

SEMI S9-1101

SAFETY GUIDELINE FOR ELECTRICAL DESIGN VERIFICATION TESTS FOR SEMICONDUCTOR MANUFACTURING EQUIPMENT

This guideline was technically approved by the Global Environmental Health and Safety Committee and is the direct responsibility of the North American Environmental Health and Safety Committee. Current edition approved by the North American Regional Standards Committee on August 27, 2001. Initially available at www.semi.org September 2001; to be published November 2001. Originally published in 1995.

NOTICE: This document as balloted is intended to replace SEMI S9-95 in its entirety.

NOTICE: Paragraphs entitled “NOTE” are not an official part of this document and are not intended to modify or supercede the official guideline. The task force has supplied them to clarify and to enhance usage of the guideline by equipment designers.

1 Purpose

1.1 The purpose of this document is to provide electrical design verification tests, test methods, and acceptance criteria for semiconductor manufacturing equipment. Some of these tests are used as part of the electrical safety evaluation in SEMI S2.

2 Scope

2.1 This safety guideline should be applied to one or more representative samples of the equipment (or parts of the equipment) used for the manufacturing, measurement, assembly, and testing of semiconductor products.

2.2 The following tests are discussed in this document:

- Leakage Current Test (Section 9.1)
- Grounding Continuity Test (Section 9.2)
- Starting Current Test (Section 9.3)
- Input Test (Section 9.4)
- Dielectric Test (Section 9.5)
- Strain Relief Test (Section 9.6)
- Transformer Output Short Circuit Test (Section 9.7)
- Power Supply Output Short Circuit Test (Section 9.8)
- Safety Circuit Function Test (Section 9.9)
- Safety Circuits Conductor Disconnection Test (Section 9.10)
- Capacitor Stored Energy Discharge Test (Section 9.11)
- Temperature Test (Section 9.12)

2.3 This safety guideline does not purport to address all of the safety issues associated with its use. It is the responsibility of the user of this safety guideline to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 This document is not intended to be a comprehensive compilation of electrical tests specified in product safety standards. This document is also not intended to replace any test methods described in any appropriate national or international product safety standards.

3.2 It is not the intent of this guideline to require repetition of tests where the equipment has been certified or tested to other relevant electrical product safety standards. Any applicable test from this guideline that has been previously completed under an applicable product standard and which satisfies the intent of that test should be accepted, even if there are differences in test methods.

3.3 Engineering analysis, when based on sound engineering principles, may serve as an alternative to conducting a test.

3.4 If it is evident from the design and construction of the equipment that a particular test is not safety-relevant, the test need not be performed.

3.5 This document is not intended to address production line or routine testing.

4 Referenced Standards

4.1 SEMI Standards

SEMI S2 — Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

4.2 IEC Standard¹

IEC 61010-1 — Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements

NOTE 1: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 *1500 ohm impedance network* — a network consisting of a 1500 ohm resistor in parallel with a 0.15 μ F capacitor.

5.2 *accessible* — capable of being contacted by an IEC accessibility probe (IEC standard test finger, as described in IEC 61010).

NOTE 2: The test finger is also known, in various IEC documents, as the “jointed test finger” and “jointed standard test finger”.

5.3 *full load current* — current when the equipment is operated at the maximum manufacturer's specified operating conditions including all motors and heaters designed to operate simultaneously.

5.4 *hazardous energy* — energy of 20 J (Joules) or more, or an available power level of 240 V*A or more.

5.5 *least favorable condition* — the condition which is most likely to result in a test failure.

5.6 *permanently connected equipment* — Equipment that is intended to be electrically connected to a supply by means of connection which can be detached only by the use of tools.

5.7 *primary circuit* — an internal circuit which is directly connected to the external supply mains or other equivalent source (such as a motor-generator set) which supplies the electric power. It includes the primary windings of transformers, motors, other load devices and the means of connection to the supply mains.

5.8 *safe condition* — a condition in which all relevant hazardous energy sources are removed or suitably contained and all relevant hazardous production materials are removed or contained, unless this results in additional hazardous conditions.

5.9 *PE Terminal* — a terminal which is bonded to conductive parts of a piece of equipment for safety purposes and is intended to be connected to an external protective earthing system.

5.10 *standby condition* — condition in which equipment is energized and in its idle state.

5.11 *tool* — an external device used to aid a person in performing a mechanical function. As used in this document, *tool* includes devices such as keys.

5.12 *V*A* — Volt-ampere.

6 Safety Precautions

6.1 The tests outlined in this document are to be performed by trained and qualified personnel who have knowledge of the techniques and the test apparatus described herein.

7 Calibration and Standardization

7.1 All test equipment should be calibrated and traceable to a calibration standards organization (e.g., National Institute of Standards and Technology (NIST) in the United States or the National Metrology Institute in Japan).

