E2Ch	1E2Eh	1E2Eh	1E30h	1E30h	1E32h	1E32h
0640h	1E34h	1E34h	1E36h	1E36h	1E38h	1E38h	1E3Ah	1E3Ah
0648h	1E3Ch	1E3Ch	1E3Eh	1E3Eh	1E40h	1E40h	1E42h	1E42h
0650h	1E44h	1E44h	1E46h	1E46h	1E48h	1E48h	1E4Ah	1E4Ah
0658h	1E4Ch	1E4Ch	1E4Eh	1E4Eh	1E50h	1E50h	1E52h	1E52h
0660h	1E54h	1E54h	1E56h	1E56h	1E58h	1E58h	1E5Ah	1E5Ah
0668h	1E5Ch	1E5Ch	1E5Eh	1E5Eh	1E60h	1E60h	1E62h	1E62h
0670h	1E64h	1E64h	1E66h	1E66h	1E68h	1E68h	1E6Ah	1E6Ah
0678h	1E6Ch	1E6Ch	1E6Eh	1E6Eh	1E70h	1E70h	1E72h	1E72h
0680h	1E74h	1E74h	1E76h	1E76h	1E78h	1E78h	1E7Ah	1E7Ah
0688h	1E7Ch	1E7Ch	1E7Eh	1E7Eh	1E80h	1E80h	1E82h	1E82h
0690h	1E84h	1E84h	1E86h	1E86h	1E88h	1E88h	1E8Ah	1E8Ah
0698h	1E8Ch	1E8Ch	1E8Eh	1E8Eh	1E90h	1E90h	1E92h	1E92h
06A0h	1E94h	1E94h	1E96h	1E97h	1E98h	1E99h	1E9Ah	1E9Bh
06A8h	1E9Ch	1E9Dh	1E9Eh	1E9Fh	1EA0h	1EA0h	1EA2h	1EA2h
06B0h	1EA4h	1EA4h	1EA6h	1EA6h	1EA8h	1EA8h	1EAAh	1EAAh
06B8h	1EACh	1EACh	1EAEh	1EAEh	1EB0h	1EB0h	1EB2h	1EB2h
06C0h	1EB4h	1EB4h	1EB6h	1EB6h	1EB8h	1EB8h	1EBAh	1EBAh
06C8h	1EBCh	1EBCh	1EBEh	1EBEh	1EC0h	1EC0h	1EC2h	1EC2h
06D0h	1EC4h	1EC4h	1EC6h	1EC6h	1EC8h	1EC8h	1ECAh	1ECAh

Table Index	Table Entries							
	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7
06D8h	1ECCh	1ECCh	1ECEh	1ECEh	1ED0h	1ED0h	1ED2h	1ED2h
06E0h	1ED4h	1ED4h	1ED6h	1ED6h	1ED8h	1ED8h	1EDAh	1EDAh
06E8h	1EDCh	1EDCh	1EDEh	1EDEh	1EE0h	1EE0h	1EE2h	1EE2h
06F0h	1EE4h	1EE4h	1EE6h	1EE6h	1EE8h	1EE8h	1EEAh	1EEAh
06F8h	1EECh	1EECh	1EEEh	1EEEh	1EF0h	1EF0h	1EF2h	1EF2h
0700h	1EF4h	1EF4h	1EF6h	1EF6h	1EF8h	1EF8h	1EFAh	1EFBh
0708h	1EFCh	1EFDh	1EFEh	1EFFh	1F08h	1F09h	1F0Ah	1F0Bh
0710h	1F0Ch	1F0Dh	1F0Eh	1F0Fh	1F08h	1F09h	1F0Ah	1F0Bh
0718h	1F0Ch	1F0Dh	1F0Eh	1F0Fh	1F18h	1F19h	1F1Ah	1F1Bh
0720h	1F1Ch	1F1Dh	1F16h	1F17h	1F18h	1F19h	1F1Ah	1F1Bh
0728h	1F1Ch	1F1Dh	1F1Eh	1F1Fh	1F28h	1F29h	1F2Ah	1F2Bh
0730h	1F2Ch	1F2Dh	1F2Eh	1F2Fh	1F28h	1F29h	1F2Ah	1F2Bh
0738h	1F2Ch	1F2Dh	1F2Eh	1F2Fh	1F38h	1F39h	1F3Ah	1F3Bh
0740h	1F3Ch	1F3Dh	1F3Eh	1F3Fh	1F38h	1F39h	1F3Ah	1F3Bh
0748h	1F3Ch	1F3Dh	1F3Eh	1F3Fh	1F48h	1F49h	1F4Ah	1F4Bh
0750h	1F4Ch	1F4Dh	1F46h	1F47h	1F48h	1F49h	1F4Ah	1F4Bh
0758h	1F4Ch	1F4Dh	1F4Eh	1F4Fh	1F50h	1F59h	1F52h	1F5Bh
0760h	1F54h	1F5Dh	1F56h	1F5Fh	1F58h	1F59h	1F5Ah	1F5Bh
0768h	1F5Ch	1F5Dh	1F5Eh	1F5Fh	1F68h	1F69h	1F6Ah	1F6Bh
0770h	1F6Ch	1F6Dh	1F6Eh	1F6Fh	1F68h	1F69h	1F6Ah	1F6Bh
0778h	1F6Ch	1F6Dh	1F6Eh	1F6Fh	1FBAh	1FBBh	1FC8h	1FC9h
0780h	1FCAh	1FCBh	1FDAh	1FDBh	1FF8h	1FF9h	1FEAh	1FEBh
0788h	1FFAh	1FFBh	1F7Eh	1F7Fh	1F88h	1F89h	1F8Ah	1F8Bh
0790h	1F8Ch	1F8Dh	1F8Eh	1F8Fh	1F88h	1F89h	1F8Ah	1F8Bh
0798h	1F8Ch	1F8Dh	1F8Eh	1F8Fh	1F98h	1F99h	1F9Ah	1F9Bh
07A0h	1F9Ch	1F9Dh	1F9Eh	1F9Fh	1F98h	1F99h	1F9Ah	1F9Bh
07A8h	1F9Ch	1F9Dh	1F9Eh	1F9Fh	1FA8h	1FA9h	1FAAh	1FABh
07B0h	1FACh	1FADh	1FAEh	1FAFh	1FA8h	1FA9h	1FAAh	1FABh
07B8h	1FACh	1FADh	1FAEh	1FAFh	1FB8h	1FB9h	1FB2h	1FBCh
07C0h	1FB4h	1FB5h	1FB6h	1FB7h	1FB8h	1FB9h	1FBAh	1FBBh
07C8h	1FBCh	1FBDh	1FBEh	1FBFh	1FC0h	1FC1h	1FC2h	1FC3h
07D0h	1FC4h	1FC5h	1FC6h	1FC7h	1FC8h	1FC9h	1FCAh	1FCBh
07D8h	1FC3h	1FCDh	1FCEh	1FCFh	1FD8h	1FD9h	1FD2h	1FD3h
07E0h	1FD4h	1FD5h	1FD6h	1FD7h	1FD8h	1FD9h	1FDAh	1FDBh
07E8h	1FDCh	1FDDh	1FDEh	1FDFh	1FE8h	1FE9h	1FE2h	1FE3h
07F0h	1FE4h	1FECh	1FE6h	1FE7h	1FE8h	1FE9h	1FEAh	1FEBh
07F8h	1FECh	1FEDh	1FEEh	1FEFh	1FF0h	1FF1h	1FF2h	1FF3h
0800h	1FF4h	1FF5h	1FF6h	1FF7h	1FF8h	1FF9h	1FFAh	1FFBh
0808h	1FF3h	1FFDh	1FFEh	1FFFh	2000h	2001h	2002h	2003h
0810h	2004h	2005h	2006h	2007h	2008h	2009h	200Ah	200Bh
0818h	200Ch	200Dh	200Eh	200Fh	2010h	2011h	2012h	2013h
0820h	2014h	2015h	2016h	2017h	2018h	2019h	201Ah	201Bh
0828h	201Ch	201Dh	201Eh	201Fh	2020h	2021h	2022h	2023h
0830h	2024h	2025h	2026h	2027h	2028h	2029h	202Ah	202Bh
0838h	202Ch	202Dh	202Eh	202Fh	2030h	2031h	2032h	2033h

Table Index	Table Entries							
	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7
0840h	2034h	2035h	2036h	2037h	2038h	2039h	203Ah	203Bh
0848h	203Ch	203Dh	203Eh	203Fh	2040h	2041h	2042h	2043h
0850h	2044h	2045h	2046h	2047h	2048h	2049h	204Ah	204Bh
0858h	204Ch	204Dh	204Eh	204Fh	2050h	2051h	2052h	2053h
0860h	2054h	2055h	2056h	2057h	2058h	2059h	205Ah	205Bh
0868h	205Ch	205Dh	205Eh	205Fh	2060h	2061h	2062h	2063h
0870h	2064h	2065h	2066h	2067h	2068h	2069h	206Ah	206Bh
0878h	206Ch	206Dh	206Eh	206Fh	2070h	2071h	2072h	2073h
0880h	2074h	2075h	2076h	2077h	2078h	2079h	207Ah	207Bh
0888h	207Ch	207Dh	207Eh	207Fh	2080h	2081h	2082h	2083h
0890h	2084h	2085h	2086h	2087h	2088h	2089h	208Ah	208Bh
0898h	208Ch	208Dh	208Eh	208Fh	2090h	2091h	2092h	2093h
08A0h	2094h	2095h	2096h	2097h	2098h	2099h	209Ah	209Bh
08A8h	209Ch	209Dh	209Eh	209Fh	20A0h	20A1h	20A2h	20A3h
08B0h	20A4h	20A5h	20A6h	20A7h	20A8h	20A9h	20AAh	20ABh
08B8h	20ACh	20ADh	20AEh	20AFh	20B0h	20B1h	20B2h	20B3h
08C0h	20B4h	20B5h	20B6h	20B7h	20B8h	20B9h	20BAh	20BBh
08C8h	20BCh	20BDh	20BEh	20BFh	20C0h	20C1h	20C2h	20C3h
08D0h	20C4h	20C5h	20C6h	20C7h	20C8h	20C9h	20CAh	20CBh
08D8h	20CCh	20CDh	20CEh	20CFh	20D0h	20D1h	20D2h	20D3h
08E0h	20D4h	20D5h	20D6h	20D7h	20D8h	20D9h	20DAh	20DBh
08E8h	20DCh	20DDh	20DEh	20DFh	20E0h	20E1h	20E2h	20E3h
08F0h	20E4h	20E5h	20E6h	20E7h	20E8h	20E9h	20EAh	20EBh
08F8h	20ECh	20EDh	20EEh	20EFh	20F0h	20F1h	20F2h	20F3h
0900h	20F4h	20F5h	20F6h	20F7h	20F8h	20F9h	20FAh	20FBh
0908h	20FCh	20FDh	20FEh	20FFh	2100h	2101h	2102h	2103h
0910h	2104h	2105h	2106h	2107h	2108h	2109h	210Ah	210Bh
0918h	210Ch	210Dh	210Eh	210Fh	2110h	2111h	2112h	2113h
0920h	2114h	2115h	2116h	2117h	2118h	2119h	211Ah	211Bh
0928h	211Ch	211Dh	211Eh	211Fh	2120h	2121h	2122h	2123h
0930h	2124h	2125h	2126h	2127h	2128h	2129h	212Ah	212Bh
0938h	212Ch	212Dh	212Eh	212Fh	2130h	2131h	2132h	2133h
0940h	2134h	2135h	2136h	2137h	2138h	2139h	213Ah	213Bh
0948h	213Ch	213Dh	213Eh	213Fh	2140h	2141h	2142h	2143h
0950h	2144h	2145h	2146h	2147h	2148h	2149h	214Ah	214Bh
0958h	214Ch	214Dh	2132h	214Fh	2150h	2151h	2152h	2153h
0960h	2154h	2155h	2156h	2157h	2158h	2159h	215Ah	215Bh
0968h	215Ch	215Dh	215Eh	215Fh	2160h	2161h	2162h	2163h
0970h	2164h	2165h	2166h	2167h	2168h	2169h	216Ah	216Bh
0978h	216Ch	216Dh	216Eh	216Fh	2160h	2161h	2162h	2163h
0980h	2164h	2165h	2166h	2167h	2168h	2169h	216Ah	216Bh
0988h	216Ch	216Dh	216Eh	216Fh	2180h	2181h	2182h	2183h
0990h	2183h	FFFFh	034Bh	24B6h	24B7h	24B8h	24B9h	24BAh
0998h	24BBh	24BCh	24BDh	24BEh	24BFh	24C0h	24C1h	24C2h
09A0h	24C3h	24C4h	24C5h	24C6h	24C7h	24C8h	24C9h	24CAh

