

What is SMART ?

SMART/S.M.A.R.T stands for Self-Monitoring, Analysis and Reporting Technology. It is basically a system that collects information about a hard disk drive (HDD) and solid state drive (SSD), and allows you to run some tests on the drive to determine its approximate health.

It is important to note that SMART is far from perfect. Although a failed "Pre-fail" SMART attribute predicts failure, having no failed attributes does NOT mean the drive is not failing. The drive can be failing with above threshold attributes. This leads us to the next section backing up your data.

Backing up your data

According to [CERT](#) you should follow the 3-2-1 rule:

- 3 - Keep 3 copies of any important file: 1 primary and 2 backups.
- 2 - Keep files on 2 different media types to protect against different types of hazards.
- 1 - Store 1 copy offsite (e.g. outside your or business facility).

In summary, keep 3 backups: 1 primary, 1 onsite, 1 offsite. This is of critical importance because your device can fail at any time without warning and for various reasons. Backing up your data is the only way to be reasonably sure that you won't lose it. You CANNOT rely on SMART to reliably tell you when your HDD is going to fail and to do so in due time to allow you to save your data.

SMART Attributes

In order to be able to use SMART you need:

1. A HDD or SSD that supports SMART
2. SMART enabled in the UEFI/BIOS
3. Software to interface with SMART

Some commonly used software to interface with SMART is [smartmontools](#), or you can find individual manufacturer's utilities on [UBCD](#). Some people prefer smartmontools because it is easily accessible from the command line. Others prefer the manufacturer's utilities because they sometimes have more features than smartmontools. Which is better is mostly down to user preference and the details of the situation. For this article we will focus on smartmontools and more specifically smartctl.

In order to display the SMART attributes with smartmontools you need to run the following as root:

```
smartctl -a /dev/sda
```

Note that we will be assuming that `/dev/sda` is your HDD/SSD device node. In many cases this is the first HDD/SSD on the system, but you need to double check to make sure it is the HDD/SSD you are

interested in.

The output will be something like:

```
bash-4.2# smartctl -a /dev/sda
smartctl 5.43 2012-06-30 r3573 [x86_64-linux-3.10.63] (local build)
Copyright (C) 2002-12 by Bruce Allen, http://smartmontools.sourceforge.net

=== START OF INFORMATION SECTION ===
Model Family:      Seagate Barracuda (SATA 3Gb/s, 4K Sectors)
Device Model:      ST1000DM003-1CH162
Serial Number:     Z1D6DR9C
LU WWN Device Id: 5 000c50 064a62447
Firmware Version: CC49
User Capacity:     1,000,204,886,016 bytes [1.00 TB]
Sector Sizes:     512 bytes logical, 4096 bytes physical
Device is:         In smartctl database [for details use: -P show]
ATA Version is:   8
ATA Standard is:  ACS-2 (unknown minor revision code: 0x001f)
Local Time is:    Sun Jan  4 16:02:08 2015 CST
SMART support is: Available - device has SMART capability.
SMART support is: Enabled

=== START OF READ SMART DATA SECTION ===
SMART overall-health self-assessment test result: PASSED

General SMART Values:
Offline data collection status: (0x82) Offline data collection activity
                               was completed without error.
                               Auto Offline Data Collection: Enabled.
Self-test execution status:      (   0) The previous self-test routine
completed
                               without error or no self-test has ever
                               been run.
Total time to complete Offline
data collection:                ( 584) seconds.
Offline data collection
capabilities:                    (0x7b) SMART execute Offline immediate.
                               Auto Offline data collection on/off support.
                               Suspend Offline collection upon new
                               command.
                               Offline surface scan supported.
                               Self-test supported.
                               Conveyance Self-test supported.
                               Selective Self-test supported.
SMART capabilities:              (0x0003) Saves SMART data before entering
power-saving mode.
                               Supports SMART auto save timer.
Error logging capability:        (0x01) Error logging supported.
                               General Purpose Logging supported.
Short self-test routine
```

```

recommended polling time:    (  1) minutes.
Extended self-test routine
recommended polling time:    ( 111) minutes.
Conveyance self-test routine
recommended polling time:    (  2) minutes.
SCT capabilities:           (0x3085)    SCT Status supported.

```

SMART Attributes Data Structure revision number: 10

Vendor Specific SMART Attributes with Thresholds:

ID#	ATTRIBUTE_NAME	FLAG	VALUE	WORST	THRESH	TYPE	UPDATED
1	Raw_Read_Error_Rate	0x000f	118	099	006	Pre-fail	Always
-	168101376						
3	Spin_Up_Time	0x0003	097	097	000	Pre-fail	Always
-	0						
4	Start_Stop_Count	0x0032	100	100	020	Old_age	Always
-	425						
5	Reallocated_Sector_Ct	0x0033	100	100	010	Pre-fail	Always
-	0						
7	Seek_Error_Rate	0x000f	069	060	030	Pre-fail	Always
-	9675211						
9	Power_On_Hours	0x0032	096	096	000	Old_age	Always
-	3982						
10	Spin_Retry_Count	0x0013	100	100	097	Pre-fail	Always
-	0						
12	Power_Cycle_Count	0x0032	100	100	020	Old_age	Always
-	433						
183	Runtime_Bad_Block	0x0032	100	100	000	Old_age	Always
-	0						
184	End-to-End_Error	0x0032	100	100	099	Old_age	Always
-	0						
187	Reported_Uncorrect	0x0032	100	100	000	Old_age	Always
-	0						
188	Command_Timeout	0x0032	100	100	000	Old_age	Always
-	0						
189	High_Fly_Writes	0x003a	100	100	000	Old_age	Always
-	0						
190	Airflow_Temperature_Cel	0x0022	071	063	045	Old_age	Always
-	29 (Min/Max 20/29)						
191	G-Sense_Error_Rate	0x0032	100	100	000	Old_age	Always
-	0						
192	Power-Off_Retract_Count	0x0032	100	100	000	Old_age	Always
-	25						
193	Load_Cycle_Count	0x0032	100	100	000	Old_age	Always
-	504						
194	Temperature_Celsius	0x0022	029	040	000	Old_age	Always
-	29 (0 18 0 0 0)						
197	Current_Pending_Sector	0x0012	100	100	000	Old_age	Always
-	0						
198	Offline_Uncorrectable	0x0010	100	100	000	Old_age	Offline
-	0						

```
199 UDMA_CRC_Error_Count      0x003e   200   200   000   Old_age   Always
-          0
240 Head_Flying_Hours         0x0000   100   253   000   Old_age   Offline
-       12154757451688
241 Total_LBAs_Written        0x0000   100   253   000   Old_age   Offline
-       14098900823
242 Total_LBAs_Read           0x0000   100   253   000   Old_age   Offline
-       800819281
```

SMART Error Log Version: 1
No Errors Logged

```
SMART Self-test log structure revision number 1
Num Test_Description      Status                    Remaining  LifeTime(hours)
LBA_of_first_error
# 1 Extended offline      Completed without error   00%        3005
-
# 2 Extended offline      Completed without error   00%        2008
-
# 3 Extended offline      Completed without error   00%        1014
-
# 4 Extended offline      Completed without error   00%         13
-
```

```
SMART Selective self-test log data structure revision number 1
SPAN  MIN_LBA  MAX_LBA  CURRENT_TEST_STATUS
  1         0         0  Not_testing
  2         0         0  Not_testing
  3         0         0  Not_testing
  4         0         0  Not_testing
  5         0         0  Not_testing
```

Selective self-test flags (0x0):

After scanning selected spans, do NOT read-scan remainder of disk.
If Selective self-test is pending on power-up, resume after 0 minute delay.

This is just an example from my current HDD. Technically `smartctl -a` lists everything, not just attributes, but the whole output is more useful than just the attributes. Some things to note on the output is that SMART support is available and enabled. If it is not available then your device may not support SMART, which can occur if this is an external HDD with a cheap enclosure or if the device is not a HDD/SSD. If it is not enabled, go into your UEFI/BIOS settings and enable it. Also note SMART overall-health self-assessment test result: PASSED, it should be PASSED unless your HDD is failing.

Note the line `Auto Offline Data Collection: Enabled`, this is a feature that is enabled by default on modern internal HDDs. `man smartctl` explains what this feature does and how to enable it:

```
-o VALUE, --offlineauto=VALUE
    [ATA only] Enables or disables SMART automatic offline
test,
```

This which scans the drive every four hours for disk defects.
valid command can be given during normal system operation. The arguments to this option are on and off.

This also updates attributes that are marked Offline. Unlike Always updated attributes, Offline attributes are only updated if this is enabled or if you run a SMART test.

Note also that the approximate times for running various tests are listed. We will discuss SMART tests in the next section.

Now about the attributes, their meaning is summarized in `man smartctl`:

Each Attribute also has a Threshold value (whose range is 0 to 255) which is printed under the heading "THRESH". If the Normalized value is less than or equal to the Threshold value, then the Attribute is said to have failed. If the Attribute is a pre-failure Attribute, then disk failure is imminent.

The Attribute table printed out by `smartctl` also shows the "TYPE" of the Attribute. Attributes are one of two possible types: Pre-failure or Old age. Pre-failure Attributes are ones which, if less than or equal to their threshold values, indicate pending disk failure. Old age, or usage Attributes, are ones which indicate end-of-product life from old-age or normal aging and wearout, if the Attribute value is less than or equal to the threshold. Please note: the fact that an Attribute is of type 'Pre-fail' does not mean that your disk is about to fail! It only has this meaning if the Attribute's current Normalized value is less than or equal to the threshold value. If the Attribute's current Normalized value is less than or equal to the threshold value, then the "WHEN_FAILED" column will display "FAILING_NOW". If not, but the worst recorded value is

will display "In_the_past". If the "WHEN_FAILED" column has no entry (not failing) and has also never failed in the past.

