

Influence of the Socket on Chip-level ESD Testing

Yu Xiao¹, Jiancheng Li², Jianfei Wu², Yunzhi Kang³, and Jianwei Su¹

¹P. O. Box 9010, Xiangtan University, Xiangtan, Hunan 411105, China

²National University of Defense Technology, Changsha, Hunan 410073, China

³Freescale Semiconductor Inc., TEDA, TianJin 300457, China

Abstract— This paper introduces a method of IC-level Electrostatic Discharge (ESD) testing and discusses the influence of the socket on Chip-Level ESD testing. During the powered ESD (PESD) testing, welding the chip to the PCB is a necessary process which can be a repetitive process and time consuming. In order to solve this problem, a ball grid array (BGA) test socket is used during the test. The socket is built from copper-clad pogo pin and is pinned in an 8×8 mm array with 121 pins on a 0.65-mm pitch. As the test results suggest, there is little difference between testing with the socket and without. So in this study we take such factors into account as the pan angle range between ESD gun and PCB, the ESD gun, etc.. It is found in this study that the difference value (D-value) percentage between socketed ESD testing and non-socketed ESD testing is within 6.4%, the D-value percentage that the pan angle range of the ESD gun produces is within 5.8%, and the D-value percentage that the ESD GUN produces is within 5.8%. Based on these findings, it is concluded that work efficiency can be greatly improved by using the socket in PESD testing.

1. INTRODUCTION

The existing system level ESD test methods and their application field have been discussed in great detail. It is noted that IEC 61000-4 is a set of EMC test standards which includes the system level ESD test method, IEC 61000-4-2 [1]. It specifies calibration waveforms, procedures and stress points for executing ESD tests on systems.

In most of the electronic modules and systems, the signal and power have to travel through few levels of interconnections, and the signal path is crossing few discontinuities from the board level up to the MCU die [2]. The BGA socket is an electromechanical system that provides a separable electrical and mechanical connection between BGA component and a test-fixture. The basic structures of a BGA type socket consist of plastic housing and metal pogo contacts. The functions of plastic housing are to electrically insulate the pogo contact members, and mechanically support, and maintain them in the original position. The pogo pin provides a stable electrical connection to the pad. The socket is built from copper-clad pogo pin and pinned in an 8×8 mm array with 121 pins on a 0.65-mm pitch. The BGA type socket is shown in Figure 1. Figure 2 shows the structure of spring probe.

During the PESD test, welding the chip to the PCB is a necessary process which can be a repetitive process and time consuming. The BGA socket is used to fix the problem. The final aim of this paper is to investigate the influence of the socket on Chip-level ESD testing.

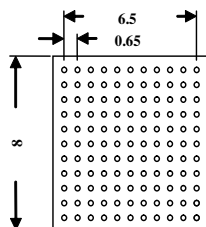


Figure 1: BGA socket for 8×8 mm matrix array.

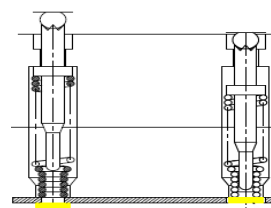


Figure 2: 0.4 mm pitch spring probe.

2. APPROCH AND TEST STRUCTURES

The existing system level ESD test methods are introduced in IEC 61000-4-2. The IEC standard defines typical discharge current waveforms, range of test levels, test equipment, test configuration, and test procedure. The characteristic of the waveform according to the system test standard IEC61000-4-2 is with a raise time of $0.85 + / - 0.15$ ns and a hold time of approximately 60 ns. The

waveform parameters are shown in Table 1 and the typical waveform of output current is shown in Figure 3 [3, 4].

Table 1: Waveform parameters.

Level	Indicated voltage kV	First peak current of discharge $\pm 10\%$ (A)	Rise time t_r with discharge switch ns
1	2	7.5	0.7 to 1
2	4	15	0.7 to 1
3	6	22.5	0.7 to 1
4	8	30	0.7 to 1

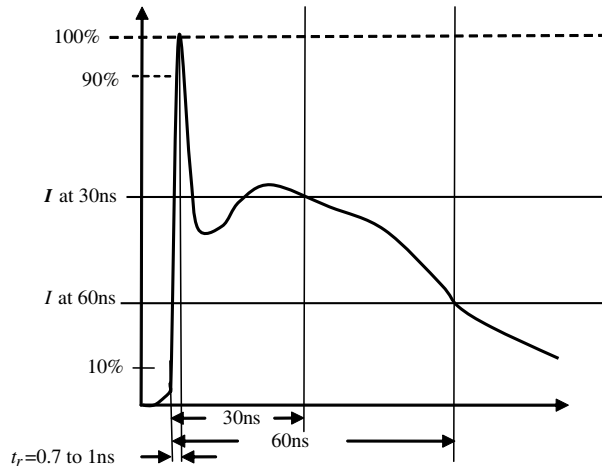


Figure 3: Typical waveform of the output current of the ESD generator.

