To: INCITS Technical Committee T10
From: Fred Knight, Network Appliance
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Date: March 10, 2008
Subject: SAT-2 – Additional Power Management support

1. ***Revision history***

Revision 0 (5 November 2007) First revision

Revision 1 (14 January 2008) Second revision

1) The START STOP UNIT command is now used to map the existing SCSI power condition field to IDLE, STANDBY, and SET FEATURES commands for ATA power management support.
2) The previously proposed TUR changes have been removed from the proposal.
3) The Power Condition Mode Page section has been re-written to propose a new Power Condition Mode sub-page and is now used for setting the STANDBY timer values, and the APM setting. The new mode page extends the old page by adding an ATA specific sub-page.

Revision 2 (20 February 2008) Third revision

Incorporate changes from January T10 SAT meeting.

1) Put generic info into SPC, and SAT details into SAT-2.
2) Include SBC REQUEST SENSE return codes for lower power conditions.
3) Create SBC proposal to commonize the head park/unload (rather than keeping it SAT specific).
4) Add SLEEP translation.
5) Incorporate feedback from HP.

Revision 3 (10 March 2008) Forth revision

Incorporate change from February T10 SAT meeting.

1) Remove SLEEP
2) Create SAFETY CONDITION field (replacing park/unload)
3) Change all “register” to “field” (since SATA doesn’t have registers)
4) Update references to SAT2r02.

2. ***Related documents***

sat2r02 – SCSI / ATA Translation - 2
spc4r11 – SCSI Primary Commands - 4
sbc3r11 – SCSI Block Commands – 3
08-0139r0 - SBC START STOP command additions

3. Overview

Not enough cases of ATA STANDBY power condition are reported to the SCSI host. This proposal enables reporting of more STANDBY power conditions and makes them more consistent, and adds definitions for enabling, disabling, and reporting APM mode using a SPC defined Power Condition mode page.

4. *Expected Use Cases:*

Manual method:

The manual method would be used by initiators that perform their own timing of I/O. When a particular idle time (no I/O sent to the device) passed, the initiator would use the START/STOP command to manually cause the device to enter the desired power condition. The initiator could step through the power conditions (from ACTIVE, to IDLE, to STANDBY, to STOPPED) as subsequent time intervals are passed. Once in IDLE or STANDBY modes, any I/O sent to the device would return the device to ACTIVE mode (after a short delay), and the I/O would be serviced. When in the STOPPED state, just as it does today, the SATL would return the NOT READY-INITIALIZING COMMAND REQUIRED error, and the initiator would respond by sending the START COMMAND before reissuing the I/O request.

For the manual mode of operation, the power condition mode pages need not be used at all.

Automatic method:

The automatic method would use the power condition mode pages. The initiator would specify values in the idle timer, standby timer, or APM fields.

If the standby timer field was set, the device would automatically transition to STANDBY mode after no I/O had occurred for that time period (as defined in the ATA spec). Any new I/O sent to the device would return the device to ACTIVE mode (after a short delay), and the I/O would be serviced (again, as already defined in the ATA spec).

The SATL will ignore the IDLE timer field since ATA does not have an IDLE timer.

If the APM field was set, the device would use APM mode. In this mode, the device is in full control of the power utilization (within the bounds specified by the value in the APM field). This field is not truly a timer, but rather the ATA APM value. To activate this mode, the initiator would program the value in the mode sub-page.

To disable APM mode, the initiator would issue a MODE SELECT and set the APM bit to one and the APM VALUE to zero.

To determine the current state of the device, the MODE SENSE command would be used to examine the current state of the power condition settings (this may return the values set via the most recent MODE SELECT Command if the SATL can determine the value to return).

Author's comments/questions are in blue text, spec changes are in red.

4 Definitions, symbols, abbreviations, and conventions

4.1 Definitions

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4.1.4 Advanced Power Management (APM): The Advanced Power Management feature set as defined in ATA8-ACS.

