SEMI SMT-ELS Standards Suite
- Surface Mount Technology – Equipment Link Standards -

As of Feb. 12, 2019

Flow Manufacturing Forum / Automation Technology Committee, SEMI
Homepage: http://www1.semi.org/jp/SEMI_SMT-ELS
This document introduces the concept and functions of

**SEMI SMT-ELS Standards suite**

that makes SMT assembly line smarter

Please visit [http://www1.semi.org/jp/SEMI_SMT-ELS](http://www1.semi.org/jp/SEMI_SMT-ELS) for up-to-date information
Demonstrations

• Demonstrations Done
  • JISSO PROTEC  Tokyo  June 2019
  • NEPCON ASIA  Shenzhen  August 2019
  • Productronica  München  November 2019
  • APEX  San Diego  February 2020

• Watch the demo videos on: http://www1.semi.org/jp/SEMI_SMT-ELS

JISSO PROTEC / Tokyo  June 2019
NEPCON ASIA / Shenzhen  August 2019
Productronica / München  November 2019
Introduction of SEMI SMT-ELS

Motivation and Overview of SEMI SMT-ELS
What is SEMI SMT-ELS?

• SEMI SMT-ELS (Equipment Link Standards)
  • The Standards suite to make SMT assembly line smarter
  • Replacement of SMEMA
  • Addition of data communication capabilities
    • Host interface including tiered host capability
    • Equipment and equipment data communication

• SEMI Standards:
  • Global Standards that have been supporting semiconductor manufacturing lines and related factories
Introduction of SEMI SMT-ELS

Purpose of SEMI SMT-ELS

• Provide the smart automation scheme of assembly line for IoT era
  • Combination of Vertical Management and Horizontal Control
  • Replacement of SMEMA and addition of data communication capability
  • Object Oriented Panel and Panel data handling/tracking
    • Panel ID, Product ID, Inspected Data, etc.
    • Functional extendibility over decades

• Provide highly interoperable equipment interface supported by global standard for:
  • Flexible mix-and-match of equipment from various suppliers
  • Quick ramp up of assembly line
  • Cost suppressions such as:
    • Use of SMEMA generation equipment with minimal modification
    • Conformance with low end PLCs
    • Use of the same protocol for both Vertical and Horizontal communications
SEMI SMT-ELS System

- Single protocol supports communications between:
  - Factory Host - Local Host/Equipment
  - Local Host - Equipment
  - Equipment – Equipment
  - Equipment - Equipment

Multiple line management (TBD)
Single line control
Equipment cooperation
Panel and Panel Data transfer

Proposed System Structure
SEMI SMT-ELS Standards Suite and Freeze Version

- SEMI SMT-ELS Standards suite consists of the following SEMI Standards

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<th>Tier</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMT Applications</td>
<td>Host / Equipment applications</td>
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<tr>
<td></td>
<td>Host – Equipment communication control</td>
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<tr>
<td></td>
<td>Equipment – Equipment communication control</td>
</tr>
<tr>
<td>SEMI A2 SMASH</td>
<td>Message and behavior for SMT assembly line</td>
</tr>
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<td>SEMI A1 PESCI</td>
<td>General-purpose equipment connection interface</td>
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<td>SEMI A1.1 TCP/IP Interface for PESCI</td>
<td>TCP/IP Interface for SEMI A1 PESCI</td>
</tr>
<tr>
<td>TCP/IP</td>
<td>TCP/IP Interface</td>
</tr>
</tbody>
</table>

- Freeze Version Management
  - For interoperability, a guide that specifies the combination of the versions of above Standards is required
  - SEMI SMT-ELS Freeze Version 0 is available now
    - SEMI A2-1019  Specification for Surface Mount Assembler Smart Hookup (SMASH)
    - SEMI A1-1019  Specification for Production Equipment Smart Connection Interface (PESCI)
    - SEMI A1.1-1019 Specification for TCP/IP Interface for Production Equipment Smart Connection Interface (PESCI)
  - Please contact SEMI staff to purchase the above documents
SMEMA Equipment Conformance

Use of SMEMA Generation Equipment in SEMI SMT-ELS Line
SMEMA Equipment Conformance

Compatibility with SMEMA Equipment

- A SMEMA equipment can be used as a SEMI SMT-ELS equipment by adding Virtual SMASH Controller on the top
  - With minimal modification to perform equipment control such as conveyor width change via Proprietary Interface
Concept of SEMI A1 PESCI

The General-Purpose Equipment Interface that SEMI SMT-ELS Uses
Concept of SEMI A1 PESCI

What is SEMI A1 PESCI?

