ESD Risk Assessment Considerations for Automated Handling Equipment

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50 Words Abstract – ESD risk assessment considerations for two units of die attached and wire bonder machines were evaluated with reference to ANSI/ESD SP10.1. Modelling and simulation was proposed and discussed to evaluate the sensitivity of the automated handling equipment ESD performance.

I. Introduction

As technology advances, Automatic Handling Equipment (AHE) considerations for ESD sensitive devices (ESDS) becomes critical, the risk of ESD occurrence increases and thus ESD control and mitigation within an AHE environment becomes increasingly important. AHE are audited regularly to ensure that best practices, stated in ANSI/ESD S20.20 [1] and ANSI/ESD S6.1 [2] are met. By doing so, the likelihood of ESD occurrence will be lower. AHE is audited through performing the required test as listed in ANSI/ESD SP10.1 [3], which acts as a guideline for test personnel. However, on top of [3], other ESD risk assessment considerations should be made so that a thorough AHE ESD assessment can be deduced quantitatively, qualitatively and adequate AHE domain expertise. This paper will discuss the additional ESD assessment reflections that can be proposed when auditing an Automated High Speed Epoxy Die Attach Machine (DA) and a High Speed Wire Bonder Machine (WB).

II. Procedure

A. Resistance Measurement in DA

Prior to conducting the ESD audit, test personnel should be properly grounded as per ANSI/ESD S1.1 [4]. A resistance meter was used, as stipulated in [3], to measure resistance to ground of stationary and moving parts of the DA. The resistance measurements were compared to [1, 2] for ESD risk assessment. Further ESD audit checks, when possible, were done on those that exceeds the required resistance in [1, 2] so that a more thorough evaluation can be made. If further checks were not possible, the resistance measurement will be taken solely to evaluate ESD risk similar to [3]. For this ESD audit the stationary and moving parts that were chosen to be measured were the machine’s Common Point Ground (CPG) and/or AC ground, unloading magazine, pick up head, input pusher and tile pick up arm.

B. Resistance Measurement in WB

Similarly, the method above was repeated for the WB. The parts that were chosen to be measured were the machine’s loading area, gold thread holder, tile clamp, input loader tile pusher, input loader conveyor belt.

C. Voltage Measurement

Referencing to [1], insulators within 1 inch of any ESDS vicinity, the control limit for electrostatic field shall be less than 125 volts. Within six inches of ESDS critical path, all process essential insulators, conductive and static dissipative materials within the vicinity were evaluated. Hence the handheld field meter and non-contact voltmeter were used to measure the tribo-charged voltage of materials within the ESDS critical path. The stationary and moving parts in the machines that exceeded the required voltage limits were checked for compliance too.

III. Results

For Table 1, the parts highlighted in red were those that exceed the required resistance as stated in [1, 2]. The ESD risk for input pusher was evaluated to be low ESD risk even though the resistance measurement value suggested a high ESD risk.

Table 1: Resistance Measurement DA

Part	Resistance (Ω)	Resistance Accepted (Ω)	ESD Risk
Machine CPG	< 1	< 1	Low
Magazine to Ground	1.0E+11	< 1E+9	High
Pick up Head	2.5E+11	<1E+6 (moving), <1E+9 (stationary)	High
Input Pusher	2.2E+11	<1E+6 (moving), <1E+9 (stationary)	Low
Tile Pick Up Arm	1.7E+00	< 1E+6	Low

Table 2: Resistance Measurement WB

Part	Resistance (Ω)	Resistance Accepted (Ω)	ESD Risk
Loading Area	< 1	< 1	Low
Gold thread holder	1.00E+04	<1E+6 (moving), <1E+9 (stationary)	Low
Tile clamp	2.90E+03	<1E+6 (moving), <1E+9 (stationary)	Low
Input loader tile pusher	9.80E+10	<1E+6 (moving), <1E+9 (stationary)	Low
Input loader converyor belt	2.70E+11	<1E+6 (moving), <1E+9 (stationary)	High

Similarly, for Table 2, the parts highlighted in red were those that exceeded the required resistance as stated in [1, 2]. The ESD risk for input loader tile pusher was evaluated to be low ESD risk even though the resistance measurement value suggested a high ESD risk.