Table Index	Table Entries							
	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7
09A8h	24CBh	24CCh	24CDh	24CEh	24CFh	FFFFh	0746h	2C00h
09B0h	2C01h	2C02h	2C03h	2C04h	2C05h	2C06h	2C07h	2C08h
09B8h	2C09h	2C0Ah	2C0Bh	2C0Ch	2C0Dh	2C0Eh	2C0Fh	2C10h
09C0h	2C11h	2C12h	2C13h	2C14h	2C15h	2C16h	2C17h	2C18h
09C8h	2C19h	2C1Ah	2C1Bh	2C1Ch	2C1Dh	2C1Eh	2C1Fh	2C20h
09D0h	2C21h	2C22h	2C23h	2C24h	2C25h	2C26h	2C27h	2C28h
09D8h	2C29h	2C2Ah	2C2Bh	2C2Ch	2C2Dh	2C2Eh	2C5Fh	2C60h
09E0h	2C60h	2C62h	2C63h	2C64h	2C65h	2C66h	2C67h	2C67h
09E8h	2C69h	2C69h	2C6Bh	2C6Bh	2C6Dh	2C6Eh	2C6Fh	2C70h
09F0h	2C71h	2C72h	2C73h	2C74h	2C75h	2C75h	2C77h	2C78h
09F8h	2C79h	2C7Ah	2C7Bh	2C7Ch	2C7Dh	2C7Eh	2C7Fh	2C80h
0A00h	2C80h	2C82h	2C82h	2C84h	2C84h	2C86h	2C86h	2C88h
0A08h	2C88h	2C8Ah	2C8Ah	2C8Ch	2C8Ch	2C8Eh	2C8Eh	2C90h
0A10h	2C90h	2C92h	2C92h	2C94h	2C94h	2C96h	2C96h	2C98h
0A18h	2C98h	2C9Ah	2C9Ah	2C9Ch	2C9Ch	2C9Eh	2C9Eh	2CA0h
0A20h	2CA0h	2CA2h	2CA2h	2CA4h	2CA4h	2CA6h	2CA6h	2CA8h
0A28h	2CA8h	2CAAh	2CAAh	2CACh	2CACh	2CAEh	2CAEh	2CB0h
0A30h	2CB0h	2CB2h	2CB2h	2CB4h	2CB4h	2CB6h	2CB6h	2CB8h
0A38h	2CB8h	2CBAh	2CBAh	2CBCh	2CBCh	2CBEh	2CBEh	2CC0h
0A40h	2CC0h	2CC2h	2CC2h	2CC4h	2CC4h	2CC6h	2CC6h	2CC8h
0A48h	2CC8h	2CCAh	2CCAh	2CCCh	2CCCh	2CCEh	2CCEh	2CD0h
0A50h	2CD0h	2CD2h	2CD2h	2CD4h	2CD4h	2CD6h	2CD6h	2CD8h
0A58h	2CD8h	2CDAh	2CDAh	2CDCh	2CDCh	2CDEh	2CDEh	2CE0h
0A60h	2CE0h	2CE2h	2CE2h	2CE4h	2CE5h	2CE6h	2CE7h	2CE8h
0A68h	2CE9h	2CEAh	2CEBh	2CECh	2CEDh	2CEEh	2CEFh	2CF0h
0A70h	2CF1h	2CF2h	2CF3h	2CF4h	2CF5h	2CF6h	2CF7h	2CF8h
0A78h	2CF9h	2CFAh	2CFBh	2CFCh	2CFDh	2CFEh	2CFFh	10A0h
0A80h	10A1h	10A2h	10A3h	10A4h	10A5h	10A6h	10A7h	10A8h
0A88h	10A9h	10AAh	10ABh	10ACh	10ADh	10AEh	10AFh	10B0h
0A90h	10B1h	10B2h	10B3h	10B4h	10B5h	10B6h	10B7h	10B8h
0A98h	10B9h	10BAh	10BBh	10BCh	10BDh	10BEh	10BFh	10C0h
0AA0h	10C1h	10C2h	10C3h	10C4h	10C5h	FFFFh	D21Bh	FF21h
0AA8h	FF22h	FF23h	FF24h	FF25h	FF26h	FF27h	FF28h	FF29h
0AB0h	FF2Ah	FF2Bh	FF2Ch	FF2Dh	FF2Eh	FF2Fh	FF30h	FF31h
0AB8h	FF32h	FF33h	FF34h	FF35h	FF36h	FF37h	FF38h	FF39h
0AC0h	FF3Ah	FF5Bh	FF5Ch	FF5Dh	FF5Eh	FF5Fh	FF60h	FF61h
0AC8h	FF62h	FF63h	FF64h	FF65h	FF66h	FF67h	FF68h	FF69h
0AD0h	FF6Ah	FF6Bh	FF6Ch	FF6Dh	FF6Eh	FF6Fh	FF70h	FF71h
0AD8h	FF72h	FF73h	FF74h	FF75h	FF76h	FF77h	FF78h	FF79h
0AE0h	FF7Ah	FF7Bh	FF7Ch	FF7Dh	FF7Eh	FF7Fh	FF80h	FF81h
0AE8h	FF82h	FF83h	FF84h	FF85h	FF86h	FF87h	FF88h	FF89h
0AF0h	FF8Ah	FF8Bh	FF8Ch	FF8Dh	FF8Eh	FF8Fh	FF90h	FF91h
0AF8h	FF92h	FF93h	FF94h	FF95h	FF96h	FF97h	FF98h	FF99h
0B00h	FF9Ah	FF9Bh	FF9Ch	FF9Dh	FF9Eh	FF9Fh	FFA0h	FFA1h
0B08h	FFA2h	FFA3h	FFA4h	FFA5h	FFA6h	FFA7h	FFA8h	FFA9h

Table Index	Table Entries							
	+ 0	+ 1	+ 2	+ 3	+ 4	+ 5	+ 6	+ 7
0B10h	FFAAh	FFABh	FFACh	FFADh	FFAEh	FFAFh	FFB0h	FFB1h
0B18h	FFB2h	FFB3h	FFB4h	FFB5h	FFB6h	FFB7h	FFB8h	FFB9h
0B20h	FFBAh	FFBBh	FFBCh	FFBDh	FFBEh	FFBFh	FFC0h	FFC1h
0B28h	FFC2h	FFC3h	FFC4h	FFC5h	FFC6h	FFC7h	FFC8h	FFC9h
0B30h	FFCAh	FFCBh	FFCCh	FFCDh	FFCEh	FFCFh	FFD0h	FFD1h
0B38h	FFD2h	FFD3h	FFD4h	FFD5h	FFD6h	FFD7h	FFD8h	FFD9h
0B40h	FFDAh	FFDBh	FFDCh	FFDDh	FFDEh	FFDFh	FFE0h	FFE1h
0B48h	FFE2h	FFE3h	FFE4h	FFE5h	FFE6h	FFE7h	FFE8h	FFE9h
0B50h	FFEAh	FFEBh	FFECh	FFEDh	FFEEh	FFEFh	FFF0h	FFF1h
0B58h	FFF2h	FFF3h	FFF4h	FFF5h	FFF6h	FFF7h	FFF8h	FFF9h
0B60h	FFFAh	FFFBh	FFFCh	FFFDh	FFFEh	FFFFh		

Table 5-22 : Recommended Up-case Table in Compressed Format

5.2.8.3. Volume Label Directory Entry

The Volume Label is a Unicode string which enables end users to distinguish their storage volumes. In the exFAT file system, the Volume Label exists as a critical primary directory entry in the root directory (see Table 5-23). The valid number of Volume Label directory entries ranges from 0 to 1.

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	CharacterCount	Numeric Value
2	22	VolumeLabel	Unicode string
24	8	Reserved	All 00h

Table 5-23 : Volume Label DirectoryEntry

(BP 0) EntryType

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 83h.

(TypeCode)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 3.

(TypeImportance)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(TypeCategory)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(InUse)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 1.

(BP 1) CharacterCount

This field shall contain the length of the Unicode string the VolumeLabel field contains. If this field is recorded as 0, it means the Unicode string is 0 characters long (which is the equivalent of no volume label). The maximum value of this field is 11.

(BP 2 to 23) VolumeLabel

This field shall contain a Unicode string, which is the user-friendly name of the volume. The VolumeLabel field has the same set of invalid characters as the FileName field of the File Name directory entry (see Section 5.2.8.9).

(BP 24 to 31) Reserved

This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

5.2.8.4. File Directory Entry

File directory entries describe files and directories. They are critical primary directory entries and any directory may contain zero or more File directory entries (see Table 5-24). For a File directory entry to be valid, at most one Stream Extension directory entry and at least one File Name directory entry

immediately follow the File directory entry (see Sections 5.2.8.8 and 5.2.8.9, respectively).

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	SecondaryCount	Numeric Value
2	2	SetChecksum	Numeric Value
4	2	FileAttributes	Numeric Value
6	2	Reserved1	All 00h
8	4	CreateTimestamp	Timestamp
12	4	LastModifiedTimestamp	Timestamp
16	4	LastAccessedTimestamp	Timestamp
20	1	Create10msIncrement	Numeric Value
21	1	LastModified10msIncrement	Numeric Value
22	1	CreateUtcOffset	Numeric Value
23	1	LastModifiedUtcOffset	Numeric Value
24	1	LastAccessedUtcOffset	Numeric Value
25	7	Reserved2	All 00h

Table 5-24 : File DirectoryEntry

(BP 0) EntryType
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 85h.

(TypeCode)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 5.

(TypeImportance)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(TypeCategory)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(InUse)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 1.

(BP 1) SecondaryCount
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2).

(BP 2 and 3) SetChecksum
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2).

(BP 4 and 5) FileAttributes
This field shall contain flags (see Table 5-25).

Field Name	Offset(bit)	Size(bits)	Comments
ReadOnly	0	1	This field describes that the corresponding file or directory has read only state.
Hidden	1	1	This field describes that the corresponding file or directory has hidden state.
System	2	1	This field describes that the corresponding file or directory is used by system.
Reserved1	3	1	This field is reserved.
Directory	4	1	This field describes this directory entry specifies a directory.
Archive	5	1	This field describes that the corresponding file or directory has archive state.
Reserved2	6	10	This field is reserved.

Table 5-25 : FileAttributes

(ReadOnly)
This field shall describe whether the corresponding file or directory has read only state or not. The valid values for this field are:

- 0, which means it has not read only state
- 1, which means it has read only state

(Hidden)
This field shall describe whether the corresponding file or directory has hidden state or not. The valid values for this field are:

- 0, which means it has not hidden state
- 1, which means it has hidden state

(System)
This field shall describe whether the corresponding file or directory is used by system or not. The valid values for this field are:

- 0, which means it is a normal file or a normal directory
- 1, which means it is a system file or a system directory

(Reserved1)
This field shall be reserved. It shall be recorded as 0. However, 0 shall not be expected at the time of operation.

(Directory)
This field shall describe whether the given directory entry specifies a directory or not. The valid values for this field are:

- 0, which means it specifies a file
- 1, which means it specifies a directory

(Archive)
This field shall describe whether the corresponding file or directory has archive state or not. The valid values for this field are:

- 0, which means it has not archive state
- 1, which means it has archive state

(Reserved2)
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 6 and 7) Reserved1
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 8 to 11) CreateTimestamp
In combination, the CreateTimestamp and Create10msIncrement fields shall describe the local date and time the given file/directory was created. The CreateUtcOffset field shall describe the offset of local date and time from UTC. Implementations shall set these fields upon creation of the given directory entry set. These fields shall conform to the definitions of the Timestamp, 10msIncrement, and UtcOffset fields.

(BP 12 to 15) LastModifiedTimestamp
In combination, the LastModifiedTimestamp and LastModified10msIncrement fields shall describe the local date and time the contents of any of the clusters associated with the given Stream Extension directory entry were last modified. The LastModifiedUtcOffset field describes the offset of local date and time from UTC. Implementations shall update these fields:

1. After modifying the contents of any of the clusters associated with the given Stream Extension directory entry (except for contents which exist beyond the point the ValidDataLength field describes)
2. Upon changing the values of either the ValidDataLength or DataLength fields

These fields shall conform to the definitions of the Timestamp, 10msIncrement, and UtcOffset fields.

(BP 16 to 19) LastAccessedTimestamp
The LastAccessedTimestamp field shall describe the local date and time the contents of any of the clusters associated with the given Stream Extension directory entry were last accessed. The LastAccessedUtcOffset field shall describe the offset of local date and time from UTC. Implementations shall update these fields:

1. After modifying the contents of any of the clusters associated with the given Stream Extension directory entry (except for contents which exist beyond the ValidDataLength)
2. Upon changing the values of either the ValidDataLength or DataLength fields

Implementations should update these fields after reading the contents of any of the clusters associated with the given Stream Extension directory entry. These fields shall conform to the definitions of the Timestamp and UtcOffset fields.

(BP 20) Create10msIncrement
This field shall be used with CreateTimestamp. See the descriptions of CreateTimestamp.

(BP 21) LastModified10msIncrement
This field shall be used with LastModifiedTimestamp. See the descriptions of LastModifiedTimestamp.

(BP 22) CreateUtcOffset
This field shall be used with CreateTimestamp. See the descriptions of CreateTimestamp.

(BP 23) LastModifiedUtcOffset
This field shall be used with LastModifiedTimestamp. See the descriptions of LastModifiedTimestamp.

(BP 24) LastAccessedUtcOffset
This field shall be used with LastAccessedTimestamp. See the descriptions of LastAccessedTimestamp.

(BP 25 to 31) Reserved2
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

[Timestamp Fields]
Timestamp fields describe both local date and time, down to a two-second resolution (see Table 5-26).

Field Name	Offset(bit)	Size(bits)	Comments
DoubleSeconds	0	5	This field describes the seconds.
Minute	5	6	This field describes the minutes.
Hour	11	5	This field describes the hours.
Day	16	5	This field describes the day.
Month	21	4	This field describes the month.
Year	25	7	This field describes the year.

Table 5-26 : Timestamp

(DoubleSeconds)
This field shall describe the seconds portion of the Timestamp field, in two-second multiples.
The valid range of values for this field is:

- 0, which represents 0 seconds
- 29, which represents 58 seconds

(Minute)
This field shall describe the minutes portion of the Timestamp field.
The valid range of values for this field is:

- 0, which represents 0 munutes
- 59, which represents 59 minutes

(Hour)
This field shall describe the hours portion of the Timestamp field.
The valid range of values for this field is:

- 0, which represents 00:00 hours
- 23, which represents 23:00 hours

(Day)

This field shall describe the day portion of the Timestamp field.
The valid range of values for this field is:

- 1, which is the first day of the given month
- The last day of the given month (the given month defines the number of valid days)

(Month)
This field shall describe the month portion of the Timestamp field.
The valid range of values for this field is:

- At least 1, which represents January
- At most 12, which represents December

(Year)
This field shall describe the year portion of the Timestamp field, relative to the year 1980. This field represents the year 1980 with the value 0 and the year 2107 with the value 127. All possible values for this field are valid.

[10msIncrement Fields]
10msIncrement fields provide additional time resolution to their corresponding Timestamp fields in ten-millisecond multiples.
The valid range of values for these fields is:

- At least 0, which represents 0 milliseconds
- At most 199, which represents 1990 milliseconds

[UtcOffset Fields]
UtcOffset fields (see Table 5-27) describe the offset from UTC to the local date and time their corresponding Timestamp and 10msIncrement fields describe. The offset from UTC to the local date and time includes the effects of time zones and other date-time adjustments, such as daylight saving and regional summer time changes.

Field Name	Offset(bit)	Size(bits)	Comments
OffsetFromUtc	0	7	This field describes the offset from UTC.
OffsetValid	7	1	This field describes the validity of OffsetFromUtc field.

Table 5-27 : UtcOffset

(OffsetFromUtc)
This field shall describe the offset from UTC of the local date and time the related Timestamp and 10msIncrement fields contains. This field describes the offset from UTC in 15 minute intervals (see Table 5-28).