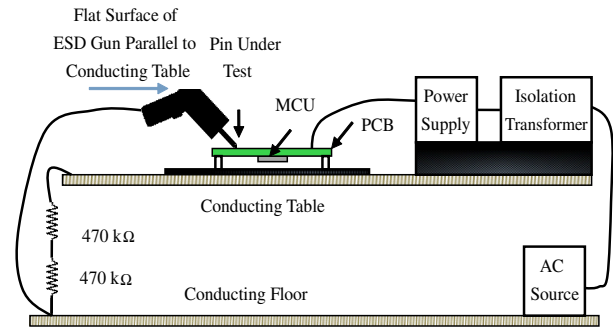


Figure 4: Powered direct contact pin ESD test table setup.

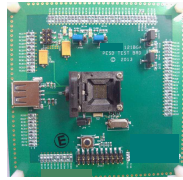


Figure 5: Bottom view of the test board (socketed).

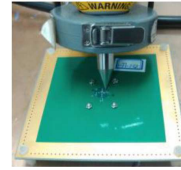


Figure 6: Measurement set up.

Powered direct contact pin ESD test platform is shown in Figure 4. The ESD gun is built in compliance with specification defined in IEC 61000-4-2, using the ESD gun model proposed and validated in [5]. The socket is used to fix the MCU on the PCB board, which is shown in Figure 5. RF current probe (Figure 6) connected to the oscilloscope is used to monitor the output voltage of the ESD generator.

3. RESULTS AND DISCUSSIONS

3.1. Analysis of the ESD GUN

To estimate the influence of the socket on the test results, we have to know how much influence the ESD gun itself may produce. The current of ESD has three paths to discharge [6].

1. Discharge from the capacitor between PCB and conducting table.
2. Discharge from the capacitor in power supply.
3. Discharge from the power supply wire.

Firstly, we measured the waveform at five different configurations:

- 1) Normal configuration (shown as Figure 4), ESD gun is configured at 1 kv.
- 2) Turning off the power supply, ESD gun is configured at 1 kv.
- 3) Cutting off the power line of the power supply, ESD gun is configured at 1 kv.
- 4) Cutting off the power line of the PCB, ESD gun is configured at 1 kv.
- 5) Cutting off both power line of power supply and PCB, ESD gun is configured at 1 kv.

During the test, the ESD gun was contacted to the GND layers of the PCB. Each configuration was tested three times and the average value was plotted in Figure 7:

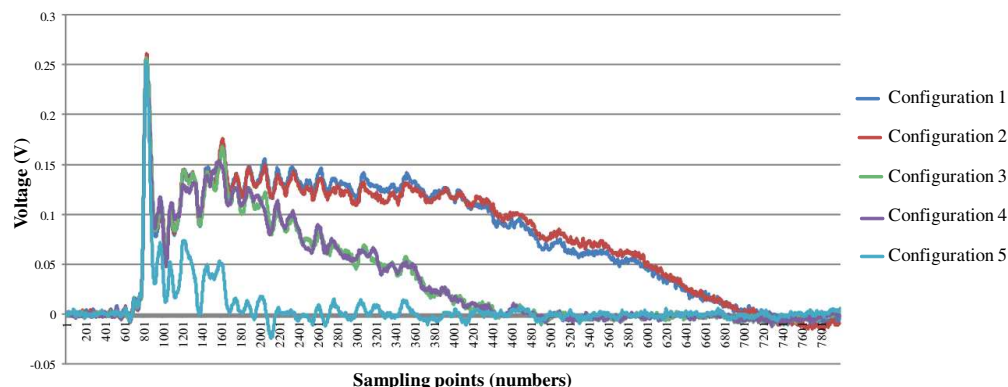


Figure 7: The test results of five different configurations.

The vertical axis represents the voltage (measured by RF current probe) of discharge as the horizontal axis demonstrates the sampling points which are extracted from the oscilloscope (8000 sampling points are extracted). From Figure 7, it can be learned that the results of configuration 1 and configuration 2 are nearly the same. Besides, the results of configuration 3 and 4 are also nearly the same. All the first peak values of the waveforms don't show much difference.

To avoid the effect of the changing test environment, we did another 1002 times of test (configuration 5). During the test the first peak values were measured. From Figure 8, it can be found that 90% of peak values are between 0.243V and 0.258V. So, the biggest D-value percentage is equal to $(0.258 - 0.243)/0.258 = 5.81\%$. Figure 9 shows the statistics of the test results.

