

SEMI A5-0722

SPECIFICATION FOR FACTORY OPERATION EXTENSION FOR SEMI A2 SMASH (SMASH-FOX)

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1 Purpose

1.1 The purpose of this Standard is to provide communication interface specifications that are used as extended specifications in conjunction with SEMI A2 for factory-level operations to be used mainly for factories that have multiple assembly lines with various equipment controlled by Local Hosts as required.

2 Scope

2.1 The scope of this Standard is to define communication interface specifications that support factory-level operations as an extension of SEMI A2. These include:

- System topology and communication paths settings
- Method to use SEMI A2 messages from upper tier control entities such as the Factory Host
- Additional messages to be used for factory-level managements

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 None.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI A1 — Specification for Production Equipment Smart Connection Interface (PESCI)

SEMI A1.1 — Specification for TCP/IP Interface for Production Equipment Smart Connection Interface (PESCI)

SEMI A2 — Specification for Surface Mount Assembler Smart Hookup (SMASH)

SEMI E10 — Specification for Definition and Measurement of Equipment Reliability, Availability, and Maintainability (RAM) and Utilization

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *E2E* — equipment-to-equipment

5.1.2 *GD* — General Data

5.1.3 *HC* — Horizontal Communication

5.1.4 *ID* — Identifier

5.1.5 *MD* — Material Data

5.1.6 *SMT* — surface mount technology

5.1.7 *TCP* — Transmission Control Protocol

5.1.8 *TCP/IP* — Transmission Control Protocol/Internet Protocol

5.1.9 *VC* — Vertical Communication

5.2 *Definitions*

5.2.1 *Data Handshake* — a handshake that transfers General Data. [SEMI A1]

5.2.2 *Factory Host* — the host that manages multiple assembly lines from the factory management perspective.

5.2.3 *General Data (GD)* — general-purpose data that is used for the communication between equipment or between the host and equipment. [SEMI A1]

5.2.4 *Horizontal Communication (HC)* — inter-equipment communication along with a physical flow line of work-in-process. Equipment here is equipment that handles work-in-process, such as process equipment, transfer equipment, metrology equipment, storage equipment, etc. [SEMI A1]

5.2.5 *host* — the factory computer system or an intermediate system that represents the factory and the user to the equipment. [SEMI A2]

5.2.6 *Line* — a connection between equipment or between the host and equipment. One Line may have multiple Tracks. [SEMI A1]

5.2.7 *Local Host* — the host that controls one or more assembly lines from production execution control perspective.

5.2.8 *Material* — a work-in-process that is transferred as one unit at a time. [SEMI A1]

5.2.9 *Material Data (MD)* — data that belongs to an individual Material and describes the Material. [SEMI A1]

5.2.10 *Node* — a communicational representation of the production line components such as the host or equipment. [SEMI A1]

5.2.11 *Panel* — a printed circuit board under production and assembly that may contain multiple products not cut out as products yet. [SEMI A2]

5.2.12 *Port* — a portion of equipment to send/receive a Material by Material Handshake. [SEMI A1]

5.2.13 *Receive Port* — a Port that has a function of receiving in a Material. [SEMI A1]

5.2.14 *Responder* — a communication role that responds to a General Data message. A response may be an internal action and/or a sending back of a General Data message. [SEMI A1]

5.2.15 *Route* — a logical path of Panels that have the commonality in production condition such as the same width of conveyor or the use of same assembly parts, etc. Multiple Routes may be set on the same Track. [SEMI A2]

5.2.16 *Segment* — a part of a production line that has a Flow Connection and controlled by one host. [SEMI A2]

5.2.17 *Send Port* — a Port that has a function of sending out a Material. [SEMI A1]

5.2.18 *Track* — a physical transfer path of Material in a Line. One Track has one Port at each end. [SEMI A1]

5.2.19 *user* — a human who represent the factory and enforce the factory operation model to the factory resources. A user is considered to be responsible for many setup and configuration activities that cause the equipment to best conform to factory operations practices. [SEMI A2]

5.2.20 *Vertical Communication (VC)* — communication between the host and equipment. [SEMI A1]

6 Conventions

6.1 *Definitions* — This Standard uses the following definitions.

6.1.1 *Data Type Definition* — This Standard uses the following data type definitions.