Value	Signed Decimal Equivalent	Description
3Fh	63	Local date and time is UTC + 15:45
3Eh	62	Local date and time is UTC + 15:30
:	:	:
01h	1	Local date and time is UTC + 00:15
00h	0	Local date and time is UTC
7Fh	-1	Local date and time is UTC - 00:15
:	:	:
41h	-63	Local date and time is UTC - 15:45
40h	-64	Local date and time is UTC - 16:00

Table 5-28 : Meaning of the Values of the OffsetFromUtc Field

As the table above indicates, all possible values for this field are valid. However, implementations should only record the value 00h for this field when:

1. Local date and time are actually the same as UTC, in which case the value of the OffsetValid field shall be 1
2. Local date and time are not known, in which case the value of the OffsetValid field shall be 1 and implementations shall consider UTC to be local date and time
3. UTC is not known, in which case the value of the OffsetValid field shall be 0

If the local date and time offset from UTC happens to not be a multiple of 15 minute intervals, then implementations shall record 00h in the OffsetFromUtc field and shall consider UTC to be local date and time.

(OffsetValid)
This field shall describe whether the contents of the OffsetFromUtc field are valid or not, as follows:

- 0, which means the contents of the OffsetFromUtc field are invalid and shall be 00h
- 1, which means the contents of the OffsetFromUtc field are valid

Implementations should only set this field to the value 0 when UTC is not available for computing the value of the OffsetFromUtc field. If this field contains the value 0, then implementations shall treat the Timestamp and 10msIncrement fields as having the same UTC offset as the current local date and time.

5.2.8.5. Volume GUID Directory Entry

The Volume GUID directory entry contains a GUID which enables implementations to uniquely and programmatically distinguish volumes. The Volume GUID exists as a benign primary directory entry in the root directory (see Table 5-29). The valid number of Volume GUID directory entries ranges from 0 to 1.

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	SecondaryCount	Numeric Value
2	2	SetChecksum	Numeric Value
4	2	GeneralPrimaryFlags	Numeric Value
6	16	VolumeGuid	GUID
22	10	Reserved	All 00h

Table 5-29 : Volume GUID DirectoryEntry

(BP 0) EntryType

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as A0h.

(TypeCode)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(TypeImportance)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 1.

(TypeCategory)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(InUse)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 1.

(BP 1) SecondaryCount

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(BP 2 and 3) SetChecksum

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2).

(BP 4 and 5) GeneralPrimaryFlags

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2) and define the contents of the CustomDefined field to be reserved.

(AllocationPossible)

This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(NoFatChain)
This field shall conform to the definition the Generic Primary DirectoryEntry template provides (see Section 5.2.7.2). This field shall be recorded as 0.

(CustomDefined)
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 6 to 21) VolumeGuid
This field shall contain a GUID which uniquely identifies the given volume.
All possible values for this field are valid, except the null GUID, which is {00000000-0000-0000-0000-000000000000}.

(BP 22 to 31) Reserved
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

5.2.8.6. TexFAT Padding Directory Entry

TexFAT Padding directory entries are useful in the context of TexFAT semantics. They are benign primary directory entries and are only valid in the first cluster of a directory and occupy every directory entry in the cluster.
The base specification of this file system specification, exFAT Revision 1.00 File System Basic Specification, does not define the TexFAT Padding directory entry. However, its type code is 1 and its type importance is 1. Implementations of this specification shall treat TexFAT Padding directory entries the same as any other unrecognized benign primary directory entries, except implementations shall not move TexFAT Padding directory entries.

5.2.8.7. Windows CE Access Control Table Directory Entry

The Windows CE Access Control Table directory entry is useful in the context of Windows CE applications. It exists as a benign primary directory entry in the root directory. The valid number of Windows CE Access Control Table directory entries ranges from 0 to 1. The base specification of this file system specification, exFAT Revision 1.00 File System Basic Specification, does not define the Windows CE Access Control Table directory entry. However, its type code is 2 and its type importance is 1. Implementations of this specification shall treat the Windows CE Access Control Table directory entry the same as any other unrecognized benign primary directory entry.

5.2.8.8. Stream Extension Directory Entry

The Stream Extension directory entry is a critical secondary directory entry in File directory entry sets (see Table 5-30). The valid number of Stream Extension directory entries in a File directory entry set is 1. Further, this directory entry is valid only if it immediately follows the File directory entry.

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	GeneralSecondaryFlags	byte
2	1	Reserved1	00h
3	1	NameLength	Numeric Value
4	2	NameHash	Numeric Value
6	2	Reserved2	All 00h
8	8	ValidDataLength	Numeric Value
16	4	Reserved3	All 00h
20	4	FirstCluster	Numeric Value
24	8	DataLength	Numeric Value

Table 5-30 : Stream Extension DirectoryEntry

(BP 0) EntryType

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as C0h.

(TypeCode)

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(TypeImportance)

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(TypeCategory)

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(InUse)

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(BP 1) GeneralSecondaryFlags

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3) and define the contents of the CustomDefined field to be reserved.

(AllocationPossible)

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(NoFatChain)

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3).

(CustomDefined)
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 2) Reserved1
This field shall be reserved. It shall be recorded as 00h. However, 00h shall not be expected at the time of operation.

(BP 3) NameLength
This field shall contain the length of the Unicode string the subsequent File Name directory entries (see Section 5.2.8.9) collectively contain. All possible values other than 0 are valid for this field. The value of the NameLength field also affects the number File Name Directory Entries (see Section 5.2.8.9).

(BP 4 and 5) NameHash
This field shall contain a 2-byte hash of the up-cased file name. This enables implementations to perform a quick comparison when searching for a file by name. Importantly, the NameHash provides a sure verification of a mismatch. Implementations shall verify all NameHash matches with a comparison of the up-cased file name.

The below algorithm describes the logic used to generate the checksum value:

```
UInt16 NameHash
(
     WCHAR *    FileName, // points to an in-memory copy of the up-cased file name
     UCHAR      NameLength
)
{
     UCHAR *    Buffer = (UCHAR *)FileName;
     UInt16     NumberOfBytes = (UInt16)NameLength * 2;
     UInt16     Hash = 0;
     UInt16     Index;

     for (Index = 0; Index < NumberOfBytes; Index++)
     {
          Hash = ((Hash&1) ? 0x8000 : 0) + (Hash>>1) + (UInt16)Buffer[Index];
     }

     return Hash;
}
```

(BP 6 and 7) Reserved2
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 8 and 15) ValidDataLength
This field shall describe how far into the data stream user data has been written. Implementations shall update this field as they write data further out into the data stream. On the storage media, the data between the valid data length and the data length of the data stream is undefined. Implementations shall return zeroes for read operations beyond the valid data length.
If the corresponding File directory entry describes a directory, then the only valid value for this field is equal to the value of the DataLength field. Otherwise, the range of valid values for this field is:

- At least 0, which means no user data has been written out to the data stream
- At most DataLength, which means user data has been written out to the entire length of the data stream

(BP 16 and 19) Reserved3
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 20 to 23) FirstCluster
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3).
This field shall contain the index of the first cluster of the data stream, which hosts the user data.

(BP 24 to 31) DataLength
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3).
If the corresponding File directory entry describes a directory, then the valid value for this field is the entire size of the associated allocation, in bytes, which may be 0. Further, for directories, the maximum value for this field is 256MB.

5.2.8.9. File Name Directory Entry

File Name directory entries are critical secondary directory entries in File directory entry sets (see Table 5-31). The valid number of File Name directory entries in a File directory entry set is NameLength / 15, rounded up to the nearest integer. Further, File Name directory entries are valid only if they immediately follow the Stream Extension directory entry as a consecutive series. File Name directory entries combine to form the file name for the File directory entry set.

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	GeneralSecondaryFlags	byte
2	30	FileName	Unicode string

Table 5-31 : File Name DirectoryEntry

(BP 0) EntryType
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as C1h.

(TypeCode)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(TypeImportance)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(TypeCategory)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(InUse)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(BP 1) GeneralSecondaryFlags
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3) and define the contents of the CustomDefined field to be reserved.

(AllocationPossible)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(NoFatChain)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(CustomDefined)
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 2 to 31) FileName
This field shall contain a Unicode string, which is a portion of the file name. In the order File Name directory entries exist in a File directory entry set, FileName fields concatenate to form the file name for the File directory entry set. Given the length of the FileName field, 15 characters, and the maximum number of File Name directory entries, 17, the maximum length of the final, concatenated file name is 255.
The concatenated file name has the same set of illegal characters as other FAT-based file systems (see Table 5-32). Implementations should set the unused characters of FileName fields to the value 0000h.

Character Code	Description	Character Code	Description	Character Code	Description
0000h	Control code	0001h	Control code	0002h	Control code
0003h	Control code	0004h	Control code	0005h	Control code
0006h	Control code	0007h	Control code	0008h	Control code
0009h	Control code	000Ah	Control code	000Bh	Control code
000Ch	Control code	000Dh	Control code	000Eh	Control code
000Fh	Control code	0010h	Control code	0011h	Control code
0012h	Control code	0013h	Control code	0014h	Control code
0015h	Control code	0016h	Control code	0017h	Control code
0018h	Control code	0019h	Control code	001Ah	Control code
001Bh	Control code	001Ch	Control code	001Dh	Control code
001Eh	Control code	001Fh	Control code	0022h	Quotation mark
002Ah	Asterisk	002Fh	Forward slash	003Ah	Colon
003Ch	Less-than sign	003Eh	Greater-than sign	003Fh	Question mark
005Ch	Back slash	007Ch	Vertical bar		

Table 5-32 : Invalid FileName Characters

The file names "." and ".." have the special meaning of "this directory" and "containing directory", respectively. Implementations shall not record either file name in the FileName field. However, implementations may generate these two file names in directory listings to refer to the directory being listed and the containing directory.

5.2.8.10. Windows CE Access Control Directory Entry

Windows CE Access Control directory entries are useful in the context of Windows CE applications. They are critical secondary directory entries and any File directory entry set may contain 0 or 1 Windows CE Access Control directory entries. The base specification of this file system specification,

exFAT Revision 1.00 File System Basic Specification, does not define the Windows CE Access Control directory entry. However, its type code is 2 and its type importance is 0. Implementations of this specification shall treat Windows CE Access Control directory entries the same as unrecognized critical secondary directory entries.

5.2.8.11. Vendor Extension Directory Entry

The Vendor Extension directory entry is a benign secondary directory entry in File directory entry sets (see Table 5-33). A File directory entry set may contain any number of Vendor Extension directory entries, up to the limit of secondary directory entries, less the number of other secondary directory entries. Further, Vendor Extension directory entries are valid only if they do not precede the required Stream Extension and File Name directory entries.

Vendor Extension directory entries enable vendors to have unique, vendor-specific directory entries in individual File directory entry sets via the VendorGuid field (see Table 5-33). Unique directory entries effectively enable vendors to extend the exFAT file system. Vendors may define the contents of the VendorDefined field (see Table 5-33). Vendor implementations may maintain the contents of the VendorDefined field and may provide vendor-specific functionality.

Implementations which do not recognize the GUID of a Vendor Extension directory entry shall treat the directory entry the same as any other unrecognized benign secondary directory entry (see Section 5.2.9.2).

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	GeneralSecondaryFlags	byte
2	16	VendorGuid	GUID
18	14	VendorDefined	Not Restricted

Table 5-33 : Vendor Extension DirectoryEntry

(BP 0) EntryType

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as E0h.

(TypeCode)

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(TypeImportance)

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(TypeCategory)

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(InUse)

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(BP 1) GeneralSecondaryFlags

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3) and define the contents of the CustomDefined field to be reserved.

(AllocationPossible)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(NoFatChain)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(CustomDefined)
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 2 to 17) VendorGuid
This field shall contain a GUID which uniquely identifies the given Vendor Extension.
All possible values for this field are valid, except the null GUID, which is {00000000-0000-0000-0000-000000000000}.
The value of this field determines the vendor-specific structure of the VendorDefined field.

(BP 18 to 31) VendorDefined
The content of this field shall be defined by the structures which derive from this template.

5.2.8.11.1. Continuous Information Manage Directory Entry

The Continuous Information Manage directory entry is a kind of the Vendor Extension directory entry. That is, this entry is a benign secondary directory entry in File directory entry sets (see Table 5-34). This directory entry is optional. The valid number of Continuous Information Manage directory entries in a File directory entry set is 1.

A file may be allocated for the set of some continuous area. These continuous area locations are managed by FAT. However, the length of cluster chain managed by FAT becomes longer in proportion to the file size. This means retrieving time of the cluster chain may take long time in case of a large size file. The Continuous Information Manage directory entry and Continuous Information directory entry enable to shorten this retrieving time, because it provides the other retrieving method without using FAT. This function is useful for large size files like video data files created by camcorder.

The Continuous Information Manage directory entry and Continuous Information directory entry shall be used as pairs. In this section, the Continuous Information Manage directory entry is specified. As for the detailed explanation of the Continuous Information directory entry, see section 5.2.8.12.1.

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	GeneralSecondaryFlags	byte
2	16	VendorGuid	GUID
18	2	Reserved1	All 00h
20	4	FatChecksum	Numeric Value
24	8	Reserved2	All 00h

Table 5-34 : Continuous Information Manage DirectoryEntry

(BP 0) EntryType
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as E0h.

(TypeCode)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(TypeImportance)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(TypeCategory)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(InUse)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(BP 1) GeneralSecondaryFlags
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3) and define the contents of the CustomDefined field to be reserved.

(AllocationPossible)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(NoFatChain)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(CustomDefined)
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 2 to 17) VendorGuid
This field shall contain a GUID which uniquely identifies the Continuous Information Manage directory entry.
This field shall be recorded, in GUID notation, as {3F80007E-D4B2-4143-ABCE-6F9809A8F4A2}.

(BP 18 and 19) Reserved1
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 20 to 23) FatChecksum
This field shall contain the checksum of a FAT chain which specifies the allocated clusters for a file. For example, if a file which is specified by this directory entry set has three allocated clusters, FatChecksum shows the checksum value of three FAT entries.
Implementations should verify the contents of this field are valid prior to using this Continuous Information Manage directory entry in the given directory entry set. If the verification fails, implementations should ignore both Continuous Information Manage directory entry and Continuous Information directory entry and should not use the continuous information.

