

SEMI E168.3-0915 (Reapproved 0923) SPECIFICATION FOR PRODUCT TIME MEASUREMENT FOR TRANSPORT

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1 Purpose

1.1 SEMI E168 defines the concepts for creating an analysis-ready set of time elements. The purpose of this Specification is to apply the concepts of SEMI E168 to define the standard product time measurement (PTM) method for product units in the domain of a transport system within a semiconductor automated material handling system (AMHS).

2 Scope

2.1 This Standard specifies the details needed to apply the PTM method to a semiconductor transport system that implements SEMI E82 and that utilizes discrete vehicles for the transport of carriers. It utilizes messages and data exchanged between the transport system controller (TSC) and the host.

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 is limited to the time substrates spend within the factory domain of a transport system.

3.2 The time elements specified in this Specification address transport systems with transport vehicles that can carry only one carrier at a time. Transport vehicles that can carry multiple carriers are not supported.

3.3 A primary objective of this Specification is to support analysis of time periods that are routine. Most error situations and infrequently occurring scenarios in the transport system are not addressed. However, these are not specifically excluded from the scope and could be added at a later time. Many such scenarios are specific to a particular implementation.

3.4 The lot identifier (LotID) and substrate identifier (SubstrateID) are not routinely available from semiconductor material handling systems. Analysis of PTM data may need to focus on the carrier identifier (CarrierID). Alternately, the LotID may be associated with the CarrierID using data from the factory information and control system (FICS) and/or production equipment.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E82 — Specification for Interbay/Intrabay AMHS SEM (IBSEM)

SEMI E151 — Guide for Understanding Data Quality

SEMI E168 — Specification for Product Time Measurement

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 MCS — material control system

5.1.2 TSC — transport system controller

5.2 Definitions

5.2.1 *carrier* — a container with one or more fixed positions at which material may be held. [SEMI E30.1]

5.2.2 *carrier location* — a location in the AMHS which may correspond to a physical location or a virtual location. [SEMI E153]

5.2.2.1 *Discussion* — In the context of this Specification, a carrier location holds a single carrier.

5.2.3 *collection event* — an event that may be used to initiate the collection and reporting of data. A collection event may trigger an event report. A collection event may also start or stop one or more trace reports. [SEMI E53]

5.2.4 *material* — a term used to refer to discrete objects used in or required by the manufacturing process and which may be transferred to and from equipment. This may include carriers, substrates, reticles, nonproduct wafers, etc.

5.2.5 *material control system (MCS)* — a supervisory control system that accepts commands from the FICS to transport material between locations within the factory and accomplishes the work by supervisory control and coordination of transport systems and stockers.

5.2.6 *overhead hoist transport (OHT)* — a rail-guided vehicle and hoist used to transport material above the factory floor over the heads of factory personnel. [SEMI E156]

5.2.7 *storage buffer* — a set of one or more locations for storing carriers in the transport system. [SEMI E82]

5.2.7.1 *Discussion* — A storage location is a type of carrier location.

5.2.8 *storage location* — a specific type of carrier location that is used for carrier storage. [SEMI E153]

5.2.8.1 *Discussion* — Stockers and storage buffers contain storage locations.

5.2.9 *transfer command* — a message from the host to the TSC requesting movement of material to a specified location within the scope of the transport system. An accepted transfer command results in the creation of an operation or job (also referred to as a ‘transfer’) that can be monitored using a provided identifier.

5.2.10 *transfer port* — point in the transport system at which a change of equipment ownership of the carrier occurs. Also refer to *internal transfer port*. [SEMI E82]

5.2.11 *transport system* — the component of AMHS that moves material from one part of the factory to another. [SEMI E88]

5.2.12 *transport system controller (TSC)* — interbay or intrabay transport system controller that communicates with the factory host and represents the system as the equipment. [SEMI E82]

5.2.12.1 *Discussion* — The host of a TSC can be an MCS.

5.2.13 *transport vehicle* — a component of a transport system that transports material between factory locations.

5.2.13.1 *Discussion* — In the context of this specification, a factory location refers to a carrier location that is accessible to a transport system or stocker supervised by an MCS.

6 Conventions

6.1 Conventions from the Primary Standard also apply to this Specification. There are no additional conventions.

7 Implementation Overview

7.1.1 This Subordinate Standard builds upon its Primary Standard. Review § 7 from SEMI E168 for an overview of its contents. To that basis is added the detail to support PTM from the viewpoint of the transport system.

