SEMI E33-0217[E]
GUIDE FOR SEMICONDUCTOR MANUFACTURING EQUIPMENT ELECTROMAGNETIC COMPATIBILITY (EMC)

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[E] This Standard was editorially modified in October 2018 to correct an error. A change was made to the header of Table A1-1.

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1 Purpose

1.1 The purpose of this Guide is make recommendations to help assure that manufacturing equipment used for manufacturing semiconductor devices will operate reliably without failures caused by electromagnetic interference (EMI). This desired characteristic is generally known as electromagnetic compatibility (EMC).

2 Scope

2.1 This Guide applies to equipment constructed for the purpose of manufacturing semiconductor devices. Equipment types include communications equipment, control equipment, processing equipment, metrology equipment, inspection equipment, automation equipment, and information technology equipment. Some terms are specialized to semiconductor facilities and equipment.

2.2 The primary focus of this Guide is semiconductor manufacturing equipment used for manufacturing semiconductor devices, but this Guide may also be applied to the equipment used for manufacturing related products (e.g., flat panel displays [FPDs], microelectromechanical systems [MEMS]).

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.

NOTE 1: Under certain conditions, sensitivity to EMI or the lack of EMC can impact equipment safety.

3 Limitations

3.1 This Guide does not apply to the equipment used for the assembly and functional testing of integrated circuits.

NOTE 2: The task force plans to consider equipment used for such assembly and testing once the acceptable limits and methodology are defined.

3.2 This Guide does not apply to EMI caused by electrostatic discharges (ESDs) from process-specific charging that may occur to semiconductor devices in manufacturing processes. Refer to SEMI E78 for more information.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI E78 — Guide to Assess and Control Electrostatic Discharge (ESD) and Electrostatic Attraction (ESA) for Equipment

SEMI F47 — Specification for Semiconductor Processing Equipment Voltage Sag Immunity

4.2 *European Commission (EC) Directive*[1]

Directive 2014/30/EU — Directive 2014/30/EU of the European Parliament and of the Council on the Approximation of the Laws of the Member States Relating to Electromagnetic Compatibility and Repealing Directive 2004/1008/EC

[1] European Commission, Rue de la Loi 200/Wetstraat 200, B-1049 Bruxelles/Brussels, Belgium; Telephone: +32.2.299.30.85, Fax: +32.2.296.17.49, http://www.europa.eu.int

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4.3 *IEEE Standards*[2]

IEEE 1100 — IEEE Recommended Practice for Powering and Grounding Electronic Equipment

NOTE 3: See Related Information 3 for a subset list of guidance standards, regulations, and directives.

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *CEN* — European Committee for Standardization

5.1.2 *CFR* — Code of Federal Regulations

5.1.3 *CISPR* — International Special Committee on Radio Interference

5.1.4 *ELF* — extremely low frequency

5.1.5 *EMC* — electromagnetic compatibility

5.1.6 *EMF* — electromagnetic field

5.1.7 *EMI* — electromagnetic interference

5.1.8 *EN* — European Standard

5.1.9 *ESD* — electrostatic discharge

5.1.10 *EUT* — equipment under test

5.1.11 *FCC* — Federal Communications Commission

5.1.12 *FIB* — focused ion beam

5.1.13 *FPD* — flat panel display

5.1.14 *IEC* — International Electrotechnical Commission

5.1.15 *IEEE* — Institute of Electrical and Electronics Engineers

5.1.16 *MEMS* — microelectromechanical systems

5.1.17 *OEM* — original equipment manufacturer

5.1.18 *RMS* — root mean square

5.1.19 *SEM* — scanning electron microscope

5.1.20 *TEM* — transmission electron microscope

5.1.21 *VLF* — very low frequency

5.2 *Definitions*

5.2.1 *electromagnetic compatibility (EMC)* — the ability of electronic equipment to function properly with respect to environmental electromagnetic interference (EMI).

5.2.2 *electromagnetic interference (EMI)* — the degradation of the performance of an equipment, transmission channel, or system caused by an electromagnetic disturbance.

5.2.3 *electrostatic discharge (ESD)* — the rapid spontaneous transfer of electrostatic charge induced by a high electrostatic field. [SEMI E78]

5.2.4 *ELF-sensitive equipment* — any equipment, such as a scanning electron microscope (SEM), with performance that is adversely affected by extremely low frequency (ELF) electromagnetic fields (EMFs).

[2] Institute of Electrical and Electronics Engineers, 3 Park Avenue, 17th Floor, New York, NY 10016-5997, USA; Telephone: +1.212.419.7900, Fax: +1.212.752.4929, http://www.ieee.org

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5.2.5 *EMI event* — an occurrence of electromagnetic interference (EMI) that may also include electromagnetic emission from electrostatic discharge (ESD) events.

5.2.6 *EMI-sensitive equipment* — any equipment with performance that is adversely affected by electromagnetic interference (EMI) present in the semiconductor manufacturing environment.

5.2.7 *enclosure* — the physical boundary of the equipment through which electromagnetic fields (EMFs) may radiate or impinge.

