

SEMI E175-1116

SPECIFICATION FOR SUBSYSTEM ENERGY SAVING MODE COMMUNICATION (SESMC)

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1 Purpose

1.1 The purpose of this Specification is to define communication between production equipment and the subsystem to enable energy saving mode (reduced energy consumption rate) operation by using sleep level transitions. A means to manage and communicate the subsystem status is provided for the production equipment to initiate (and terminate) subsystem energy saving mode operation in a coordinated manner.

2 Scope

2.1 This Specification defines communication and behavior between the production equipment and each subsystem to facilitate energy saving mode operation or sleep level management.

2.2 This Specification addresses:

- Definition of subsystem energy saving mode operation in the form of a state model.
- Communication to manage the subsystem's energy saving mode operation via sleep levels.

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 Safety interlocks are not part of this Specification.

3.2 This Specification applies to subsystems capable of transition to one or more energy saving modes or sleep levels on command for the purpose of energy reduction operation.

3.3 This Specification applies to only one-on-one connections between the production equipment and a subsystem. Multiple equipment connections to one subsystem are outside the scope of this Document.

3.4 This Specification does not define the amount of energy saving to be attained or how that energy saving is to be achieved.

3.5 The energy reduction rates based on sleep levels or the reporting of the supplier's subsystem defined energy savings are not specified in this Document.

3.6 The specific protocol for messaging between production equipment and the subsystem including the detailed message structure is not part in this Specification.

NOTE 1: Related Information sections are included in this Document to show examples of potential dry contact and EtherCAT protocol communication solutions. These proposed solutions need to be validated via implementation.

3.7 Additional state machines and internal controls between production equipment and the subsystems may exist and are beyond the scope of this Specification.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI E167 — Specification for Equipment Energy Saving Mode Communication (EESM)

SEMI S23 — Guide for Conservation of Energy, Utilities 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 *AMHS* — automated material handling system

5.1.2 *SESM* — subsystem energy saving mode

5.2 Definitions

5.2.1 *automated material handling system (AMHS) equipment* — a piece of equipment which has a carrier transfer robot that transfers carriers from and to passive equipment. It includes rail guided vehicles (RGV), automated guided vehicles (AGV) overhead hoist transports (OHT), overhead shuttles (OHS), and stockers. [SEMI E84]

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

5.2.3 *production equipment* — equipment used to produce semiconductor devices, including wafer sorting, process, and metrology equipment and excluding AMHS equipment.

NOTE 2: When reading SEMI S23 for the purpose of this Specification, ‘semiconductor manufacturing equipment’ or ‘equipment’ should be understood as ‘production equipment’.

5.2.4 *sleep level* — one of several possible functional conditions in which the production equipment or subsystem is in sleep mode. Different subsystem sleep levels will provide different equivalent energy consumption rates.

5.2.5 *subsystem* — a functionally related aggregate of components that is a part of a production equipment, that operates as a unit and is capable of performing one or more specific functions. A subsystem may be a constituent of another subsystem.

5.2.6 *subsystem idle mode* — the mode of operation where the subsystem is ready to transition into process mode without significant delay, this transition may be made with or without requiring any specific control command.

NOTE 3: It is possible that a subsystem has no idle mode.

5.2.7 *subsystem process mode* — the mode of operation where the subsystem is energized, and performing its intended function (such as abating gas, pumping gas, or controlling temperature).

5.2.8 *subsystem sleep mode* — the mode, entered by the subsystem in response to an external command, in which there will be a delay to return to ready but it is otherwise ready for processing. Average equivalent energy consumption rate in this mode is less than in subsystem ready mode.

5.2.9 *subsystem ready mode* — the mode, where the subsystem is supporting or ready to support its intended purpose.

6 Conventions

6.1 Requirements Identification

6.1.1 The following notation specifies the structure of requirement identifiers in numbered sections.

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.
Nnnnn	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 Non-requirements 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 non-requirement text.