7.1.2 Transport System Concepts

7.1.2.1 Transport systems are responsible for transferring carriers among carrier locations in the factory, which include production equipment, stockers, and storage buffer locations.

7.1.2.2 Figure 1 illustrates coordination of carrier transfer by the transport system.

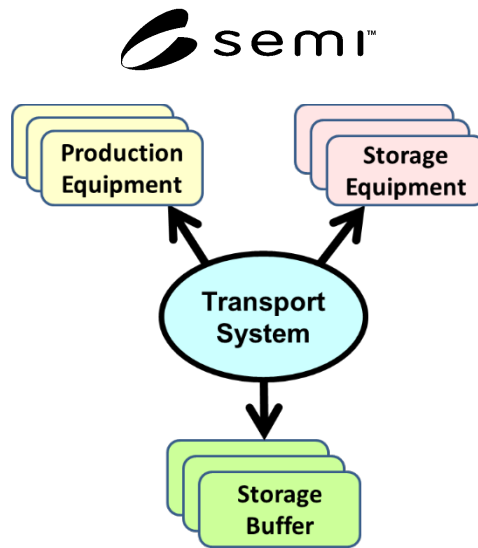


Figure 1
Illustration of Transport System Physical Connections

7.1.2.3 Transport systems may be of different types and employ various means of transport. Some transport system types include overhead hoist transport (OHT), automated guided transport (AGT), and direct WIP conveyor (DWC).

7.1.2.4 Communication from the host to the transport system for control purposes is specified by SEMI E82. The host side of the communications link can be an MCS. The role of an MCS is to coordinate activities of transport systems, stockers, and any other AMHS equipment that might exist.

7.1.2.5 Figure 2 illustrates the communication link between host and transport system.

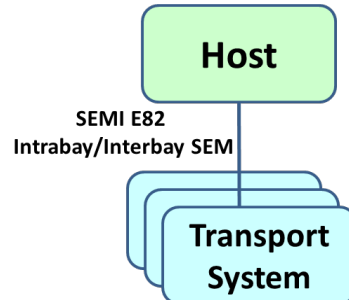


Figure 2
Transport System Communication

7.1.2.6 In this Specification, it is assumed that the transport system uses a vehicle of some type upon which the carrier is transported. For transport systems that do not use vehicles, the user of the PTM method will need to adjust the time elements accordingly. This might be done by identifying events that approximate the vehicle-related events used in Table 7 or by merging existing time elements separated by vehicle-related events. This adjustment is beyond the scope of this Specification.

7.1.2.7 Communication with TSCs is specified in SEMI E82.

7.1.2.8 A transport system may consist of various hardware resources. The only transport system resources visible from the PTM standpoint are the storage buffer locations, the vehicles, and the carrier locations on those vehicles. While the TCS will report on carrier handoff operations, some resources involved in those operations are not tracked. Events denoting the pathway for delivery are also not tracked except for cases where a carrier is transferred from one vehicle to another.

7.1.2.9 A transport system will also have access to external resources in the form of transfer ports. Production equipment and stockers have carrier locations that serve as transfer ports. While the transport system does not typically control these transfer ports, it normally has a means of coordinating carrier handoff with the owner of the related carrier locations. The transfer system does not have visibility to other carrier locations within production equipment or stockers.

7.1.2.10 SEMI E82 specifies state models for the following objects. Each state model has a number of transitions between states. Each transition may result in an event report.

- *Transport System Controller* — The TSC executes host commands to move carriers from one carrier location to another among its accessible locations.
- *Transfer Command* — A transfer command message from the host that results in the creation of an operation or job referred to as a ‘transfer command’.
- *Transport Vehicle* — A component of a transport system that transports carriers between factory locations. A transport vehicle is also referred to in this Specification simply as a ‘vehicle’.
- *Carrier* — A container that holds one or more product units.
- *Transfer Port* — A point in a transport system at which a change of ownership of the carrier occurs.

7.1.2.11 Note that once a carrier is delivered to a production equipment or stocker, that carrier can no longer be tracked by the transport system. The carrier will once again be tracked when the transport system is commanded to pick it up.

7.1.3 Events

7.1.3.1 Events based upon the SEMI E82 transfer command and transport vehicle state models are used in the definition of time elements in Table 7.