• A general-purpose Production Equipment Smart Connection Interface

• General-purpose Data communication channel (GD)
  • Tiered Host connection
    • Equipment Group ➔ Local Host ➔ Upper Tier Host
  • Various addressing modes
    • Equipment to equipment, equipment to the local host, equipment to upper tier host, inter host
  • Message definitions are open to upper tier Standard per application area

• Up to ten Material and Material Data transfer channels (Tracks)
  • Object Oriented simultaneous transfer of Material and its Material Data
    • Material Data definition is open to the upper tier Standard per application area
  • Compatible with various transfer means such as conveyors, AGVs, robots
  • Support Uni-direction, Alternate-direction, and Bi-direction transfer operation

• For the up-to-date information, visit:
  • http://www1.semi.org/jp/SEMI_A1_PESCI
Concept of SEMI A1 PESCI

Orthogonal “Line Management” and “Execution Control”

Production Line Management in Vertical and Production Execution Control in Horizontal

- **Production Line Management:**
  - Through Host-equipment communication (Point to Point)
  - Equipment settings and observations
  - Material tracking

- **Production Execution Control:**
  - By equipment-equipment communication (Daisy chain)
  - Autonomous Production Execution:
    - By equipment-equipment collaboration
    - Through General Data communication
  - Object Oriented Material and Material Data transfer
    - Simultaneous handoff of Material and Material Data
    - Direct reference of attached Material Data
    - Exception handlings of handoff (Pause – Recovery)

Production Line Management

Set, Trace, and Log by the Host

Autonomous Production Execution by Equipment

Production Execution Control

Object Oriented “Material and Material Data” Transfer

Industry Network free PLC conformance
Segment and Tiered Host Operation Capability

- Tiered Host operation
- Localization of equipment dependent detail control in a Segment
- Easy to change per Segment
Application of SEMI A1 PESCI

- Host and Equipment connection (point to point) for:
  - Equipment management
  - WIP tracing
- Equipment and Equipment connection (daisy chain) for:
  - Generic communication between equipment via the adjacent equipment
  - Simultaneous handoff of Material and its Material Data
Definition Overview of SEMI A1/1.1

• SEMI A1 defines communication channels for equipment
  • **Material and Material Data (MD)** (Material Handshake)
    • Performs simultaneous handoff of Material and its Data
  • **General Data (GD)** (Data Handshake)
    • Performs generic data communication
    • Both for host-equipment and equipment-equipment communications
  • Simple “Memory Image Exchange” type of messaging
    • Better conformance even with low-end PLC

• SEMI A1.1 defines TCP/IP interface for SEMI A1
  • TCP/IP interface for both MD and GD Handshakes
  • “Memory Image Exchange” messaging scheme
    • for better conformance with low cost control components such as PLC
  • Direct mapping on TCP/IP
    • for higher compatibility among various control components
Concept of SEMI A1 PESCI

Connectivity and Interoperability

- Connections for production line (SEMI A1)
  - General Data between the host and equipment (Data Handshake)
  - General Data between adjacent equipment (Data Handshake)
  - Material and Material Data handoff between equipment (Material Handshake)

- Communication Protocol for SEMI A1 (SEMI A1.1)
  - Direct mapping on TCP/IP
    - Connectivity between PLCs based on different Fieldbus
      (Intra equipment communication may be done by own Fieldbus)

- PLC conformance (SEMI A1/1.1)
  - Messaging to exchange Memory Mapped Data
**Concept of SEMI A1 PESCI**

**Equipment Model of SEMI A1 PESCI**

- **Production Line Management in Vertical**
  - Preset of Recipe, Route, etc.
  - Start Event
  - Line Management by the Host
    - Equipment setting, watch, log
    - Material Data creation, trace, log
    - Information aggregation to the host
  - Exception Handling
  - Completion Event Log (for analysis)

- **Production Execution Control in Horizontal (Multiple Tracks)**
  - Inter-Equipment Collaboration
  - Material Data + Material
  - Inter-Equipment Communication
    - Autonomous coordination along with the line
    - Reduction of Host load/cost
  - Simultaneous handoff of Material and Material Data
    - Instance ID, Product ID, Log
    - Material require equipment to process according to the Material Data
    - Object Oriented

- **Autonomous Execution by Equipment**
  - Refer Material Data and follow to the preset recipes
  - Reduction of load and cost of the host

- **Standardized communication specification**
  - Direct use of TCP/IP
  - Memory Block transfer for PLC conformance
  - Connectivity, quick launch

VC: Vertical Communication
HC: Horizontal Communication
SEMI A1 supports various Addressing Modes for Vertical Communication
General Data Communication (Horizontal)