Table 3: Tribo-charged Voltage of insulative parts in DA and WB

Part	Tribocharged (V)	Control Limit (V)	ESD Risk
Insulative Strip on Magazine	>200	<125	High
Input Pusher	<-60	<125	Low
Input loader tile pusher	<20	<125	Low

Table 3 shows the tribo-charged voltage of the insulative parts in DA and WB respectively. The ESD risk of input pusher and input loader tile pusher were evaluated to be low ESD risk as the tribo-charged voltage were below the control limit.

IV. Modelling & Simulation

In all AHE, there will be some form of pick and place (PnP) of ESDS from one position to another position. This is no different for DA and WB machines. Figure 1 illustrates a typical PnP with ESDS traversing from P1 to P2 and eventually placing at P3. It is critical for the PnP vacuum pick up head (Vac) resistance to CPG to be as low as possible; to ensure that the charge build up on Vac due to tribo-charging phenomenon will remain minimal.

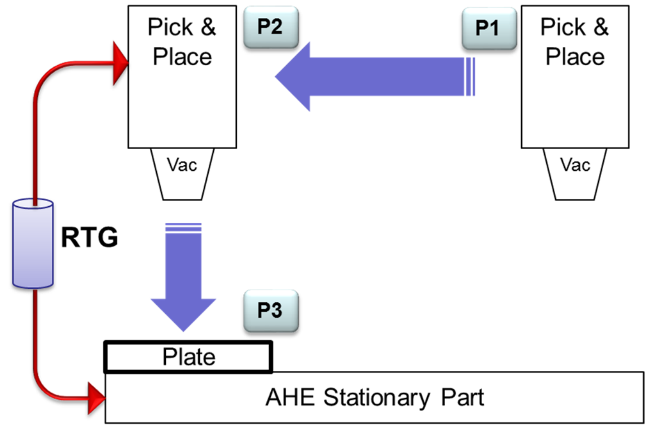

Figure 1 PnP traversing from P1 to P2 and eventually placing ESDS at P3

The moving parts is governed by the equations (1), (2) and (3) from [5].

$$q(t) = q_o e^{t/\tau} \quad (1)$$

$$v(t) = V_o e^{t/\tau} \quad (2)$$

$$\tau = RC \quad (3)$$

$q(t)$ and $v(t)$ denote instantaneous charge and voltage respectively with respect to time. q_o and V_o denotes initiate charge and voltage respectively. τ is the time constant, R is the resistance and C is the capacitance. Hence, at time equal five time constant (i.e. t=5τ) equation (1) and (2) will effective reach 0.7% of its initial value.

The resistance to ground (RTG) measured (P1, P2 and P3) using the high resistance meter, as shown in Figure 1 will play an important role impacting on the time constant. The RTG measured is closely associated to equation (3) to have effective charge decay whilst the Vac is in motion with ESDS. For modelling and simulation, the range of RTG selected is from 1.0xE3Ω to 1.0xE11Ω.

Similarly, the capacitance C will contribute an equally important role in the time constant equation (3). Human Body Model (HBM) and Machine Model (MM) have been published extensively in a variety of literature [6-8]. Hence, the capacitance used in HBM and MM can be associated with the modelling and simulation. Though, MM has been discontinued by JEDEC Solid State Technology Association 2014, publication number 172 [9], the intent for this paper is to study the sensitivity of RTG with respect to the capacitance variability.

In addition, a digital storage scope was attached to the non-contact voltmeter with 8milli-second respond time analogue output studying the speed of a DA mechanical arm traversing to and fro. The round trip cycle time of the DA mechanical arm was determined at 0.2second. This established the critical operation time for the models' analysis.