The below algorithm describes the logic used to generate the checksum value:

```
UInt32 ContinuousInformationManageEntryFatChecksum
(
```

```
        Uint32     FirstCluster // FirstCluster field of File directory entry
    )
    {
        UInt32     Checksum = 0;
        UInt32     Index;
        Uint32     Current;
        Uint32     Next;


        if ( FirstCluster == 0 )
        {
           return 0;
        }

        Current = FirstCluster;
        for (Index = 0; Index < 0xFFFFFFFF; Index++)
        {
             Checksum =
              ((Checksum&1) ? 0x80000000 : 0) + (Checksum>>1) + Current;

             if (Current == 0xFFFFFFFF)
             {
                  break;
             }

             Next = GetNextCluster( Current );
             Current = Next;
        }

        return Checksum;
    }
```

Note: “GetNextCluster” function returns the FAT entry value corresponding to the cluster number which is specified by argument. Moreover, this algorithm doesn’t include error case handling. Implementations should handle some error cases in connection with FAT chain.

(BP 24 to 31) Reserved2

This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

5.2.8.12. Vendor Allocation Directory Entry

The Vendor Allocation directory entry is a benign secondary directory entry in File directory entry sets (see Table 5-35). A File directory entry set may contain any number of Vendor Allocation directory entries, up to the limit of secondary directory entries, less the number of other secondary directory entries. Further, Vendor Allocation directory entries are valid only if they do not precede the required Stream Extension and File Name directory entries.

Vendor Allocation directory entries enable vendors to have unique, vendor-specific directory entries in individual File directory entry sets via the VendorGuid field (see Table 5-35). Unique directory entries effectively enable vendors to extend the exFAT file system. Vendors may define the contents of the associated clusters, if any exist. Vendor implementations may maintain the contents of the associated clusters, if any, and may provide vendor-specific functionality.

Implementations which do not recognize the GUID of a Vendor Allocation directory entry shall treat the directory entry the same as any other unrecognized benign secondary directory entry (see Section 5.2.9.2).

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	GeneralSecondaryFlags	byte
2	16	VendorGuid	GUID
18	2	VendorDefined	Not Restricted
20	4	FirstCluster	Numeric Value
24	8	DataLength	Numeric Value

Table 5-35 : Vendor Allocation DirectoryEntry

(BP 0) EntryType
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as E1h.

(TypeCode)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(TypeImportance)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(TypeCategory)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(InUse)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(BP 1) GeneralSecondaryFlags
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3) and define the contents of the CustomDefined field to be reserved.

(AllocationPossible)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(NoFatChain)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3).

(CustomDefined)
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 2 to 17) VendorGuid
This field shall contain a GUID which uniquely identifies the given Vendor Allocation.
All possible values for this field are valid, except the null GUID, which is {00000000-0000-0000-0000-000000000000}.
The value of this field determines the vendor-specific structure of the content of the associated clusters,

if any exist.

(BP 18 and 19) VendorDefined
The content of this field shall be defined by the structures which derive from this template.

(BP 20 to 23) FirstCluster
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3).

(BP 24 to 31) DataLength
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3).

5.2.8.12.1. Continuous Information Directory Entry

The Continuous Information directory entry is a kind of the Vendor Allocation directory entry. That is, this entry is a benign secondary directory entry in File directory entry sets (see Table 5-36). This directory entry is optional. The valid number of Continuous Information directory entries in a File directory entry set is 1.

Basically, a file having Continuous Information directory entry is managed by FAT. In addition, the continuous information, which shows the location of these continuous areas, may be stored in some clusters specified by Continuous Information directory entry. This information is used only as a hint of the recognition of cluster chain. Therefore, even if a File directory entry set contains this directory entry, FAT shall be used to store the link information of cluster chain. That is, AllocationPossible flag of Stream Extension directory entry shall be set to 1 and NoFatChain flag of Stream Extension directory entry shall be set to 0.

The Continuous Information Manage directory entry and Continuous Information directory entry shall be used as pairs. In this section, the Continuous Information directory entry is specified. As for the detailed explanation of the Continuous Information Manage directory entry, see section 5.2.8.11.1.

BP	Length (bytes)	Field Name	Contents
0	1	EntryType	byte
1	1	GeneralSecondaryFlags	byte
2	16	VendorGuid	GUID
18	2	SetChecksum	Numeric Value
20	4	FirstCluster	Numeric Value
24	8	DataLength	Numeric Value

Table 5-36 : Continuous Information DirectoryEntry

(BP 0) EntryType
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as E1h.

(TypeCode)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(TypeImportance)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(TypeCategory)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(InUse)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(BP 1) GeneralSecondaryFlags
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3) and define the contents of the CustomDefined field to be reserved.

(AllocationPossible)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 1.

(NoFatChain)
This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall be recorded as 0.

(CustomDefined)
This field shall be reserved. It shall be recorded as ZEROs. However, 00h shall not be expected at the time of operation.

(BP 2 to 17) VendorGuid
This field shall contain a GUID which uniquely identifies the Continuous Information directory entry. This field shall be recorded, in GUID notation, as {5DA16ECC-68B8-4041-B580-332D4A3329A1}.

(BP 18 and 19) SetChecksum
This field shall contain the checksum of all directory entries in the given directory entry set. However, the checksum excludes this field, the SetChecksum field of File directory entry, the LastAccessedTimestamp field of File directory entry, and the LastAccessedUtcOffset field of File directory entry. Implementations shall verify the contents of this field are valid prior to using this Continuous Information directory entry in the given directory entry set. If the verification fails, implementations shall ignore both Continuous Information Manage directory entry and Continuous Information directory entry and shall not use the continuous information.

The below algorithm describes the logic used to generate the checksum value:

```
UInt16 ContinuousInformationEntrySetChecksum
(
    UCHAR *    Entries, // points to an in-memory copy of the directory entry set
    UCHAR      SecondaryCount
)
{
    UInt16     NumberOfBytes = ((UInt16)SecondaryCount + 1) * 32;
    UInt16     Checksum = 0;
    UInt16     Index;

    for (Index = 0; Index < NumberOfBytes; Index++)
    {
        if ((Index == 2) || (Index == 3) || (Index == 16) || (Index == 17)
         || (Index == 18) || (Index == 19) || (Index == 24))
        {
            continue;
        }
```

```
                else if ((Index % 32) == 18)
                {
                     if ((UCHAR)Entries[(Index / 32) * 32] == 0xE1)
                     {
                          if (CheckContInfoGUID( (UCHAR *)(&Entries[((Index/32)*32)+2]) )
                            == TRUE)
                          {
                               Index++;
                               continue;
                          }
                     }
                }
                Checksum =
                 ((Checksum&1) ? 0x8000 : 0) + (Checksum>>1) + (UInt16)Entries[Index];
           }

           return Checksum;
     }
```

Note: “CheckContInfoGUID” function returns TRUE, if GUID which is specified by argument matches up to the value of VendorGuid of Continuous Information directory entry. Otherwise, this function returns FALSE.

(BP 20 to 23) FirstCluster

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3).

This field shall contain the index of the first cluster of the cluster chain, as the FAT describes, which hosts the Continuous Information.

(BP 24 to 31) DataLength

This field shall conform to the definition the Generic Secondary DirectoryEntry template provides (see Section 5.2.7.3). This field shall describe the size, in bytes, of the area which hosts the Continuous Information. The actual used area size shall be recorded in this field. That is, if there was some reserved area at the end of the Continuous Information, the value of this field isn't the multiple size of cluster.

[Continuous Information]
A Continuous Information records the location of the continuous areas in a file. Each entry in a Continuous Information indicates a location of single continuous area. The Continuous Information occupies one or more clusters. Therefore, there may be some reserved area at the end of the array.

Field Name	Offset(byte)	Size(bytes)	Comments
ContEntry[0]	0	8	This field corresponds to the first continuous area in the file.
:	:	:	:
ContEntry[ContinuousAreaCount - 1]	(ContinuousAreaCount-1)*8	8	This field corresponds to the last continuous area in the file.
Reserved	ContinuousAreaCount*8	DataLength - ContinuousAreaCount * 8	The contents of this field, if any, are undefined.

Table 5-37 : Continuous Information

Each ContEntry field in this array represents a continuous area in a file. ContEntry[0] represents the first continuous area in the file and ContEntry[ContinuousAreaCount-1] represents the last continuous area in the file.

(ContEntry)
A ContEntry shall indicate a location of single continuous area.

BP	Length (bytes)	Field Name	Contents
0	4	FirstCluster	Numeric Value
4	4	ClusterCount	Numeric Value

Table 5-38 : ContEntry

(BP 0 to 3) FirstCluster
This field shall contain the index of the first cluster of an allocation in the Cluster Heap associated with a continuous area in a file. This field shall be recorded as the valid cluster number in the volume.

(BP 4 to 7) ClusterCount
This field shall describe the number of the allocated clusters for a continuous area in a file. This field shall be recorded as any numbers other than 0. In any cases including the case of the last ContEntry (ContEntry[ContinuousAreaCount-1]), this field describes the cluster count. Therefore, this field doesn't mean the actual byte size of a file. The actual byte size is described in the Stream Extension directory entry.

[Examples of Continuous Information]
Figure5-3 shows the Continuous Information management image.

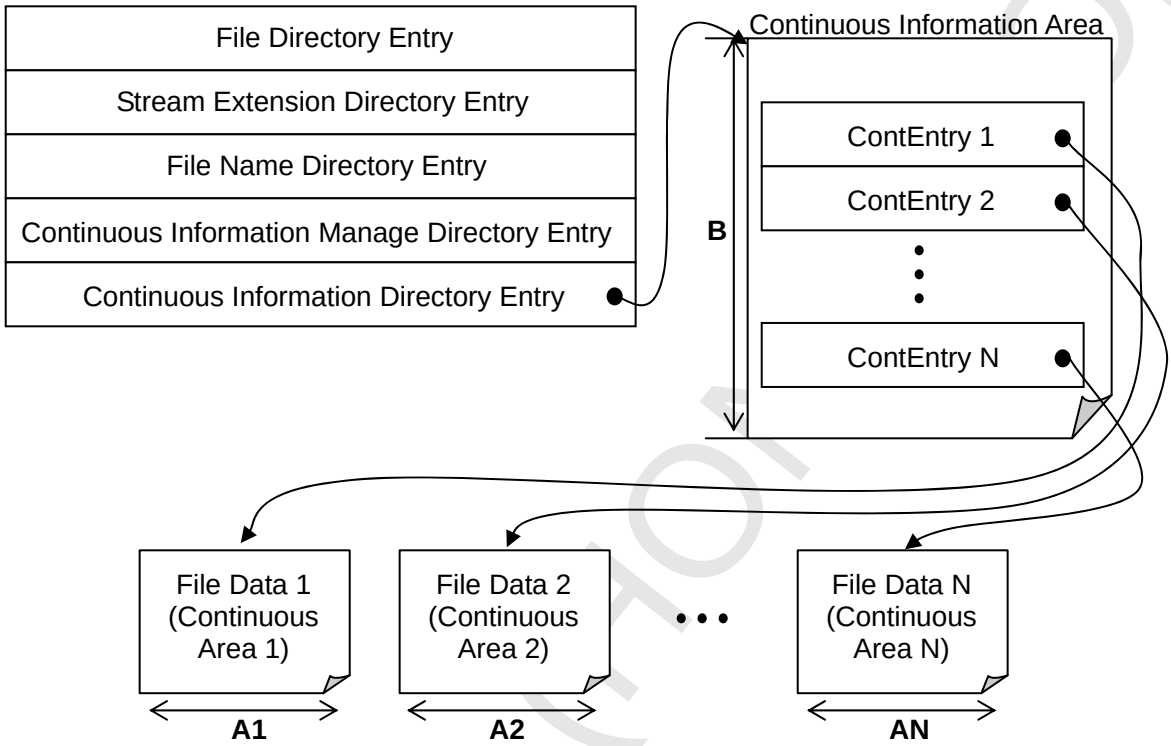


Figure 5-3 : Continuous Information Management

Continuous Information directory entry indicates the starting cluster number and size of Continuous Information Area. That is, the byte size of “B” is stored in the “DataLength” field of Continuous Information directory entry. In case that Continuous Information Area has some reserved area at the end of the area, this “DataLength” field stores the actual used area size excluding reserved area.

Continuous Information Area consists of one or more ContEntry. Each ContEntry indicates a continuous area which includes a portion of a file. That is, the cluster count of “A1” is stored in the “ClusterCount” field of ContEntry 1. And the cluster count of “A2” and “AN” are stored in ContEntry 2 and ContEnty N each.

Stream Extension directory entry indicates the starting cluster number and size of the file. That is, the total byte size from “A1” to “AN” is stored in the “DataLength” field of Stream Extension directory entry. This field may not be set the multiple size of cluster, because file size may not be the multiple size of cluster.

Figure5-4 shows an example of Continuous Information management. This example shows a 256KB file which consists from two discontinuous clusters. The cluster size is assumed as 128KB, and the file size is assumed as the multiple size of cluster. In this case, two ContEntry are stored in the Continuous Information Area. The values to be stored in each field are shown in Table 5-39.

