

SEMI E167-1213

SPECIFICATION FOR EQUIPMENT ENERGY SAVING MODE COMMUNICATIONS (EESM)

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1 Purpose

1.1 The purpose of this Specification is to define messaging and behavior to facilitate a reduced rate of energy consumption in production equipment. A mechanism is provided for the factory system (host) to initiate (and terminate) an equipment energy saving mode.

2 Scope

2.1 This Standard defines message services and behavior between the host and production equipment to facilitate a reduced rate of energy consumption in the production equipment.

2.2 This Standard addresses:

- Definition of Equipment Energy Saving Mode Communications behavior in the form of a state model
- Specification of message services and content for the communication needed to manage Equipment Energy Saving Mode Communications

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This Specification applies only to equipment that provide a sleep mode as described in SEMI S23.

3.2 This Standard does not specify the amount of energy savings to be attained or how that energy savings is to be achieved. This approach gives the production equipment supplier the freedom to optimize the reduction in rate of energy use.

3.3 The specific protocol for messaging between production equipment and host and the detailed message structure is not included in this Specification.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI E30 — Generic Model for Communications and Control of Manufacturing Equipment (GEM)

SEMI S23 — Guide for Conservation of Energy, Utility and Materials Used by Semiconductor Manufacturing Equipment

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *EESM* — Equipment Energy Saving Mode Communications

5.2 *Definitions*

5.2.1 *collection event* — an event (or grouping of related events) on the equipment that is considered to be significant to the host. [SEMI E30]

5.2.2 *Equipment Energy Saving Mode Communications* — a capability that allows the host to manage a production equipment's entry and exit of sleep mode for the purpose of reduction of the rate of energy consumption.

5.2.3 *host* — the factory computer system or an intermediate system that represents the factory and the user to the equipment. [SEMI E87]

5.2.4 *idle mode* — the condition where the equipment is energized and readied for process mode (all systems ready and temperatures controlled) but is not actually performing any active function such as material movement or processing. [SEMI S23]

5.2.5 *process mode* — the condition where the equipment is energized and performing its intended function on target materials (such as implanting wafers, pumping gas, or inspecting photo-masks). [SEMI S23]

5.2.6 *production equipment* — equipment used to produce semiconductor devices, including wafer sorting, process, and metrology equipment, and excluding material handling equipment. [SEMI E157]

5.2.7 *sleep mode* — the condition where the equipment is energized but it is using less energy than in idle mode. The sleep mode is primarily differentiated from idle mode in that it is initiated by a specific single command signal provided to equipment, either from an equipment actuator, from an equipment electric interface, or a message received through factory control software (e.g., SECS). Other than the possible initiation of the sleep mode by an equipment actuator, entry into the sleep mode does not require manual actions. [SEMI S23]

6 Conventions

6.1 Requirements Identification

6.1.1 The following notation specifies the structure of requirement identifiers.

6.1.1.1 The following requirements prefix format is used at the beginning of requirement text. See Table 1 for the format notation of the requirements prefix.

- [Esss.ss-RQ-nnnnnn-nn]

6.1.1.2 To mark the end of the requirement text the following suffix format is used.

- [/RQ]

6.1.1.3 Requirements in the body text are highlighted with a border and light green background (may appear gray in black and white printouts)

[Esss.ss-RQ-nnnnnn-nn] Requirement text. [/RQ]

Table 1 Requirement Identifiers

<i>Format Notation</i>	<i>Purpose</i>
Esss.ss	SEMI Standards Specification identifier. Examples: E087.00, E087.01, E134.00.
RQ	Indicates this is a requirement identifier.
nnnnnn	Unique five-digit number within this Specification. 90000–99999 are reserved for use by SEMI.
.nn	Two-digit number that indicates version level of the requirement (.00 is used for the first version of a requirement).
/RQ	Indicates the end of a requirement.