A. HBM Simulation

Using [7], the HBM model is determined as shown in Figure 2 with source resistance and capacitance of 1.5kΩ and 100pF respectively. Scope 1 measures the transient current with RTG added into the circuit from 1.0xE3Ω to 1.0xE11Ω, which resulted in Figure 3.

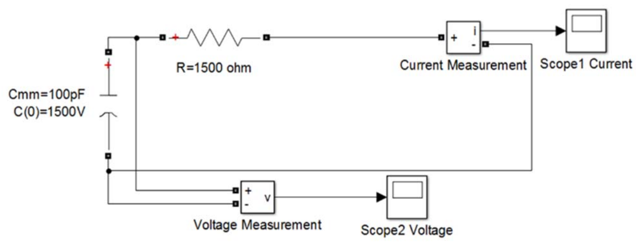

Figure 2 HBM for analyzing charge decay

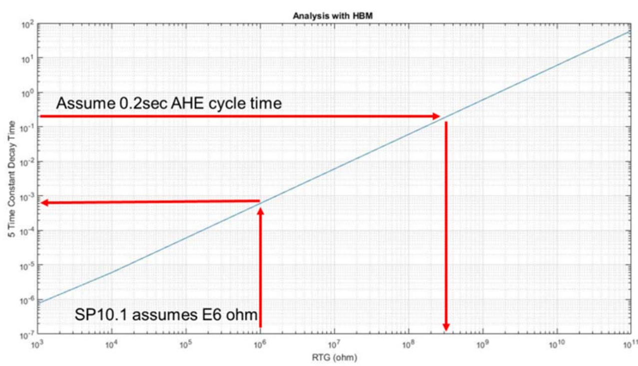

Figure 3 Charge decay time vs RTG analysis using HBM

To maintain RTG at lesser or equal to 1.0E6Ω, the charge decay is less than 1milli-second. Hence, the charge decay is more than two decay less than the AHE cycle time of 0.2second.

B. MM Simulation

Using a modified [6], the MM model is determined as show in Figure 4 with source capacitance of 200pF, source inductance 0.5uH in parallel with resistance of 10kΩ and an initial RTG of 1Ω resistance. Scope1 current measures the transient current with RTG added into the circuit from 1.0E3Ω to 1.0xE11Ω, which resulted in Figure 5.

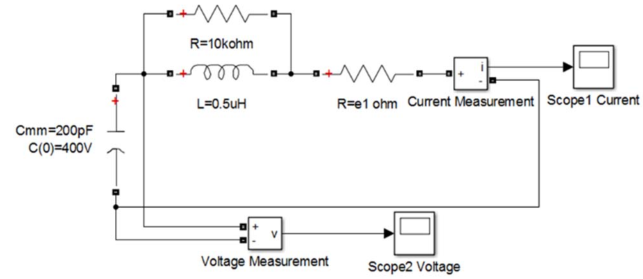

Figure 4 MM for analyzing charge decay

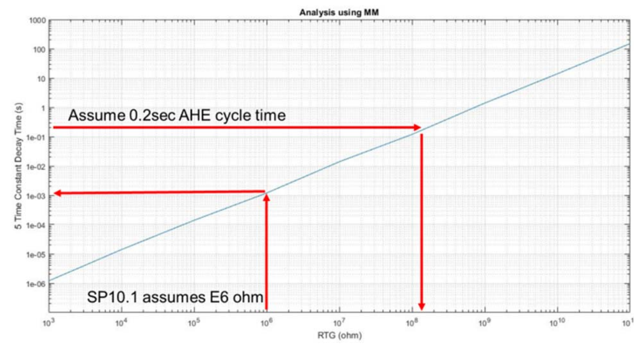

Figure 5 Charge decay time vs RTG analysis using MM

Similarly, to maintain RTG at lesser or equal to 1.0E6Ω, the charge decay is less than 1milli-second. Hence, the charge decay is more than two decay less than the AHE cycle time of 0.2second.