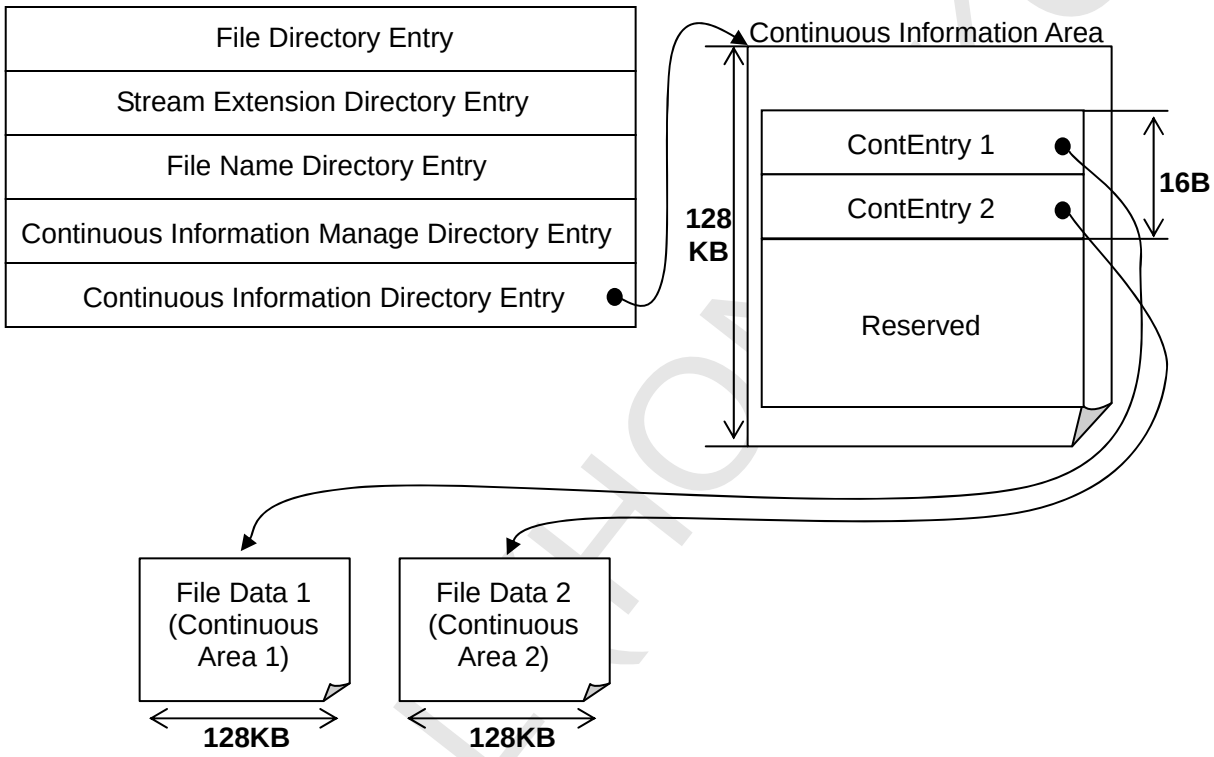


Figure 5-4 : Example 1 of Continuous Information Management

Field Name	Contents	Comments
“DataLength” field of Stream Extension directory entry	262144	File Size
“DataLength” field of Continuous Information directory entry	16	Continuous Information Area Size (Excluding reserved area)
“ClusterCount” field of ContEntry 1	1	Cluster Count of the 1st Continuous Area
“ClusterCount” field of ContEntry 2	1	Cluster Count of the 2nd Continuous Area Size

Table 5-39 : Field values of Example 1

Figure5-5 shows the other example of Continuous Information management. This example shows a 138KB file which consists from two discontinuous clusters. Similarly to the previous example, the cluster size is assumed as 128KB. However, the file size is not the multiple size of cluster. In this case, two ContEntry are stored in the Continuous Information Area too. The values to be stored in each field are shown in Table 5-40.

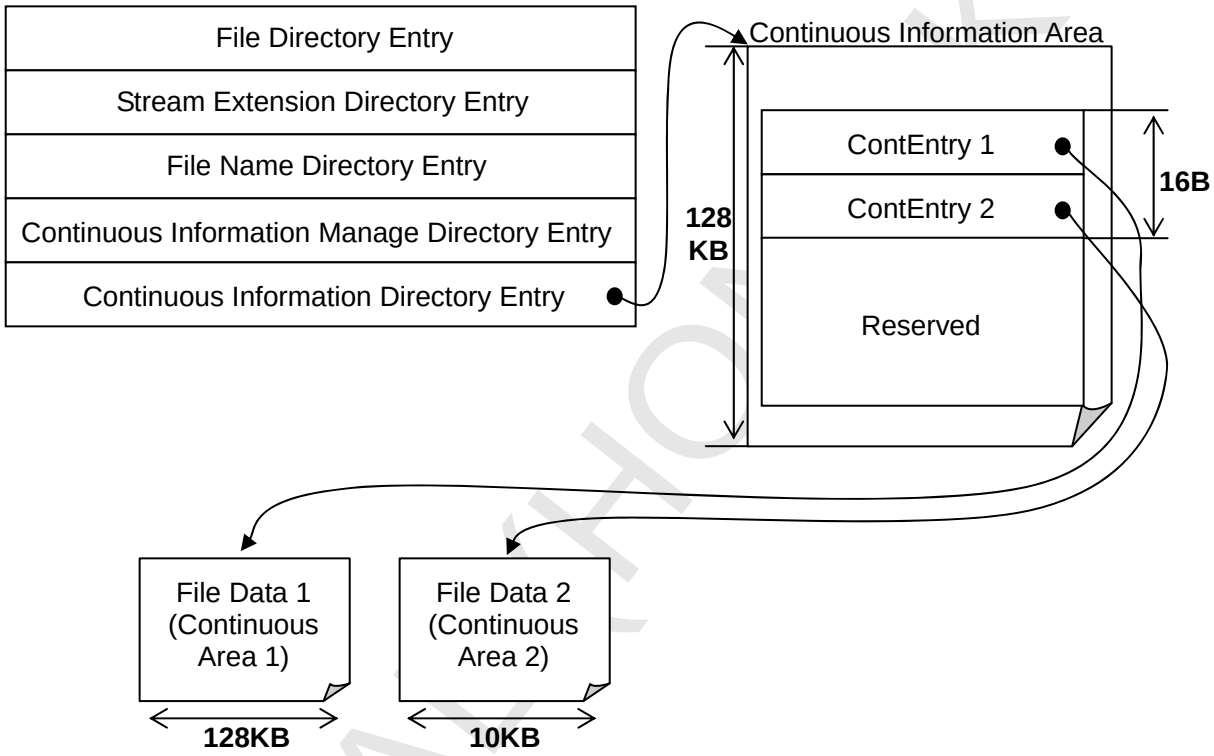


Figure 5-5 : Example 2 of Continuous Information Management

Field Name	Contents	Comments
“DataLength” field of Stream Extension directory entry	141312	File Size
“DataLength” field of Continuous Information directory entry	16	Continuous Information Area Size (Excluding reserved area)
“ClusterCount” field of ContEntry 1	1	Cluster Count of the 1st Continuous Area
“ClusterCount” field of ContEntry 2	1	Cluster Count of the 2nd Continuous Area

Table 5-40 : Field values of Example 2

5.2.9. Implementation Notes

5.2.9.1. Recommended Write Ordering

Implementations should ensure the volume is as resilient as possible to power faults and other unavoidable failures. When creating new directory entries or modifying cluster allocations, implementations should generally follow this writing order:

1. Set the value of the VolumeDirty field to 1
2. Update the active FAT, if necessary
3. Update the active Allocation Bitmap
4. Create or update the directory entry, if necessary
5. Clear the value of the VolumeDirty field to 0, if its value prior to the first step was 0

When deleting directory entries or freeing cluster allocations, implementations should follow this writing order:

1. Set the value of the VolumeDirty field to 1
2. Delete or update the directory entry, if necessary
3. Update the active FAT, if necessary
4. Update the active Allocation Bitmap
5. Clear the value of the VolumeDirty field to 0, if its value prior to the first step was 0

Note: VolumeDirty field is optional. If the host doesn't support this flag, Set/Clear operation of the VolumeDirty may be omitted.

5.2.9.2. Implications of Unrecognized Directory Entries

Future exFAT specifications of the same major revision number, 1, and minor revision number higher than 0, may define new benign primary, critical secondary, and benign secondary directory entries. Only exFAT specifications of a higher major revision number may define new critical primary directory entries. Implementations of this specification, exFAT Revision 1.00 File System Basic Specification, should be able to mount and access any exFAT volume of major revision number 1 and any minor revision number. This presents scenarios in which an implementation may encounter directory entries which it does not recognize. The following describe implications of these scenarios:

1. The presence of unrecognized critical primary directory entries in the root directory renders the volume invalid. The presence of any critical primary directory entry, except File directory entries, in any non-root directory, renders the hosting directory invalid.
2. Implementations shall not modify unrecognized benign primary directory entries or their associated cluster allocations. However, when deleting a directory, and only when deleting a directory, implementations shall delete unrecognized benign primary directory entries and free all associated cluster allocations, if any.
3. Implementations shall not modify unrecognized critical secondary directory entries or their associated cluster allocations. The presence of one or more unrecognized critical secondary directory entries in a directory entry set renders the entire directory entry set unrecognized. When deleting a directory entry set which contains one or more unrecognized critical secondary directory entries, implementations shall free all cluster allocations, if any, associated with unrecognized critical secondary directory entries. Further, if the directory entry set describes a directory, implementations may:

    - Traverse into the directory
    - Enumerate the directory entries it contains
    - Delete contained directory entries
    - Move contained directory entries to a different directory

However, implementations shall not:

- Modify contained directory entries, except delete, as noted
- Create new contained directory entries
- Open contained directory entries, except traverse and enumerate, as noted

4. Implementations shall not modify unrecognized benign secondary directory entries or their associated cluster allocations. Implementations should ignore unrecognized benign secondary directory entries. When deleting a directory entry set, implementations shall free all cluster allocations, if any, associated with unrecognized benign secondary directory entries.

5.2.10. Globally Unique Identifiers (GUIDs)

A GUID is the Microsoft implementation of a universally unique identifier. A GUID is a 128-bit value consisting of one group of 8 hexadecimal digits, followed by three groups of 4 hexadecimal digits each, and followed by one group of 12 hexadecimal digits, for example {6B29FC40-CA47-1067-B31D-00DD010662DA}, (see Table 5-41).

Field Name	Offset(byte)	Size(bytes)	Comments
Data1	0	4	This field contains the four bytes from the first group of the GUID (6B29FC40h from the example).
Data2	4	2	This field contains the two bytes from the second group of the GUID (CA47h from the example).
Data3	6	2	This field contains the two bytes from the third group of the GUID (1067h from the example).
Data4[0]	8	1	This field contains the most significant byte from fourth group of the GUID (B3h from the example).
Data4[1]	9	1	This field contains the least significant byte from fourth group of the GUID (1Dh from the example).
Data4[2]	10	1	This field contains the first byte from fifth group of the GUID (00h from the example).
Data4[3]	11	1	This field contains the second byte from fifth group of the GUID (DDh from the example).
Data4[4]	12	1	This field contains the third byte from fifth group of the GUID (01h from the example).
Data4[5]	13	1	This field contains the fourth byte from fifth group of the GUID (06h from the example).
Data4[6]	14	1	This field contains the fifth byte from fifth group of the GUID (62h from the example).
Data4[7]	15	1	This field contains the sixth byte from fifth group of the GUID (DAh from the example).

Table 5-41 : GUID Structure

Note: Each field of Data1, Data2, and Data3 is stored as little endian. This means the first byte of GUID field is not 6Bh but 40h in this example.

Appendix A (Normative)

A.1 Reference

This specification refers the following documents.

1) ISO/IEC 646:1991
Information technology – ISO 7-bit code character set for information interchange

2) ISO/IEC 9293:1994
Information technology – Volume and file structure of disk cartridges for information interchange

3) Microsoft FAT Specification: August 30 2005

4) exFAT Revision 1.00 File System Basic Specification: June 8, 2008

5) SD Specifications Part1 Physical Layer Specification

6) SD Specifications Part3 Security Specification

7) Application Notes Relating to SD File System Specification

Appendix B (Informative)

B.1 Abbreviations and Special Terms

ASCII	American Standard Code for Information Interchange
BIOS	Basic Input Output System
BP	Byte Position within a certain field, starting with 0 from the first byte of the field
byte	a string of binary digits operated upon as a unit
CPU	Central Processing Unit
defective sector	a sector that cannot be read or write
descriptor	a recorded structure containing information about the volume or a file
exFAT	extensible File Allocation Table
FAT	File Allocation Table
FAT12	File Allocation Table, 12-bit cluster indices
FAT16	File Allocation Table, 16-bit cluster indices
FAT32	File Allocation Table, 32-bit cluster indices
FDC	Flexible Disk Cartridge
file	a named collection of information
GUID	Globally Unique Identifier
INT	Interrupt
MBR	Master Boot Record
sector / block	a unit of data that can be accessed independently of other units on the SD Memory Card
texFAT	Transaction-safe exFAT
partition	an extent of sectors within a volume
user	a person or other entity that causes the invocation of the services provided by an implementation
UTC	Coordinated Universal Time
volume	a sector address space as specified in the relevant standard for recording
ZERO	represents a single bit with the value 0
KB	Kilo Bytes (=1,024bytes)
MB	Mega Bytes (=1,024×1,024bytes)
GB	Giga Bytes (=1,024×1,024×1,024bytes)
TB	Tera Bytes (=1,024×1,024×1,024×1,024bytes)

B.2 Arithmetic Notation

ip(*x*)	The notation shall mean the integer part of *x*.
ceil(*x*)	The notation shall mean the minimum integer that is not less than *x*.
rem(*x*,*y*)	The notation shall mean the reminder of the integer division of *x* by *y.*

B.3 Character Strings

A value for a sequence of bytes for FAT12 / FAT16 file system may be specified by a quoted sequence of characters, encoded according to the ISO/IEC 646 standard.

B.4 Data Types

B.4.1 Numerical Values in One-byte Fields

A numerical value in a one-byte field shall be recorded as an 8-bit number in one-byte field.

B.4.2 Numerical Values in Two-byte Fields

A numerical value in a two-byte field shall be recorded in the little endian representation. It shall be recorded according to ISO/IEC 9293.

B.4.3 Numerical Values in Four-byte Fields

A numerical value in a four-byte field shall be recorded in the little endian representation. It shall be recorded according to ISO/IEC 9293.

B.4.4 Numerical Values in Eight-byte Fields

A numerical value in a eight-byte field shall be recorded in the little endian representation.

B.4.5 Pairs of 12-bit Integers

A pair of 12-bit numbers shall be recorded in three-byte field according to ISO/IEC 9293.

