SFF specifications are available at http://www.snia.org/sff/specifications
or ftp://ftp.seagate.com/sff

This specification was developed by the SFF Committee prior to it becoming the SFF TA (Technology Affiliate) TWG (Technical Working Group) of SNIA (Storage Networking Industry Association).

The information below should be used instead of the equivalent herein.

POINTS OF CONTACT:

Chairman SFF TA TWG
Email: SFF-Chair@snia.org

If you are interested in participating in the activities of the SFF TWG, the membership application can be found at:
http://www.snia.org/sff/join

The complete list of SFF Specifications which have been completed or are currently being worked on can be found at:
http://www.snia.org/sff/specifications/SFF-8000.TXT

The operations which complement the SNIA's TWG Policies & Procedures to guide the SFF TWG can be found at:
http://www.snia.org/sff/specifications/SFF-8032.PDF

Suggestions for improvement of this specification will be welcome, they should be submitted to:
http://www.snia.org/feedback

SFF Committee documentation may be purchased in electronic form.
SFF specifications are available at ftp://ftp.seagate.com/sff

SFF Committee

SFF-8447

Specification for

LBA Count for Disk Drives

Rev 0.5 May 14, 2015

Secretariat: SFF Committee

Abstract: This specification defines the logical block address (LBA) count for advertised capacities of 3.5" form factor (see SFF-8300) and 2.5" form factor (see SFF-8200) disk drives.

This specification defines the methods of calculating the number of LBAs from the advertised capacity. The calculations method in this specification address multiple aspects in determining the number of LBAs for a disk drive. These include:

- advertised capacity;
- common logical block sizes;
- adjustments for SCSI Protection Information (PI);
- a factor to allow for inefficiencies in fitting the logical block configuration to the media for high capacity disk drives;
- adjustments to achieve an integer multiple of 8 LBAs for 5xx disk drives to support 4xxx physical sectors; and
- adjustments to achieve an integer multiple of 1 GiB, nominal, for high capacity disk drives to support zoned block devices.

This specification defines the method of calculating the standard LBA count for an advertised capacity by defining formulas that take the advertised capacity, logical block size, and inclusion of SCSI Protection Information as independent input parameters.

This specification provides a common reference for systems manufacturers, system integrators, and suppliers. This is an internal working specification of the SFF Committee, an industry ad hoc group.

This specification is made available for public review, and written comments are solicited from readers. Comments received by the members will be considered for inclusion in future revisions of this specification.

Support: This specification is supported by the identified member companies of the SFF Committee.

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EXPRESSION OF SUPPORT BY MANUFACTURERS

The following member companies of the SFF Committee voted in favor of this industry specification.

All Best
Dell Computer
EMC
Hewlett Packard
HGST
IBM
NetApp
Sandisk
Seagate
Shenzhen
Toshiba
Volex
Western Digital

The following member companies of the SFF Committee voted to abstain on this industry specification.

AMI
Amphenol
Applied Micro
Avago
Broadcom
FCI
Finisar
Foxconn
JDS Uniphase
Jess-Link
Luxshare-ICT
Molex
QLogic
Sumitomo
TE Connectivity

Update History

Rev 0.1 May 7, 2014
- Initial release

Rev 0.2 July 9, 2014
- Complete rewrite to support zoned configurations. Changes not tracked.

Rev 0.3 July 30, 2014
- Minor editorial updates. No changes to technical content of determining LBA count for large capacity drives.
- Added formulas for low capacity disk drives equivalent to IDEMA LBA1-03 (logical block sizes of 512 and 4096 bytes).
- Editorial changes to consistently use LBA count and not logical block count.
- Editorial changes to define additional user payload as SCSI Protection Information.

Rev 0.4 October 23, 2014
- Updated definitions of ceiling and floor.
- Added requirements regarding labeling if a low capacity drive doesn’t meet the IDEMA formula block count.
- Changed cut in point to >8 000 GB regardless of form factor.

Rev 0.5 May 14, 2015
- Clarified in 1.1 and 4.3 that sample calculations do not describe product offerings.

Foreword

The development work on this specification was done by the SFF Committee, an industry group. The membership of the committee since its formation in August 1990 has included a mix of companies which are leaders across the industry.

When 2 1/2" diameter disk drives were introduced, there was no commonality on external dimensions e.g. physical size, mounting locations, connector type, connector location, between vendors.

The first use of these disk drives was in specific applications such as laptop portable computers and system integrators worked individually with vendors to develop the packaging. The result was wide diversity, and incompatibility.

