Proposal for Extensions
To Drive Self Test

To: **T13 Technical committee**
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          Date: Sept. 24, 2001

Introduction:

In a computer system integration environment, as any manufacturing process, time is money. With disk drives now in excess of 100 Gbytes, the time to complete even one read verify scan of a drive is becoming prohibitively expensive. If however, damage imparted to the drive during the conveyance of the drive from its manufacturing physicality to the point of integration is the primary concern, then certain assumptions about the modes of physical damage can allow greatly accelerated testing of these very large drives, yet still maintain a very high confidence of finding individual damage drives. It is the intent of the proposed new test—the Conveyance test—to focus on this class of drive testing.

Proposed Changes:
The following additions/ modifications are proposed for the ATA/ATAPI-6 standard.

8.54.4 SMART EXECUTE OFF-LINE IMMEDIATE

8.54.4.1 Command code

B0h with the content of the Features register equal to D4h

8.54.4.2 Feature set

SMART feature set.

  - Optional when the SMART feature set is implemented.
  - Use prohibited when the PACKET Command feature set is implemented.

8.54.4.3 Protocol

Non-data (see 9.4).

8.54.4.4 Inputs

The Features register shall be set to D4h. The LBA Mid register shall be set to 4Fh. The LBA High register shall be set to C2h. Table 40 defines the subcommand that shall be executed based on the value in the LBA Low register.

Register	7	6	5	4	3	2	1	0
Features	D4h							
Sector Count	na							
LBA Low	Subcommand specific							
LBA Mid	4Fh							
LBA High	C2h							
Device	obs	na	obs	DEV	na			
Command	B0h							

Device register -
> DEV shall indicate the selected device.

8.54.4.5 Normal Outputs

Register	7	6	5	4	3	2	1	0
Features	na							
Sector Count	na							
LBA Low	na							
LBA Mid	na or 4Fh							
LBA High	na or C2h							
Device/Head	obs	na	obs	DEV	na			
Status	BSY	DRDY	DF	na	DRQ	na	na	ERR

LBA Mid -
> na when the subcommand specified an off-line routine (including an off-line self-test routine).
> 4Fh when the subcommand specified a captive self-test routine (see 8.54.4.8.2) that has executed without failure.

LBA High -
> na when the subcommand specified an off-line routine (including an off-line self-test routine).
> C2h when the subcommand specified a captive self-test routine that has executed without failure.

Device register -
    DEV shall indicate the selected device.
Status register -
    BSY shall be cleared to zero indicating command completion.
    DRDY shall be set to one indicating that the device is capable of receiving any command.
    DF (Device Fault) shall be cleared to zero.
    DRQ shall be cleared to zero.
    ERR shall be cleared to zero.

8.54.4.6 Error Outputs

If the device does not support this command, if SMART is disabled, or if the values in the Features, LBA Mid, or LBA High registers are invalid, the device shall return command aborted. When a failure occurs while executing a test in captive mode, the device shall return command aborted with the LBA Mid register value of F4h and the LBA High value of 2Ch.

Register	7	6	5	4	3	2	1	0
Error	na	na	na	IDNF	na	ABRT	na	obs
Sector Count	na							
LBA Low	na							
LBA Mid	na or 4Fh or F4h							
LBA High	na or C2h or 2Ch							
Device	obs	na	obs	DEV	na			
Status	BSY	DRDY	DF	na	DRQ	na	na	ERR

Error register -
    IDNF shall be set to one if SMART data sector's ID field could not be found.
    ABRT shall be set to one if this command is not supported, if SMART is not enabled, if register
        values are invalid, or if a self-test fails while executing a sequence in captive mode. ABRT
        may be set to one if the device is not able to complete the action requested by the command.
LBA Mid register –
    na when the subcommand specified an off-line routine (including an off-line self-test routine).
    4Fh when the subcommand specified a captive self-test routine and some error other than a self-test
        routine failure occurred (i.e., if the sub-command is not supported or register values are invalid)
    F4h when the subcommand specified a captive self-test routine which has failed during execution.
LBA High register –
    na when the subcommand specified an off-line routine (including an off-line self-test routine).
    2Ch when the subcommand specified a captive self-test routine which has failed during execution.
    C2h when the subcommand specified a captive self-test routine and some error other than a self-test
    routine failure occurred (i.e., if the sub-command is not supported or register values are invalid)
Device register -
    DEV shall indicate the selected device.
Status register -
    BSY shall be cleared to zero indicating command completion.
    DRDY shall be set to one indicating that the device is capable of receiving any command.
    DF (Device Fault) shall be set to one indicating that a device fault has occurred.
    DRQ shall be cleared to zero indicating that there is no data to be transferred.
    ERR shall be set to one if any Error register bit is set to one.