Appendix C (Informative)

C.1 Appendix for FAT12/FAT16 File System

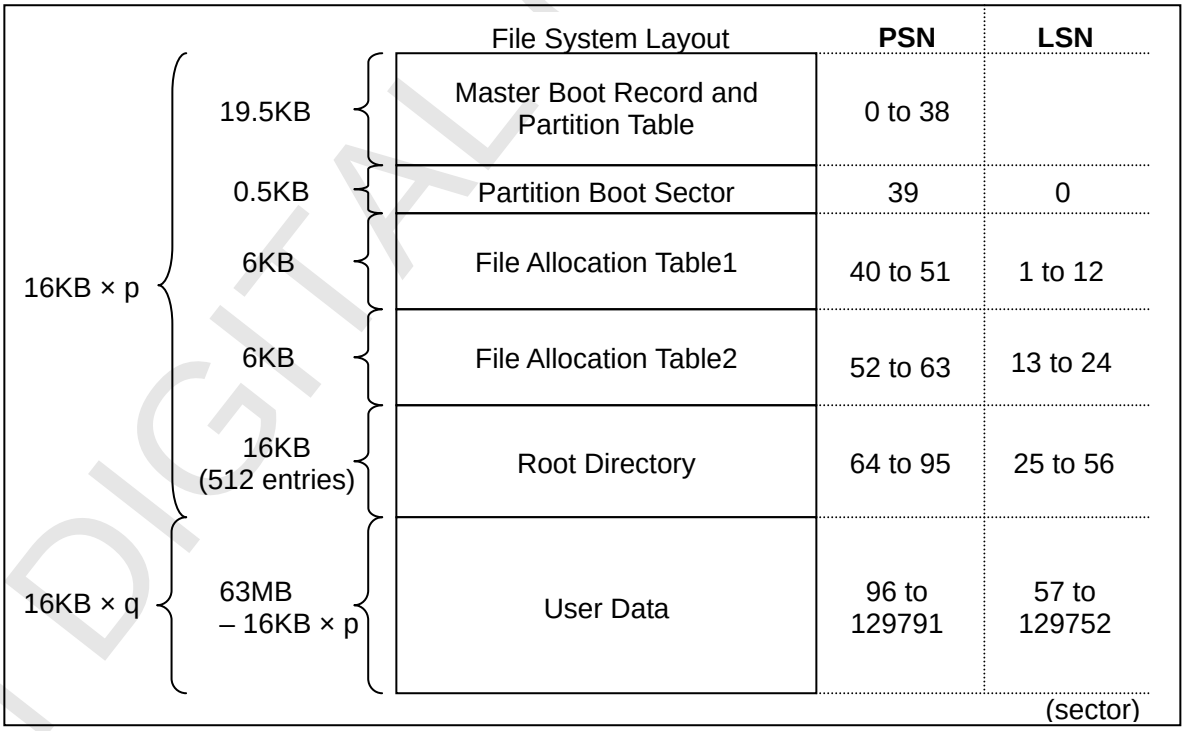
C.1.1 File System Layout

Reading/writing of the User Area should be done with the unit whose minimum size is the same as the recommended size of reading/writing at physical layer. Therefore, Cluster Size should be determined considering the recommended size. And the starting sector of the User Area should be to the boundary of the recommended size.

The structure of the file system should be implemented as follows.

1. The combined size of Master Boot Record, Partition Table, Partition Boot Sector, File Allocation Table and Root Directory is a multiple size of the Boundary Unit. Boundary Unit is the logical value determined taking the recommended size at physical layer into account. The concrete value is described in Appendix C.1.3.
2. The number of the sectors before Partition Boot Sector adjusts the above size.
3. Master Boot Record and Partition Boot Sector belong to different Boundary Unit.
4. The first sector of the Master Boot Record and the first sector of the User Data are always placed on the boundary of Boundary Unit.

The following is an example of a partition when the size of Boundary Unit is 16KB.



p,q : a natural number, PSN : Physical Sector Number, LSN : Logical Sector Number

Figure A-1 : Example of File System Layout

C.1.2 CHS Recommendation

The following table shows the recommendation for CHS parameter. In this table, Card Capacity means the total size of Data Area and Protected Area.
In this specification, “Number of Sides” defined in the Partition Boot Sector and “Number of Heads” of CHS parameter are almost the same meaning. Therefore, “Number of Heads” defined in Table A-1 should be used as the field value of “Number of Sides” field in the Partition Boot Sector.

Card Capacity	Number of Heads	Sectors per Track
~2MB	2	16
~16MB	2	32
~32MB	4	32
~128MB	8	32
~256MB	16	32
~504MB	16	63
~1008MB	32	63
~2016MB	64	63
~2048MB	128	63

Table A-1 : CHS Recommendation

Starting Head, Starting Sector, Starting Cylinder, Ending Head, Ending Sector, and Ending Cylinder shall be calculated with the above CHS parameter, Total Sector, and Relative Sector as described below.

$$\text{Starting Head} = ip\{\frac{rem(\text{Relative Sector}, \text{Number of Heads} \times \text{Sectors per Track})}{\text{Sectors per Track}}\}$$

$$\text{Starting Sector} = rem(\text{Relative Sector}, \text{Sectors per Track}) + 1$$

$$\text{Starting Cylinder} = ip(\frac{\text{Relative Sector}}{\text{Number of Heads} \times \text{Sectors per Track}})$$

$$\text{Ending Head} = ip\{\frac{rem(\text{Relative Sector} + \text{Total Sector} - 1, \text{Number of Heads} \times \text{Sectors per Track})}{\text{Sectors per Track}}\}$$

$$\text{Ending Sector} = rem(\text{Relative Sector} + \text{Total Sector} - 1, \text{Sectors per Track}) + 1$$

$$\text{Ending Cylinder} = ip(\frac{\text{Relative Sector} + \text{Total Sector} - 1}{\text{Number of Heads} \times \text{Sectors per Track}})$$

The following is an example of a Partition Table when the size of the Data Area 63MB.

BP	Length (bytes)	Field Name	Contents
0	1	Boot Indicator	00h
1	1	Starting Head	1
2	2	Starting Sector / Starting Cylinder	8 / 0
4	1	System ID	06h
5	1	Ending Head	7
6	2	Ending Sector / Ending Cylinder	32 / 506
8	4	Relative Sector	39
12	4	Total Sector	129753

Table A-2 : Example of Partition Table

C.1.3 Sectors per Cluster and Boundary Unit Recommendation for Data Area

The following table shows the recommendation for Sectors per Cluster and Boundary Unit of Data Area. Number of sectors before the starting sector of User Data is multiple size of Boundary Unit. In this table, Card Capacity means the total size of Data Area and Protected Area.

Card Capacity	Sectors per Cluster (sectors)	Boundary Unit (sectors)
~8MB	16	16
~64MB	32	32
~256MB	32	64
~1024MB	32	128
~2048MB	64	128

Table A-3 : Sectors per Cluster and Boundary Unit Recommendation (Data Area)

Maximum Data Area size and an example of format parameters are shown in the following table. The format parameters in this table are examples. They should be calculated with some steps described in the following section.

Card Capacity	Sectors per Cluster (sectors)	Max Data Area size (sectors)	An example of format parameters (These values vary depending on Data Area size)				
			Clusters	FAT Sec (sectors)	Hidden (sectors)	FAT bits	User Data Offset (sectors)
~4MB	16	8032	498	2	27	12	64
~8MB	16	16224	1010	3	25	12	64
~16MB	32	32448	1011	3	57	12	96
~32MB	32	64896	2025	6	51	12	96
~64MB	32	129792	4053	12	39	12	96
~128MB	32	259584	8106	32	95	16	192
~256MB	32	519168	16216	64	95	16	256
~512MB	32	1038336	32432	127	225	16	512
~1024MB	32	2076672	64872	254	227	16	768
~2048MB	64	4153344	64884	254	227	16	768

Table A-4 : Maximum Data Area size and Format Parameters

However,

Card Capacity … SD Memory Card Capacity.
Sectors per Cluster … Number of sectors per cluster. This parameter is defined from Card Capacity.
Max Data Area size … Maximum number of sectors for Data Area.
Clusters … Number of clusters in User Data. This parameter varies with the Data Area size.
FAT Sec … Number of sectors per FAT. This parameter varies with the Data Area size.
Hidden … Number of sectors existing before Partition Boot Sector. This parameter varies with the Data Area size.
FAT bits … If the area is formatted with FAT12, FAT bits is 12. And if the area is formatted with FAT16, FAT bits is 16. This parameter varies with the Data Area size.
User Data Offset … Number of sectors existing before the starting sector of User Data.

Sectors per Cluster is defined from Card Capacity. Clusters, FAT Sec, Hidden, FAT bits, and User Data Offset vary with the Data Area size (Use the parameters in Table A-3 for calculation).

C.1.4 Format Parameter Computations

In this section, format parameter computations are proposed. Data Area should be formatted by the following steps.

1. Sectors per Cluster (SC) is determined from the area size.

2. Number of Root-directory Entries (RDE) is 512.

3. Sector Size (SS) is 512.

4. Reserved Sector Count (RSC) is 1.

5. Total Sectors (TS) is the number of all sectors of the area.

6. FAT bits (12[FAT12], 16[FAT16]) is determined by SC and TS.

7. Sectors per FAT (SF) is computed as following:

$$SF = ceil\{ \frac{TS/SC \times FAT\ bits}{SS \times 8} \}$$

8. Number of sectors in the system area (SSA) is computed as following:

$$SSA = RSC + 2 \times SF + ceil(\frac{32 \times RDE}{SS})$$

9. Number of Sectors in Master Boot Record (NOM) is computed as following:

$$NOM + SSA = BU \times n$$

Here, n means the minimum natural number satisfying above expression. And BU means the Boundary Unit.

10. If NOM isn't equal to BU, NOM is added BU.

11. Maximum Cluster Number (MAX) is computed as following:

$$MAX = ip(\frac{TS - NOM - SSA}{SC}) + 1$$

12. Sectors per FAT (SF') is recalculated as following:

$$SF' = ceil\{ \frac{[2 + (MAX - 1)] \times FAT\ bits}{SS \times 8} \}$$

In this formula, 'MAX-1' means the number of clusters. And '2+(MAX-1)' means the number of FAT entries including two signature entries.

13. If SF' is greater than SF, NOM is added BU. And recalculate from step 11.

14. If SF' isn't equal to SF, SF' is used as SF. And recalculate from step 8.

15. If SF' is equal to SF, parameter computing is complete.

Example of a SD Memory Card including 63MB Data Area:
- TS = 129792 Sectors
- SC = 32 Sectors
- RDE = 512 Entries
- SS = 512 B
- RSC = 1 Sectors
- FAT bits = 12 [FAT12]
- SF = 12 Sectors
- SSA = 57 Sectors
- NOM = 39 Sectors
- MAX = 4054

Example of Extended FDC Descriptor for the above example:

BP	Length (bytes)	Field Name	Contents
0	3	Jump Command	EBh, 00h, 90h
3	8	Creating System Identifier	"SYSTEMID"
11	2	Sector Size	512
13	1	Sectors per Cluster	32
14	2	Reserved Sector Count	1
16	1	Number of FATs	2
17	2	Number of Root-directory Entries	512
19	2	Total Sectors	0
21	1	Medium Identifier	F8h
22	2	Sectors per FAT	12
24	2	Sectors per Track	32
26	2	Number of Sides	8
28	4	Number of Hidden Sectors	39
32	4	Total Sectors	129753
36	1	Physical Disk Number	80h
37	1	Reserved	00h
38	1	Extended Boot Record Signature	29h
39	4	Volume ID Number	01234567h
43	11	Volume Label	"VOLUME1 "
54	8	File System Type	"FAT12 "
62	448	(Reserved for system use)	Not Restricted
510	2	Signature Word	55h, AAh

Table A-5 : Extended FDC Descriptor

C.2 Appendix for FAT32 File System

C.2.1 File System Layout

NOTE: Recommendation of FAT32 described in this section includes portions of Microsoft FAT Specification, the copyright of which is owned by Microsoft but licensed to SD Card Association.

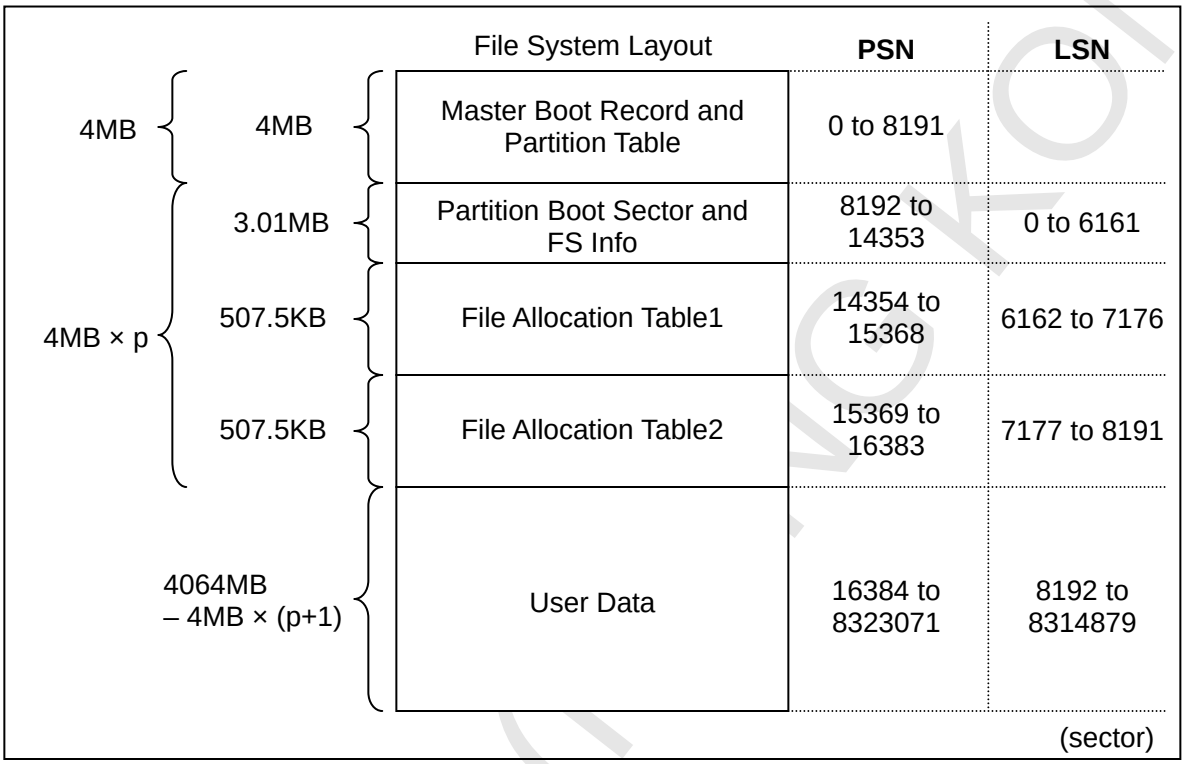
FAT32 file system for SD Memory Card has the similar recommendation with FAT12 / FAT16 file system described in the previous section. The differences with FAT12 / FAT16 recommendation are as follows.

- The file system layout is modified in order to comply with FAT32 structure.
- The adjustment area is changed from the reserved sectors existing before Partition Boot Sector to the reserved sectors existing before FAT.

The structure of the file system should be implemented as follows.

