

ANSI/ESD STM5.5.1-2016

ESD Association Standard Test Method

ANSI/ESD STM5.5.1-2016

*Revision and Consolidation of ANSI/ESD STM5.5.1-2014
and ANSI/ESD SP5.5.2-2007*

***For Electrostatic Discharge
Sensitivity Testing –***

***Transmission Line Pulse (TLP) –
Device Level***



***EOS/ESD Association, Inc.
7900 Turin Road, Bldg. 3
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***An American National Standard
Approved January 5, 2017***



***ESD Association Standard Test Method
for Electrostatic Discharge Sensitivity Testing –
Transmission Line Pulse (TLP) –
Device Level***

EOS/ESD Association, Inc.
Approved November 2, 2016



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FOREWORD

This document defines a method for pulse testing to evaluate the voltage-current response of the component under test. This technique is known as “transmission line pulse” (TLP) testing. This document simultaneously describes the techniques traditionally known as TLP methods (pulse duration in the order of 100 ns), VF-TLP methods (pulse duration shorter than or equal to 10 ns), and long pulse TLP methods (pulse duration more than 200 ns).

TLP testing techniques are being used for semiconductor process development, device and circuit design and failure analysis. This technique or practice is being utilized on products in both wafer level and packaged environments. TLP testing is used as an ESD characterization tool to obtain voltage-current pulse characterization parameters, failure levels, and ESD metrics. The TLP technique is being used today as a standard measurement for ESD devices. The TLP system to the ESD engineer is a tool as critical as the “parameter analyzer” is to the semiconductor engineer.

TLP systems are commercially available and can be made by engineers in a laboratory environment. With the usage of TLP data for ESD characterization, technology benchmarking, and product quality evaluation, there is a need to have standard methodologies, failure criteria, and means of reporting to allow dialogue between semiconductor suppliers, vendors, and product customers.

This document defines the standard test method¹ used today in the semiconductor industry for the TLP testing method and techniques in both industrial and academic institutions. It also covers the methods used to verify measurement accuracy and to perform system calibration. This document is intended to be used by electrical technicians, electrical engineers, semiconductor process and device engineers, ESD reliability and quality engineers, and circuit designers. The document is intended as a reference for the practices being used today.

The context of this document is the application of TLP techniques for the electrical characterization of semiconductor components. These semiconductor components can be single devices, a plurality of devices, integrated circuits, or semiconductor chips. This methodology is relevant to both active and passive elements. This test method is applicable to diodes, MOSFET devices, bipolar transistors, resistors, capacitors, inductors, contacts, vias, wire interconnects and related components.

This document covers transmission line based systems applying quasi-rectangular pulses with a wide range of pulse widths and rise times. All are referred to as TLP systems. Further subdivision is discussed in the document. This document can also serve as a basis to describe variants of such systems, e.g. nonrectangular pulses or systems based on solid-state pulsers or source measurement units.

This document was originally designated ANSI/ESD SP5.5.1-2004, and approved on February 22, 2004. ANSI/ESD STM5.5.1-2008 was a revision and re-designation of ANSI/ESD SP5.5.1-2004 and was approved on February 24, 2008. ANSI/ESD STM5.5.1-2014 was a revision of ANSI/ESD STM5.5.1-2008 and was approved on August 26, 2014. The additional document being merged was designated ANSI/ESD SP5.5.2-2007 and was approved September 16, 2007. ANSI/ESD STM5.5.1-2016 is a revision, consolidation, and redesignation of ANSI/ESD STM5.5.1-2014 and ANSI/ESD SP5.5.2-2007; and was approved on November 2, 2016.

¹ **ESD Association Standard Test Method (STM):** A definitive procedure for the identification, measurement and evaluation of one or more qualities, characteristics or properties of a material, product, system or process that yields a reproducible test result.

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ESD Association Standard Test Method for Electrostatic Discharge (ESD) Sensitivity Testing – Transmission Line Pulse (TLP) – Device Level**1.0 PURPOSE, SCOPE, AND APPLICATION****1.1 Purpose**

The purpose of the document is to establish a methodology for both testing and reporting information associated with transmission line pulse (TLP) testing. This document covers TLP systems applying quasi-rectangular pulses with a wide range of pulse widths and rise times. All such systems are referred to as TLP systems.

1.2 Scope

The scope and focus of this document pertains to TLP testing techniques of semiconductor components. The focus of the document is on quasi-static application of TLP testing techniques, however the techniques can also be applied to study transient behavior of semiconductor components.

1.3 Application

The term VF-TLP is used for very short pulses (≤ 10 ns), consistent with the definition of this term in this document, and standard TLP for longer pulses ($10 \text{ ns} < \text{pulse duration} \leq 200 \text{ ns}$). The term long pulse TLP is used when discussing pulses longer than 200 ns pulse length and where special considerations need to be taken into account due to the long pulse length.