Table 1 Data Type Definition

<i>Data Type^{#1}</i>	<i>Definition^{#1}</i>
STRUCT	Structured data of Elements (parameters, STRUCTs, LISTs, or values), which is defined as below. STRUCT of: Element a Element b : Element n

<i>Data Type</i> ^{#1}	<i>Definition</i> ^{#1}
LIST	Listed data of multiple instances of single parameter, which is defined as below. LIST of: Number of the Parameter Instances (a parameter or a value) Parameter The actual structure of the LIST generated by the above definition is: n (= the number of the Parameter Instances) Parameter Instance (1) Parameter Instance (2) : Parameter Instance (n)
BOOL	1-bit Boolean: TRUE (Signal On) = 1, FALSE (Signal Off) = 0
BYTE	8-bit binary data
WORD	16-bit binary data
CHAR	Single-byte ASCII character
STRING	ASCII character string. Alphanumeric characters only. Fixed length. Unless otherwise specified, use from the lowest address byte and fill unused bytes with NULL.
UINT8	8-bit unsigned integer
UINT16	16-bit unsigned integer
UINT32	32-bit unsigned integer

#1 Note that these definitions are in sync with the items defined in SEMI A2.

6.1.2 *Value Expression* — This Standard uses the following value expressions.

- *Hexadecimal Format* — The 0x is used for numbers in hexadecimal format.
- *ASCII Character Format* — Direct character expression is used for characters in ASCII format. Alphanumeric characters only.

6.1.3 *Requirement Level Definition* — This Standard uses the following requirement levels in the ‘Rq.’ column of tables.

Table 2 Requirement Level Definition

<i>Mnemonic</i>	<i>Name</i>	<i>Implementation</i>	<i>Use</i>	<i>Description</i>
R	Required	Mandatory	Mandatory	An item that shall be implemented and used. For parameters, the item shall be implemented and given a valid value for use.
C	Conditional	Mandatory	Not a mandatory	An item that shall be implemented but may not be used in some cases. For parameters, the item shall be implemented but may not be given a valid value for use in some cases.
O	Optional	Not a mandatory	Not a mandatory	An item that may be implemented and used in some cases.

6.2 *Table Formats* — This Standard uses the following table formats.

6.2.1 *Parameter Definition Table* — This Standard uses the following table format for parameter definitions.

Table 3 Parameter Definition Table

<i>Parameter Name</i>	<i>Form/Type</i>	<i>Range/Multiplicity</i>	<i>Description</i>

- *Parameter Name* — This column defines the name of the parameter.
- *Form/Type* — This column defines the format or type of the parameter. Refer to the section ‘Data Type Definition’ for Type expressions.
- *Range/Multiplicity* — This column defines the range or multiplicity of the value for the parameter.
- *Description* — This column is used to describe the parameter.

6.2.2 *Message Category Definition Table* — This Standard uses the following table format for Message Category Definitions.

- *Message Category* — A group of messages that supports functions for similar purpose. A Message Category is specified by AC and CC.

Table 4 Message Category Definition Table

<i>Message Category</i>	<i>General Data ID</i>			<i>Description</i>
	<i>AC</i>	<i>CC</i>	<i>FC</i>	
			-	

6.2.2.1 *Message Category* — This column defines the name of the message category.

6.2.2.2 *General Data ID* — This column and sub-columns define the values to be used for General Data ID defined in SEMI A1. Refer to definitions in SEMI A1.

- *AC* — Application Code
- *CC* — Category Code
- *FC* — Function Code. Values are defined in the corresponding Message Description tables.

6.2.2.3 *Description* — This column is used to describe the message category.

6.2.3 *Message Thread Description Table* — This Standard uses the following table format for message thread descriptions.

Table 5 Message Thread Description Table

<i>Originator</i>		<i>Responder</i>			<i>Rq.</i>	<i>Description</i>
<i>Message</i>	<i>Nd.</i>	<i>Addressing ID</i>		<i>Message</i>		
<i>ORIG_RESP = 0</i>		<i>ORIG_ID</i>	<i>RESP_ID</i>	<i>ORIG_RESP = 1</i>		

6.2.3.1 *Originator, Responder* — These columns shows which side the following rows are mentioning on.

6.2.3.2 *Message* — These two Message columns define the messages used for the message thread.

- *ORIG_RESP* — ORIG_RESP =0 is the message from Originator and ORIG_RESP =1 is the message from the Responder. Refer to SEMI A1 for the definition of ORIG_RESP.