6.1.2.5 Cells that contain requirements are shaded light green.

6.1.2.6 Table 2 provides an example of a requirement 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 The word ‘should’ is used in some non-requirements 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.

6.2 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 among 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.

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

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 data 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 non-transient 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>
[Esss.ss-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 Overview

7.1 This section provides an overview of the energy saving mode capability in subsystems controlled by the production equipment. 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 subsystem energy saving mode concepts so that the detailed requirements that follow can be more easily understood.

7.2 Basic Concepts

7.2.1 The subsystem energy saving mode capability provides the opportunity for the production equipment to manage the reduction of energy use by a subsystem and achieve different rates of energy consumption depending on the length of time the production equipment does not require the subsystem for production or a related task.

7.2.2 The amount of energy consumed by a subsystem varies over time depending on the process load and mode of operation. A subsystem is likely to consume the most energy when the production equipment is processing material. However, a significant amount of energy is still being consumed when the production equipment is not being used for processing material. This Specification addresses the opportunities for subsystem reduced energy operation, in particular when the production equipment is not currently in use and the factory has no plans to use the production equipment resources for an extended amount of time.

7.2.3 When SEMI E167 is used, the host will indicate to the production equipment how long it will not be needed for production. This allows the production equipment to reduce the rate of energy usage during this time. This Specification provides an opportunity for energy savings that the production equipment may gain by standardizing the request for reduced energy operation to its subsystems. This Specification does not specify how these savings are achieved but provides a method to coordinate such savings.

7.2.4 It is assumed that idle subsystems can consume less energy than during processing while still maintaining the ability to respond immediately to the production equipment when it is ready to process new material. It is expected that further reduction of energy consumption rates could come at the price of a time delay to recover from the lower energy use.

7.3 Energy Saving Mode Operation

7.3.1 This Specification standardizes communications related to subsystem's reduced energy mode operation. 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 production equipment and suppliers of subsystems as much leeway as possible to optimize the energy reduction implementation.

7.4 Subsystem Sleep Levels

7.4.1 A subsystem may provide more than one sleep level which could result in additional energy savings. While this Specification does not require the support of sleep levels, it does provide a mechanism for commanding the subsystem to a sleep level if the subsystem supports that concept.

7.4.2 Where multiple levels of sleep are supported by the subsystem, the production equipment requests the level of sleep to be used in each case. To aid the selection of sleep level, each manufacturer of the subsystem defines the estimated required time for waking up or return to be ready for processing. It is expected that such estimates are known when a sleep or wake up request is made by the equipment to the subsystem.

7.5 Energy Saving Mode Control and Communication

7.5.1 The requests or message services in this Specification are defined independently of the mechanism or protocol to be used. Additional specification of how these requests or message services and the related data are mapped to a specific signal or protocol is necessary in order to implement the subsystem energy conservation capability.

NOTE 4: Examples of such signals and protocol for control and communication using dry contacts or EtherCAT; see the Related Information sections.

7.6 Simple Usage Scenario

7.6.1 This Document provides a very simple base scenario for managing the subsystem reduced energy consumption operation. It begins when the production equipment is idle and determines based on a host request that no material will be processed for a given amount of time.

- The production equipment decides that one or more subsystems can provide energy consumption savings.
- The production equipment requests these subsystems to operate at reduced energy consumption rate (sleep level) based on the time the subsystem will not be required for production.
- Each subsystem accepts or rejects the production equipment sleep level request.
- Subsystem rate of energy consumption is reduced.
- Each subsystem that accepted the sleep request remains in sleep mode until commanded to wake up (assuming no fault occurs).
- Allowing enough lead time for the subsystem to wake up, the production equipment sends a wake up request to each subsystem that was commanded to sleep.
- Each subsystem begins the waking up process. When the subsystem reaches the SubsystemReady state as specified in § 9.3, it acknowledges to the production equipment that it is ready for process.

8 Prerequisites

8.1 The Subsystem Energy Saving Mode capability requires a communication protocol or signals to support exchange of requests or messages between production equipment and subsystem to manage the energy reduction.