5.2.8 *ESD Audit* — an internal or external verification of some or all provisions in electrostatic discharge (ESD) control programs and related standards.

5.2.9 *ESD event* — an occurrence of electrostatic discharge (ESD) that can cause an electromagnetic emission.

5.2.10 *extremely low frequency* (*ELF)* — the spectrum range less than 3 kHz.

5.2.11 *extremely low frequency* (*ELF) electromagnetic field (EMF)* — an electromagnetic field (EMF) generated by extremely low frequency (ELF) current flow (most commonly at 60 Hz in the U.S., parts of Japan, and Taiwan and at 50 Hz in most of Asia and in Europe) within equipment and facilities.

5.2.12 *port* — a particular interface (e.g., ground port) of the specified equipment with the external electromagnetic environment (see Figure 1).

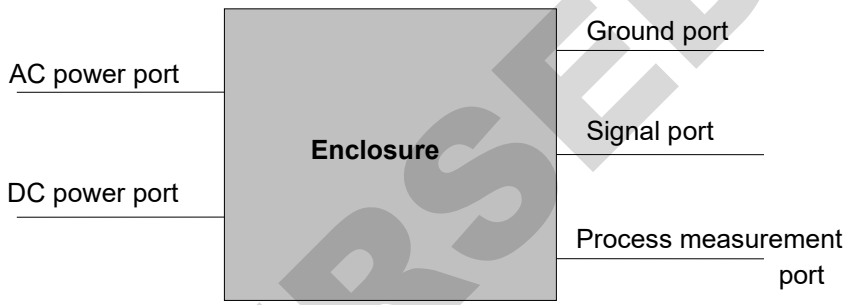

Figure 1
Equipment Ports

5.2.13 *supplier* — provider of equipment and related services to the user (e.g., unit manufacturer). Also called equipment vendor or original equipment manufacturer (OEM). [SEMI E10]

5.2.14 *user* — party that acquires equipment for the purpose of using it to manufacture semiconductors. See also the definition for supplier. [SEMI S2]

5.2.15 *very low frequency* (*VLF)* — the spectrum range from 3 kHz to 30 kHz.

6 Recommended Performance Criteria Classification

6.1 *Recommended Performance Criteria* — The following are recommended generic performance criteria for the various classes of equipment and electronic systems used in semiconductor manufacturing. Any kind of failure or aberration during EMC testing should be recorded in the test report.

6.1.1 *Performance Criteria A* — The semiconductor manufacturing equipment operates as intended during and after the test. In the case of process equipment, all process results are within specifications. No observable increase in risk attributed to EMI or false alarms. In some cases, the performance level may be replaced by a documented permissible loss of performance if such loss is deemed minor and agreeable to the concerned parties.

6.1.2 *Performance Criteria B* — The semiconductor manufacturing equipment operates as intended after the test, but experiences a loss of function or degradation of performance during the test to a level specified by the supplier. No change of operating state or loss of stored data is allowed. Restoration of performance or function does not require human intervention.

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NOTE 4: If the temporary loss of function can create a safety hazard, the appropriate Safety Guidelines or Standards should be used to evaluate the risk.

6.1.3 *Performance Criteria C* — Temporary loss of function is allowed, provided the function is recoverable, either automatically or through operation of the controls.

NOTE 5: If the temporary loss of function can create a safety hazard, the appropriate Safety Guidelines or Standards should be used to evaluate the risk.

7 Semiconductor Manufacturing Equipment Compliance Recommendations

7.1 Conformance to the requirements of applicable EMC-related regulations (e.g., codes, directives) in the location where semiconductor manufacturing equipment is to be used should be independent of and may supercede this Guide and any agreements between the supplier and the user. Considerations beyond regulatory requirements should be negotiated between the supplier and the user.

7.2 Conformance to the requirements of the EMC Directive 2014/30/EU is the recommended performance of the equipment and represents the expectation for meeting the recommendations in this Guide.

7.3 If additional equipment performance characteristics beyond the requirements of the EMC Directive (such as those listed below) are requested, they should be negotiated between the supplier and the user.

- Performance criteria defined in § 6
- Extremely low frequency (ELF) electromagnetic field (EMF) strength level and testing defined in Appendix 1
- Conformance to the voltage sag immunity requirements defined in SEMI F47

8 Semiconductor Manufacturing Equipment Compliance Responsibility Recommendations

8.1 *Alternate Locations* — If semiconductor manufacturing equipment is purchased for use at one location and is compliant with EMC-related standards, rules, and regulations for that location, but is used in another location with different EMC-related standards, rules, and regulations, compliance with the latter should not be the responsibility of the manufacturer of that equipment. Compliance with the applicable EMC-related regulations of the original use location is the responsibility of the equipment supplier. Regulatory guidance and negotiation between the supplier and the user are recommended for compliance of equipment relocated to alternate locations.

