Annex P Power Management Functions (Informative)

P 1 Power Management States

Four power states are defined. These are named Active, Idle, Standby, and Sleep with Active being the “Full-On” state, Sleep the “Off” state and “Idle, Standby and Sleep” progressively more aggressive power managed states. This model differs significantly from previous ATA and SCSI power management definitions. This new model defines power states in terms of the perceived impact on the end user, instead of absolute power levels. The Idle state is optimized for minimal end user performance impact. The Standby state is optimized for power savings.

To provide consistent behavior across Logical Units, standard definitions are used for the power states of Logical Units. These states are defined in terms of the following criteria.

- Power Consumption: How much power the Logical Unit uses.

- Logical Unit Context: How much of the internal state of the Logical Unit is retained by hardware and what must be restored by the responsible software.

- Restore time: How long it takes to raise the power level to the active power state and to put the Logical Unit into operational condition (including mechanical operation such as spin up) required before entering into the Active power state. Restoring is vendor specific and any mechanism can be employed here to raise the power consumption and to put the Logical Unit in operation condition required in a higher power state. For example, “turning on or raising internal Vcc’s for power hungry circuits such as motors, laser sensors”, “raising internal Vcc or the clock frequency for the digital circuits”, etc. A critical factor is how quickly restoring the Logical Unit to operation condition required in a higher power state (e.g. spin up).

- De-power time: How long it takes to reduce the power to the desired level in lower power state after entering the lower power state from higher power state. De-powering is vendor specific and any mechanism can be employed here to reduce the power consumption. For example, “turning off or lowering internal Vcc’s for power hungry circuits such as motors, laser sensors”, “lowering internal Vcc or reducing the clock frequency for the digital circuits”, “dynamic clock gating”, “cutting off the DC paths for unused circuits”, “turning off PLLs”, etc.

Table P1 - Power Management Model States

Logical Unit State	Power Consumption	Logical Unit Context Retained	Restore Time
Active (D0)	As needed for operation	All	None
Idle (D1)	Less than Active	All	The Logical Unit shall be restored to active state within 1 second on any request to enter active state, independent of the de-powering process.
Standby (D2)	Less than idle	All buffers are empty before entering Standby state.	Vendor specific: Greater than or equal to Idle to Active
Sleep (D3)	Less than Standby	None, Buffer & All of Command queues are empty before entering Sleep state.	Greater than or equal to Standby to Active. Vendor Specific. May Need full initialization. The Host may remove Vcc.

Transitions between these power states may occur at the request of the host or the logical unit. Transitions to a higher power state from a lower power state shall occur after restoring the logical unit to the operating conditions (including mechanical operation if applicable, such as spin up) required in the higher power state. When the logical unit transitions from a higher power state to a lower power state, the logical unit shall be considered to be in the lower power state when the logical unit is assured of reaching the lower power condition. Actual de-powering occurs after the logical unit enters the lower power state. The logical unit shall generate a power event when the logical unit is considered to have entered a power state.

In order to create a robust power management environment, logical units shall support the following:

- Four power states: Active(D0), Idle(D1), Standby(D2) and Sleep(D3).

- Idle Timer. Provides a method for the logical unit to enter Idle state from Active state, following a programmed period of inactivity.

- Standby Timer. Provides a method for the logical unit to enter Standby state from either Active or Idle state, following a programmed period of inactivity.

- START/STOP UNIT Command and the Power Condition Field. Provides a method for the host to request the logical unit to enter a power state.

- GET EVENT STATUS NOTIFICATION Command. Notifies the host of power state changes and current power status.

- Power Condition Mode page. Enables or disables timers and specifies the reload value of the Idle and Standby timers.

P 2 Power State Transitions

Active State (D0):

The logical unit is completely active and responsive. The logical unit is consuming its highest level of power. During the execution of a media access command (commands that reload both timers) the logical unit shall be in active state.

The logical unit should minimize power consumption at all times, even when in the active state. Any mechanism can be employed, as long as it is transparent to software and does not prevent the logical unit from performing expected functions.

For example, the logical unit may dynamically gate on/off internal clocks by monitoring bus activities and internal activities.