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4.2 Symbols and abbreviations

APM **Advanced Power Management (see 4.1.4)**

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6 SCSI architectural elements

6.1 Overview

Clause 6 defines SCSI / ATA translation elements that impact the representation of the storage domains defined in SAM-3 and ATA8-AAM. Figure 4 shows a SATL providing a communication path between a SCSI application client and an ATA device.

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6.2 Multi-Initiator Configurations

SAM defines configurations that may include multiple initiators. Operation of a SATL with multiple initiators is not specified in this standard. For example, interactions of RESERVE, RELEASE, START STOP UNIT, REQUEST SENSE, and other commands from different initiators is not specified in this standard

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9.8 REQUEST SENSE command

9.8.1 REQUEST SENSE command overview

The REQUEST SENSE command requests any available sense data to be returned to the application client.

If the SCSI transport protocol for the SATL supports autosense (see 4.1.31), the SATL shall return sense data using autosense. Otherwise, the SATL shall return sense data in response to the REQUEST SENSE command (see SAM-2).

The SATL shall determine if there is sense data to return to the application client. To determine if there is power condition sense data to return, the SATL shall issue the ATA CHECK POWER MODE command to the ATA device. If the SATL has no sense data to return, then the SATL shall complete the REQUEST SENSE command with GOOD status with the sense key set to NO SENSE and the additional sense code set to NO ADDITIONAL SENSE DATA (see SPC-3). Power condition status (Idle, Standby, Stopped) shall be reported with a higher precedence than other statuses. Table 18 lists examples of conditions where the SATL has sense data to return.

Table 18 — Special Request Sense behavior reference

Emulated device state	Reference
Status other than GOOD to return	SPC-3
FORMAT UNIT in progress	9.8.2
SMART threshold exceeded condition	9.8.3
Stopped power condition (~~i.e.~~e.g., After returning GOOD status to a START STOP UNIT command with the power condition field set to zero, and the START bit set to zero. ~~ATA device in standby power management state~~)	9.8.4
Unit attention condition established	9.8.5
Idle power condition (e.g., After returning GOOD status to a START STOP UNIT command with the power condition field set to IDLE.)	9.8.6
Standby power condition (e.g., After returning GOOD status to a START STOP UNIT command with the power condition field set to STANDBY.)	9.8.7

Table 19 shows the fields in the REQUEST SENSE CDB.

Table 19 — REQUEST SENSE CDB field translations

Field	Description or reference
OPERATION CODE	Set to 03h. The SATL shall return any available sense data to the application client.
DESCa	Unspecified (see 4.4.2)
ALLOCATION LENGTH	Unspecified (see 4.4.2)
CONTROL	6.4
[a] If the SATL supports the ATA PASS-THROUGH command (see 12.2), then the SATL shall support returning descriptor format sense data (i.e., specified by the DESC bit set to one).	

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9.8.4 Stopped power condition

If the emulated logical unit is in the stopped power condition (~~i.e.~~e.g., after returning GOOD status to a START STOP UNIT command with the power condition field set to zero, and the START bit set to zero (see table 42) ~~the ATA device is in the Standby power management state~~) and there is no sense data to return for a previously returned CHECK CONDITION status, then the SATL shall:

1) return parameter data containing sense data with the sense key set to NO SENSE with the additional sense code set to NO ADDITIONAL SENSE DATA; and
2) complete the REQUEST SENSE command with GOOD status.

Sense data returned for a previously returned CHECK CONDITION status resulting from a media access command or a TEST UNIT READY command received when the logical unit is in the stopped power condition is described in 9.12 (i.e., the TEST UNIT READY command) and 9.11 (i.e., the START STOP UNIT command).

9.8.5 Unit attention condition established

The SATL shall:

1) return parameter data containing sense data describing the unit attention condition (see SPC-3); and
2) complete the REQUEST SENSE command with GOOD status.