- *0x<ee>* — A representation of an even value of Function Code (FC) used for the suffix of the message name.

6.2.3.3 *Nd*. — This column defines the type of Node. F is the Factory Host; H is the Local Host; E is the equipment.

6.2.3.4 *Addressing ID* — This column and its subcolumns (ORIG_ID and RESP_ID) define the values to be used for the Addressing ID of the message thread. Refer to definitions in SEMI A1 for the definition of Addressing ID.

- *0x<gg>* — A representation of Group ID in hexadecimal. Normally, for intra-Group communication, 0x00 is used. Other values are used for the case inter-Group communication is required.

- *0x<ii>* — A representation of unique Intra-group ID of equipment in hexadecimal.

6.2.3.5 *Rq*. — This column defines the requirement level. Refer to the section ‘Requirement Level Definition’.

6.2.3.6 *Description* — This column is used to describe the message.

6.2.4 *Message Description Table* — This Standard uses the following table format for message descriptions.

- *Message Description* — A description of messages within the specified Message Category that assigns FC and provides the following explanations.

Table 6 Message Description Table

Message	General Data ID			Description
	AC	CC	FC	
	-			

6.2.4.1 *Message* — This column defines the name of the message.

- *0x<ee>* — A representation of an even value of Function Code (FC) used for the suffix of the message name.

6.2.4.2 *General Data ID* — This column and subcolumns define the values to be used for General Data ID defined in SEMI A1. Refer to definitions in SEMI A1.

- *AC* — Application Code. Actual value is not defined in this table but defined in the Message Category Definition table the category belongs.
- *CC* — Category Code. Actual value is not defined in this table but defined in the Message Category Definition table the category belongs.
- *FC* — Function Code. 0x<ee> is a representation of an even value.

6.2.4.3 *Description* — This column is used to describe the message.

6.2.5 *Message Parameter Definition Table* — This Standard uses the following table format to define the parameters used in a message.

- *Ordered List in GD_CONTENT* — Message parameters are put as an ordered list into GD_CONTENT defined in SEMI A1.

Table 7 Message Parameter Definition Table

<i>Parameter Name</i>	<i>Rq.</i>	<i>Description</i>

- *Parameter Name* — This column defines the name of the used parameter.
- *Rq.* — This column defines the requirement level. Refer to the section ‘Requirement Level Definition’.
- *Description* — This column is used to describe the message parameter.

7 Conceptual Description

7.1 *Conceptual Description* — This section describes the concept of this Standard and includes no requirements.

7.2 *Image of Typical SMT Factory* — The configuration of typical SMT factory to which this Standard is applied is as shown below. Multiple production lines are installed in parallel.

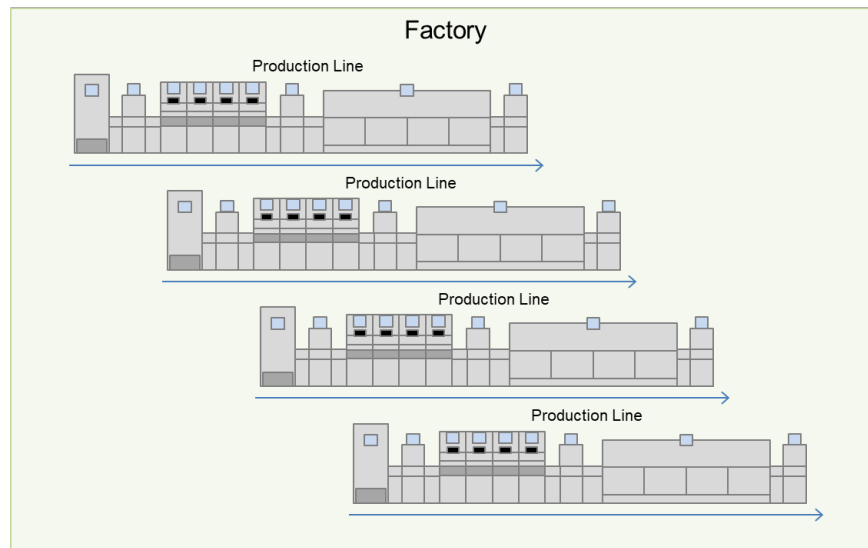


Figure 1
Image of Typical SMT Factory

7.3 *Coverage of this Standard* — This Standard covers the following aspects.