8.54.4.7 Prerequisites

DRDY set to one. SMART enabled.

8.54.4.8 Description

This command causes the device to immediately initiate the optional set of activities that collect SMART data in an off-line mode and then save this data to the device's non-volatile memory, or execute a self-diagnostic test routine in either captive or off-line mode.

Table 40 – SMART EXECUTE OFF-LINE IMMEDIATE LBA Low register values

Value	Description of subcommand to be executed
0	Execute SMART off-line routine immediately in off-line mode
1	Execute SMART Short self-test routine immediately in off-line mode
2	Execute SMART Extended self-test routine immediately in off-line mode
3	Execute SMART Conveyance self-test routine immediately in off-line mode
3-63	Reserved
64-126	Vendor specific
127	Abort off-line mode self-test routine
128	Reserved
129	Execute SMART Short self-test routine immediately in captive mode
130	Execute SMART Extended self-test routine immediately in captive mode
131	Execute SMART Conveyance self-test routine immediately in captive mode
131-191	Reserved
192-255	Vendor specific

8.54.4.8.1 Off-line mode

The following describes the protocol for executing a SMART EXECUTE OFF-LINE IMMEDIATE subcommand routine (including a self-test routine) in the off-line mode.

a) The device shall execute command completion before executing the subcommand routine.
b) After clearing BSY to zero and setting DRDY to one after receiving the command, the device shall not set BSY nor clear DRDY during execution of the subcommand routine.
c) If the device is in the process of performing the subcommand routine and is interrupted by any new command from the host except a SLEEP, SMART DISABLE OPERATIONS, SMART EXECUTE OFF-LINE IMMEDIATE, or STANDBY IMMEDIATE command, the device shall suspend or abort the subcommand routine and service the host within two seconds after receipt of the new command. After servicing the interrupting command from the host the device may immediately re-initiate or resume the subcommand routine without any additional commands from the host (see 8.54.5.8.4).
d) If the device is in the process of performing a subcommand routine and is interrupted by a SLEEP command from the host, the device may abort the subcommand routine and execute the SLEEP command. If the device is in the process of performing any self-test routine and is interrupted by a SLEEP command from the host, the device shall abort the subcommand routine and execute the SLEEP command.
e) If the device is in the process of performing the subcommand routine and is interrupted by a SMART DISABLE OPERATIONS command from the host, the device shall suspend or abort the subcommand routine and service the host within two seconds after receipt of the command. Upon receipt of the next SMART ENABLE OPERATIONS command the device may, either re-initiate the subcommand routine or resume the subcommand routine from where it had been previously suspended.
f) If the device is in the process of performing the subcommand routine and is interrupted by a SMART EXECUTE OFF-LINE IMMEDIATE command from the host, the device shall abort the subcommand routine and service the host within two seconds after receipt of the command. The device shall then service the new SMART EXECUTE OFF-LINE IMMEDIATE subcommand.
g) If the device is in the process of performing the subcommand routine and is interrupted by a STANDBY IMMEDIATE or IDLE IMMEDIATE command from the host, the device shall suspend or abort the subcommand routine, and service the host within two seconds after receipt of the command. After receiving a new command that causes the device to exit a power saving mode, the device shall initiate or resume the subcommand routine without any additional commands from the host unless these activities were aborted by the host (see 8.54.5.8).
h) While the device is performing the subcommand routine it shall not automatically change power states (e.g., as a result of its Standby timer expiring).

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i) If a test failure occurs while a device is performing a self-test routine the device may discontinue the testing and place the test results in the Self-test execution status byte.

8.54.4.8.2 Captive mode

When executing a self-test in captive mode, the device sets BSY to one and executes the self-test routine after receipt of the command. At the end of the routine the device places the results of this routine in the Self-test execution status byte and executes command completion. If an error occurs while a device is performing the routine the device may discontinue its testing, place the results of this routine in the Self-test execution status byte, and complete the command.

8.54.4.8.3 SMART off-line routine

This routine shall only be performed in the off-line mode. The results of this routine are placed in the Off-line data collection status byte (see Table 42).

8.54.4.8.4 SMART Short self-test routine

Depending on the value in the LBA Low register, this self-test routine may be performed in either the captive or the off-line mode. This self-test routine should take on the order of ones of minutes to complete (see 8.54.5.8).

8.54.4.8.5 SMART Extended self-test routine

Depending on the value in the LBA Low register, this self-test routine may be performed in either the captive or the off-line mode. This self-test routine should take on the order of tens of minutes to complete (see 8.54.5.8).