To indicate a TLP setup with a specific pulse duration we will use terminology like 100 ns-TLP (for TLP using 100 ns pulses); 1 ns-TLP (for TLP using 1 ns pulses), etc.

Therefore, previous versions of ANSI/ESD STM5.5.1 (2014 and older) typically dealt with 100 ns-TLP, while ANSI/ESD SP5.5.2 (VF-TLP) dealt with TLP systems ranging from 1 ns-TLP to 10 ns-TLP.

The requirements for the equipment and procedures described in this document have been demonstrated to produce repeatable results for quasi-static TLP on different structures in different labs. The results were published in ESD TR5.5-02-08 and ESD TR5.5-03-14.

For specific applications and/or practical reasons useful results may be achieved with parts of the equipment not fully meeting these requirements. If such results are reported, the limitations of the equipment used need to be documented and the results will not be compliant with this STM.

2.0 REFERENCED DOCUMENTS

Unless otherwise specified, the following documents of the latest issue, revision or amendment, form a part of this standard to the extent specified herein:

ESD ADV1.0, ESD Association Glossary of Terms²

ANSI/ESD S20.20, Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)²

IEC 61340-5-1 – Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General Requirements³

JESD625 – Requirements for handling Electrostatic-Discharge-Sensitive (ESDS) Devices⁴

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³ IEC – International Electrotechnical Commission, www.iec.ch

⁴ JEDEC, 3103 North 10th Street, Arlington, VA 22201; Ph: 703-907-7534; FAX: 703-907-7534; www.jedec.org

3.0 DEFINITIONS

The terms used in the body of this document are in accordance with the definitions found in ESD ADV1.0, ESD Association's Glossary of Terms available for complimentary download at www.esda.org.

transmission line pulse (TLP). A rectangular current pulse formed by discharging a charged transmission line cable.

transmission line pulse test system. A test system that applies a transmission line pulse to a device under test (DUT) and allows measurement of device electrical characteristics during a pulsed state. The system typically measures current and voltage across the device, and typically performs an evaluation measurement after TLP pulse application.

standard TLP. A TLP system with pulse duration greater than 10 ns and less than or equal to 200 ns.

VF-TLP. A TLP system with a pulse duration less than or equal to 10 ns.

long pulse TLP. A TLP system with a pulse duration greater than 200 ns.

4.0 PERSONNEL SAFETY

THE PROCEDURES AND EQUIPMENT DESCRIBED IN THIS DOCUMENT MAY EXPOSE PERSONNEL TO HAZARDOUS ELECTRICAL CONDITIONS. USERS OF THIS DOCUMENT ARE RESPONSIBLE FOR SELECTING EQUIPMENT THAT COMPLIES WITH APPLICABLE LAWS, REGULATORY CODES AND BOTH EXTERNAL AND INTERNAL POLICY. USERS ARE CAUTIONED THAT THIS DOCUMENT CANNOT REPLACE OR SUPERSEDE ANY REQUIREMENTS FOR PERSONNEL SAFETY.

GROUND FAULT CIRCUIT INTERRUPTERS (GFCI) AND OTHER SAFETY PROTECTION SHOULD BE CONSIDERED WHEREVER PERSONNEL MIGHT COME INTO CONTACT WITH ELECTRICAL SOURCES.

ELECTRICAL HAZARD REDUCTION PRACTICES SHOULD BE EXERCISED AND PROPER GROUNDING INSTRUCTIONS FOR EQUIPMENT MUST BE FOLLOWED.

THE RESISTANCE MEASUREMENTS OBTAINED THROUGH THE USE OF THIS TEST METHOD SHALL NOT BE USED TO DETERMINE THE RELATIVE SAFETY OF PERSONNEL EXPOSED TO HIGH AC OR DC VOLTAGES.

5.0 EQUIPMENT

TLP systems vary in their use of equipment, configurations, and methodology to extract the current and voltage characteristics of a device. TLP design and system configurations are contained in Annex A.

Most TLP systems have a cable impedance of 50 ohms and that impedance is often assumed in this document. If working with a system with cable impedances other than 50 ohms, load conditions specified as 50 ohms shall be changed to match the impedance of the system being used.

The sections below specify the minimum bandwidth requirements for measurement equipment in a TLP system. These requirements are sufficient for quasi-static TLP, i.e. for accurate measurements in a window after the initial transient effects have settled. Higher bandwidths can be used to obtain more detailed information in the waveforms. VF-TLP systems must achieve a minimum system bandwidth to achieve time resolved measurements of the DUT. System bandwidth will be limited by the lowest bandwidth component. The minimum requirements stated in Section 5.0 may limit total bandwidth. No element in the signal path, such as attenuators, cables and switches, shall limit the bandwidth below that of the measurement equipment.

All equipment within the test system shall be able to withstand the maximum current for the largest pulse width applied. Additionally, all equipment shall withstand the maximum voltage from the initial pre-charge voltage (including the reflected voltage) observed in the test system. Current and voltage probes shall not saturate and/or fail during TLP testing.