NOTE 5: For examples of such communication protocol or signals using dry contacts or EtherCAT; see the Related Information sections of this Specification.

9 Requirements

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

[E175.00-RQ-00001-00] Conformance to this Specification requires conformance to all identified requirements in this Document as stated conditions apply. [/RQ]

9.2 The requirements for this Specification can be divided into two parts: behavior and message services. The behavior is specified in the form of a state model as specified in § 9.3. Message services are specified in § 9.4.

[E175.00-RQ-00002-00] The subsystem energy saving capability shall not affect the subsystem's ability to communicate. [/RQ]

9.3 Subsystem Energy Saving State Model

9.3.1 This state model specifies the generic subsystem behavior related to the subsystem energy saving mode capability. Figure 1 shows the diagram of the Subsystem Energy Saving State Model. The states are described in this section and the transitions are specified in Table 7. Some subsystems may use specific transitions that represent their state model behavior. The requirements in Table 7, Table 8 and in Appendix 1 define the implemented signals or events and the expected subsystem operational behavior.

[E175.00-RQ-00003-00] Each subsystem capable of energy savings mode shall implement the behavior of the Subsystem Energy Saving State Model according to the descriptions of its states, transitions, and associated signals or events. [/RQ]

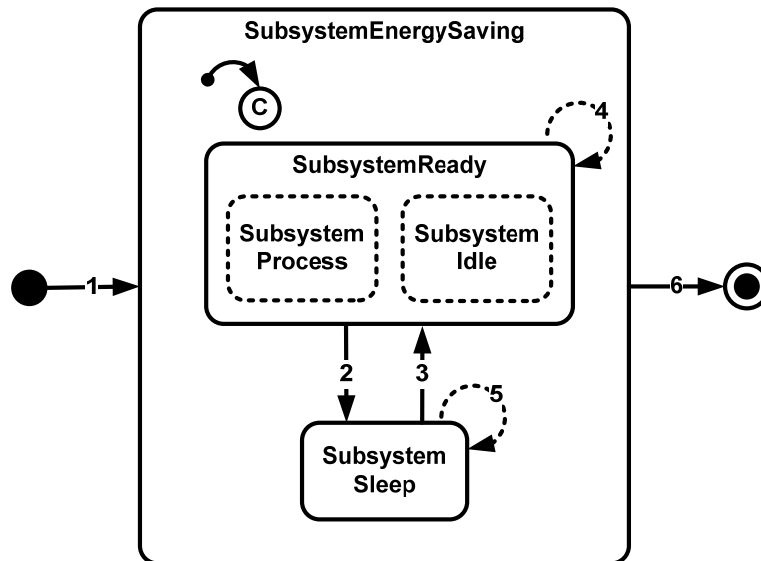


Figure 1
Subsystem Energy Saving State Model

9.3.1.1 NoState

9.3.1.1.1 The states of the Subsystem Energy Saving State Model, referred to as NoState, are represented in Figure 1 as a solid black dot and a ring with a solid black dot. NoState is not a true state. It is a pseudo state representing the time when the subsystem is initializing the state machine (solid black dot) or when it is exiting the state machine (ring with a solid black dot). The state model is not actively tracked when the subsystem control system is not operational (e.g., when the subsystem is powered down). This condition is referred to as 'NoState'. NoState is not a genuine state.

9.3.1.2 SubsystemEnergySaving State

9.3.1.2.1 The SubsystemEnergySaving state represents the time the subsystem is controlled by and can provide energy saving mode capability to the production equipment.

[E175.00-RQ-00004-00] The SubsystemEnergySaving state shall be in effect only when the subsystem's control system is operational. [/RQ]

9.3.1.2.2 The substates of the SubsystemEnergySaving state are SubsystemReady and SubsystemSleep.

9.3.1.3 SubsystemReady State

[E175.00-RQ-00005-00] The SubsystemReady state is a substate of SubsystemEnergySaving. [/RQ]