9.8.6 IDLE power condition

If the emulated logical unit is in the IDLE power condition (e.g., after returning GOOD status to a START STOP UNIT command with the power condition field set to IDLE) then the SATL shall return GOOD status with the sense key set to NO SENSE with the additional sense code set to:

A) LOW POWER CONDITION ON if the reason for the entry into the idle power condition is unknown;
B) IDLE CONDITION ACTIVATED BY COMMAND if the logical unit entered the idle power condition due to a START STOP UNIT command or receipt of a command requiring the idle power condition.

9.8.7 STANDBY power condition

If the emulated logical unit is in the STANDBY power condition (e.g., after returning GOOD status to a START STOP UNIT command with the power condition field set to STANDBY) then the SATL shall return GOOD status with the sense key set to NO SENSE with the additional sense code set to:

A) LOW POWER CONDITION ON if the reason for the entry into the standby power condition is unknown;
B) STANDBY CONDITION ACTIVATED BY COMMAND if the logical unit entered the standby power condition due to a START STOP UNIT command or receipt of a command requiring the standby power condition.

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9.11.1 START STOP UNIT command overview

The START STOP UNIT command provides a method for controlling the power ~~state~~ condition of a logical unit.

If a SATL receives a command that requires medium access while the device is in the Stopped state (see

SBC-2), then the SATL shall return CHECK CONDITION status, with the sense key set to NOT READY and the additional sense code set to LOGICAL UNIT NOT READY, INITIALIZING COMMAND REQUIRED.

Table 41 shows the translation for fields specified in the START STOP UNIT CDB.

The POWER CONDITION field is used to specify that the logical unit be placed into a specific power condition or to adjust a timer as defined in table 41. If the POWER CONDITION field contains a value other than 0h, then the SATL shall not consider the ATA device to be in the stopped state (see 8.12.2). If this field is not supported and is set to a value other than 0h, then the SATL shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.

TABLE 41 – START/STOP UNIT CDB field translations

Field	Description or reference	
OPERATION CODE	Set to 1Bh. See 9.11.2 and 9.11.3	
IMMED	The SATL shall implement this field as defined in 9.11.2 and 9.11.3	
POWER CONDITION	See SBC3 - START STOP Command definitions	
	0 – START_VALID	The SATL shall process the LOEJ and START fields as defined in section 9.11.3
	01h - ACTIVE	The SATL shall: 1) If the IMMED bit is set to one, then return GOOD status; 2) Issue an ATA verify command (see 3.1.23) to the ATA device with the Sector Count set to one and the LBA set to a value between zero and the maximum LBA supported by the ATA device in its current configuration[a]; 3) If the ATA verify command completes with any error, then process ending status according to the IMMED bit (see 9.11.2) with the additional sense code set to COMMAND SEQUENCE ERROR;<note – sense key is defined in 9.11.2 below> 4) If the ATA verify command completes without error and the IMMED bit is set to zero, then return GOOD status (see 9.11.2) and the SATL shall no longer consider the ATA device to be in the stopped power state.
	02h - IDLE	The SATL shall: 1) If the IMMED bit is set to one, then return GOOD status; 2) If NOFLUSH bit is set to zero, then Issue an ATA flush command (see 3.1.11) to the ATA device; 3) If the ATA flush command completes with any error, then process ending status according to the IMMED bit (see 9.11.2) with the additional sense code set to COMMAND SEQUENCE ERROR; 4) If the ATA flush command was issued (step 2 above) and completes without error, then a. if the SAFETY CONDITION field = 0, then to enable IDLE mode immediately, issue an ATA IDLE IMMEDIATE command to the ATA device with the

		following field values:
		i. Feature = 0;
		ii. Sector Count = 0;
		iii. LBA = 0;
		b. if the SAFETY CONDITION field is set to one, then to enable IDLE mode immediately with head unload/park[b], issue an ATA IDLE IMMEDIATE command to the ATA device with the following field values:
		i. Feature = 44h;
		ii. Sector Count = 0;
		iii. LBA = 554E4Ch;
		5) If the ATA IDLE IMMEDIATE command completes with any error, then process ending status according to the IMMED bit (see 9.11.2) with the additional sense code set to COMMAND SEQUENCE ERROR; and
		6) If the ATA IDLE IMMEDIATE command completes without error and the IMMED bit is set to zero, then return GOOD status (see 9.11.2).