1. The number of the sectors before Partition Boot Sector is the same as the Boundary Unit size. Boundary Unit is the logical value determined taking the recommended size at physical layer into account. The concrete value is described in Appendix C.2.3.
2. The number of the sectors included in the area between Partition Boot Sector and the end sector of FAT2 is a multiple size of the Boundary Unit. Here, this size shall be set to minimum complying with the format parameter computations described in Appendix C.2.4.
3. The first sector of the Master Boot Record, the first Partition Boot Sector, and the first sector of the User Data are always placed on the boundary of Boundary Unit.

The following is an example of a partition when the size of Boundary Unit is 4MB.



p : a natural number, PSN : Physical Sector Number, LSN : Logical Sector Number

Figure A-2 : Example of File System Layout

C.2.2 CHS Recommendation

The recommendation for CHS parameters of the High Capacity SD Memory Card is as follows. In this table, Card Capacity means the total size of Data Area and Protected Area.
In this specification, “Number of Sides” defined in the Partition Boot Sector and “Number of Heads” of CHS parameter are almost the same meaning. Therefore, “Number of Heads” defined in Table A-6 should be used as the field value of “Number of Sides” field in the Partition Boot Sector.

Card Capacity	Number of Heads	Sectors per Track
2,088.5MB ~ 4032MB	128	63
~32768MB	255	63

Table A-6 : CHS Recommendation

Starting Head, Starting Sector, Starting Cylinder, Ending Head, Ending Sector, and Ending Cylinder shall be calculated by the same computations for the FAT12 / FAT16 described in C.1.2. However, these parameters have the upper limit and they can represent up to 8032.5MB (8,422,686,720Bytes). Therefore, these parameters shall set to maximum values in case that the corresponding location exceeds 8032.5MB.

C.2.3 Sectors per Cluster and Boundary Unit Recommendation for Data Area

The recommendation for Sectors per Cluster and Boundary Unit of Data Area of the High Capacity SD Memory Card is as follows. In this table, Card Capacity means the total size of Data Area and Protected Area.

Card Capacity	Sectors per Cluster (sectors)	Boundary Unit (sectors)
2,088.5MB ~ 32768MB	64	8192

Table A-7 : Sectors per Cluster and Boundary Unit Recommendation (Data Area)

Maximum Data Area size and an example of format parameters are shown in following table. The format parameters in this table are examples. They should be calculated with some steps described in the following section.

Card Capacity	Sectors per Cluster (sectors)	Max Data Area size (sectors)	An example of format parameters (These values vary depending on Data Area size)					
			Clusters	FAT Sec (sectors)	Hidden (sectors)	Reserved Sector Count (sectors)	FAT bits	User Data Offset (sectors)
2088.5MB ~ 4096MB	64	8323072	129792	1015	8192	6162	32	16384
~8192MB	64	16678912	260352	2035	8192	4122	32	16384
~16384MB	64	33423360	521984	4079	8192	34	32	16384
~32768MB	64	66945024	1045632	8170	8192	44	32	24576

Table A-8 : Maximum Data Area Size and Format Parameters

However,

Card Capacity … SD Memory Card Capacity.
Sectors per Cluster … Number of sectors per cluster. This parameter is defined from Card Capacity.
Max Data Area size … Maximum number of sectors for Data Area.
Clusters … Number of clusters in User Data. This parameter varies with the Data Area size.
FAT Sec … Number of sectors per FAT. This parameter varies with the Data Area size.
Hidden … Number of sectors existing before Partition Boot Sector.
Reserved Sector Count … Number of reserved sector count. This parameter varies with the Data Area size.
FAT bits … FAT bits is 32, because the area shall be formatted with FAT32.
User Data Offset … Number of sectors existing before the starting sector of User Data.

Sectors per Cluster is defined from Card Capacity. Clusters, FAT Sec, Hidden, Reserved Sector Count, FAT bits, and User Data Offset vary with the Data Area size (Use the parameters in Table A-7 for calculation).

C.2.4 Format Parameter Computations

In this section, format parameter computations for the High Capacity SD Memory Card are proposed. The basic policy is the same as the FAT12 / FAT16 computations described in the previous section. However, it is slightly modified in order to comply with FAT32 structure.

1. Sectors per Cluster (SC) is 64.

2. Sector Size (SS) is 512.

3. Total Sectors (TS) is the number of all sectors of the area.

4. FAT bits is 32 [FAT32].

5. Sectors per FAT (SF) is computed as following:

$$SF = ceil\{ \frac{TS/SC \times FAT\ bits}{SS \times 8} \}$$

6. Number of Sectors in Master Boot Record (NOM) is computed as following:

$$NOM = BU$$

Here, BU means the Boundary Unit.

7. Reserved Sector Count (RSC) is computed as following:

$$RSC = BU \times n - 2 \times SF$$

Here, n means the minimum natural number satisfying above expression.

8. If RSC is smaller than 9, RSC is added BU.

9. Number of sectors in the system area (SSA) is computed as following:

$$SSA = RSC + 2 \times SF$$

10. Maximum Cluster Number (MAX) is computed as following:

$$MAX = ip(\frac{TS - NOM - SSA}{SC}) + 1$$

11. Sectors per FAT (SF') is recalculated as following:

$$SF' = ceil\{ \frac{[2 + (MAX - 1)] \times FAT\ bits}{SS \times 8} \}$$

In this formula, 'MAX-1' means the number of clusters. And '2+(MAX-1)' means the number of FAT entries including two signature entries.

12. If SF' is greater than SF, SSA and RSC are added BU. And recalculate from step 10.

13. If SF' isn't equal to SF, 'SF-1' is used as new SF. And recalculate from step 7.

14. If SF' is equal to SF, parameter computing is complete.

Example of a SD Memory Card including 4066MB Data Area:
- TS = 8323072 Sectors
- SC = 64 Sectors
- SS = 512 B
- RSC = 6162 Sectors
- FAT bits = 32 [FAT32]
- SF = 1015 Sectors
- SSA = 8192 Sectors
- NOM = 8192 Sectors
- MAX = 129793

Example of Partition Boot Sector and FS Info Sector for the above example:

BP	Length (bytes)	Field Name	Contents
0	3	Jump Command	EBh, 00h, 90h
3	8	Creating System Identifier	"SYSTEMID"
11	2	Sector Size	512
13	1	Sectors per Cluster	64
14	2	Reserved Sector Count	6162
16	1	Number of FATs	2
17	2	Number of Root-directory Entries	0
19	2	Total Sectors	0
21	1	Medium Identifier	F8h
22	2	Sectors per FAT	0
24	2	Sectors per Track	63
26	2	Number of Sides	255
28	4	Number of Hidden Sectors	8192
32	4	Total Sectors	8314880
36	4	Sectors per FAT for FAT32	1015
40	2	Extension Flag	00h
42	2	FS Version	0000h
44	4	Root Cluster	2
48	2	FS Info	1
50	2	Backup Boot Sector	6
52	12	Reserved	All 00h
64	1	Physical Disk Number	80h
65	1	Reserved	00h
66	1	Extended Boot Record Signature	29h
67	4	Volume ID Number	01234567h
71	11	Volume Label	"VOLUME1 "
82	8	File System Type	"FAT32 "
90	420	(Reserved for system use)	Not Restricted
510	2	Signature Word	55h, AAh

Table A-9 : Partition Boot Sector

BP	Length (bytes)	Field Name	Contents
0	4	Lead Signature	52h, 52h, 64h, 41h
4	480	Reserved	All 00h
484	4	Structure Signature	72h, 72h, 41h, 61h
488	4	Free Cluster Count	FFFFFFFFh
492	4	Next Free Cluster	FFFFFFFFh
496	12	Reserved	All 00h
508	4	Trail Signature	00h, 00h, 55h, AAh

Table A-10 : FS Info Sector

C.3 Long File Name Implementation (optional)

C.3.1 LFN in SD Memory Card File System

For all FAT12/FAT16/FAT32 file system of SD Memory Card, the file name format shall support 8.3 format as mandatory. Moreover, hosts can also support Long File Name (LFN) as optional. This section describes Long File Name format and usages.

NOTE: Long File Name described in this section is OPTIONAL. The Long File Name specification described in this section includes portions of Microsoft FAT Specification, the copyright of which is owned by Microsoft but licensed to SD Card Association.

C.3.2 FAT Long Directory Entries

The Name and Name Extension field in the directory entry only allows for a 11 character file / sub-directory name comprised of a main part (maximum length of 8 characters) and an extension (maximum length of 3 characters). The contents of this field are also known as the “short name” and the corresponding directory entry is also known as the short name directory entry. Applications and users typically prefer creating longer (more descriptive) names for files/sub-directories. This section describes how such long file names can be stored on media.

A long file name for a target file or sub-directory is stored in a set (one or more) of additional directory entries associated with the short name directory entry describing the target file or sub-directory. This set of additional directory entries (also known as the long name directory entries) shall immediately precede the corresponding short name directory entry and is, therefore, physically contiguous with the short name directory entry.

NOTE: The sequence of long name directory entries is stored in reverse order (last entry in the set is stored first, followed by entry n-1, followed by entry n-2, and so on, until entry 1).

A long name directory entry structure is described in the table below:

BP	Length (bytes)	Field Name	Description
0	1	LDIR_Ord	The order of this entry in the sequence of long name directory entries (each containing components of the long file name) associated with the corresponding short name directory entry. The contents of this field shall be masked with 40h (LAST_LONG_ENTRY) for the last long directory name entry in the set. Therefore, each sequence of long name directory entries begins with the contents of this field masked with LAST_LONG_ENTRY.
1	10	LDIR_Name1	Contains characters 1 through 5 constituting a portion of the long name.
11	1	LDIR_Attr	Attributes – shall be set to ATTR_LONG_NAME defined as below: ATTR_LONG_NAME = (ATTR_READ_ONLY | ATTR_HIDDEN | ATTR_SYSTEM | ATTR_VOLUME_ID) NOTE: A mask to determine whether a directory entry is part of the set of a long name directory entries is defined below: #define ATTR_LONG_NAME_MASK = (ATTR_READ_ONLY | ATTR_HIDDEN | ATTR_SYSTEM | ATTR_VOLUME_ID | ATTR_DIRECTORY | ATTR_ARCHIVE)
12	1	LDIR_Type	Shall be set to 0.
13	1	LDIR_Chksum	Checksum of name in the associated short name directory entry at the end of the long name directory entry set.
14	12	LDIR_Name2	Contains characters 6 through 11 constituting a portion of the long name.
26	2	LDIR_FstClusLO	Shall be set to 0.
28	4	LDIR_Name3	Contains characters 12 and 13 constituting a portion of the long name.

Table A-11 : FAT Long Directory Entry Structure

The below illustrates how long name directory entries are stored:

Entry	Ordinal
Nth long name directory entry	LAST_LONG_ENTRY (40h) | N
… Additional long name directory entries	…
1st long name directory entry	1
Short Entry Associated with Preceding Long Entries	(not applicable)

Table A-12 : Sequence of Long Directory Entries

C.3.3 Ordinal Number Generation

The below rules shall be followed in storing ordinal numbers for each long name directory entry in a set of such entries (associated with a short name directory entry):

The first member of a set has an LDIR_Ord value of 1.
The LDIR_Ord value for each subsequent entry shall contain a monotonically increasing value.
The Nth (last) member of the set shall contain a value of (N | LAST_LONG_ENTRY)

If any member of the set of long name directory entries does not follow the rules above, the set is considered corrupt.

C.3.4 Checksum Generation

An 8-bit checksum is computed on the name contained in the short name directory entry at the time the short and long name directory entries are created. All 11 characters of the name in the short name entry are used in the checksum calculation. The check sum is placed in every long name directory entry in the LDIR_Chksum field. If any of the check sums in the set of long name entries associated with the appropriate short name directory entry, do not agree with the computed checksum of the name contained in the short name directory entry, the set of long name directory entries is considered corrupt.

The below algorithm describes the logic used to generate the check sum value:

```
//------------------------------------------------------------------------
//      ChkSum()
//      Returns an unsigned byte checksum computed on an unsigned byte
//      array.  The array must be 11 bytes long and is assumed to contain
//      a name stored in the format of a MS-DOS directory entry.
//      Passed:  pFcbName    Pointer to an unsigned byte array assumed to be
//                          11 bytes long.
//      Returns: Sum         An 8-bit unsigned checksum of the array pointed
//                           to by pFcbName.
//------------------------------------------------------------------------
unsigned char ChkSum (unsigned char *pFcbName)
{
        short FcbNameLen;
        unsigned char Sum;

        Sum = 0;
        for (FcbNameLen=11; FcbNameLen!=0; FcbNameLen--) {
                // NOTE: The operation is an unsigned char rotate right
                Sum = ((Sum & 1) ? 0x80 : 0) + (Sum >> 1) + *pFcbName++;
        }
        return (Sum);
}
```

C.3.5 Example illustrating persistence of a long name

The following example is provided to illustrate how a long name is stored across several long name

directory entries. Names are also NULL terminated and padded with FFFFh characters in order to detect corruption of long name fields. A name that fits exactly in a set of long name directory entries (i.e. is an integer multiple of 13) is not NULL terminated and not padded with FFFFh.

Name: "The quick brown.fox"

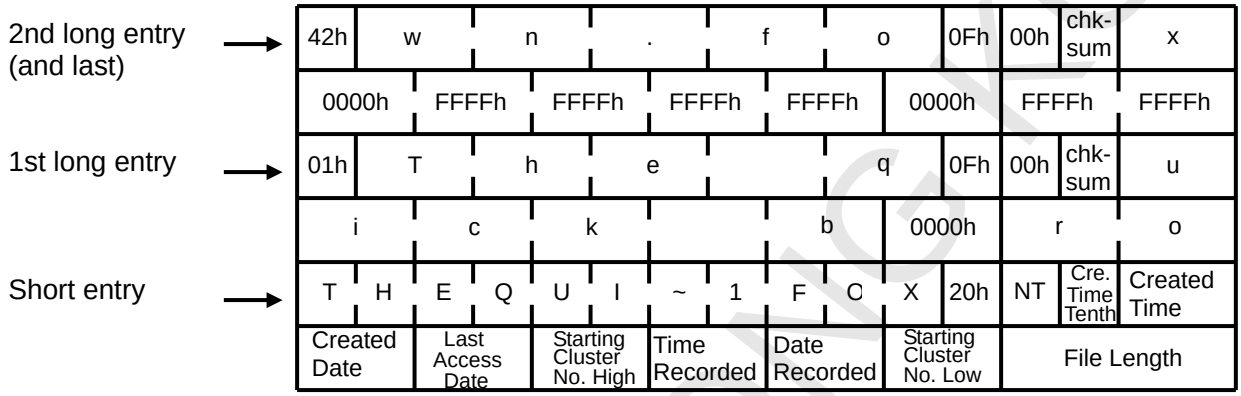


Figure A-3 : Example of Long Directory Entries

C.3.5.1 Name Limits and Character Set for Long File Names

Long file names are limited to 255 characters, not including the trailing NULL. The characters may be any combination of those defined for short file names with the addition of the period (“.”) character used multiple times within the long name. A space is also a valid character in a long file name as it always has been for a short file name. The following six special characters are allowed in a long file name (they are not legal in a short file name):

+ , ; = [ ]

Embedded spaces within a long file name are allowed. Leading and trailing spaces in a long file name are ignored.