SEMI A1 supports various Addressing Modes for Horizontal Communication

- Autonomous Process Execution and Line Management by Equipment Chain
- Full Duplex
- Broadcasting
- Thread Management
- Interleaving Management
Concept of SEMI A1 PESCI

Material and Material Data Transfer

SEMI A1 supports simultaneous handoff of Material and Material Data
Multiple Tracks are controlled independently

➢ Object Oriented way
➢ Material carries its characteristics as Material Data
➢ Equipment refers Material Data and executes prespecified operation
Typical Example of Material Data (MD)

- **Material Data** is an identification tag of the WIP

- Consists of the following three sections
  - **Instance ID**: Identifier of the individual material
  - **Class ID**: Identifier of the product class, the material belongs to
  - **Log**: Result record at each equipment
    - Applied parameters or measured results (value or classification)
    - To be used as process log
    - May also be used for notifications for process/route changes to the equipment after

<table>
<thead>
<tr>
<th>Field</th>
<th>Mnemonic</th>
<th>Definition</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instance ID</td>
<td>Material ID</td>
<td>Identifier of this individual material</td>
<td>To be used to identify this individual material</td>
</tr>
<tr>
<td>Class ID</td>
<td>Product ID</td>
<td>Identifier of Product this material to be</td>
<td>To be used to select recipe or route</td>
</tr>
<tr>
<td></td>
<td>Version ID</td>
<td>Identifier of Version of the product</td>
<td>May be used for modification of recipe or route</td>
</tr>
<tr>
<td>Log</td>
<td>Result E0</td>
<td>Result record at equipment 0</td>
<td>Control of process or branch in the equipment after</td>
</tr>
<tr>
<td></td>
<td>Result E1</td>
<td>Result record at equipment 1</td>
<td></td>
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<tr>
<td></td>
<td>Result E2</td>
<td>Result record at equipment 2</td>
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<tr>
<td></td>
<td>Result En</td>
<td>Result record at equipment n</td>
<td></td>
</tr>
</tbody>
</table>
"Line" a Connection between Equipment

One “Line” Consists of

➢ One Line Information channel
➢ Up to ten Track Information channels

• Line Information
  • Full duplex data channel
  • For “General Data”
  • By “Data Handshake”

• Track Information 1 .. n
  • n tracks of half duplex transportation channels
  • For “Material and Material Data”
  • By “Material Handshake”
**Concept of SEMI A1 PESCI**

**Track Types**

- **Three Track Types**
  - **Uni-Direction**
    - Material flows to one direction
  - **Alternate-Direction**
    - Material flows both directions alternatively
  - **Bi-Direction**
    - Materials are swapped in one cycle

- **Multiple Tracks per one Line**

<table>
<thead>
<tr>
<th>Single set</th>
<th>Multiple set</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Uni-Direction”</strong>&lt;br&gt;Equipment A</td>
<td>S R&lt;br&gt;</td>
</tr>
<tr>
<td>Equipment B</td>
<td>A(S/R) A(S/R)&lt;br&gt;</td>
</tr>
<tr>
<td><strong>“Alternate-Direction”</strong>&lt;br&gt;Equipment A</td>
<td>A(S/R) A(S/R)&lt;br&gt;</td>
</tr>
<tr>
<td>Equipment B</td>
<td>X(S+R) X(S+R)&lt;br&gt;</td>
</tr>
<tr>
<td><strong>“Bi-Direction”</strong>&lt;br&gt;Equipment A</td>
<td>X(S+R) X(S+R)&lt;br&gt;</td>
</tr>
<tr>
<td>Equipment B</td>
<td>X(S+R) X(S+R)&lt;br&gt;</td>
</tr>
</tbody>
</table>

• Supports line topology that includes:
  • Branch
  • Merge
  • Loop
  • Turn back
Handoff Function

• Handoff Step function
  • Compatible with handoff mechanisms that require multiple handoff steps
  • Conveyor, Robot, Isolation doors, etc.

• Operator assistance and recovery
  • Pause – Recovery functions
    • Operator or equipment initiated upon handoff exception
    • Restart, Resume, Forward, Abort can be selected for recovery
Concept of SEMI A1 PESCI

Pizza Factory Analogy of SEMI A1 Application

General Data: Work Order Setting and Log by the Host

Material Data:
➢ My name is #132
➢ I am going to be Pizza Type A
➢ 13:20.15 Started

Work Order:
➢ If Type A comes, I make it t=5mm
➢ If Type B comes, I make it t=4mm

13:20.45 12in. t=5mm @E1
13:21.30 Cheese and tomatoes are put @E2
13:24.55 3 minutes @E3

General Data:
Hey, getting thick! 😝
Ok, I adjust!