	03h - STANDBY	The SATL shall: 1) If the IMMED bit is set to one, then return GOOD status; 2) Issue an ATA flush command (see 3.1.11) to the ATA device; 3) If the ATA flush command completes with any error, then process ending status according to the IMMED bit (see 9.11.2) with the additional sense code set to COMMAND SEQUENCE ERROR; 4) If the ATA flush command completes without error, then the SATL shall issue an ATA STANDBY IMMEDIATE command to the ATA device; 5) If the ATA STANDBY IMMEDIATE command completes with any error, then process ending status according to the IMMED bit (see 9.11.2) with the additional sense code set to COMMAND SEQUENCE ERROR; and 6) If the ATA STANDBY IMMEDIATE command completes without error and the IMMED bit is set to zero, then return GOOD status (see 9.11.2).
	0Bh – Force S_0	The SATL shall: 1) If the IMMED bit is set to one, then return GOOD status; 2) Issue an ATA flush command (see 3.1.11) to the ATA device; 3) If the ATA flush command completes with any error, then process ending status according to the IMMED bit (see 9.11.2) with the additional sense code set to COMMAND SEQUENCE ERROR; 4) If the ATA flush command completes without error, then the count field shall be set to zero, and the SATL shall issue an ATA STANDBY command to the ATA device; 5) If the ATA STANDBY command completes with any error, then process ending status according to the IMMED bit (see 9.11.2) with the additional sense code set to COMMAND SEQUENCE ERROR; and 6) If the ATA STANDBY command completes without error and the IMMED bit is set to zero, then return GOOD status (see

		9.11.2).
	All others	The SATL shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.
LOEJ	If the POWER CONDITION field = 0, ~~T~~the SATL shall implement this field as defined in 9.11.3	
START	If the POWER CONDITION field = 0, ~~T~~the SATL shall implement this field as defined in 9.11.3	
SAFETY CONDITION	The SATL shall cause the device to enter the specified safety condition (e.g., for those devices that have movable read/write heads, park/unload the drive heads as specified above (see POWER CONDITION field = IDLE)).	
NOFLUSH	If the NOFLUSH bit is set to one, the SATL shall not issue the ATA flush command as specified above (see POWER CONDITION field = IDLE).	
CONTROL	6.4	
[a] An ATA device medium access occurs when an LBA is specified whose data is not contained in ATA device's cache memory. If a value in LBA is specified for an ATA verify command where the data is contained in ATA device's cache memory, then an ATA device may not be in the Active power mode (see ATA8-ACS) after completion of the ATA verify command. [b] Actual ATA device behavior during this operation is vendor unique.		

9.11.2 Processing ending status if an error occurs

If an error occurs during the processing of the START STOP UNIT command and the IMMED bit is set to zero, then the SATL shall terminate the START STOP UNIT command with CHECK CONDITION status with a sense key set to ABORTED COMMAND, and the additional sense code set to the value specified for the error being reported (see table 41 and 42).

If an error occurs during the processing of the START STOP UNIT command and the IMMED bit is set to one, then the SATL shall terminate the START STOP UNIT command and return CHECK CONDITION status as a deferred error (see SPC-3) with a sense key set to ABORTED COMMAND, and the additional sense code set to the value specified for the error being reported (see table 41 and 42).

9.11.3 START STOP UNIT START bit LOEJ bit combinations

If the POWER CONDITION field is set to zero, ~~T~~the SATL shall perform the actions shown in table 42 in response to a START STOP UNIT command.