The problems faced by integrators, device suppliers, and component suppliers led to the formation of the SFF Committee as an industry ad hoc group to address the marketing and engineering considerations of the emerging new technology.

During the development of the form factor definitions, other activities were suggested because participants in the SFF Committee faced more problems than the physical form factors of disk drives. In November 1992, the charter was expanded to address any issues of general interest and concern to the storage industry. The SFF Committee became a forum for resolving industry issues that are either not addressed by the standards process or need an immediate solution.

Those companies which have agreed to support a specification are identified in the first pages of each SFF Specification. Industry consensus is not an essential requirement to publish an SFF Specification because it is recognized that in an emerging product area, there is room for more than one approach. By making the documentation on competing proposals available, an integrator can examine the alternatives available and select the product that is felt to be most suitable.

SFF Committee meetings are held during T10 weeks (see www.t10.org), and Specific Subject Working Groups are held at the convenience of the participants. Material presented at SFF Committee meetings becomes public domain, and there are no restrictions on the open mailing of material presented at committee meetings.

Most of the specifications developed by the SFF Committee have either been incorporated into standards or adopted as standards by EIA (Electronic Industries Association), ANSI (American National Standards Institute) and IEC (International Electrotechnical Commission).

If you are interested in participating or wish to follow the activities of the SFF Committee, the signup for membership and/or documentation can be found at:
www.sffcommittee.com/ie/join.html

The complete list of SFF Specifications which have been completed or are currently being worked on by the SFF Committee can be found at:
ftp://ftp.seagate.com/sff/SFF-8000.TXT

If you wish to know more about the SFF Committee, the principles which guide the activities can be found at:
ftp://ftp.seagate.com/sff/SFF-8032.TXT

Suggestions for improvement of this specification will be welcome. They should be sent to the SFF Committee, 14426 Black Walnut Ct, Saratoga, CA 95070.

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SFF Committee --

LBA Count for Disk Drives

1. Scope

This specification defines the method for determining the number of logical block addresses (LBAs) a disk drive shall have based on the advertised capacity, logical block size, and, if present, the SCSI Protection Information type of the drive.

1.1 Disk Drive Capacities Applicable to This Specification

This specification applies to 3.5" form factor (see SFF-8300) 160 GB and greater and 2.5" form factor (see SFF-8200) 80 GB and greater disk drives. The sample calculations include drive capacities above those known at the time of publication, and do not represent anticipated product offerings. The sample tables are for illustrative purposes, and provide a means to verify that the results of algorithms used by an implementor correspond to this specification.

2. References

2.1 Industry Documents

The following interface standards are relevant to this SFF Specifications:

- CEI IEC 60027-2 *Letter symbols to be used in electrical technology - Part 2: Telecommunications and electronics*
- IDEMA Document *LBA1-03, LBA Count for Disk Drives Standard*
- SATA-IO *Serial ATA revision 3.2*
- BSR Number: INCITS 505 *SAS Protocol Layer-2 (SPL-2)*
- BSR Number: INCITS 492 *SAS Protocol Layer-3 (SPL-3)*
- BSR Number: INCITS 514 *SCSI Block Commands - 3 (SBC-3)*
- BSR Number: INCITS 503 *SCSI Block Commands - 4 (SBC-4)*
- BSR Number: INCITS 513 *SCSI Primary Commands - 4 (SPC-4)*
- BSR Number: INCITS 502 *SCSI Primary Commands - 5 (SPC-5)*
- BSR Number: INCITS 536 *Zoned Block Commands (ZBC)*
- BSR Number: INCITS 537 *Zoned-device ATA Commands (ZAC)*
- ANSI INCITS 482-2012, *Information technology - AT Attachment-8 ATA/ATAPI Command Set (ATA8-ACS)*
- SFF-8200 2.5" Form Factor Drives (all of 82xx family) aka EIA-720
- SFF-8300 3.5" Form Factor Drives (all of 83xx family) aka EIA-740

2.2 SFF Specifications

There are several projects active within the SFF Committee. The complete list of specifications which have been completed or are still being worked on are listed in the specification at ftp://ftp.seagate.com/sff/SFF-8000.TXT

2.3 Sources

Those who join the SFF Committee as an Observer or Member receive electronic copies of the minutes and SFF specifications (http://www.sffcommittee.com/ie/join.html).

Copies of ANSI standards may be purchased from the InterNational Committee for Information Technology Standards (http://www.techstreet.com/incitsgate.tmpl).