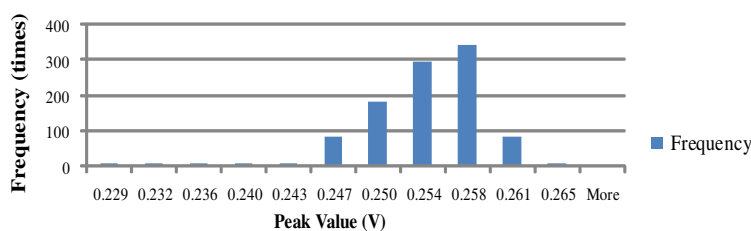


Figure 8: Percentage of the peak value.

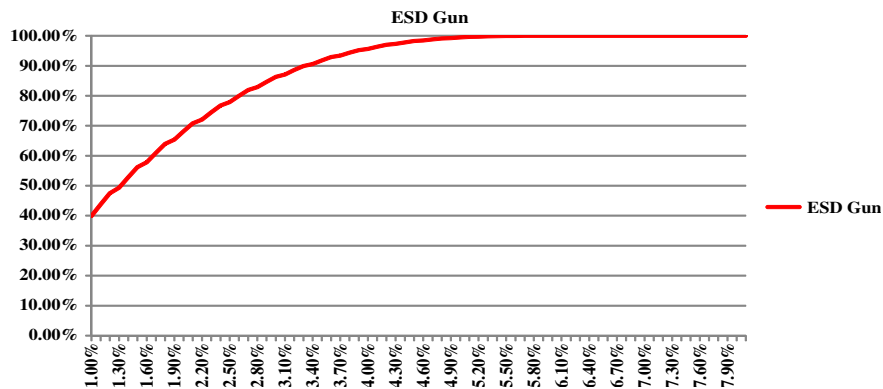


Figure 9: D-value percentage produced by ESD gun.

3.2. Alterations in the Test Results Resulted from the Pan Angle Range of the Printed Circuit Board

In the non-socketed ESD test, the printed circuit board was respectively revolved 0, 45, 90, 135, 180 degree horizontally. It was tested three times for each angle and the voltage is changed from 1 kV to 8 kV (step: 1 kV). 1440 sets of D-value percentage data are obtained from the test. Figure 8 shows the statistics on these test results:

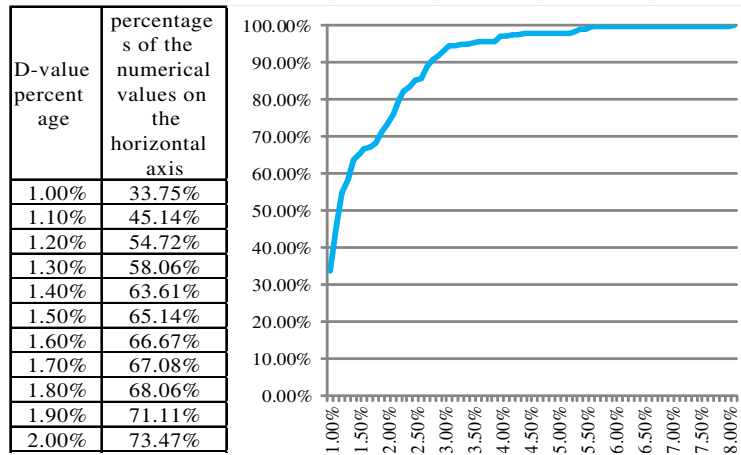


Figure 10: D-value percentage between different angles.

From the raw data and Figure 10 we can see that the D-value percentage is within 5.8%, which is less than 10% (shown in Table 1).

3.3. D-value Percentage between Using with and without Socket

Because we care about the voltage on the pad, the voltage instead of current was measured by the oscilloscope. The first discharge peak voltage was measured and three pins were tested (VSS, VDD and VDD2). Each pin was tested three times at the same voltage level ranging from ± 1 kV to ± 8 kV (step: 1 kV).

After the test, 432 sets of D-value percentage data are obtained. The statistics are shown in Figure 11. The horizontal axis presents D-value percentages ranging from 1.0% to 8.1% as the vertical axis showcases percentages of the numerical values on the horizontal axis (e.g., There are 102 sets of data which are lower than 1.0% in numerical values. So, the numerical value on the vertical axis would be $102/432 = 23.61\%$). “non-socketed” represents “without socket”.