6.1.2 Requirements in tables are delimited in one of two ways.

6.1.2.1 Where the requirement occupies an entire row in the table, the requirement ID is placed in column 1. No ‘[/RQ]’ is used to mark the end of the requirements text in this case. The table may also contain rows that are not requirements. In this case, the column 1 cell is left blank.

6.1.2.2 Nonrequirements text related to a requirements row may be included in an adjacent row. The relationship between the rows is indicated by a broken line separating the two.

6.1.2.3 Where the requirement occupies only one cell, the text in the cell includes the requirement ID prefix and suffix similar to requirements in the body text.

6.1.2.4 No cell in a table will contain both requirement and nonrequirement text.

6.1.2.5 Cells that contain requirements are shaded light green.

6.1.2.6 Table 2 provides an example of requirements in a table. Note that in this example, the same requirement is presented in two alternative formats. In practice, mixing the two approaches in the same table is not typically done.

Table 2 Example Table With Requirements

<i>RequirementID</i>	<i>Statement</i>	<i>Additional Detail</i>
Esss.ss-RQ-nnnnn-nn	The light shall be blue	There shall be no similar color in the light panel.
	The blue light is typically placed at the leftmost position in the light panel.	
	[Esss.ss-RQ-nnnnn-nn] The light shall be blue. There shall be no similar color in the light panel. [/RQ]	The blue light is typically placed at the leftmost position in the light panel.

6.1.3 Only text marked with the requirement identifier is a requirement of this Specification.

6.1.3.1 Clarification, examples, and related recommendations may be provided near a requirement, but are not part of the requirement.

6.1.3.2 Note that the word ‘should’ is used in some nonrequirements text, where it denotes a recommendation or a best practice, not a requirement.

6.1.4 Parent-child relationships of requirements are noted in the tables in Appendix 1. Where a parent requirement includes conditions or selection criteria, these are passed to their children. For example, if a parent requirement is stated to apply only to photolithography equipment, any child requirements also apply only to such equipment. The condition need not be restated for each child requirement.

6.1.5 The following is the top level parent requirement of all others in this Specification.

[E167.00-RQ-00001-00] Conformance to this Specification requires conformance to all other identified requirements in this Document as stated conditions apply. [/RQ]

6.2 State Model Methodology

6.2.1 This Document uses the Harel state chart convention for describing dynamic operation of defined objects. The outline of this convention is described in an attachment of SEMI E30. The official definition of this convention is described in “State Charts: A Visual Formalism for Complex Systems” written by David Harel in Science of Computer Programming 8, 1987.

6.2.2 The Harel convention does not have the concept of ‘creation’ and ‘extinction’ of state models for a temporary entity. In this Document, a filled, black circle denotes the entry to the state model (entity creation). If needed, a circle with a filled, black circle inside is used for expressing extinction of an entity.

6.2.3 Transition tables are provided in conjunction with the state diagrams to describe explicitly the nature of each state transition. A transition table contains columns for RequirementID, Transition number (#), Previous State, Trigger, New State, and Actions (see Table 3). The ‘trigger’ (column 4) for the transition occurs while in the ‘previous’ state. The ‘actions’ (column 5) includes a combination of:

1. Actions taken upon exit of the previous state.
2. Actions taken upon entry of the new state.
3. Actions taken which are most closely associated with the transition.

6.2.3.1 When reporting to the host, no differentiation is made between these cases.

Table 3 Example Transition Table

<i>Requirement ID</i>	<i>#</i>	<i>Previous State</i>	<i>Trigger</i>	<i>New State</i>	<i>Action(s)</i>

6.2.4 A state model consists of a state model diagram, state definitions, and a state transition table.

[E167.00-RQ-00002-00] All state transitions in this Standard, unless otherwise specified, shall correspond to collection events. [/RQ]

6.2.5 A state model represents the host's view of the equipment, and does not necessarily describe the internal equipment operation.

[E167.00-RQ-00003-00] All state model transitions shall be mapped into the appropriate internal equipment events that satisfy the requirements of those transitions. [/RQ]

6.2.6 In certain implementations, the equipment may enter a state and have already satisfied all of the conditions required by the state models for transition to another state. In that case, the next state transition may occur immediately.