2.4 Conventions

The ISO convention of numbering is used i.e., the thousands and higher multiples are separated by a space and a period is used as the decimal point. This is equivalent to the English/American convention of a comma and a period.

American	French	ISO
0.6	0,6	0.6
1,000	1 000	1 000
1,323,462.9	1 323 462,9	1 323 462.9

The example code uses no separator for numbers larger than 999 or for decimals with greater than three places.

The caret character (^) is used as a surrogate symbol for superscript and exponentiation (e.g., b^n for b raised to the n-th power).

2.5 Definitions

For the purpose of SFF Specifications, the following definitions apply:

4xxx: a reference to logical block sizes of 4 096, 4 160, 4 192, or 4 224 bytes.

5xx: a reference to logical block sizes of 512, 520, 524, or 528 bytes.

advertised capacity: a number of bytes used to describe the capacity of a disk drive expressed in IEC 60027-2 units (e.g., 250 GB (250 000 000 000 bytes), or 3 TB (3 000 000 000 000 bytes)).

ceiling: a function with two operands. If the first operand is an integer multiple of the second then the function returns the value of the first operand; otherwise, the function returns the first integer multiple of the second operand which is higher than the first operand. That is, ceiling(x,y) resolves to x rounded up to the nearest multiple of y.

floor: a function with two operands. If the first operand is an integer multiple of the second then the function returns the value of the first operand; otherwise, the function returns the first integer multiple of the second operand which is lower than the first operand. That is, floor(x,y) resolves to x rounded down to the nearest multiple of y.

GB: Gigabyte (i.e., 10^9 bytes). See IEC 60027-2.

GiB: Gibibyte (i.e., 2^30 bytes). See IEC 60027-2.

logical block address (LBA): a value used to reference a logical block.

logical block size: the number of bytes in a logical block that are user data and is neither SCSI Protection Information nor other information that may not be accessible to the application client.

low capacity disk drive: a disk drive with an advertised capacity of 160 GB to 8 000 GB for a 3.5" form factor (see SFF-8300) device or a disk drive with an advertised capacity of 80 GB to 8 000 GB for a 2.5" form factor (see SFF-8200) device.

high capacity disk drive: a disk drive with an advertised capacity of greater than 8 000 GB for a 3.5" form factor (see SFF-8300) device or a 2.5" form factor (see SFF-8200) device.

SCSI Protection Information (PI): a group of fields at the end of each logical block that contains a logical block guard, an application tag, and a reference tag (see SBC-4).

TB: Terabyte (i.e., 10^12 bytes). See IEC 60027-2.

3. General Description

For interchangeability of storage devices in some systems, the advertised capacity of the storage device needs to be associated with the same LBA count for products from different suppliers. This specification defines the standard method for determining the LBA count for disk drives. This specification defines the functions to calculate the LBA count using the advertised capacity, logical block size, and inclusion of SCSI Protection Information.

The following logical block sizes are supported:

Low capacity disk drives:
- 512 bytes
- 4 096 bytes

High capacity disk drives:
- 512 bytes
- 520 bytes
- 524 bytes
- 528 bytes
- 4 096 bytes
- 4 160 bytes
- 4 192 bytes
- 4 224 bytes

The size of SCSI Protection Information is defining by the following:
a) For ATA devices: SCSI Protection Information size = 0 bytes.
b) For SCSI devices with Protection Information Type 0: SCSI Protection Information size = 0 bytes.
c) For SCSI devices with SCSI Protection Information Type 1, 2 or 3: SCSI Protection Information size = 8 bytes.

A fit adjustment factor is used for high capacity disk drives when the block size is not equal to:
512 bytes with zero bytes of SCSI Protection Information; or
4 096 bytes with zero bytes of SCSI Protection Information.
The fit adjustment factor is a constant value:
fit adjustment factor = 0.995

The number of LBAs is an integer multiple of 8 for 512 byte block size low capacity disk drives to maximize the value of devices with physical sectors that each accommodate 8 logical blocks.

The high capacity disk drive number of LBAs is an integer multiple of 2^21 for 5xx and 2^18 for 4xxx to maximize the value to common space allocation methods such as power-of-two block groups in ext and other file systems, and for shingled magnetic recording (SMR) with Host Aware and Host Managed methodology. These are two examples where fractional capacity between useful granularity points has no value. This granularity provides support for Zoned-device ATA Commands (ZAC) and SCSI zoned block commands (ZBC). The LBA count granularity is a constant.