- *Support of Host Hierarchy Within Factory* — This Standard supports a hierarchical connection between Factory Host, Local Hosts, and equipment, especially a connection between the Factory Host and equipment via the Local Hosts, for hierarchical management of a factory.
- *Conformance with SEMI A2 Characteristics* — This Standard conforms and inherits SEMI A2 characteristics such as: Object-Oriented Panel and Panel Data transfer, equipment to equipment communication, Local Host to equipment communication, and programmable logic controller (PLC) conformance.
- *Single Communication Protocol SEMI A1* — For easier implementation, SEMI A2 and this Standard perform all communication with a single communication protocol SEMI A1. (between equipment and equipment, Local Host and equipment, Factory Hosts and equipment, and Factory Host and Local Host).
- *Use of SEMI A2 Messages from the Factory Host* — This Standard defines the method to use SEMI A2 messages from the Factory Host.

- *Definition of Additional Messages for Factory-level Operations* — This Standard defines additional messages for factory-level operation as an extension to SEMI A2.

7.4 *Prerequisites and Restrictions* — This Standard has the following prerequisites and restrictions.

- *Implementation of SEMI A1* — This Standard is designed to use SEMI A1 as the communication protocol. Normally, SEMI A1.1 is used to map SEMI A1 to TCP/IP.
- *Implementation of SEMI A2* — Normally, this Standard is used with the Local Hosts compliant with SEMI A2. In the case Local Hosts are not used, the Factory Host implements the required part of SEMI A2.

7.5 *Connection Topology* — This Standard supports the following connection topologies.

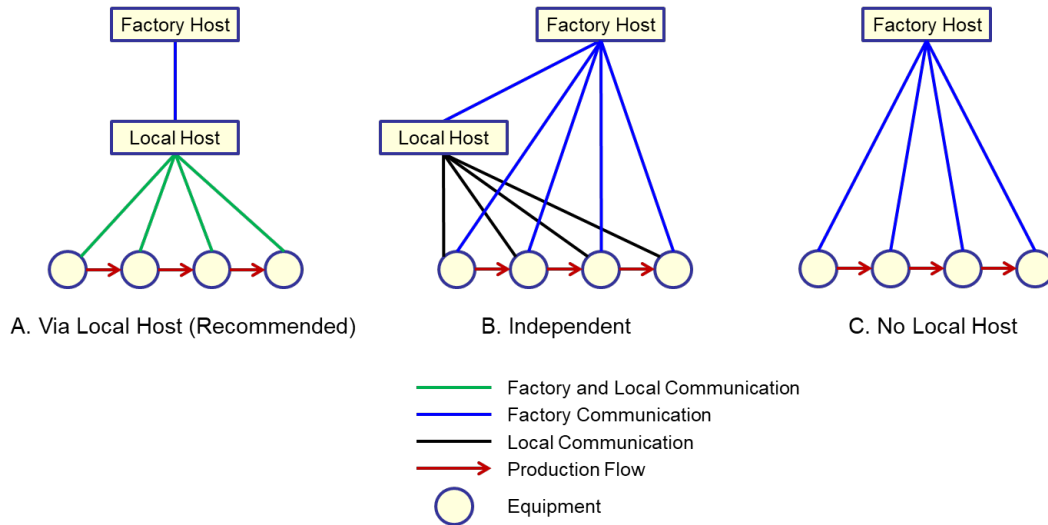


Figure 2
Connection Topology Types

Table 8 Connection Topology Types

<i>Topology</i>	<i>Via Local Host</i>	<i>Independent</i>	<i>No Local Host</i>	<i>Note</i>
<i>Item</i>				
Case	A 'Local Host compliant with SEMI A1 including message propagation' is used.	A 'Local Host compliant with SEMI A1 except message propagation' is used.	No 'Local Host compliant with SEMI A1' is used.	
Communication between the Factory Host and equipment	Through the Local Host.	Direct.	Direct.	
Workload of the Factory Host	Lower (Shared by Local Hosts)	Lower (Shared by Local Hosts)	Higher	
Optimization of each production line	Typically done by the Local Host	Typically done by the Local Host	Typically done by the Factory Host	
Real time control requirements of Factory Host	Lower (Done by Local Hosts)	Lower (Done by Local Hosts)	Higher	
Number of VC ports equipment need to maintain	1	2	1	

7.5.1 *Hierarchical Host Connection* — This Standard supports a hierarchical host connection as shown below.