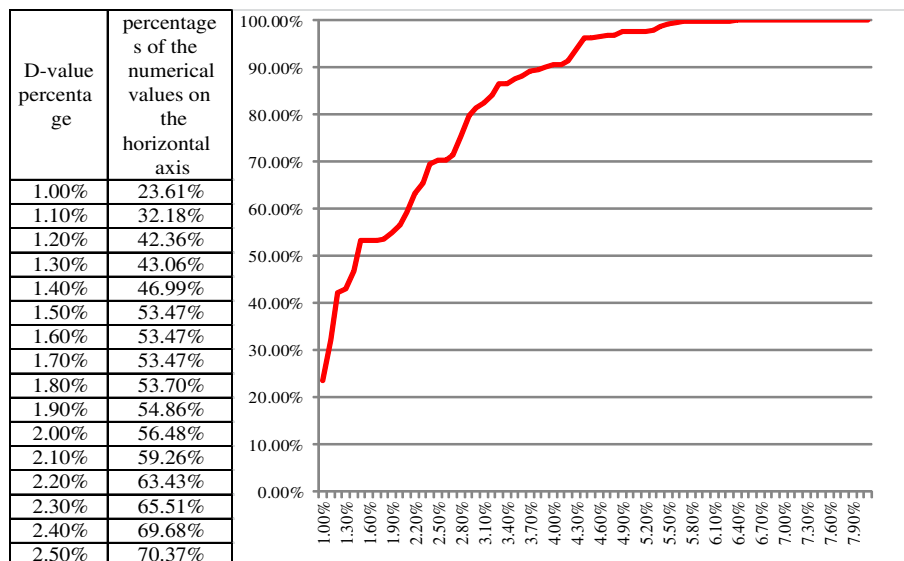


Figure 11: D-value percentage between socketed & non-socketed.

The first peak current of discharge is one of the main reasons that causes the MCU failure and damage. From the Raw data and Figure 11, it can be concluded that the D-value percentage between socketed and non-socketed is within 6.4%. It is less than 10% (shown in Table 1).

3.4. Comparison between Testing with and without Socket

In order to compare all the results above and describe the results more intuitively, Figure 12 is presented as follows. The test results of D-value percentage between 3 tests without using the socket and D-value percentage between 3 tests using the socket is added in this figure, which are not discussed above.

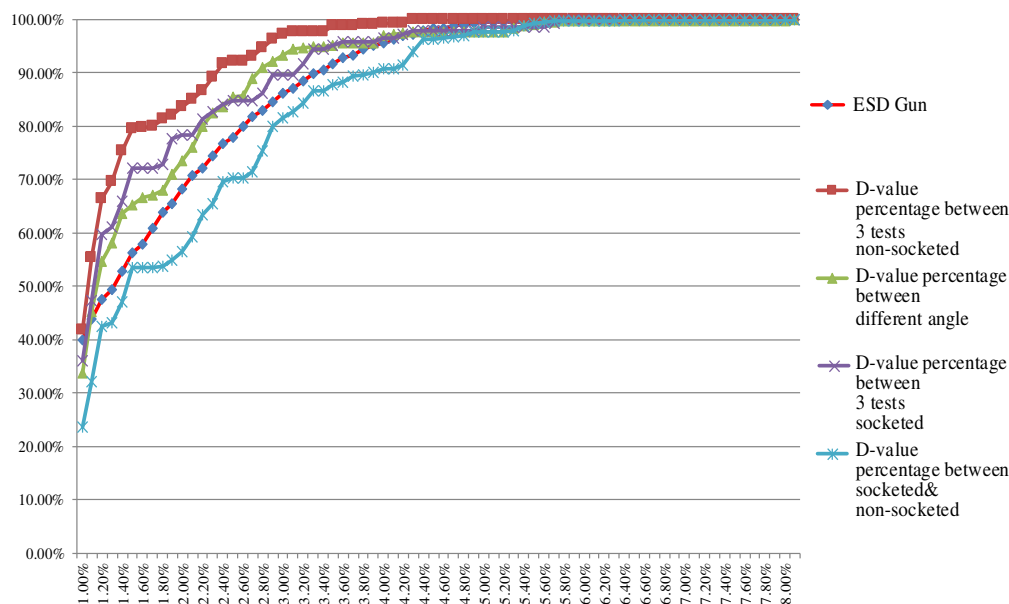


Figure 12: D-value percentage of all the test results.

From Figure 12, it can be seen that D-value percentage between socketed & non-socketed is the worst case. The curve related to ESD Gun is between the worst case and others. It means that the D-value produced by the test itself is inevitable. Statistically speaking, this test result is acceptable.

4. CONCLUSION

From the test results, it can be found that the D-value percentage which the ESD GUN produces is within 5.8%, 3 tests non-socketed is within 4.2%, different angles is within 5.8%, 3 tests by using the socket is within 5.7% and D-value percentage between socketed and non-socketed is within 6.4%. All the results are less than 10%. The test results show a good performance of the socket. Therefore, the socket can be used during the PESD test with little influence on the test results.

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