See Below

Table 42 — Definition of START and LOEJ bits in the START STOP UNIT CDB

START	LOEJ	Definition
0	0	The SATL shall: 1) If the IMMED bit is set to one, then return GOOD status; 2) Issue an ATA flush command (see 3.1.11) to the ATA device; 3) If the ATA flush command completes with any error, then process ending status according to the IMMED bit (see 9.11.2) with the additional sense code set to COMMAND SEQUENCE ERROR; 4) If the ATA flush command completes without error, then issue an ATA STANDBY IMMEDIATE command to the ATA Sector Count set to zero; 5) If the ATA STANDBY IMMEDIATE command completes with any error, then process ending status according to the IMMED bit (see 9.11.2) with the additional sense code set to COMMAND SEQUENCE ERROR; and 6) If the ATA STANDBY IMMEDIATE command completes without error and the IMMED bit is set to zero, then return GOOD status (see 9.11.2) [a].
0	1	If the ATA device supports the Removable Media feature set (see ATA/ATAPI-7), then the SATL shall: 1) If the IMMED bit is set to one, then return GOOD status; 2) Issue an ATA MEDIA EJECT command to the ATA device; 3) If the ATA MEDIA EJECT command completes with any error, then process ending status according to the IMMED bit (see 9.11.2) with the additional sense code set to MEDIA LOAD OR EJECT FAILED; and 4) If the MEDIA EJECT command completes without error and the IMMED bit is set to zero, then return GOOD status. If the ATA device does not support the Removable Media feature set, then the SATL shall return CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB.
1	0	The SATL shall: 1) If the IMMED bit is set to one, then return GOOD status; 2) Issue an ATA verify command (see 3.1.23) to the ATA Sector Count set to one and the LBA set to a value between zero and the maximum LBA supported by the ATA device in its current configuration [b]; and 3) If the IMMED bit is set to one, then return GOOD status when command completion is received for the ATA verify command (see 3.1.23) [c].
1	1	The SATL shall return CHECK CONDITION status with the sense key set to ILLEGAL REQUEST, with the additional sense code set to INVALID FIELD IN CDB.

[a] After returning GOOD status for a START STOP UNIT command with the START bit set to zero, the SATL shall consider the ATA device to be in the Stopped power state (see SBC-2).

[b] An ATA device medium access occurs when an LBA is specified whose data is not contained in ATA device's cache memory. If a value in LBA is specified for an ATA verify command where the data is contained in ATA device's cache memory, then an ATA device may not be in the Active power mode (see ATA8-ACS) after completion of the ATA verify command.

[c] After returning GOOD status for a START STOP UNIT command with the START bit set to one, the SATL shall consider the ATA device to be in the Active power state (see SBC-2).

and the power condition field set to zero,

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Section 9.11.3 (table 42 <above>) – TYPO correction:

4) If the ATA flush command completes without error, then issue an ATA STANDBY IMMEDIATE command to the ATA device with the Sector Count set to zero;

2) Issue an ATA verify command (see 3.1.23) to the ATA device with the Sector Count set to one and the LBA set to a value between zero and the maximum LBA supported by the ATA device in its current configuration [b]; and

~~Section~~ 10.1.9 Power Condition Mode Page

The SCSI START/STOP command is used to specifically change power condition. The Power Condition mode page~~s~~ allow~~s~~ setting of the ATA APM mode setting, and the ATA STANDBY timer value. It also provides information about the current power condition. Values in the Standby Timer field shall be rounded as defined in table X and shall not use the SPC option to return Check Condition status for values that require rounding.

To determine if APM mode is enabled the SATL shall verify that the ATA IDENTIFY DEVICE data word 83, bit 3 is set to one and word 86, bit 3 is also set to one.

To determine if the Standby timer is supported the SATL shall verify that the ATA IDENTIFY DEVICE data word 49, bit 13 is set to one.

Table X – Standby Timer Mappings

Power Condition Mode page STANDBY CONDITION TIMER value (uses 100 millisecond granularity)	ATA count field value (See STANDBY Command in ATA8-ACS)
1-12 000 (.001 second to 1 200 seconds)	INT((Value - 1) / 50) + 1 (a)
12 001 – 12 600	0xFC (21 minutes)
12 601 – 12 750	0xFF (21 minutes + 15 seconds)
12 751 – 17 999	0xF1
18 000 – 198 000 (30 minutes – 330 minutes)	INT(Value / 18 000) + 240 (a)
Others	0xFD (8 hours – 12 hours)
Note: Times are approximate. (a) – INT() refers to the integer result of the specified division operation (with any decimal remainder truncated).	