- *A Local Host per a Segment* — A Local Host manages and controls the equipment and Panels in a Segment of the production line. Specifically, the Local Host starts a production of a Panel by preparing the Panel Data, communicating with the first equipment, and concludes the production of the Panel by gathering the Panel Data, communicating with the last equipment.

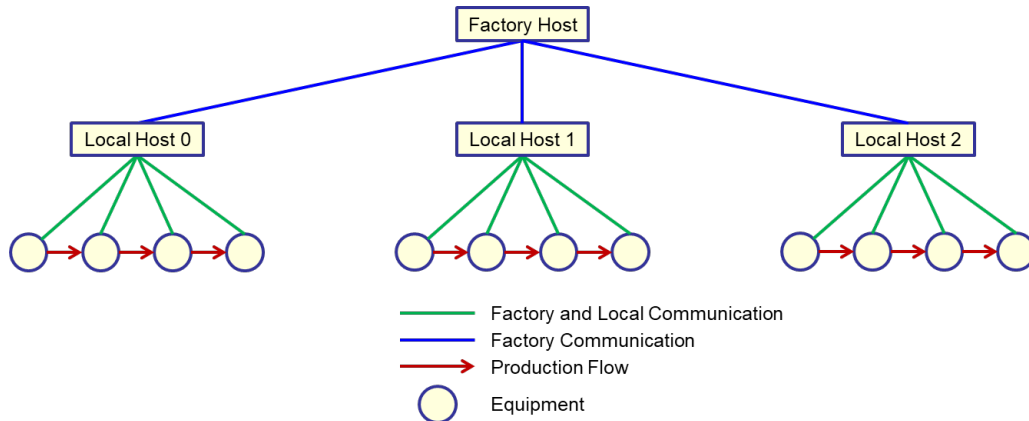


Figure 3
Hierarchical Host Connection Topology

7.5.2 *Horizontal Communication (HC) Conformance* — Normally, a SMT production line has some type of HC (E2E) interface between adjacent equipment to maintain Panel and Panel Data transfer. This Standard has the following relationship with HC interface.

- *HC as a Default* — This Standard is designed to be used with a HC interface. In the case no HC interface is used, additional messages are required to perform Panel and Panel Data transfer.
- *Type of HC Interface* — This Standard is designed to have the best conformance with the HC interface defined in SEMI A2.

7.5.3 *Supported Communication Paths* — This Standard supports the following communication paths.

- *Factory Host and Equipment* — A direct communication path between Factory Host and equipment.
- *Factory Host and Equipment via Local Host* — A communication path between Factory Host and equipment via a Local Host supported by SEMI A1's message propagation function.
- *Factory Host and a Local Host* — A direct communication path between Factory Host and a Local Host.
- *Equipment and Equipment via Local Host or Factory Host* — A communication path between equipment and equipment via a Local Host or Factory Host supported by SEMI A1's message propagation function.

7.6 *Position of this Standard in Communication Tier* — This Standard is in the upper tier of SEMI A1, SEMI A1.1, and SEMI A2 and provides the communication paths between:

- *Factory Host and Local Hosts* — Direct connection.
- *Factory Host and Equipment* — Via a Local Host or direct.