8.54.4.8.6 SMART Conveyance self-test routine

Depending on the value in the LBA Low register, this self-test routine may be performed in either the captive or the off-line mode. This self-test routine should take on the order of minutes to complete (see 8.54.5.8).

8.54.5 SMART READ DATA

8.54.5.1 Command code

B0h with the content of the Features register equal to D0h.

8.54.5.2 Feature set

SMART feature set.
- Optional when the SMART feature set is implemented.
- Use prohibited when the PACKET Command feature set is implemented.

8.54.5.3 Protocol

PIO data-in (see 9.5).

8.54.5.4 Inputs

The Features register shall be set to D0h. The LBA Mid register shall be set to 4Fh. The LBA High register shall be set to C2h.

Register	7	6	5	4	3	2	1	0
Features	D0h							
Sector Count	na							
LBA Low	na							
LBA Mid	4Fh							
LBA High	C2h							
Device	obs	na	obs	DEV	na			
Command	B0h							

Device register -
      DEV shall indicate the selected device.

8.54.5.5 Normal outputs

Register	7	6	5	4	3	2	1	0
Features	na							
Sector Count	na							
LBA Low	na							
LBA Mid	na							
LBA High	na							
Device	obs	na	obs	DEV	na			
Status	BSY	DRDY	DF	na	DRQ	na	na	ERR

Device register -
      DEV shall indicate the selected device.
Status register -
      BSY shall be cleared to zero indicating command completion.
      DRDY shall be set to one indicating that the device is capable of receiving any command.
      DF (Device Fault) shall be cleared to zero.
      DRQ shall be cleared to zero.
      ERR shall be cleared to zero.

8.54.5.6Error outputs

If the device does not support this command, if SMART is disabled, or if the values in the Features, LBA Mid, or LBA High registers are invalid, the device shall return command aborted.

Register	7	6	5	4	3	2	1	0
Error	na	UNC	na	IDNF	na	ABRT	na	obs
Sector Count	na							
lba Low	na							
Lba Mid	na							
LBA High	na							
Device	obs	na	obs	DEV	na			
Status	BSY	DRDY	DF	na	DRQ	na	na	ERR

Error register -
    UNC shall be set to one if SMART data is uncorrectable.
    IDNF shall be set to one if SMART data sector's ID field could not be found or data structure checksum occurred.
    ABRT shall be set to one if this command is not supported, if SMART is not enabled, or if register values are invalid. ABRT may be set to one if the device is not able to complete the action requested by the command.
Device register -
    DEV shall indicate the selected device.
Status register -
    BSY shall be cleared to zero indicating command completion.
    DRDY shall be set to one indicating that the device is capable of receiving any command.
    DF (Device Fault) shall be set to one indicating that a device fault has occurred.
    DRQ shall be cleared to zero indicating that there is no data to be transferred.
    ERR shall be set to one if any Error register bit is set to one.

8.54.5.7Prerequisites

DRDY set to one. SMART enabled.

8.54.5.8Description

This command returns the Device SMART data structure to the host.

Table 41 defines the 512 bytes that make up the Device SMART data structure. All multi-byte fields shown in this structure follow the byte ordering described in 3.2.9.

Table 41 – Device SMART data structure

Byte	F/V	Descriptions
0-361	X	Vendor specific
362	V	Off-line data collection status
363	X	Self-test execution status byte
364-365	V	Total time in seconds to complete off-line data collection activity
366	X	Vendor specific
367	F	Off-line data collection capability
368-369	F	SMART capability
370	F	Error logging capability 　　7-1　　Reserved 　　0　　　1=Device error logging supported
371	X	Vendor specific
372	F	Short self-test routine recommended polling time (in minutes)
373	F	Extended self-test routine recommended polling time (in minutes)
374	F	Conveyance self-test routine recommended polling time (in minutes)
375-385	R	Reserved
386-510	X	Vendor specific
511	V	Data structure checksum
Key: F=the content of the byte is fixed and does not change. V=the content of the byte is variable and may change depending on the state of the device or the commands executed by the device. X=the content of the byte is vendor specific and may be fixed or variable. R=the content of the byte is reserved and shall be zero.		

8.54.5.8.1　　Off-line collection status byte

The value of the off-line data collection status byte defines the current status of the off-line activities of the device. Table 42 lists the values and their respective definitions.

