

Logical Unit Self-tests

To: T10 Technical committee
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1 Introduction

As the complexity of today's systems increases, a method is needed to quickly identify the root cause of system problems at the end-user's site. Self-test routines implemented in a logical unit (e.g., a hard disk drive) would provide a mechanism to quickly determine whether the logical unit is faulty or indicate that some other component is causing the system to fail. These self-test routines could be performed by a logical unit without removing it from its installation. This proposal recommends changes to SPC-2 to provide these features.

2 Reference documents

Elements from the draft standard SCSI Primary Commands – 2 (SPC-2) Revision 10, 19 May 1999 are referenced in this proposal. For more detail, see the referenced clauses. This draft is available at <ftp://ftp.t10.org/t10/drafts/spc2/spc2-r10.pdf>.

3 Overview model

3.1 The short and extended self-tests

There are two types of self-tests that may be invoked using the FUNCTION CODE field in the SEND DIAGNOSTICS command: a short self-test and an extended self-test. The goal of the short self-test is to quickly identify if the logical unit determines that it is faulty. A goal of the extended self-test routine is to simplify factory testing during integration by having logical units perform more comprehensive testing without application client intervention. A second goal of the extended self-test is to provide a more comprehensive test to validate the results of the short self-test if its results are judged by the application client to be inconclusive.

The criteria for the short self-test are that it has one or more segments and completes in two minutes or less. The criteria for the extended self-test are that it has one or more segments and that the completion time is vendor-specific. Any tests performed in the segments are vendor-specific.

The following are examples of segments:

- a) An electrical segment wherein the logical unit tests its own electronics. The tests in this segment are vendor specific, but some examples of tests that might be included in this segment are: a buffer RAM test, a read/write circuitry test, and/or a test of the read/write head elements.
- b) A seek/servo segment wherein a device tests its capability to find and servo on data tracks.
- c) A read/verify scan segment wherein a device performs read scanning of some or all of the medium surface.

The tests performed in the segments may be the same for the short and extended self-tests. The time required by a logical unit to complete its extended self-test is reported in the EXTENDED SELF-TEST ROUTINE COMPLETION TIME field in the Control mode page.

3.2 Self-test modes

There are two modes for each type of self-test: a foreground mode and a background mode.

3.2.1 The foreground mode

It is recommended that, before an application client initiates a self-test in the foreground mode, it should reserve the logical unit. When a device server receives a SEND DIAGNOSTICS command specifying a self-test to be performed in the foreground mode, the device server shall return status for that command after the self-test has been completed.

While performing a self-test in the foreground mode, the device server shall respond to all commands except INQUIRY, REPORT LUNS, and REQUEST SENSE with a CHECK CONDITION status with a sense key of NOT READY and an additional sense code of LOGICAL UNIT NOT READY, SELF-TEST IN PROGRESS.

If a device server is performing a self-test in the foreground mode and a test segment error occurs during the test, the device server shall update the Self-test results log page and report CHECK CONDITION/HARDWARE ERROR/LOGICAL UNIT FAILED SELF-TEST. The application client may obtain additional information about the failure by reading the Self-test results log page. If the device server is unable to update the Self-test results log page it shall respond by returning a CHECK CONDITION with a sense key of HARDWARE ERROR and an additional sense code of LOGICAL UNIT UNABLE TO UPDATE SELF-TEST LOG.

An application client may terminate a self-test that is being performed in the foreground mode by sending an Abort Task message. If a device server receives an Abort Task message while performing a self-test in the background mode, the device server shall abort the self-test and update the Self-test results log page.

3.2.2 The background mode

When a device server receives a SEND DIAGNOSTICS command specifying a self-test to be performed in the background mode, the device server shall return status for that command as soon as the command descriptor block has been validated.

After returning status for the SEND DIAGNOSTICS command specifying a self-test to be performed in the background mode, the device server shall set the function code value into the FUNCTION CODE field and set the SELF-TEST RESULTS VALUE field to be Fh in its Self-test results log page, then begin the first self-test segment.