Leading and embedded periods are allowed in a name and are stored in the long file name. Trailing periods are ignored.

Long file names are stored in long directory entries in UNICODE. UNICODE characters are 16-bit characters. It is not be possible to store UNICODE in short name directory entries since the names stored there are 8-bit characters or DBCS characters.

Long file names passed to the file system are not converted to upper case and their original case value is preserved. UNICODE solves the case mapping problem prevalent in some OEM code pages by always providing a translation for lower case characters to a single, unique upper case character

C.3.6 Rules Governing Name Creation and Matching

The union of all long and short file names is defined as the namespace of objects contained in the volume.

For such a namespace, the following rules shall be observed:

- Any name within a specific directory, whether it is a short name or a long name, can occur only once (difference in case is ignored and such names shall be considered as conflicting)

- When a character on the media (whether stored in the OEM character set or in UNICODE) cannot be translated into the appropriate character in the OEM or ANSI code page, it is always translated to the "_" (underscore) character – the character is not modified on the media. The “_” character is the same in all OEM code pages and ANSI.

C.4 Differences from Microsoft FAT Specification

FAT32 file system described in this specification complies with Microsoft FAT Specification. However, some parameters are limited for optimization. The main differences are as follows.

Item / Field		FAT32 of Microsoft FAT Specification	FAT32 of SD Specification
Support Capacity		Over 32.5MB	2088.5MB ~ 32GB
Master Boot Record and Partition Table		Not specified	Specified in the same way as Ver1.01
Boot Sector	Sector Size	512, 1024, 2048 or 4096 bytes	512 bytes
	Cluster Size	1, 2, 4, 8, 16, 32, 64, or 128 sectors	1, 2, 4, 8, 16, 32, or 64 sectors (‘64’ is strongly recommended.)
	Number of FATs	1 or 2 (Recommendation is 2)	2
	Medium Identifier	The legal values for this field are F0h, F9h, FAh, FBh, FCh, FEh, and FFh. F8h is the standard value for "fixed" (non-removable) media. For removable media, F0h is frequently used.	F8h
	Sectors per Track	Not specified	The recommended values are specified in Appendix.
	Number of Sides	Not specified	The recommended values are specified in Appendix.
	FS Info	Usually 1.	1
	Backup Boot Sector	0 or 6	6
	Physical Disc Number	00h or 80h	80h
	Extended Boot Signature	Set value to 29h if either of the following two fields are non-zero.	29h
FAT Entry Value		FFFFFF8h to FFFFFFEh is reserved and should not be used. It may be interpreted as an allocated cluster and the final cluster in the file.	FFFFFF8h to FFFFFFEh show the corresponding cluster is already allocated, and it is the final cluster of the file.
File System Layout		The method of User Data area offset alignment is not specified.	The method of User Data area offset alignment is specified in Appendix.

Table A-13 : Comparison Table for FAT32 File Systems

C.5 Appendix for exFAT File System

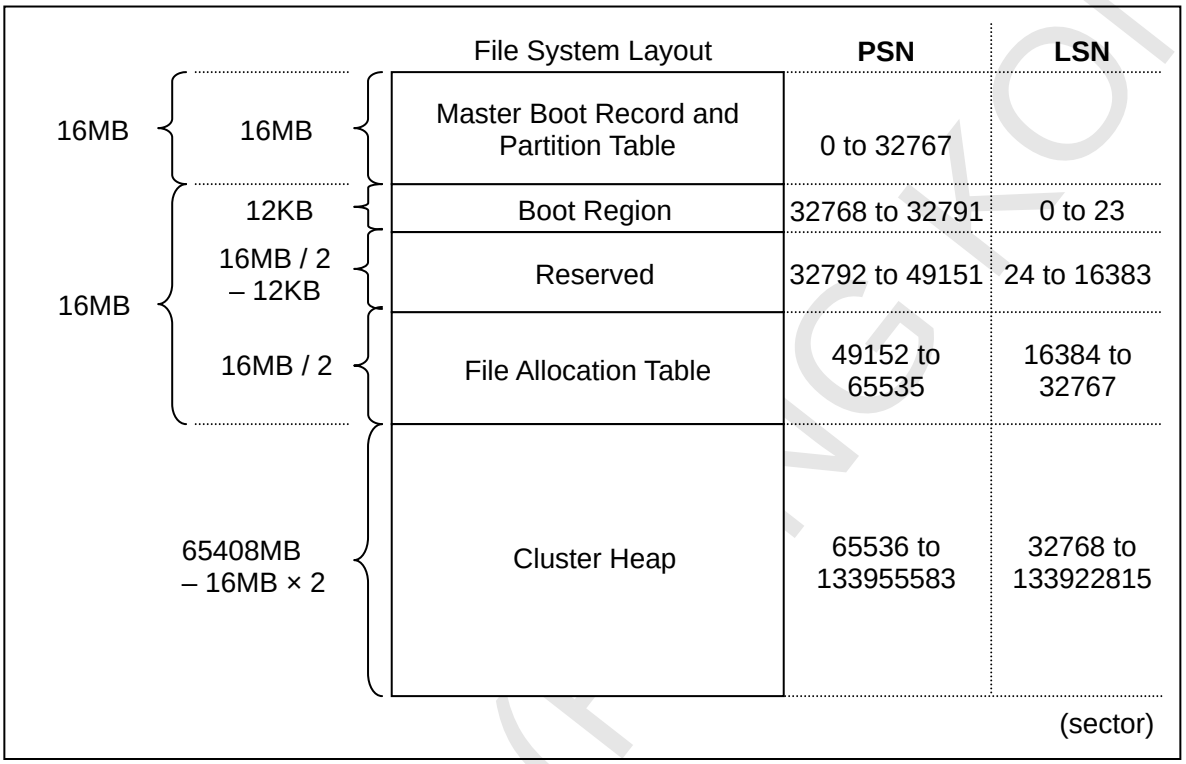
C.5.1 File System Layout

NOTE: Recommendation of exFAT described in this section includes portions of "exFAT Revision 1.00 File System Basic Specification", the copyright of which is owned by Microsoft but licensed to SD Card Association.

exFAT file system for SD Memory Card has the similar recommendation with FAT32 file system described in the previous section. The structure of the file system should be implemented as follows.

1. The number of the sectors before Boot Region is the same as the Boundary Unit size. Boundary Unit is the logical value determined taking the recommended size at physical layer into account. The concrete value is described in Appendix C.5.3.
2. The total number of the sectors included in Boot Region and FAT is a multiple size of the Boundary Unit. Here, this size shall be set to minimum complying with the format parameter computations described in Appendix C.5.4.
3. The first sector of the Master Boot Record, the Main Boot Sector, and the first sector of the Cluster Heap are always placed on the boundary of Boundary Unit.

The following is an example of a partition when the size of Boundary Unit is 16MB.



PSN : Physical Sector Number, LSN : Logical Sector Number

Figure A-4 : Example of File System Layout

C.5.2 CHS Recommendation

The recommendation for CHS parameters of the Extended Capacity SD Memory Card is as follows. In this table, Card Capacity means the total size of Data Area and Protected Area.
In the exFAT volume, there are no fields which store these parameters. However, these parameters are used to calculate the starting location of partition with CHS addressing.

Card Capacity	Number of Heads	Sectors per Track
32896MB ~ 2TB	255	63

Table A-14 : CHS Recommendation

Starting Head, Starting Sector, and Starting Cylinder shall be calculated by the same computations for the FAT12 / FAT16 described in C.1.2. However, these parameters have the upper limit and they can represent up to 8032.5MB (8,422,686,720Bytes). Therefore, these parameters shall set to maximum values in case that the corresponding location exceeds 8032.5MB.

C.5.3 Sectors per Cluster and Boundary Unit Recommendation for Data Area

The recommendation for Sectors per Cluster and Boundary Unit of Data Area of the Extended Capacity SD Memory Card is as follows. In this table, Card Capacity means the total size of Data Area and Protected Area.

Card Capacity	Sectors per Cluster (sectors)	Boundary Unit (sectors)
32896MB ~ 128GB	256	32768
~512GB	512	65536
~2TB	1024	131072

Table A-15 : Sectors per Cluster and Boundary Unit Recommendation (Data Area)

Maximum Data Area size and an example of format parameters are shown in following table. The format parameters in this table are examples. They should be calculated with some steps described in the following section.

Card Capacity	Sectors per Cluster (sectors)	Max Data Area size (sectors)	An example of format parameters (These values vary depending on Data Area size)				
			Clusters	Partition Offset (sectors)	FAT Offset* (sectors)	FAT Length (sectors)	Cluster Heap Offset* (sectors)
32896MB ~ 64GB	256	133955584	523008	32768	49152	16384	65536
~128GB	256	268173312	1047296	32768	49152	16384	65536
~256GB	512	536608768	1047808	65536	98304	32768	131072
~512GB	512	1073479680	2096384	65536	98304	32768	131072
~1024GB	1024	2147221504	2096640	131072	196608	65536	262144
~2048GB	1024	4294705152	4193792	131072	196608	65536	262144

*) See the following notes.

Table A-16 : Maximum Data Area Size and Format Parameters

However,

Card Capacity … SD Memory Card Capacity.
Sectors per Cluster … Number of sectors per cluster. This parameter is defined from Card Capacity.
Max Data Area size … Maximum number of sectors for Data Area.
Clusters … Number of clusters in Cluster Heap. This parameter varies with the Data Area size.
Partition Offset … Number of sectors existing before Main Boot Sector.
FAT Offset … The starting offset of FAT. Note that this value shows the sector offset from Master Boot Record. Therefore, this value is not the same meaning with FatOffset field of Boot Sector.
FAT Length … Number of sectors per FAT. This parameter varies with the Data Area size.
Cluster Heap Offset … The starting offset of Cluster Heap. Note that this value shows the sector offset from Master Boot Record. Therefore, this value is not the same meaning with ClusterHeapOffset field of Boot Sector.

Sectors per Cluster is defined from Card Capacity. Clusters, Partition Offset, FAT Offset, FAT Length, and Cluster Heap Offset vary with the Data Area size (Use the parameters in Table A-15 for calculation).

C.5.4 Format Parameter Computations

In this section, format parameter computations for the Extended Capacity SD Memory Card are proposed. The basic policy is the same as the FAT32 computations described in the previous section. However, it is slightly modified in order to comply with exFAT structure.

1. Sectors per Cluster (SC) is determined from the area size.

2. Boundary Unit (BU) is determined from the area size.

3. Sector Size (SS) is 512.

4. Total Sectors (TS) is the number of all sectors of the area.

5. FAT bits is 32 [exFAT].

6. Number of FATs is 1.

7. PartitionOffset field of Boot Sector is computed as following:

PartitionOffset = BU

8. VolumeLength field of Boot Sector is computed as following:

VolumeLength = TS - BU

9. FatOffset field of Boot Sector is computed as following:

FatOffset = BU / 2

10. FatLength field of Boot Sector is computed as following:

FatLength = BU / 2

11. ClusterHeapOffset field of Boot Sector is computed as following:

ClusterHeapOffset = BU

12. ClusterCount field of Boot Sector is computed as following:

ClusterCount = (TS - BU × 2) / SC

Example of a SD Memory Card including 65408MB Data Area:
- TS = 133955584 Sectors
- SC = 256 Sectors
- BU = 32768 Sectors
- SS = 512 B

- PartitionOffset = 32768 Sectors
- VolumeLength = 133922816 Sectors
- FatOffset = 16384 Sectors
- FatLength = 16384 Sectors
- ClusterHeapOffset = 32768 Sectors
- ClusterCount = 523008 Clusters

Example of Main Boot Sector for the above example:

BP	Length (bytes)	Field Name	Contents
0	3	JumpBoot	EBh, 76h, 90h
3	8	FileSystemName	“EXFAT “
11	53	MustBeZero	All 00h
64	8	PartitionOffset	32768
72	8	VolumeLength	133922816
80	4	FatOffset	16384
84	4	FatLength	16384
88	4	ClusterHeapOffset	32768
92	4	ClusterCount	523008
96	4	FirstClusterOfRootDirectory	4
100	4	VolumeSerialNumber	01234567h
104	2	FileSystemRevision	00h, 01h
106	2	VolumeFlags	0000h
108	1	BytesPerSectorShift	9
109	1	SectorsPerClusterShift	8
110	1	NumberOfFats	1
111	1	DriveSelect	80h
112	1	PercentInUse	00h
113	7	Reserved	All 00h
120	390	BootCode	Not Restricted
510	2	BootSignature	55h, AAh

Table A-17 : Main Boot Sector

C.6 Differences from Microsoft exFAT Specification

exFAT file system described in this specification complies with ”exFAT Revision 1.00 File System Basic Specification”.
However, some parameters are limited for optimization. The main differences are as follows.

Item / Field		exFAT of Microsoft exFAT Specification	exFAT of SD Specification
Support Capacity		1MB ~ 128PB	32896MB ~ 2TB
Master Boot Record and Partition Table		Only “System ID” field of Partition Table is specified.	All fields of Partition Table are specified.
Boot Sector	BytesPerSectorShift	9 ~ 12	9
	SectorsPerClusterShift	0 ~ (25-BytesPerSectorShift)	0 ~ 16 (Moreover, the recommended values are specified in Appendix.)
	NumberOfFats	1 or 2	1 or 2 (However, 1 should be used by default.)
	DriveSelect	All possible values are valid.	80h
Flash Parameters (OEM Parameters)		This field may be used by manufacturer.	This field should be used by manufacturer. And some field’s values are limited.
Continuous Information Manage Directory Entry, Continuous Information Directory Entry		Not specified	Specified as optional directory entries
File System Layout		The method of Cluster Heap offset alignment is not specified.	The method of Cluster Heap offset alignment is specified in Appendix.

Table A-18 : Comparison Table for exFAT File Systems