Informational: Drive capacity is an integer multiple of 1 GiB for the nominal logical block sizes of 512 and 4096 bytes with SCSI Protection Information size of zero bytes.

4. LBA Counts from Advertised Capacity

4.1 LBA Counts from Advertised Capacity for Low Capacity Disk Drives

4.1.1 LBA Counts from Advertised Capacity for 512 Low Capacity Disk Drives

For low capacity disk drives with logical block size of 512 bytes with or without PI, the following formula shall apply:

LBA count = (97 696 368) + (1 953 504 x (advertised capacity in GB - 50))
Where:
   a. 97 696 368, 1 953 504, and 50 are constants; and
   b. the lower three digits of the LBA count is divisible by 8 with a remainder of 0 (rounded up if necessary).

This formula may also be expressed as:

LBA count = ceiling((0.001 953 504 * advertised capacity) + 21 168, 8)

The drive label should include an indication if the Low capacity disk drive does not support the defined LBA count.

4.1.2 LBA Counts from Advertised Capacity for 4096 Low Capacity Disk Drives

For low capacity disk drives with logical block size of 4 096 bytes with or without PI, the following formula shall apply:

LBA count = (12 212 046) + (244 188 x (advertised capacity in GB - 50))

Where:
12 212 046, 244 188, and 50 are constants.

This formula may also be expressed as:

LBA count = ceiling((0.000 244 188 * advertised capacity) + 2 646, 1)

The drive label should include an indication if the Low capacity disk drive does not support the defined LBA count.

4.2 LBA Counts from Advertised Capacity for High Capacity Disk Drives

4.2.1 LBA Counts from Advertised Capacity for 5xx High Capacity Disk Drives

For high capacity disk drives with logical block size of 512, 520, 524 and 528 bytes the following formulas shall apply:

For logical block size of 512 bytes with SCSI Protection Information size of zero bytes, the following formula applies:

LBA count = ceiling(advertised capacity/512, 2^21)

For logical block size of 512 bytes with SCSI Protection Information size of eight bytes, and logical block sizes of 520, 524, and 528 bytes, the following formula shall apply:

LBA count = floor(ceiling(advertised capacity/512, 2^21) * (512 /
(logical block size + PI size)) * fit adjustment factor, 2^21)

4.2.2 LBA Counts from Advertised Capacity for 4xxx High Capacity Disk Drives

For high capacity disk drives with logical block sizes of 4 096, 4 160, 4 192, and 4 224 bytes the following formulas shall apply:

For logical block size of 4 096 bytes with SCSI Protection Information size of zero bytes, the following formula shall apply:

LBA count = ceiling(advertised capacity/4 096, 2^18)

For logical block size of 4 096 bytes with SCSI Protection Information size of eight bytes, and logical block sizes of 4 160, 4 192, and 4 224 bytes, the following formula shall apply:

LBA count = floor(ceiling(advertised capacity/4 096, 2^18) * (4096 /
(logical block size + PI size)) * fit adjustment factor, 2^18)

4.3 Sample calculations

The sample calculations are provided as a means of verification for calculation tools (e.g. spreadsheets or code) that may be used by an implementor. The illustrative capacities in the tables below may not reflect actual products or planned product offerings.

LBA counts for an advertised capacity of 10 TB are shown in Table 4-1.

TABLE 4-1 LBA COUNTS FOR DISK DRIVES WITH AN ADVERTISED CAPACITY OF 10 TB

Logical block size	PI size	LBA count
512 bytes	0 bytes	19 532 873 728
512 bytes	8 bytes	19 134 414 848
520 bytes	0 bytes	19 134 414 848
520 bytes	8 bytes	18 845 007 872
524 bytes	0 bytes	18 989 711 360
524 bytes	8 bytes	18 704 498 688
528 bytes	0 bytes	18 845 007 872
528 bytes	8 bytes	18 563 989 504
4 096 bytes	0 bytes	2 441 609 216
4 096 bytes	8 bytes	2 424 569 856
4 160 bytes	0 bytes	2 391 801 856
4 160 bytes	8 bytes	2 387 345 408
4 192 bytes	0 bytes	2 373 713 920
4 192 bytes	8 bytes	2 368 995 328
4 224 bytes	0 bytes	2 355 625 984
4 224 bytes	8 bytes	2 351 169 536

LBA counts for disk drives with logical block size of 512 bytes and SCSI Protection Information size of 0 bytes are shown in Table 4-2.