Work Order:
➢ If Type A comes, I bake it for 3 minutes
➢ If Type B comes, I bake it for 2 minutes

Work Order:
➢ If Type A comes, I put cheese and tomatoes
➢ If Type B comes, I put four different cheeses

General Data:
I’m getting sick 😞
Ok, I halt.

Material Data:
➢ My name is #132
➢ I am going to be Pizza Type A
➢ 13:20.15 Started
➢ 13:20.45 12in. t=5mm @E1
➢ 13:21.30 Cheese and tomatoes are put @E2

Manufacturing Management:
➢ I am the host.
➢ I preset all work orders to my workers.
➢ I start material and take all working log.

General Data:
Hey, getting thick! 😝
Ok, I adjust!

General Data:
I’m getting sick 😞
Ok, I halt.

General Data:
Hey, getting thick! 😝
Ok, I adjust!

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 General Data: Autonomous Process Execution and Line Management by Equipment Chain

Material Data: Object Oriented “Material and Material Data” Transfer throughout Equipment Chain

Material Data: Autonomous Process Execution and Line Management by Equipment Chain

Material Data: Object Oriented “Material and Material Data” Transfer throughout Equipment Chain
Functions of SEMI SMT-ELS
Currently Available Functions of SEMI SMT-ELS
Functions of SEMI SMT-ELS

Position of SEMI SMT-ELS Standards Suite

• SEMI SMT-ELS Standard Suite supports both:
  • Host – equipment (Vertical) communication  Point to point
  • Equipment – equipment (Horizontal) communication  Daisy chain

• SEMI SMT-ELS Standard Suite has the following tier structure
  • SEMI A2 SMASH  Messages and behaviors for SMT assembly line
  • SEMI A1 PESCI  General-purpose equipment connection interface
  • SEMI A1.1 TCP/IP Interface for PESCI  TCP/IP Interface for SEMI A1 PESCI
Functions of SEMI SMT-ELS

Functions Currently SEMI SMT-ELS Provides

• Equipment management by the host
  • Inter-equipment network setting (can also be done manually)
  • Route setting of Panel (can also be done manually)

• Equipment to equipment communication/cooperation
  • Panel Data reference mode setting
  • Immediate product change

• Simultaneous transfer of Panel and Panel Data
  • On-demand product change by Panel attached Panel Data
  • Traceability of a Panel
  • Handoff functions by using conveyor
    • Handoff Step function which executes multiple step handoff
    • Pause – Recovery function for exception handling

• Preconditions
  • SMEMA equipment conformance with Virtual SMASH Controller
  • PLC conformance (not only for PC level controller)
Inter-equipment Network Setting/Checking

SetNetConfig message from the host sets IP Address and Port Number to be used for equipment-equipment communication (Can also be set manually)

Inter-equipment communication is opened by this action
Functions of SEMI SMT-ELS

Route Setting of Panel

SetRouteConfig message sets required number of Routes to each equipment (can also be set manually)
Route is selected and used per Product or Inspection Result

SetRouteConfig links logical Routes and the physical Tracks (lanes) of the equipment
Branch condition can also be set
Panel Arrival/Departure Events

PanelArrived and PanelDeparted messages from equipment provides Panel tracking. Panel Data and user defined production data are reported to the host.
Panel Data

- The following Panel Data is defined
- Items can optionally be added per the requirements of each production line

<table>
<thead>
<tr>
<th>Field</th>
<th>Mnemonic</th>
<th>Definition</th>
<th>MD Mode</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instance ID</td>
<td>Panel IX</td>
<td>Panel Index used by SMASH</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Panel ID</td>
<td>Panel Identifier</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Top Bottom</td>
<td>Specify the surface, top or bottom</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Class ID</td>
<td>Product IX</td>
<td>Product Index used by SMASH</td>
<td>C</td>
<td>C</td>
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<tr>
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<td>Product ID</td>
<td>Product ID of the Panel</td>
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<tr>
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<td>Panel Width</td>
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<td>C</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Panel Length</td>
<td>Length of the Panel</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Panel Thickness</td>
<td>Thickness of the Panel</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Log</td>
<td>Inspection Result</td>
<td>Result from inspection equipment</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>User defined</td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

R: Required, C: Conditional, O: Optional
- Panel and Panel Data are transferred simultaneously
- Assembly line can select M0 to M2 per Panel Data availability