7.1.3.2 The events of interest available from the TSC are listed in Table A2-1 found in Appendix 2.

7.1.4 Carrier to Represent Product Units

7.1.4.1 A significant challenge of using transport system data for PTM is that it typically does not contain product identification (e.g., lot and substrate identifiers). Host commands to the TSC are keyed on the CarrierID. The transport system is focused upon moving carriers. The content of the carrier has no bearing on the function of the transport system.

7.1.4.2 A full analysis of transport system data requires a mapping of product identification (lot and substrate identifiers) to the carrier. This data is typically available within the FICS as well as in production equipment communication logs.

7.1.4.3 Data fields are provided in the PTMData output file format for inclusion of product identifiers. The means of populating the product identifier fields is not addressed in this Specification. It may not be possible to populate those data fields.

7.1.4.4 If the product identifier is not available, meaningful analysis of the PTM data is still possible for generic cases. For example, comparison of transport times from stocker A to production equipment B is valid, independent of the specific product units in the carrier.

7.1.4.5 However, analysis of product time for specific product units is severely limited if product identifiers are not available.

7.1.5 Lot-Level vs. Substrate-Level Data

7.1.5.1 The PTM method is designed to support analysis of carrier-based data. If LotID or SubstrateID values are available, it will also support analysis at either the lot-level or for individual substrates.

7.1.5.2 When the product units are under the control of the transport system, the substrates are grouped in carriers. Typically, a carrier contains exactly one lot. However, this may not always be true. It is possible for a lot to span multiple carriers or for multiple lots to be represented in a single carrier. This poses a challenge for lot-level data collection and analysis.

7.1.5.3 Another challenge for lot-level data collection and analysis is that the product units in a carrier might not be consistent from one process step to the next. Lots can be split and merged for various reasons.

7.1.5.4 In general, lot-level data collection is only viable for a limited span of process steps where the entire lot is in a carrier. Such a view does not work well beyond the point where a lot may be split or merged.

7.1.5.5 When the SubstrateID values are available, the user of the PTM method should consider using substrate-level data collection and analysis. This avoids the issue of how lots are aligned with carriers and whether they split or merge. A single substrate can be chosen as representative of the lot, or each wafer in the lot can be analyzed separately. The data set can span the entire lifecycle of the substrate if desired.

7.1.5.6 In the absence of product identification such as LotID or SubstrateID, analysis may need to proceed with the assumption that a carrier represents a single unidentified lot.

7.1.6 Carrier Reroute

7.1.6.1 A carrier is said to be rerouted when the original destination for a carrier is changed to an alternate destination. When a carrier is rerouted, the time for delivery of that carrier may vary widely from the typical duration. The PTM method allows for marking time elements associated with a transfer command that includes a reroute. This allows those message sequences to be separated and categorized differently from the others during analysis if so desired.

7.1.6.2 A carrier reroute may be initiated by an external system that needs the carrier to go elsewhere. It may also be initiated by the TSC because the original delivery cannot be made due to conditions in the factory (e.g., the destination port is occupied).

7.1.6.3 Carrier reroute is detected by the PTM method by means of an indicator event that occurs during the message sequence of a transfer command that includes a carrier reroute (refer to § 9.5.6). Each time element related to such a transfer command is marked in the Reroute field of the PTMData file (refer to Table 3).

7.1.6.4 There are a number of other problems that may occur during carrier delivery to extend carrier delivery (e.g., mechanical problems, traffic jams). The PTM method can help identify times when transport duration is longer than usual, but in some cases, the PTMData is not sufficient to support identification of the cause.

7.1.7 Time Elements

7.1.7.1 The time element definitions for transport systems are the same for lot-level as for substrate-level analysis. Since the substrate cannot leave the carrier except within production equipment (including sorters), all TSC events, and thus all of the related time elements, apply equally to all substrates in the carrier.

7.1.8 Transfer Command Queuing and Overlap

7.1.8.1 Some TSC implementations may allow transfer commands for a carrier to be accepted and queued when another transfer command is already executing. There may be cases where a queued transfer command begins execution before the previous transfer command has completed.

7.1.8.2 For example, the second transfer command may start a vehicle to a stocker for carrier pickup before the previous transfer command has completed delivery of the carrier to that stocker.