6.3 Parameter Listings

6.3.1 Parameters that can be included with collection events corresponding to state model transitions are represented in table form using the format of Table 4. Table 5 explains the contents of each column in the example parameter table.

Table 4 Example Parameter Table

<i>Requirement ID</i>	<i>Data Parameter</i>	<i>Req</i>	<i>Description</i>	<i>Data Type</i>

Table 5 Parameter Table Columns

<i>Column</i>	<i>Description</i>
RequirementID	Requirement identifier defined according to § 6.1.
Data Parameter	Name of the parameter.
Req	Whether the parameter is required: Y – Required N – Not Required C – Conditional (required in specified circumstances)
Description	Explanation of the parameters contents. For data parameters, the description includes whether the parameter is transient.
Data Type	The format of the parameter's contents (integer, string, etc.).

6.3.2 A data parameter is noted as transient in the description column if its value is assured to be valid only on specified collection events. A nontransient parameter has a valid value at any time and can be reported with any collection event.

6.4 Service Message Representation

6.4.1 A message service definition table defines the specific set of message services for this Specification.

Table 6 Example Message Service Definition Table

<i>RequirementID</i>	<i>Message Service Name</i>	<i>Type</i>	<i>Description</i>
[E167.00-RQ-00xxx-00]	Message name	N or R	Purpose of the message service

6.4.1.1 Type can be either N = Notification or R = Request. Notification type message services are initiated by a service provider and the provider does not need to get a response from the service user or requester. Request message services ask for data or an activity from the provider. Each request message expects a specific response message to return data or confirm acceptance or completion of a command.

7 Implementation Overview

7.1 This section provides an overview of the Equipment Energy Saving Mode Communications (EESM) capability. This overview refers to requirements defined later in the Document. However, no statement in this overview section is intended to specify a requirement. The overview is intended to provide a general understanding of the EESM concepts so that the detailed requirements that follow can be more easily understood.

7.2 Basic Concepts

7.2.1 The Equipment Energy Saving Mode Communications capability provides the opportunity for the host and various production equipment to cooperate in the reduction of energy use in the factory.

7.2.2 The amount of energy consumed by a production equipment varies over time. It is likely to consume the most energy when processing material. However a significant amount of energy is still being consumed when the equipment is idle. This Specification addresses the situation when the production equipment is not processing material.

7.2.3 In a semiconductor factory, not all production equipment are in constant use. However, with no instructions to the contrary, production equipment must be ready for operation the instant that product appears on the load port. This constant readiness comes at the price of energy consumption. This Specification enables the factory to notify the production equipment that the next material for it to process will not appear for an estimated time period. This allows the production equipment to reduce the rate of energy usage during this time. The SEMI Guideline S23 calls this condition ‘sleep mode.’

7.2.4 It is assumed that idle equipment consume as little energy as possible while still maintaining the ability to respond immediately to a command to process new material. It is expected that further reduction of energy usage will come at the price of a time delay to achieve the lower rate of energy use and to recover from it.

7.2.4.1 Note that the user should also consider other potential negative effects from the use of sleep mode. For example, thermal cycling of some components may shorten their lifetime.

7.2.5 Communication of the required wakeup time is important to the process of managing sleep mode. If the host does not understand the time needed to wake up the equipment, then production delays could result when insufficient time is allowed for the wake up process. It is assumed that the estimate of the wakeup time will be a rough calculation of the longest wakeup time needed in normal operation (i.e., excluding error cases). It is understood that the actual wakeup time may vary significantly from the estimate.

7.2.5.1 Because of the complexity of some equipment’s energy saving schemes, there are a few cases where the equipment might not be able to provide a valid estimate of the time needed to wake up. This Specification allows for that possibility under certain conditions (see Table 12). However, it is discouraged due to the host’s need for an adequate wakeup time estimate.