While performing a self-test in the background mode, the device server shall suspend the self-test to service any other commands with the exceptions listed in Table 1 and the SEND DIAGNOSTICS command with any function other than the Abort background self-test function. If one of the exception commands listed in Table 1 is received, the device server shall abort the self-test, update the self-test log, and service the command as soon as possible but not longer than two seconds after the command descriptor block has been validated.

Table 1 – Exception commands for background self-tests

Device Type	Command	Where Defined
Direct access	FORMAT UNIT START/STOP UNIT WRITE BUFFER (with the mode set to any Download microcode option)	SBC
Sequential access	ERASE REWIND FORMAT MEDIUM SPACE LOAD UNLOAD VERIFY LOCATE WRITE READ WRITE BUFFER READ POSITION WRITE FILEMARKS READ REVERSE	SSC
Printer	WRITE BUFFER	SSC
Processor	NONE	SPC
Write once read multiple	WRITE BUFFER	SBC
C/DVD	WRITE BUFFER	MMC-2
Optical memory	WRITE BUFFER	SBC
Media changer	EXCHANGE MEDIUM READ ELEMENT INITIALIZE ELEMENT STATUS (if STATUS CURDATA = 0 and MOVE MEDIUM device motion is POSITION TO required) ELEMENT WRITE BUFFER	SMC
Storage array	WRITE BUFFER	SCC
Enclosure services	NONE	SES
Simplified direct-access	N/A	RBC

If a device server is performing a self-test in the background mode and receives a SEND DIAGNOSTICS command with any function other than the Abort background self-test function, the device server shall respond by returning a CHECK CONDITION with a sense key of NOT READY and an additional sense code of LOGICAL UNIT NOT READY, SELF-TEST IN PROGRESS.

Whenever there are commands other than the exception commands or the SEND DIAGNOSTICS command to service while the device server is performing a self-test in the background mode, the device server shall suspend the self-test as soon as possible to service the command. Suspension of the self-test and beginning to service the command shall never take longer than two seconds.

An application client may terminate a self-test that is being performed in the background mode by issuing a SEND DIAGNOSTICS command with the Abort background self-test function. If a device server receives a SEND DIAGNOSTICS command with the Abort background self-test function while performing a self-test in the background mode, the device server shall abort the self-test, update the Self-test results log page, and complete the command.

3.2.3 Elements common to both self-test modes

The PROGRESS INDICATION field returned in response to a REQUEST SENSE command may be used by the application client at any time during execution of a self-test to poll the logical unit's progress. While executing a self-test unless an error has occurred, a device server shall respond to a REQUEST SENSE command by returning a sense key of NOT READY and an additional sense code of LOGICAL UNIT NOT READY, SELF-TEST IN PROGRESS with the sense key specific bytes set for progress indication.

The application client may obtain information about the twenty most recently completed self-tests by reading the Self-test results log page. This is the only method for an application client to obtain information about self-tests performed in the background mode.

The Table 2 summarizes when a logical unit returns status after receipt of a self-test command, how an application client may abort a self-test, how a logical unit handles new commands that are received while a self-test is in progress, and how a logical unit reports a self-test failure.

Table 2 – Self-test mode summary

Mode	When Status is Returned	How to abort the self-test	Processing of subsequent commands while self-test is executing	Self-test failure reporting
Fore-ground	After the self-test is complete	Abort Task message	CHECK CONDITION / NOT READY / LOGICAL UNIT NOT READY, SELF-TEST IN PROGRESS [note item (1)] (except INQUIRY, REPORT LUNS and REQUEST SENSE)	CHECK CONDITION / HARDWARE ERROR / LOGICAL UNIT FAILED SELF-TEST [note item (2)] or / LOGICAL UNIT UNABLE TO UPDATE SELF-TEST LOG [note item (3)]
Back-ground	After the CDB for the self-test is validated	SEND DIAGNOSTICS with Abort background self-test function	Process the command (except FORMAT, START / STOP UNIT, and WRITE BUFFER with the mode set to any of the Download microcode options – then abort the self-test)	Application client checks Self-test results log page after the PROGRESS INDICATION field returned from REQUEST SENSE indicates the self-test is complete
[EDITOR'S NOTE 2 (mse – 23 Jul 99): It is recommended that the following codes be assigned and included in SPC-2 (1) 04h,09h, (2) 3Eh,03h, (3) 3Eh,04h.				