Thus, the most important attributes are marked Pre-fail. If the value of a Pre-fail attribute is below threshold, the attribute is failing implying that the HDD is failing. A failing attribute will be marked as FAILING_NOW or In_the_past if it has failed now or in the past, respectively. Old_age attribute failures do NOT necessarily mean imminent failure, but rather that the drive is getting old and it should be monitored more carefully or replaced at some point.

For the exact meaning of each attribute, please see the [Wiki](#) page. Some specific attributes that I would like to discuss are as follows:

#4 Start_Stop_Count and #12 Power_Cycle_Count and #193 Load_Cycle_Count

This attribute is important for laptop HDDs, because they default to powering off when not in use. Now, although laptop HDDs are designed to spin up and down more times than desktop HDD and this is an Old_age attribute, it still wears down the drive. Unless you run on batteries all the time you may want to consider turning off this feature by adding this to a boot script such as /etc/rc.d/rc.local:

```
hdparm -B 254 /dev/sda
```

#9 Power_On_Hours

This is the age of the drive in hours. This is rather important because it tells you how old the drive is and thus how likely it is to fail. HDD failure among other things follows the [Bathtub curve](#). As such, the highest failure rate is among very young (infant mortality) and very old (worn out) drives. This is important because I hear many people saying, "Oh, but the drive is brand new, it can't be failing." Wrong, a new drive is more likely to fail than a middle-aged drive, much like an old drive.

#174 Unexpected power loss count and #192 Power-Off_Retract_Count

Sudden power loss is detrimental to both HDDs and [SSDs](#). UPS power backups should be used for systems that are on all time for this reason as well as many others. Make sure to also shutdown your computer properly whenever possible to prevent damage and data loss.

#190 Airflow_Temperature_Cel and 194 Temperature_Celsius

Although many people believe that HDDs should be kept cool and are sensitive to heat, a [large Google internal study](#) suggests that high temperatures are only significantly detrimental to old HDDs.

Bad Blocks (#5, 196, 197, 198)

Bad blocks are basically areas of the disk surface that are damaged and can no longer hold data reliably. Internally the HDD/SSD deals with these by marking them and remapping/reallocating them to other areas. Bad blocks increase with the age of the drive. It can be expected that you will encounter bad blocks with every HDD and SSD. The question is when does this become something to be concerned about ? That is hard to say, and in general you will have to deal with each device on an individual basis. A large increase in the number of bad blocks could mean the drive is nearing its end. Keep monitoring the Pre-fail attributes and decide when to change it out.

SMART Tests

There are 3 main types of SMART tests that you can perform.

- short: a superficial test that tests electrical and mechanical performance and updates offline attributes
- conveyance: identifies damage during transport (mostly useful for external or laptop HDDs)
- long: a short test plus it scans the disk surface for bad blocks

These tests are run with the -t option like:

```
smartctl -t long /dev/sda
```

These tests can all be run on a running system without major side-effects. If you expect the long test to finish, you should minimize HDD usage as it has to scan the whole disk to finish the test.

After waiting for the test to finish, you can get the results using the -a option as shown in the previous section.

Short and Conveyance tests should always pass. If these fail, check the attributes as the drive is probably failing. A long test can fail if there are bad blocks, and this does NOT mean the drive is failing. The long test stops when it finds an error on the disk, so if there is a bad block it just stops. This doesn't mean the drive is failing, but you will have to wait for the HDD to remap/reallocate the block, or technically you could try to force it to do so:

<http://www.smartmontools.org/browser/trunk/www/badblockhowto.xml> However, this method is difficult to implement safely, so you should usually just wait for the HDD to remap/reallocate.

How often should you run these tests ? That depends. If you run a server then more often is better, the smartmontools site recommends weekly tests. For a home user, I usually run a long test every

1000 power on hours, but that is up to you and also depends on the details of the drive and situation.

Is my drive failing ?

A failing drive is defined as:

1. Having a Pre-fail attribute below or near threshold, marked FAILING_NOW or In_the_past.
2. Having an Old_age attribute below or near threshold, marked FAILING_NOW or In_the_past **PLUS** other signs of failure such as consistent failure of SMART tests, strange noises, slowing down, corrupt data, etc.



A failed long test does NOT mean your drive is failing, it could be just bad blocks. See previous section.

Do not ignore your senses, if the HDD sounds unusual or makes strange noises, monitor it closely and/or replace it. Again, SMART cannot tell you with great accuracy if or when the drive will fail. The drive can fail with above threshold attributes and minimal signs. The only hope you have to keep your data safe is to backup your data, use the 3-2-1 strategy as mentioned above.

smartd

What is smartd ? It is a daemon that monitors SMART. So if you don't want to manually monitor and run tests, you can set up smartd to run them on a regular basis. You should refer to `man smartd` and `man smartd.conf` and `/etc/smartd.conf` for everything you need to know about setting up smartd to do what you want it to do.

Sources

- [Wiki](#)
- [CERT Data Backup Options](#)
- `man smartctl`

[howtos](#), [template](#)

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