7.2.5.2 In the case where production equipment does not provide estimated wakeup time, the implementer must document any situations where the equipment cannot estimate the wake up time and provide guidance to users for making their own estimate of wakeup time (see ¶ 9.3.4.2.4).

7.2.6 Figure 1 qualitatively illustrates the concepts addressed in this Specification. This diagram shows a scenario where the energy consumption rate is highest for processing, intermediate for idle, and lowest for sleep.

7.2.6.1 A ‘WakingUp’ period is included during which the production equipment moves from sleep mode to idle mode. Note that waking up may take significant time in some cases. The diagram also shows that energy consumption rate during the WakingUp period can be significantly higher than for idle mode. This suggests that the savings of a very short sleep time might not balance the extra energy used in waking up.

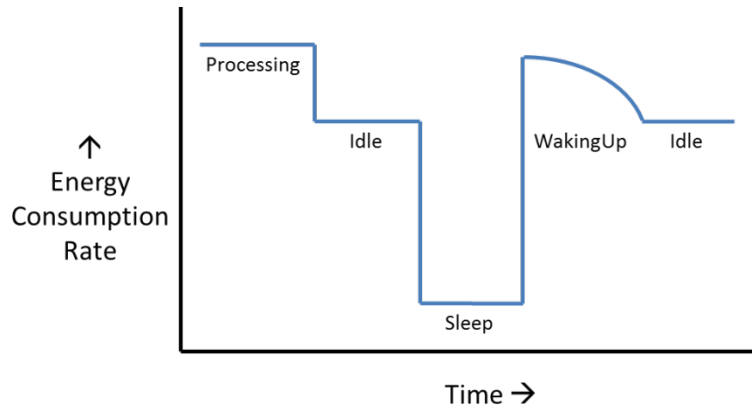


Figure 1
Relative Energy Consumption Rate At Different Equipment Operating States

7.2.6.2 It is the host's responsibility to determine the minimum practical sleep time, based on information from the equipment supplier. The equipment does not evaluate the potential savings when it receives a command to enter the sleep mode.

7.2.6.3 Figure 1 is not meant to be quantitatively accurate. Results will vary depending on the production equipment selected and on other factors.

7.3 Black Box Operation

7.3.1 This Specification standardizes communications related to sleep mode. It does not attempt to constrain the amount of energy savings or the methods used to achieve a reduction in the rate of energy consumption. This Specification allows the equipment supplier as much freedom as possible to optimize the implementation.

7.3.2 Each production equipment is different. The major components included with production equipment may vary even within the same make and model. Therefore, the EESM capability treats the equipment as a black box.

7.3.2.1 When a production equipment enters sleep mode, there is no mandated communication of which production equipment components are affected by sleep mode.

7.3.2.2 Only the overall state of the equipment is considered. For example, if one chamber of a multichamber production equipment is off-line for repair, but the remainder of the equipment is available for normal operation, then, when idle, that equipment can be placed in sleep mode.

7.4 Coordination of Remote and Local Commands

7.4.1 Some production equipment may provide the local user with the capability to control the equipment energy saving mode. This is particularly useful when an equipment is switched from remote to local control. A production equipment which is in sleep mode when switched to local control would be trapped in this condition if no user interface command is available to wake the equipment.

7.4.2 If local control of the equipment energy saving mode is provided, the implementer should consider potential conflicts.

7.4.3 This Specification defines the Equipment Energy Saving state model to track the EESM capability. This state model provides data collection events that allow the host to track changes initiated at the equipment.

7.4.4 It is possible for the state of the production equipment to change without the knowledge of the host. This may be due to either the host or the equipment being off-line. As long as the equipment control system is operational, it is responsible to continue updating the Equipment Energy Saving state, even when there are no communications.

7.4.4.1 There is a nontransient parameter named EnergySavingState that provides the current state from the Equipment Energy Saving state model. When communications are restored, the host can collect the value of this parameter to learn the current state. The host can then take the appropriate action, if any (e.g., wake up the equipment