Table 42 – Off-line data collection status byte values

Value	Definition
00h or 80h	Off-line data collection activity was never started.
01h	Reserved
02h or 82h	Off-line data collection activity was completed without error.
03h	Reserved
04h or 84h	Off-line data collection activity was suspended by an interrupting command from host.
05h or 85h	Off-line data collection activity was aborted by an interrupting command from host.
06h or 86h	Off-line data collection activity was aborted by the device with a fatal error.
07h-3Fh	Reserved
40h-7Fh	Vendor specific
81h	Reserved
83h	Reserved
87h-BFh	Reserved
C0h-FFh	Vendor specific

8.54.5.8.2　　Self-test execution status byte

The self-test execution status byte reports the execution status of the self-test routine.

- Bits 0-3 (Percent Self-Test Remaining) The value in these bits indicates an approximation of the percent of the self-test routine remaining until completion in ten percent increments. Valid values are 0 through 9. A value of 0 indicates the self-test routine is complete. A value of 9 indicates 90% of total test time remaining.

– Bits 4-7 (Self-test Execution Status) The value in these bits indicates the current Self-test Execution Status (see Table 43**)**.

Table 43 – Self-test execution status values

Value	Description
0	The previous self-test routine completed without error or no self-test has ever been run
1	The self-test routine was aborted by the host
2	The self-test routine was interrupted by the host with a hardware or software reset
3	A fatal error or unknown test error occurred while the device was executing its self-test routineand the device was unable to complete the self-test routine.
4	The previous self-test completed having a test element that failed and the test element that failed is not known.
5	The previous self-test completed having the electrical element of the test failed.
6	The previous self-test completed having the servo (and/or seek) test element of the test failed.
7	The previous self-test completed having the read element of the test failed.
8	The previous self-test completed having a test element that failed and the drive is suspected of having handling damage
8-14	Reserved.
15	Self-test routine in progress.

8.54.5.8.3 Total time to complete off-line data collection

The total time in seconds to complete off-line data collection activity word specifies how many seconds the device requires to complete the sequence of off-line data collection activity. Valid values for this word are from 0001h to FFFFh.

8.54.5.8.4 Off-line data collection capabilities

The following describes the definition for the off-line data collection capability bits. If the value of all of these bits is cleared to zero, then no off-line data collection is implemented by this device.

– Bit 0 (EXECUTE OFF-LINE IMMEDIATE implemented bit) - If this bit is set to one, then the SMART EXECUTE OFF-LINE IMMEDIATE command is implemented by this device. If this bit is cleared to zero, then the SMART EXECUTE OFF-LINE IMMEDIATE command is not implemented by this device.

– Bit 1 (vendor specific).

– Bit 2 (abort/restart off-line by host bit) - If this bit is set to one, then the device shall abort all off-line data collection activity initiated by an SMART EXECUTE OFF-LINE IMMEDIATE command upon receipt of a new command within 2 seconds of receiving the new command. If this bit is cleared to zero, the device shall suspend off-line data collection activity after an interrupting command and resume off-line data collection activity after some vendor-specified event.

– Bit 3 (off-line read scanning implemented bit) - If this bit is cleared to zero, the device does not support off-line read scanning. If this bit is set to one, the device supports off-line read scanning.

– Bit 4 (self-test implemented bit) – If this bit is cleared to zero, the device does not implement the Short and Extended self-test routines. If this bit is set to one, the device implements the Short and Extended self-test routines.

– Bit 5 (conveyance self-test implemented bit) – If this bit is cleared to zero, the device does not implement the Conveyance self-test routines. If this bit is set to one, the device implements the Conveyance self-test routines.

– Bits (7:6) (Reserved).

8.54.5.8.5   SMART capablilities

The following describes the definition for the SMART capabilities bits. If all of these bits are cleared to zero, then automatic saving of SMART data is not implemented by this device.

−   Bit 0 (power mode SMART data saving capability bit) - If this bit is set to one, the device saves SMART data prior to going into a power saving mode (Idle, Standby, or Sleep) or immediately upon return to Active or Idle mode from a Standby mode. If this bit is cleared to zero, the device does not save SMART data prior to going into a power saving mode (Idle, Standby, or Sleep) or immediately upon return to Active or Idle mode from a Standby mode.

−   Bit 1 (SMART data autosave after event capability bit) - This bit is set to one for devices complying with this standard.

−   Bits 2-15 (Reserved).

8.54.5.8.6   Self-test routine recommended polling time

The self-test routine recommended polling time shall be equal to the number of minutes that is the minimum recommended time before which the host should first poll for test completion status. Actual test time could be several times this value. Polling before this time could extend the self-test execution time or abort the test depending on the state of bit 2 of the off-line data capability bits.

8.54.5.8.7   Data structure checksum

The data structure checksum is the two's complement of the sum of the first 511 bytes in the data structure. Each byte shall be added with unsigned arithmetic, and overflow shall be ignored. The sum of all 512 bytes will be zero when the checksum is correct. The checksum is placed in byte 511.