Idle State (D1):

In Idle state, the logical unit is capable of responding to commands but may take up to one second longer to complete commands than the Active state. The logical unit is consuming less power than the Active state. Any mechanism can be employed as long as the restoring time is less than one second. The logical unit may, for example:

- Reduce internal clock frequency

- Lower the internal Vcc for digital circuits

- Dynamically gate internal clocks by monitoring bus/internal activities

Standby State (D2):

In Standby state the logical unit shall only be required to accept commands from the host. All other mechanisms are in the power save condition. In Standby state, the logical unit is capable of responding to commands but the logical unit takes longer to complete commands than when in Idle state. Buffers shall be emptied before entering into Standby state. The logical unit context shall be preserved. The logical unit is consuming less power than when in Idle state.

Sleep State (D3):

Maximum power saving state. Buffers and all command queues, including GET EVENT STATUS NOTIFICATION commands, shall be emptied before entering into the Sleep state. When the logical unit enters the sleep state, any GESN commands present in the command queue, shall be removed from the command queue, without command completion. In this Sleep state, all functions are stopped and no commands, except for reset can be received. The unit is consuming less power than when in the Standby state. The logical unit context is invalid in the Sleep state.

The host software shall fully initialize the logical unit after exiting Sleep state, as all context may be lost in the Sleep state. Therefore, disc(s)/cassette may be manually ejected or inserted while in sleep state, independent of any lock/unlock mechanism employed. For the host to consistently rely on the logical unit Media Status Notifications, when the logical unit is unable to determine if media has been changed while the Logical Unit was in the sleep state, the logical unit shall report NEW MEDIA on the next GET EVENT STATUS NOTIFICATION (Media Status) command.

In the Sleep state, the host may completely remove power from the device by turning off Vcc.

P 3 Power Management State Diagram

The state diagram "Figure 51 - State Transition, Events and Status" on page 128 and "Table 42 - State Transition, Events and Status" on page 129 define state transitions for the power management model.

A power-on or hard reset always returns the Power State to the Standby state. A Device Reset does not alter the current power state, unless the current power state is Sleep. A Device Reset received while in sleep state returns the power state to Standby.

The Sleep state is entered when the logical unit has been commanded to go to Sleep but Vcc is still applied to the device. Removing Vcc always takes the device to the Power Off state. Removing Vcc is recommended only when all Logical Units on a given bus are in sleep state.

"Table 42 - State Transition, Events and Status" on page 129 shows transition conditions for this model, and shows the Initial state, the Resultant state, Notification class, and Event class (Media or Power). Notification class and Event class fields specify the events that shall be generated during the transitions as outlined in the GET EVENT STATUS NOTIFICATION command.

In Idle or Standby states, the logical unit should attempt to maintain the minimal power level for that state at all times. However, the logical unit may create transitory, higher power level conditions as needed. The transitory power conditions shall not affect the reported power state, or generate power state events. Example transitory conditions are: flushing the buffers, emptying command queues, media insertion spin up, or auto off-line, etc. On insertion of new media, the logical unit may enter a transitory, higher power condition and stay in this condition for vendor specific time period. If the logical unit has not received a media access command (commands which reload both timers) during this period, the logical unit shall return to the normal power level for the current power state. This prevents excessive power consumption while the host is off-line.

It is permissible to enter intermediate states while in transition between states, however, the logical unit shall not report power change events for the intermediate states. If the logical unit fails to enter the target power state, the logical unit shall return to the original power state. Simultaneous expiration of multiple timers, shall cause the logical unit to enter the lower power state, and shall only report the result of the transition to that state.

When the logical unit is reporting NOT READY, the logical unit shall enter the Standby State.

If a power change event has not been reported to the host, when a new event is generated, the logical unit may choose only to report the most recent power event.