4 Mode page entry

Table 3 describes the EXTENDED SELF-TEST ROUTINE COMPLETION TIME field:

[EDITOR'S NOTE 3 (mse – 26 Apr 99): I recommend that bytes 10 and 11 (currently "reserved") in the Control mode page be used for this (see 8.3.4 in SPC-2).]

Table 3 – Control mode page

Bit	7	6	5	4	3	2	1	0
Byte								
.....							
10	(MSB) EXTENDED SELF-TEST ROUTINE COMPLETION TIME							
11								(LSB)

The EXTENDED SELF-TEST ROUTINE COMPLETION TIME is an advisory parameter that an application client may use to determine the time in seconds that the device server requires to complete the extended self-test routine when the device server is not interrupted by an application client and no errors occur during execution of the self-test routine. The application client should expect this time to increase significantly if other commands are sent to the logical unit while a self-test is in progress or if errors occur during execution of the self-test.

Device servers supporting FUNCTION CODE field values other than 000b for the SEND DIAGNOSTIC command, shall support the EXTENDED SELF-TEST ROUTINE COMPLETION TIME field.

5 Modifications to the SEND DIAGNOSTICS command

Note: The last line in the first paragraph of this clause in SPC-2 is changed to, “Except when the SELFTTEST bit is one or the FUNCTION CODE field is not 000b, this command is usually followed by a RECEIVE DIAGNOSTIC RESULTS command (see 7.15).” Reserved bits 7, 6 and 5 in byte 1 of the SEND DIAGNOSTICS command are changed to a FUNCTION CODE field.

Table 4 – SEND DIAGNOSTICS command

Bit	7	6	5	4	3	2	1	0	
0	OPERATION CODE (1Dh)								
1	FUNCTION CODE			PF	RESERVED	SELFTTEST	DEVOffFL	UNITOffFL	
2	RESERVED								
3	(MSB)	PARAMETER LIST LENGTH							
4							(LSB)		
5	CONTROL								

When the SELFTTEST bit is set to one the FUNCTION CODE field shall be 000b. When the SELFTTEST bit is cleared to zero the content of FUNCTION CODE field is specified in Table 5.

Table 5 – Function code field values

Value	Function Name	Description
000b	NA	Value to be used when the SELFTTEST bit is set to one or if the SEND DIAGNOSTIC command is not invoking one of the other self-test function codes (e.g., Translate Address page (see SBC)).
001b	Background short self-test	The device server shall start its short self-test routine in the background mode.
010b	Background extended self-test	The device server shall start its extended self-test routine in the background mode.
011b	NA	Reserved
100b	Abort background self-test	Abort the current self-test running in background mode. This value is only valid if a previous SEND DIAGNOSTIC command specified a Background self-test function and that function has not completed. If either of these conditions is not true, then the device server shall it shall respond by returning a CHECK CONDITION with a sense key of NOT READY and an additional sense code of LOGICAL UNIT NOT READY, SELF-TEST IN PROGRESS.
101b	Foreground short self-test	The device server shall start its short self-test routine in the foreground mode.
110b	Foreground extended self-test	The device server shall start its extended self-test routine in the foreground mode.
111b		Reserved

6 Self-test results log page

This log page provides the results from the twenty most recent self-tests. Results from the most recent self-test or the self-test currently in progress shall be reported in the first self-test log structure parameter; results from the second most recent self-test shall be reported in the second self-test log structure parameter; etc. If fewer than twenty self-tests have occurred, the unused self-test log structure parameter entries shall be zero filled.

Table 6 describes the Self-test results log page format that shall be returned by the device server upon request by the application client.