<table>
<thead>
<tr>
<th>Reference Mode</th>
<th>M0</th>
<th>M1</th>
<th>M2</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>For transition use Panel Data is not valid yet</td>
<td>Product Management</td>
<td>Product and Panel Managements</td>
<td></td>
</tr>
<tr>
<td>Panel Data to be used</td>
<td>Not used</td>
<td>Top Bottom Panel ID</td>
<td>Panel ID Top Bottom Panel ID</td>
<td>Panel ID Panel ID reader is required</td>
</tr>
<tr>
<td>Trace of a Panel</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Top / Bottom</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>On demand Product change</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Product ID Panel Width</td>
</tr>
<tr>
<td>Immediate Product Change</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>By horizontal communication</td>
</tr>
<tr>
<td>Panel Handoff</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
Functions of SEMI SMT-ELS

Setting of Panel Data Reference Mode

SetMDReferMode sets Panel Data Reference Mode by using Horizontal Communication.

- SetMDReferMode (M0) No Panel Data reference
- SetMDReferMode (M1) Refer Production ID
- SetMDReferMode (M2) Refer Panel ID as well

Setting shall be done when no Panel is in the line.
Product Change per Panel Data Reference Mode

M0: Advance change of product setting to the Route by SetRouteSpec message
M1, M2: On-demand change of product setting of the Panel by Panel Data

SetRouteSpec is used to change product setting change of the Route
M0: Panel Data is not referenced
M1, M2: Panel Data is referenced to change product setting

Immediate change of Product

Panel Data Reference Mode

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M0: No Panel Data Reference

Panel Data is transferred with the Panel but not referenced
(Transition use, equivalent function with SMEMA)

SetRouteSpec is sent to the next equipment before changing to the new product

Route Specification Setting

Equipment deals the Panel with the Product specification set to the Route

Panel Data is not referenced

Panel
M1, M2: Panel Data Reference

Panel Data is transferred with the Panel and referenced

- Panel Data can be acquired (especially in M2)
- SetRouteSpec may be used as a preannouncement of product change
- Route Specification Setting (Optional)
- Route 0
- Route 1
- Route 2

Equipment deals the Panel with the Product specification brought by the Panel Data

Panel Data is referenced
Panel
Functions of SEMI SMT-ELS

Functions to be Added Shortly

• Vertical Communication
  • Production Program management (Recipe Management)
  • Equipment production events

• Horizontal Communication
  • Inter-Segment connection (such as carrier handling AGV interface)
SEMI SMT-ELS Activities
Organization, Activities and Document Control
SEMI SMT-ELS Activities

SEMI SMT-ELS Organization

Technology Community that consists of the members who have the same Business Interest

Global Standardization organization that is open for those who have the same Technical Interest

The forum for Flow shop type manufacturing line

The technical committee that is responsible to flow shop type manufacturing line

Responsible Working Groups

Responsible Task Forces

Application knowhow sharing
Hosting of Interoperability Testing
Industry interactions (promotion, feedback)

Development and improvement of Standards
Ballot actions and adjudications

Flow Manufacturing (FM) Forum

Automation Technology (AT) Committee

SEMI Tech. Community

SEMI Standards

A1 WG
(SEMI A1)
Responsible to SEMI A1/A1.1 PESCI

SMT WG
(Surface Mount Technology)
Responsible to SEMI A2 SMASH

A1 TF
(SEMI A1)
Responsible to SEMI A1/A1.1 PESCI

SMT TF
(Surface Mount Technology)
Responsible to SEMI A2 SMASH

SEMI

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Relationship between FM Forum and AT Committee

**SEMI SMT-ELS Activities**

- **SEMI Technology Community**
  - FM Forum
    - Factory Requirements
    - Interoperability Testing
    - PDCA Cycle
  - Prototyping
  - Standard Requirements

- **Industry**

- **SEMI Standards**
  - AT Committee
    - Standard Proposal
    - Standard Development
    - Standard Publication
    - Standard Voting / Review
    - PDCA Cycle
Interoperability Testing Support

- Flow Manufacturing Forum hosts interoperability testing
  - Interoperability should be managed by the forum members since SEMI should be neutral and is not in the position to test or certificate

- Two testing categories
  - Equipment Level Testing
  - Package Level Testing

- Participants who appropriately performed the testing with multiple proven members are posted to SEMI SMT-ELS homepage

- Please visit SEMI SMT-ELS homepage for up-to-date information
SEMI SMT-ELS Activities

For More Information

• SEMI SMT-ELS homepage
  • http://www1.semi.org/jp/SEMI_SMT-ELS

• SEMI A1 PESCI homepage
  • http://www1.semi.org/jp/SEMI_A1_PESCI

• Association Contact
  • Junko Collins, Director, Standards & EHS /SEMI Japan
  • Email: jcollins@semi.org
Thank you!

SEMI SMT-ELS