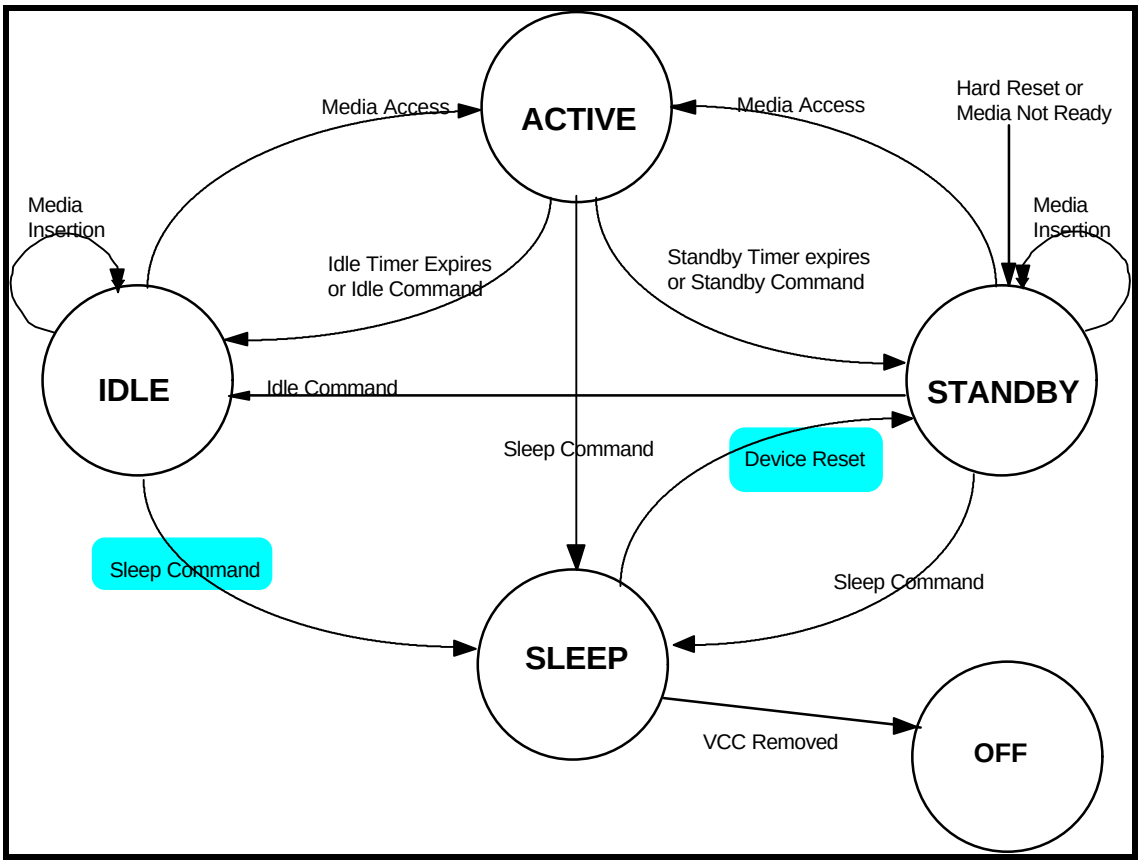

Figure 1 - STATE Diagram

P 4 Power Management Timers

The Idle and Standby timers provide a method for the logical unit to enter lower power states after a host programmable period of inactivity, without direct host command.

A timer is deactivated (no longer used by the Logical Unit, regardless of Enable / Disable setting provided from the host) when the logical unit is in the associated power state or a lower power state.

A timer is both reactivated (the logical unit shall use the timer if enabled) and reloaded when a logical unit transitions to power state higher than the associated timer.

Timers shall be reloaded, as specified in "Table 43 - Effects of Host Actions on Timers" on page 130, using the current timer value from the POWER CONDITION mode page.

Timers shall be disabled/enabled as specified in the POWER CONDITION mode page.

Timers shall be set to default conditions upon receiving a power-on, or hard reset. The default condition for the Timers shall be enabled with the values of the timers vendor specific.

P 5 Standby Timer

If the Standby Timer expires the logical unit shall attempt to flush all buffers.

If this operation fails, the logical unit shall remain in the current power state, and the Standby timer is reloaded. If the flush succeeds, the logical unit shall enter the Standby State.