C. Sensitivity Study

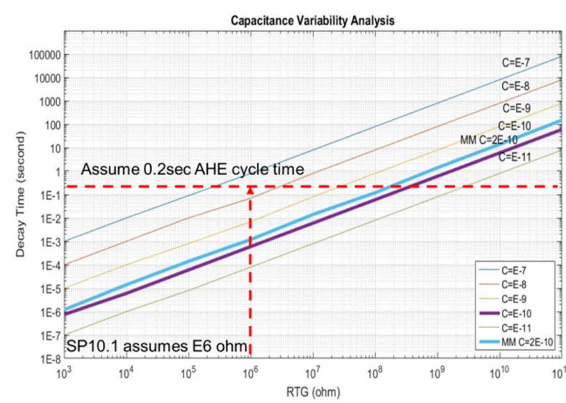

Figure 6 Charge decay time vs RTG analysis with varying source capacitance

HBM and MM model assume a pre-determined capacitance, which is linear time invariant. In this section, the variability of the model source capacitance could impact the charge decay with a varying RTG. The variability of the model source capacitance from 1.0E-7 Farad to 1.0E-11 Farad is shown in Figure 6. With the AHE 0.2second cycle time as the first constraint, the tolerable capacitance is between 1.0E-7 Farad to 1.0E-8 Farad for 1.0E6Ω RTG. Hence, it can be seen that keeping RTG at

1.0E6Ω, the variability of the source capacitance can be two orders larger than the HBM and MM models.

V. Discussion

From the results above, it was observed that some resistance values of certain parts in DA and WB did not comply with the standards in [2, 3]. However, after further assessment was made, some of the parts do not pose a high ESD risk due to a low tribo-charged value. This additional check was not proposed in [3]. However, it would be beneficial in assessing the ESD risk the machine part poses. Certain changes are proposed to help the DA and WB machine to comply with the requirements of [1, 2]. In the DA, it was recommended to change the material of the insulative strip in the magazine to a conductive or static dissipative material, implement ionization or charge control. This will help to reduce the tribo-charged voltage to meet the control limit of less than 125V/inch. The input pusher need not be changed as it only came into contact with the insulative tile and not the ESDS. However continuous monitoring was required to ensure tribo-charged voltage was below the control limit. If that cannot be done, it was recommended to change the material to a conductive or static dissipative material and connected to ground. The recommendations mention will aid to make the DA comply and maintain within the requirement of [1, 2].

In the WB machine, it was recommended that all the input loader conveyor belt, which came into contact with ESDS shall have resistance to ground below 1.0E9Ω. The input loader tile was recommended to have a lower resistance, preferably less than1.0E6Ω, even though the tribo-charged voltage was below the control limit. The recommendations mentioned will help to make the WB machine comply and maintain within the requirement of [1, 2].

Either using HBM, MM or studying the variability of capacitance for RTG from 1.0xE3Ω to 1.0xE11Ω, it is intriguing to read that 1.0xE6Ω RTG the charge decay time meets the requirement of 0.2second AHE cycle time. However, for larger source capacitance, 1.0xE5Ω would be adequate.

VI. Conclusion

The purpose of the paper was to discuss the additional ESD checklists made on top of those stated in [3]. A measurement of tribo-charged voltage of insulative parts of the machine was proposed as an additional check which will help to assess the ESD risk more thoroughly. This also helped test personnel to go beyond the guidelines in [3] and perform other relevant checks to aid them in assessing ESD risk assessment. Recommendations were also proposed to aid in maintaining the AHE so that it complied with the requirements of [1, 2]. An RTG 1.0xE5Ω would satisfy a source capacitance from 1.0E-7 Farad to 1.0E-11 Farad. A combination of quantitative analysis, qualitative analysis and AHE domain experience shall be the key justification factor for ESD risk assessment considerations in any AHE.

References

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