7.1.8.3 The design of the time elements provides for this type of overlap, should it occur.

7.1.8.4 Transfer command queuing and overlap are not required by this Specification.

8 Prerequisites

8.1 The basic prerequisite for this Subordinate Standard is conformance to the Primary Standard.

[E168.03-RQ-00002-00] Application of the PTM method to Host-TSC communication logs shall conform to the requirements in SEMI E168. [/RQ]

8.2 Communication Interface Support

[E168.03-RQ-00003-00] The transport system shall support an interface with the host conforming to the requirements of SEMI E82. [/RQ]

8.2.1 Details about the key SEMI E82 events are listed in Table A2-1 found in Appendix 2. Key SEMI E82 context data variables are listed in § 9.4.2.5.

[E168.03-RQ-00006-00] Host-TSC communication logs for the selected system shall be made available for processing by the PTM method. [/RQ]

8.2.2 Note that if the factory utilizes multiple transport systems, a carrier might be transferred by multiple such systems during its factory cycle time. When employing the PTM method, it may be necessary to include communication logs from multiple Host-TSC interfaces to ensure that all time elements during the selected time period for a given carrier are included in the output.

8.2.3 The mapping of LotID and SubstrateIDs to CarrierID will typically need to come from external sources within the FICS. The user of the PTM method is responsible for this mapping. Without the LotID information, application of this method might be valid only for time periods covering transport of the product unit among factory equipment where the product units cannot change carriers.

8.3 Data Quality

8.3.1 Important aspects of data quality are discussed in SEMI E168 and in SEMI E151.

8.3.2 A key part of data quality is synchronization of transport system clock(s) with the factory system time. The clock used by the TSC should be synchronized with a factory-selected time server using the Network Time Protocol (NTP) or an equivalently accurate method, if possible.

9 Requirements

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

[E168.03-RQ-00001-00] Conformance to this Specification requires conformance to all other identified requirements in this Specification as stated conditions apply. [/RQ]

9.2 This Specification applies the SEMI E168 PTM method to the transport system.

[E168.03-RQ-00007-00] The requirements in this Specification apply only to communications exchanged between the host and a TSC. [/RQ]

9.3 SEMI E168's requirements consist of two parts: dataset construction and time element definition. In this Specification, these topics are revisited with a focus on data and events present in communications between the host and a TSC.

9.4 Product Time Data Set Construction

9.4.1 Product Time Inputs

[E168.03-RQ-00008-00] In order to support PTM for transport systems, the data specified in Table 1 shall be provided. [/RQ]

Table 1 Data Required for PTM for Transport Systems

RequirementID	Required Data	Description
E168.03-RQ-00009-00	Communication Log	A record of the messages exchanged between host and TSC during the time period specified for analysis. This can be a message log recorded by the host or a log recorded by the TSC. Necessary context data shall be included in the event reports (refer to §§ 9.4.2.5 and 9.5.4). The format for this log is not specified.
E168.03-RQ-00010-00	Collection Event Documentation	A list of the collection event identifiers (CEIDs) supported by the TSC. The documentation for each event shall include the event identifier, the supplier name for the event, and a description of when and why the event occurs. Refer to Table A2-1 for a list of the TSC events used in this Specification.

<i>RequirementID</i>	<i>Required Data</i>	<i>Description</i>
E168.03-RQ-00011-00	Data Variable Documentation	A list of the variable identifiers (VIDs) supported by the TSC. The documentation for each data variable shall include the variable identifier, the supplier-assigned name for the variable, the format, the size, and a description of the content of the variable.
E168.03-RQ-00012-00	Event Configuration	A list of the event reports (RPTIDs) linked to each collection event (CEID), along with definitions for the event reports, including the identifiers of the variables (VIDs) to be included with each report. ^{#1}

^{#1} Note that the event reports for a SECS-II interface may be reconfigured at any time. This listing needs to pertain to the particular communication log under investigation.

9.4.1.1 *Host-TSC Communication Log*

9.4.1.1.1 SECS-II messages are structured as a set of nested lists. Each data item in the message is either a data value or a list designator with the length of the list included. Each item in a list may also be a data value or a list (nested list).

9.4.1.1.2 The communication log format for the Host-TSC interface is not specified. However, the content is addressed in the following two requirements.