Table P2 - State Transition, Events and Status

Initial State	Resultant State	Cause of Transition	Notification Class	Event
Active	Active	Unsuccessful Idle, Standby, or Sleep command	Power	PwrChg-Fail
	Idle	Successful completion of Idle command	Power	PwrChg-Succ
	Idle	The expiration of Idle timer	Power	PwrChg-Succ
	Standby	Successful completion of Standby command	Power	PwrChg-Succ
	Standby	The expiration of Standby timer, all Buffers are empty	Power	PwrChg-Succ
	Sleep	Successful completion of Sleep Command	Power	PwrChg-Succ
Idle	Idle	Successful completion of Idle command	Power	PwrChg-Succ
	Idle	Unsuccessful Idle, Standby, or Sleep command	Power	PwrChg-Fail
	Idle	Insertion of media and ready to use	Media	New Media
	Standby	The expiration of Standby timer, all buffers are empty	Power	PwrChg-Succ
	Standby	Successful completion of Standby command	Power	PwrChg-Succ
	Sleep	Successful completion of Sleep command	Power	PwrChg-Succ
	Active	Receptions of a command which reloads both timers	Power	PwrChg-Succ
Standby	Standby	Successful completion of Standby command	Power	PwrChg-Succ
	Standby	Unsuccessful Idle, Standby, or Sleep command	Power	PwrChg-Fail
	Standby	Insertion of media and ready to use	Media	NewMedia
	Idle	Successful completion of Idle command	Power	PwrChg-Succ
	Sleep	Successful completion of Sleep command	Power	PwrChg-Succ
	Active	Receptions of a command which reloads both timers	Power	PwrChg-Succ
Any	Standby	A power-on, or hard reset occurred, or the logical unit becomes NOT READY	Power	PwrChg-Succ
Sleep	Standby	Device Reset	Power	PwrChg-Succ

Table P3 - Effects of Initiator Commands on Timers

Initiator Command Issued	Timer Effects	Comments
BLANK	Reload Both	Recordables only
CHANGE DEFINITION	None	
CLOSE TRACK/RZONE	Reload Both	Recordables only
COMPARE	Reload Both	SCSI only
EXCUTE DRIVE DIAGNOSTIC	Reload Both	ATA command
FLUSH CACHE	Reload Both	
FORMAT UNIT	Reload Both	Recordables only
GET CONFIGURATION	None	
GET EVENT STATUS NOTIFICATION	None	
INQUIRY	None	
LOAD/UNLOAD C/DVD	Reload Both	
LOCK/UNLOCK CHACHE	None	SCSI only A Lock Cache command shall prevent the logical unit from entering Standby or Sleep states.
LOG SELECT/SENSE	None	SCSI only
MECHANISM STATUS	None	
MODE SELECT	May Reload Timers	A MODE SELECT commandthat changes the Standby or Idle timers shall reload the timer.
MODE SENSE	None	
PLAY AUDIO/MSF	Reload Both	
PLAY CD	Reload Both	
PREFETCH	Reload Both	SCSI only
PREVENT/ALLOW MEDIUM REMOVAL	Reload Standby	
READ (12)	Reload Both	
READ BUFFER	Reload Standby	
READ C/DVD CAPACITY	Reload Both	
READ CD	Reload Both	
READ CD MSF	Reload Both	
READ DISC INFORMATION	Reload Both	
READ DVD STRUCTURE	Reload Both	
READ FORMATABLE CAPACITIES	Reload Standby	
READ HEADER	Reload Both	
READ LONG	Reload Both	SCSI only
READ TRACK/RZONE INFORMATION	Reload Both	
READ SUB-CHANNEL	Reload Both	
READ TOC/PMA/ATIP	Reload Both	
REALEASE	None	SCSI only
REPAIR TRACK/RZONE	Reload Both	Sequential CD/DVD Recordable
REPORT KEY	Reload Both	
REPORT PERFORMANCE	Reload Both	May need to access media
REQUEST SENSE	None	
RESERVE	None	SCSI only
RESERVE TRACK/RZONE	Reload Both	Recordables only

Table P3 - Effects of Initiator Commands on Timers(continued)

Initiator Command Issued	Timer Effects	Comments
REZERO	Reload Both	SCSI only
SCAN	Reload Both	
SEEK	Reload Both	
SEND EVENT	Reload Both	May effect media access
SEND KEY	Reload Both	
SEND DVD STRUCTURE	Reload Both	Sequential DVD Recordable
SEND OPC INFORMATION	Reload Both	Recordables only
SET C/DVD SPEED	Reload Both	Obsolete
SET READ AHEAD	Reload Both	
SET STREAMING	Reload Both	
START/STOP UNIT	See Start Stop Unit Command	
TEST UNIT READY	Reload Both	
VERIFY	Reload Both	
WRITE	Reload Both	Recordables only
WRITE AND VERIFY	Reload Both	Recordables only
WRITE DVD STRUCTURE	Reload Both	Recordables only
Device Reset	Reload Both	Reset operation, the logical unit shall not return to default timer conditions.
Other Commands	Vendor Specific	

P 6 Power Management Status Reporting

The POWER STATUS field of the GESN (Power Management Class) event data shall always report the current Logical Unit power state. This provides a mechanism for the host to query the current power state, irrespective of state transitions.