NOTE 6: One example includes when a supplier in good faith sold equipment for use in a certain location with its own regulatory requirements, however the customer or a distributor has rerouted the equipment to a different location with different regulatory requirements. Another example is the case of the sale of used equipment by a party that is not the original manufacturer of that equipment. In such cases, the manufacturer should not be held responsible for retrofitting the equipment to meet new regulatory requirements that were not included at the time of the original sale.

8.2 *Semiconductor Manufacturing Equipment EMI Protection Deviations* — If the user operates semiconductor manufacturing equipment in a configuration different from the manufacturer's instructions (e.g., operates equipment with service access covers removed, cable bundles exposed), the user may compromise the equipment's EMC. Additional protection measures or test requirements should be provided for electromagnetic compliance, as agreed between the equipment supplier and the user.

8.3 *Recommended Semiconductor Manufacturing Equipment Compliance Assignments* — Table 1 is provided to assist in defining EMC compliance roles and responsibilities. Unless there are contractual agreements to the contrary, the responsibilities defined in Table 1 should be followed.

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Table 1 Recommended EMC-Related Compliance Assignments

Item	*Responsibility*
Semiconductor manufacturing equipment itself	Supplier (semiconductor manufacturing equipment manufacturer)
Semiconductor manufacturing equipment in combination with other equipment if supplied (i.e., integrated) by one supplier	Supplier (semiconductor manufacturing equipment integrator)
Semiconductor manufacturing equipment in combination with other equipment if integrated by the user	User
Facility-level electromagnetic environment[#1]	User
Semiconductor manufacturing equipment installation-related compliance and EMI-performance	Party responsible for installation
Semiconductor manufacturing equipment collocation	User
Semiconductor manufacturing equipment after repair or maintenance	Party responsible for repair or maintenance
Post-sale additions or modifications made by the supplier that affect EMC compliance	Supplier (semiconductor manufacturing equipment manufacturer or integrator)
Post-sale additions or modifications made by the user that affect EMC compliance	User

#1 Refer to ¶ R4-1.4 for guidance on facility-level EMI environment.

8.4 *Facility-Level Electromagnetic Environment* — Although the scope of this Guide is semiconductor manufacturing equipment, electromagnetic performance includes the facility in which the equipment is installed. The facility and electrical interface are equally important to successful equipment EMC. Information in this Guide may be used by suppliers to guide users in establishing a compatible electromagnetic environment for equipment and processes.

NOTE 7: See Related Information 4 for further details on electromagnetic environments on a facility level.

8.5 *ESD-Related Electromagnetic Environment* — Electromagnetic emission can be generated also by ESD events within or nearby the semiconductor manufacturing equipment or in combination with integrated equipment. ESD generates an EMF with a characteristic signature. Refer to SEMI E78 for more information on controlling these ESD events.

9 Test Method Recommendations

9.1 *Applicable Standards* — Semiconductor manufacturing equipment should be evaluated per the relevant requirements in applicable regulations, standards, and directives as well as to the requirements that are agreed by the supplier and the user.

NOTE 8: A subset list of potentially relevant EMC-related standards, regulations, and directives is provided in Related Information 3. Both suppliers and users are encouraged to check periodically for and use updates to the relevant guidance documents.

9.2 *Recommended Conditions During Testing*

9.2.1 EMC testing should be performed with the semiconductor manufacturing equipment fully installed and operational if doing so is practical and reasonable.

9.2.2 The test configuration should be according to the supplier installation, operation, maintenance, and service requirements and should represent a realistic operating environment.

9.2.3 Substitutes may be used for hazardous gases and chemicals and other modifications may be made as deemed reasonable to ensure testing can be performed in a reduced-risk and environmentally acceptable manner.

9.2.4 Special EMC facilities should not be required by this Guide. Knowledge of EMC testing and equipment characteristics should guide compliance approach: analysis vs. lab test or in situ testing.

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9.3 *Optional Alternative Testing*

9.3.1 Testing completed using different, but 'substantially similar' (as agreed by the supplier and the user) methods may be substituted for the test methods recommended in this Guide if the performance criteria and test levels are similar.

9.3.1.1 The assessor should note such substitutions in the test plan and report.

NOTE 9: In situ testing may be in a simulated use environment or at the user's facility.

10 Semiconductor Manufacturing Equipment Installation and Grounding Recommendations

10.1 Special installation, power, and grounding requirements necessary to meet this Guide should be thoroughly documented by the supplier.

NOTE 10: IEEE 1100 (*IEEE Emerald Book*) is a suggested source of information for recommended practices in this area.

10.2 Suppliers and users should be aware of the importance of reference grounding in the control of EMI. Absent or ineffective semiconductor manufacturing equipment grounding may cause semiconductor manufacturing equipment malfunction.

10.2.1 It is recommended that the supplier or the user conduct the EMI ground audit portion of an EMI Audit (see Appendix 2) on the semiconductor manufacturing equipment ground (i.e., ground port) prior to installation of EMI-sensitive semiconductor manufacturing equipment and after installation of all equipment.

11 Documentation Recommendations

11.1 A nonproprietary test method and report should be available to the user upon request by the user.

NOTE 11: Proprietary test methods and reports may require nondisclosure agreements between a user and a supplier.

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