7.2 The calibration interval for test equipment should not exceed one year.

8 Test Conditions

8.1 Except where noted otherwise, the equipment should be tested under the least favorable conditions within the manufacturer's operating specifications. These conditions include:

- supply potential
- supply frequency
- position of movable parts
- operating mode (e.g. full temperature conditions, motors in operation)
- adjustment of thermostats, regulating devices, or similar controls in operator-accessible areas

8.2 *Test Supply Potential* — To determine the least favorable supply potential for a test, consider:

- multiple-nominal rated potentials (e.g., 120/240 V)
- extremes of nominal rated potential ranges (e.g., 208–240 V)

8.2.1 Consideration of the tolerance on a nominal rated potential (e.g., $120 \pm 5\%$) is not necessary.

NOTE 3: Some standards (e.g., IEC 61010-1 and IEC 60950) may specify 90% and 110% of any rated supply voltage.

8.3 *Test Supply Frequency* — To determine the least favorable supply frequency for a test, consider the nominal frequencies as specified (e.g., 50 Hz, 60 Hz, or 50/60 Hz).

¹ International Electrotechnical Commission, 1, rue de Varembe, Case Postale 131, CH-1211 Geneva 20, Switzerland. Website: www.iec.ch

NOTE 4: Consideration of the tolerance on a nominal rated frequency (e.g., 50 ± 0.5 Hz) is not usually necessary.

8.4 As an alternative to carrying out tests on the complete equipment, tests may be conducted on circuits, components and sub-assemblies independent of the equipment, provided that the results of the tests would be representative of those performed as part of the assembled equipment.

EXCEPTION: The leakage current and grounding continuity tests identified in Sections 9.1 and 9.2 should be completed only on fully assembled equipment.

9 Electrical Tests

9.1 Leakage Current Test for Cord-and-Plug Equipment

9.1.1 *Test Equipment* — A 1500 ohm impedance network and a true RMS voltmeter with an accuracy of 1.0%. The impedance network can be a separate assembly or incorporated within a leakage current measuring instrument.

9.1.2 *Procedure* — For equipment connected to the facility branch circuit with a cord-and-plug (plug/socket combination), ensure that the equipment is isolated (e.g., by placing the equipment on a wooden or other isolating surface). Connect the equipment to its rated source of supply with the equipment grounding (PE) conductor disconnected and operate it at the least favorable conditions specified by the manufacturer. Connect the 1500 ohm impedance network between each accessible metal part and the supply equipment grounding (PE) conductor. In determining accessibility of live parts, remove all doors, panels, etc. that are to be removed by the operator during normal operation. Using a true RMS voltmeter, measure the voltage drop across the impedance network. Calculate the leakage current using the formula:

$$I_{\text{leakage}} = \frac{\text{Voltage}_{\text{measured}}}{1500 \text{ ohms}}$$

9.1.3 *Acceptable Results* — The maximum calculated leakage current does not exceed 3.5 mA.

9.2 Grounding Continuity Test

9.2.1 *Test Equipment* — Low range ohmmeter with a range to measure 0.10 ohm with an accuracy of 1.0%.

9.2.2 *Procedure* — Disconnect the equipment from the supply. For equipment installed with fixed wiring methods, disconnect the supply equipment grounding conductor (protective earthing conductor) from the main equipment grounding terminal (PE Terminal). Measure the resistance between the power supply equipment grounding terminal (PE Terminal) and each

accessible metal part (handle, monitor, doors, etc.) on the equipment using a low-range ohm-meter. Upon test completion, reconnect the supply equipment grounding conductor (protective earthing conductor).

EXCEPTION: Grounding Continuity Test is not required to be measured where accessible metal surfaces are not likely to become energized in a single fault condition.

NOTE 5: Some standards (e.g., IEC 60204-1, IEC 61010-1) may specify this test to be performed using a current injection method.

9.2.3 *Acceptable Results* — The resistance between the grounding conductor terminal and each accessible part shall not exceed 0.1 ohm.

9.3 Starting Current Test

9.3.1 *Test Equipment* — None.

9.3.2 *Procedure* — Start the equipment in accordance with manufacturer's instructions three times from a completely stopped condition. Ensure that the time interval between successive starts is sufficient to allow the equipment return to ambient conditions.

9.3.3 *Acceptable Results* — None of the equipment's overload or overcurrent protections activates during this test.

NOTE 6: It is recommended that the peak inrush starting current be measured using an appropriate current measuring device and recorded in the test report.

9.4 Input Test

9.4.1 *Test Equipment* — True RMS current measuring equipment, with accuracy of 3.0%.

9.4.2 *Procedure* — Measure the input current to the equipment under the maximum normal operating load conditions (i.e., with all motors, heaters, etc. running at manufacturer's specified maximum loading conditions).

9.4.3 *Acceptable Results* — The measured current does not exceed 110% of the rated full load current value specified on the equipment nameplate.

9.5 Dielectric Test

9.5.1 *Test Equipment* — Timer with accuracy of ± 5 seconds. Dielectric Withstand Tester with means of indicating test potential, as well as an audible or visual indicator of electrical breakdown, or an automatic-reject feature for any unacceptable unit. In an alternating current test, the test equipment should include a transformer having sinusoidal output. This transformer should have a rating of 500 VA or greater unless it is provided with a voltmeter that directly measures the applied output potential.