TABLE 4-2 LBA COUNTS FOR DISK DRIVES WITH LOGICAL BLOCK SIZE OF 512 BYTES AND SCSI PROTECTION INFORMATION SIZE OF 0 BYTES

Advertised capacity	Capacity type	LBA count
80 GB	Low capacity disk drive	156 301 488
160 GB	Low capacity disk drive	312 581 808
320 GB	Low capacity disk drive	625 142 448
500 GB	Low capacity disk drive	976 773 168
1 TB	Low capacity disk drive	1 953 525 168
2 TB	Low capacity disk drive	3 907 029 168
4 TB	Low capacity disk drive	7 814 037 168
6 TB	Low capacity disk drive	11 721 045 168
8 TB	Low capacity disk drive	15 628 053 168
10 TB	High capacity disk drive	19 532 873 728
12 TB	High capacity disk drive	23 437 770 752
15 TB	High capacity disk drive	29 297 213 440

5. Example Pseudo Code for Calculating LBA Count from Advertised Capacity

The following pseudo code may be used to calculate the LBA count from advertised capacity. This code is provided for reference only. Refer to Section 4 for normative requirements.

```
function LBACount(HighCapacity, AdvertisedCapacity, LogicalBlockSize, PISize)
   // This function returns the LBA count for the specified
   // - capacity type (low or high capacity)
   // - advertised capacity in bytes
   // - logical block size in bytes
   // - SCSI Protection Information size in bytes
   // The advertised capacity and logical block size shall be positive.
   // The SCSI Protection Information size shall be non-negative.

   assert (PISize == 0) or (PISize == 8)

   if HighCapacity
      FitAdjustmentFactor = 0.995
      FourxxxGranularity = 2^18   // units are logical blocks

      // Determine which range the logical block size is in
      // and set the granularity.
      if LogicalBlockSize < 4096
         Granularity = 8 * FourxxxGranularity
      else
         Granularity = FourxxxGranularity

      // Calculate the LBA count for 4096-byte logical blocks
      // with PI size of zero bytes.
      LBACount = ceiling(AdvertisedCapacity / 4096, FourxxxGranularity)

      // Adjust for the specific logical block payload of logical block size
      // and PI size.
      LBACount = LBACount * 4096 / (LogicalBlockSize + PISize)

      // Apply the fit adjustment factor for all but 512 and 4096
      // with PI size of zero bytes.
      if (PISize > 0) or ((LogicalBlockSize != 512) and (LogicalBlockSize != 4096))
         LBACount = LBACount * FitAdjustmentFactor

      // Adjust downward to be integer multiple of the granularity.
      LBACount = floor(LBACount, Granularity)
   else
      assert (LogicalBlockSize == 512) or (LogicalBlockSize == 4096)

      LBACount = ((1.000194048 * AdvertisedCapacity) + 10838016) / LogicalBlockSize

      // Adjust the LBA count to the correct integer multiple.
      if LogicalBlockSize < 4096
         LBACount = ceiling(LBACount, 8)
      else
         LBACount = ceiling(LBACount, 1)

   return LBACount
end function
```

6. Example Formula Using Microsoft Excel Syntax for Calculating LBA Count from Advertised Capacity

The following formula using Microsoft Excel syntax may be used to calculate the LBA count from advertised capacity. This formula returns a #DIV/0! error if PISize is invalid, or if HighCapacity is false and LogicalBlockSize is invalid for a low capacity disk drive. This code is provided for reference only. Refer to Section 4 for normative requirements.

```
=IF(
   OR(PISize=0, PISize=8),
   IF(HighCapacity,
      FLOOR(CEILING(AdvertisedCapacity/4096, 2^18)*4096/(LogicalBlockSize+PISize)*
         IF(PISize>0, FitAdjustmentFactor,
         IF(OR(LogicalBlockSize=512, LogicalBlockSize=4096), 1,
         FitAdjustmentFactor)),
         IF(LogicalBlockSize<4096, 2^21, 2^18)),
      IF(OR(LogicalBlockSize=512, LogicalBlockSize=4096),
         CEILING(((1.000194048*AdvertisedCapacity)+10838016)/LogicalBlockSize,
            IF(LogicalBlockSize<4096, 8, 1)),
         1/0)),
   1/0)
```

Where:
- HighCapacity, AdvertisedCapacity, LogicalBlockSize, PISize and FitAdjustmentFactor are to be resolved by named cells, or replaced by values, expressions or cell references.
- HighCapacity evaluates to either TRUE or FALSE.
- AdvertisedCapacity, LogicalBlockSize, and PISize are in units of bytes.