Table Y – Power Condition Control mode page fields

Field	Changeable	Description or reference
PS	n/a	Unspecified (see 3.4.2)
SPF	no	Shall be set to zero.
Page Code	no	Shall be set to 1Ah
Page Length	no	Shall be set to 0~~1~~Ah
IDLE	no	When processing a MODE SENSE command, the IDLE bit shall be returned as zero. When processing a MODE SELECT command, if the IDLE bit is set to one, then the SATL shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER LIST.
STANDBY	yes	When processing a MODE SENSE command, if a standby timer is supported, the STANDBY bit shall be returned as one. If the standby timer is not supported, the STANDBY bit shall be returned as zero. When processing a MODE SELECT command, if the

		STANDBY bit is set to one, then: 1) if the ATA IDENTIFY DEVICE data word 49, bit 13 is set to zero, the SATL shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER LIST; 2) the SATL shall issue the ATA STANDBY command to the ATA device, and the value in the STANDBY CONDITION TIMER field shall be translated as defined in tabled X and used to set the Timer period value (TPV) (i.e., count field).
IDLE CONDITION TIMER	no	When processing a MODE SENSE command, this field shall be returned as zero. When processing a MODE SELECT command, this field shall be ignored.
STANDBY CONDITION TIMER	yes	When processing a MODE SENSE command: If the standby timer is not supported, then the STANDBY CONDITION TIMER shall return zero. If a standby timer is supported and has been retained by the SATL, then it shall be translated (see table X) and returned in this field (if the translated value is in a range, then the highest value in that range shall be returned). If a standby timer is supported and has not been retained by the SATL, then the STANDBY CONDITION TIMER shall return FFFFFFFFh. When processing a MODE SELECT command: If STANDBY is set to one, then the value in this field shall be translated as defined in table X and used to set the Timer period value (TPV) (i.e., count field).

12.3.3 ATA Power Condition Mode Page

The ATA Power Condition Mode Page provides ATA specific controls for a SATL to configure ATA specific power management functions.

Table ZZ shows the ATA Power Condition Mode Page.

Table ZZ - ATA Power Condition Mode Page

Bit Byte	7	6	5	4	3	2	1	0
0	PS	SPF (1b)	Page Code (1Ah)					
1	Sub Page Code (F1h)							

2	**(MSB)**	
3	**Page Length (0Ch)** **(LSB)**	
4	**Reserved**	
5	**Reserved**	**APM**
6	**APM Value**	
7	**Reserved**	
15		

The PS bit, SPF bit, PAGE CODE field, and PAGE LENGTH field are described in SPC.

The SPF bit (see SPC) shall be set to one to access this mode page.

The PAGE CODE field shall be set to 1Ah.

The SUBPAGE CODE field shall be set to F1h.

When processing a MODE SELECT, if the APM bit is set to zero, then the SATL shall ignore the APM value.

When processing a MODE SELECT, if the APM bit is set to one, then the SATL shall alter APM mode by issuing an ATA SET FEATURES command. If the APM VALUE contains a non-zero value, the ATA SET FEATURES – Enable/disable advanced power management (i.e., subcommand 05h) command shall be used and APM VALUE shall be used to set the power management level (i.e., count field). If APM VALUE contains a zero, the ATA SET FEATURES – Disable advanced power management (i.e., subcommand 85h) command shall be used (if possible).

~~The SATL may store the APM VALUE for return during a MODE SENSE operation.~~

When processing a MODE SENSE, if the APM bit is set to zero, then APM mode is not supported. If the APM bit is set to one, then APM mode is supported. If the APM bit is set to one, ~~and the SATL stores the APM VALUE, then~~ the APM VALUE field shall contain the value from IDENTIFY DEVICE word 91.~~that was set. If the APM bit is set to one, and the SATL does not store the APM value, then the APM VALUE field shall contain FFh.~~