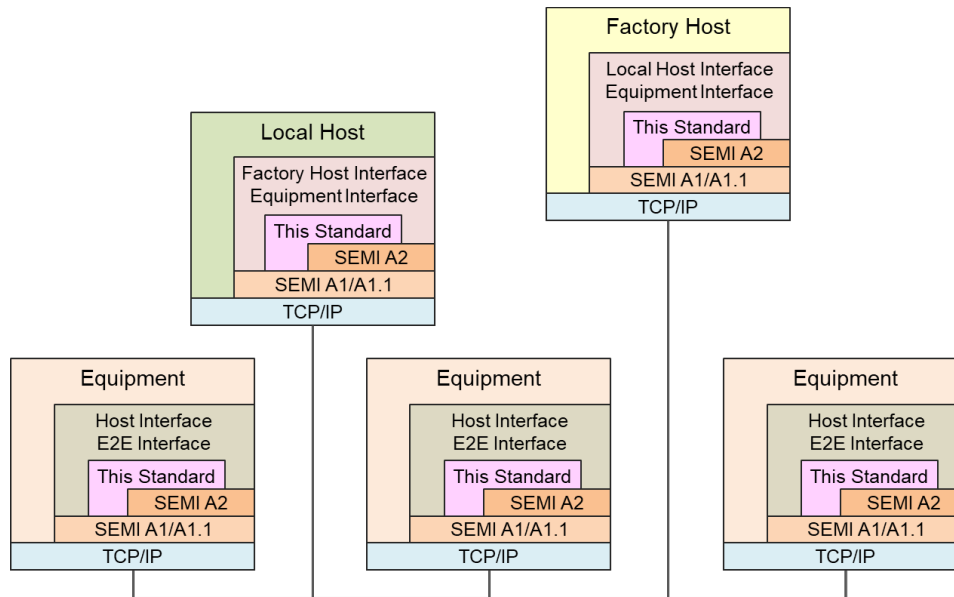


Figure 4
Position of this Standard

7.7 Management Operation Concept — This Standard covers the following management operation concepts to deal with the data for efficient factory management.

7.7.1 Equipment State Management Based on SEMI E10 — This Standard supports equipment state management to observe efficiency of equipment.

- **Adoption of SEMI E10 Equipment State Hierarchy** — This Standard adopts the equipment state hierarchy defined in SEMI E10.
- **Support of Messages for Equipment State Management Based on SEMI E10** — This Standard provides services and events to manage equipment states based on SEMI E10.

8 Network Connection Requirements

8.1 Type of Connection — SEMI A1.1 compliant network connection is used.

- **When Using SEMI A2 Compliant Local Hosts** — The network connection setup of the equipment under the Local Hosts is done by those Local Hosts. The Factory Host shall set up the network connections with those Local Hosts and share the Equipment IDs of those equipment.
- **When Not Using a SEMI A2 Compliant Local Host** — The network connections with the equipment the Factory Host need to control shall be done by the Factory Host per the definition in SEMI A2.

Table 9 Network Connection Setup per Connection Topology

Connection Topology	Via Local Host	Independent	No Local Host	Note
Items to be set up	A 'Local Host compliant with SEMI A1 including message propagation' is used.	A 'Local Host compliant with SEMI A1 except message propagation' is used.	No 'Local Host compliant with SEMI A1' is used.	
Vertical Connection				
Factory Host to Equipment Connection	➤ Factory Host shall establish and manage a connection with equipment indirectly, via the Factory Host to Local Host connection per this Standard. ➤ Local Host shall provide message propagation between the Factory Host to the Local Host connection and the Local Host to equipment connection per SEMI A1. ➤ Equipment shall respond per this Standard.	➤ Factory Host shall establish and manage a direct connection with equipment per SEMI A2. ➤ Equipment shall respond per SEMI A2 in addition to the connection with the Local Host.	➤ Factory Host shall establish and manage a direct connection with equipment per SEMI A2. ➤ Equipment shall manage a connection with the Factory Host per SEMI A2.	
Factory Host to Local Host Connection	➤ Factory Host shall establish and manage the connection per this Standard. ➤ Local Host shall respond per this Standard.	➤ Factory Host shall establish and manage the connection per this Standard. ➤ Local Host shall respond per this Standard.	Not applicable	
Local Host to Equipment Connection	➤ Local Host shall establish and manage the connection per SEMI A2. ➤ Equipment shall respond per SEMI A2.	➤ Local Host shall establish and manage the connection per SEMI A2. ➤ Equipment shall respond per SEMI A2.	Not applicable	
Horizontal Connection	➤ Shall be established and managed among the Local Host and multiple equipment in the Segment per SEMI A2.	➤ Shall be established and managed among the Local Host and multiple equipment in the Segment per SEMI A2.	➤ Shall be established and managed among the Factor Host and multiple equipment in the Segment per SEMI A2.	

9 Parameter Definitions

9.1 *Endian* — The same endian as SEMI A1 and SEMI A1.1 shall be used.

9.2 *Parameter Definitions* — This section defines the parameters used in this Standard.

9.2.1 *SEMI A1 Defined Parameters* — The following parameters are defined in SEMI A1 and explanations are included here for convenience. Refer to SEMI A1 for the latest definitions.

- *NODE_ID* — Node ID.
- *TIME_STAMP* — Time stamp.

9.2.2 *SEMI A2 Defined Parameters* — The following parameters are defined in SEMI A2 and explanations are included here for convenience. Refer to SEMI A2 for the latest definitions.