Table 6 – Self-test results log page format

Bit	7	6	5	4	3	2	1	0	
0	PAGE CODE (10h)								
1	RESERVED								
2	(MSB)	PAGE LENGTH (0190h)							
3								(LSB)	
	SELF-TEST RESULTS LOG PARAMETERS								
4									
....			FIRST SELF-TEST RESULTS LOG PARAMETER						
23									
....								
384									
....			TWENTIETH SELF-TEST RESULTS LOG PARAMETER						
403									

The PAGE CODE field shall be 10h.

The PAGE LENGTH field specifying the length in bytes of the parameter list that shall be transferred from the device server to the application client shall be 0190h.

Table 7 describes the nth SELF-TEST RESULTS LOG PARAMETER field.

Table 7 – nth self-test results log parameter

Bit	7	6	5	4	3	2	1	0	
Byte									
0	(MSB) PARAMETER CODE (LSB)								
1									
2	DU (= 0)	DS (= 0)	TSD (= 0)	ETC (= 0)	TMC (= 00b)		LBIN (= 1)	LP (= 1)	
3	PARAMETER LENGTH (0Ch)								
4	FUNCTION CODE			RSVD	SELF-TEST RESULTS VALUE				
5	EXTENDED SEGMENT NUMBER								
6	(MSB) TIMESTAMP								
7									
8	(MSB)								
.....	LBA OF FIRST FAILURE								
15	(LSB)								
16	RESERVED				SENSE KEY				
17	ADDITIONAL SENSE CODE								
18	ADDITIONAL SENSE CODE QUALIFIER								
19	VENDOR SPECIFIC								

The PARAMETER CODE field identifies the log parameter being transferred for that log page. The PARAMETER CODE field for the results of the most recent test shall contain 0001h; the PARAMETER CODE field for the results of the second most recent test shall contain 0002h; etc.

The FUNCTION CODE field contains the content of the FUNCTION CODE field in the SEND DIAGNOSTICS command that initiated this self-test. See Table 5 for a description of the FUNCTION CODE field values.

Table 8 defines the content of the SELF-TEST RESULTS VALUE field.

Table 8 – Self-test results values

Value	Description
0h	The self-test routine completed without error.
1h	The background self-test routine was aborted by the application client using a SEND DIAGNOSTICS command with the Abort background self-test function.
2h	The self-test routine was aborted by an application client not using a SEND DIAGNOSTICS command with the Abort background self-test function (e.g., by a Task Management function, by a reset, or by issuing an exception command as defined in Table 1).
3h	An unknown error occurred while the device server was executing the self-test routine and the device server was unable to complete the self-test routine.
4h	The self-test completed having a test segment that failed, and the test segment that failed is not known.
5h	The first segment of the self-test failed.
6h	The second segment of the self-test failed.
7h	An other segment of the self-test failed (see the EXTENDED SEGMENT NUMBER field).
8h-Eh	Reserved
Fh	The self-test is in progress

The EXTENDED SEGMENT NUMBER field may be used to identify the number of the segment that failed during the self-test. If no segment failed, this field shall contain 00h.

The `TIMESTAMP` field contains the total accumulated power-on hours of the device server at the time the self-test operation was completed. If the test is still in progress, the content of the `TIMESTAMP` field shall be zero. If the power-on hours for the device server at the time the self-test operation was completed is greater than `FFFFh` then the content of the `TIMESTAMP` field shall be `FFFFh`.

If the logical unit implements logical blocks, the content of the `LBA OF FIRST FAILURE` field is the first logical block address where a self-test error occurred. This implies nothing about the quality of any other LBA on the logical unit. The testing during which the error occurred may not have been performed in a sequential manner. This value shall not change (e.g., as the result of block reassignment). The content of the `LBA OF FIRST FAILURE` field shall be `FFFFFFFFFFFFFFFFh` if no errors occurred during the self-test or if the error that occurred is not related to a logical block address.

The `SENSE KEY`, `ADDITIONAL SENSE CODE`, and `ADDITIONAL SENSE CODE QUALIFIER` fields may contain a hierarchy of additional information relating to error or exception conditions that occurred during the self-test.