ESD Association Technical Report

ESD TR5.5-05-20

For Electrostatic Discharge Sensitivity Testing

Transmission Line Pulse (TLP) – Transient Response Evaluation

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Transmission Line Pulse

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FOREWORD

The transmission line pulse (TLP) technique is a method for pulse testing a semiconductor device to evaluate its voltage-current response, which is commonly used as an ESD characterization tool.

The basic requirements of TLP methodology are defined in the standard test method ANSI/ESD STM5.5.1, which is focused on the quasi-static behavior of the device under test (DUT). All the relevant quasi-static device parameters obtained from TLP characterization following ANSI/ESD STM5.5.1 are obtained by averaging in a pre-defined measurement window. However, many semiconductor devices show peculiar physical effects when stressed by the fast-rising edge of the TLP voltage/current waveform, which in some cases may induce premature and unexpected failures during ESD testing.

These effects are not completely addressed by the TLP characterization test method in ANSI/ESD STM5.5.1. Therefore, to have a complete picture of device behavior in the ESD regime, an extension of the analysis into the initial transient phase is also necessary.

This technical report[1] was published on June 15, 2020, and was designated ESD TR5.5-05-20. At the time ESD TR5.5-05-20 was prepared, the 5.5 (TLP) Device Testing Subcommittee had the following members:

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[1] **ESD Association Technical Report (TR):** A collection of technical data or test results published as an informational reference on a specific material, product, system or process.

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1.0 PURPOSE

The purpose of this technical report is to address two key points:

1) Measurement issues: under what conditions it is possible to perform a valid measurement of transient response and know that the results are real characteristics of the device being tested and not set-up artifacts.
2) Report a collection of already available and published characterization examples, useful to assess better the relevance of this type of measurement and the expected impact on ESD performances (especially during CDM stress).

The starting point of this report is the TLP system and its related requirements, as described in ANSI/ESD STM5.5.1. The most important modifications needed to address the initial transient response will be presented here.

2.0 PROBLEM DEFINITION AND MAIN CHALLENGES

2.1 Goal: What do We Want to Measure?

The transient response of circuit elements is important for the effectiveness of ESD protection design not only at the device level for HBM and CDM protection but also in system-level ESD protection. A circuit element with low dynamic impedance and a low clamping voltage measured in a time range between 50 ns and 100 ns may be ineffective as an ESD protection device if the low impedance state takes a long time to turn on, or there is a large voltage overshoot required to enter the low impedance state. It is, therefore, extremely helpful to know the transient responses of all circuit elements in an ESD protection design, both the circuit elements providing protection as well as the circuit elements being protected. It can also be useful to examine the transient response of the full protection design to determine if the protection elements and the circuit elements requiring protection work well together and as expected. The list of potential circuit elements and circuits suitable for study with transient TLP is quite long. Transient response TLP may have applications outside of the field of ESD. The following list includes some of the most obvious candidates for study, but it is by no means complete:

- Diodes, especially those used as steering diodes in protection design
- MOS transistors
- SCR (npnp) structures
- Transient Voltage Suppressors (TVS) used as protection elements on printed circuit boards
- Gate oxides
- Full I/O buffers

2.2 Differences with Respect to ANSI/ESD STM5.5.1

The current EOS/ESD Association, Inc. standard test method for TLP and VF-TLP, ANSI/ESD STM5.5.1 [1], gives guidance for obtaining valid current versus voltage measurement using TLP methods. That document defines 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). In principle, this document applies to all, but in practice, most transient analysis will be done with VF-TLP systems. The standard test method targets device behavior characterization, assuming that the DUT is in a quasi-static state during the measurement windows for current and voltage. The waveforms used to obtain the quasi-static information may also be used to derive information on the transient behavior of the DUT. The current TLP document, ANSI/ESD STM5.5.1, discusses bandwidth requirements for quasi-static measurements but does not give guidance on how to obtain time-dependent information from TLP data. This technical report