[E168.03-RQ-00013-00] Communication logs shall contain all messages exchanged over the time period to be examined. [/RQ]

[E168.03-RQ-00014-00] Communication logs shall include the following for each message: a) an identification of the type of message (e.g., SECS stream and function), b) a timestamp associated with the message, and c) all data items from the original message, including the format and value of each data item. [/RQ]

9.4.1.2 *Collection Event Documentation*

9.4.1.2.1 In transport systems that support SEMI E82, all event data is communicated using collection events that trigger event reports. These are typically reported by the TSC using the S6F11 message.

9.4.1.2.2 Refer to Appendix 1, ¶ A2-1.1 for a list of the events from SEMI E82 that is used in this Specification.

9.4.1.3 *User Configuration*

9.4.1.3.1 SECS-II provides the capability to configure SECS-II event data collection. This is done in three stages. The first stage is the definition of event reports. Each event report is assigned an identifier (RPTID) and a list of variable identifiers (VIDs). The S2F33 message is used to request the definition of event reports.

9.4.1.3.2 The second stage of SECS-II event configuration is the linking of event reports to specific events. The S2F35 message is used to provide a list of collection event identifiers (CEIDs) and the reports (RPTIDs) to be attached to each.

9.4.1.3.3 The final stage of SECS-II event configuration is the enabling of each event to be reported. This is requested by the host using the S2F37 message.

[E168.03-RQ-00015-00] A list of all collection events enabled for the TSC (referenced by the CEIDs) shall be provided, including the reports attached to each (referenced by the RPTIDs). This list serves as input to the PTM process. [/RQ]

9.4.2 *Product Time Data Transformations*

9.4.2.1 This section builds upon the data transformation steps defined in SEMI E168. It adds SEMI E82 Standard-specific information and requirements.

9.4.2.2 *Step 1 — Communication Log Normalization* – no additional comment.

9.4.2.3 *Step 2 — Message Filtering*

[E168.03-RQ-00016-00] For communications between Host and TSC, the message filtering step shall retain the following messages when they appear in the communication log:

- S6F11 – Event Report Send
- S2F33 – Define Report
- S2F35 – Link Event Report
- S2F37 – Enable/Disable Event Report
- S2F41 – Host Command Send
- S2F42 – Host Command Acknowledge
- S2F49 – Enhanced Remote Command
- S2F50 – Enhanced Remote Command Acknowledge [/RQ]

9.4.2.4 Step 3 — Data Code Translation

9.4.2.4.1 The collection event documentation (RQ-00010), data variable documentation (RQ-00011), and user configuration (RQ-00012) serve as the inputs to the data code translation.

9.4.2.5 Step 4 — Context Data Population

9.4.2.5.1 Key context data variables include the following:

- *CarrierID* — The identifier of the carrier that holds the product unit(s). This is likely to appear in most TSC events and other messages.
- *CommandID* — The identifier of the command (i.e., job) that is currently associated with the carrier. This value corresponds to the JobID field in the PTMData.
- *CarrierLocationID* — The identifier of the current location of the carrier. This should consist of two parts: the identifier of the production equipment, stocker, or transport vehicle concatenated with the identifier of the specific location within that equipment, stocker, or vehicle.
- *SourceLocationID* — The location of the carrier at the start of the command.
- *DestinationLocationID* — The intended new location for the carrier as specified in the command.
- *VehicleID* — The identifier of the transport vehicle associated with the command. In some cases, the VehicleID is the same as the CarrierLocationID associated with the vehicle.
- *LotID and/or SubstrateID* — The identifier of the product unit or group of product units being transported. The identification of the product unit(s) is typically not available within the TSC or is not populated in the messages.

9.4.2.5.2 Naming of these context variables is not standardized because the variable names are not communicated. The variable names may vary from one implementation to another.

9.4.2.5.3 Selected messages provide links between certain key context data items. This includes the events listed in Table A2-1 as well as the various command messages and responses.

9.4.2.5.4 Timestamps need to be included with each message in the log (RQ-00014).

9.4.2.6 Step 5 — Time Segment Construction

[E168.03-RQ-00017-00] Time segment construction shall be done using the Level 4 time elements specified in § 9.5.3. [/RQ]

9.4.3 Dataset Output Format

9.4.3.1 SEMI E168 specifies the PTMData output file format. This Subordinate Standard adds detail to some PTMData fields defined in the Primary Standard (refer to Table 2) and adds new fields specific to the Host-TSC interface (refer to Table 3).

9.4.3.1.1 Unaffected fields are not included.

9.4.3.1.2 The field order, as specified in the Primary Standard, is not affected.