Fan Driver ESD Enhance Solution

Application Note

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ABSTRACT

This application note introduces two different Electrostatic Discharge (ESD) models, Human Body Model (HBM) and system level ESD (IEC61000-4-2). Base on the difference between the ESD models, MPS provides some additional solution to enhance the ESD capability, to protect the fan in system level ESD.

INTRODUCTION

Electrostatic can be accumulated in human body, machine, device and even IC itself, the voltage is extremely high, up to several kV. When electrostatic discharge happens, the high voltage or large discharge current may make IC Electrical Over Stress (EOS) without proper ESD protection.

Human Body Model (HBM) ESD

The electrostatics is accumulated in human body by friction or some other reason, if human body touches IC, the electrostatics would discharge to IC's pin to ground, and it generates several Amperes discharge current in hundreds of nanoseconds. This discharging current may damage IC.

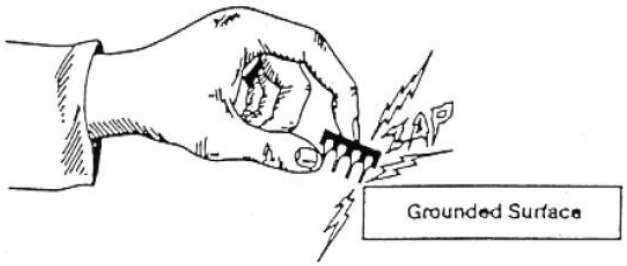

Figure 1: Electrostatic Discharge

Based on JESD22-A114-B, the HBM ESD can be expressed as following figure

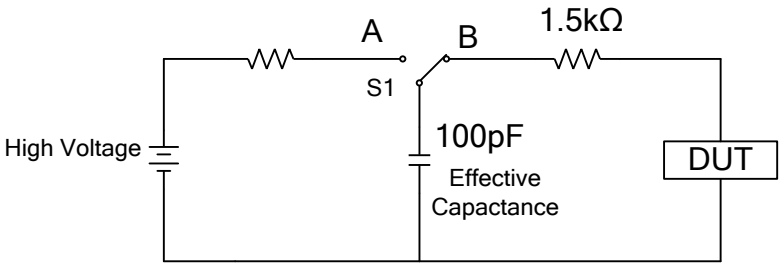

Figure 2: Typical Equivalent HBM ESD Circuit

The effective capacitance (human body equivalent capacitance) is charged by high voltage source when the switch S1 is in A, if the switch S1 is in B, the high voltage discharge to DUT (device under test) through a 1.5kΩ resistor (human body equivalent resistance).

From the equivalent HBM ESD circuit, the peak current of HBM is as follow

Table 1: Peak Discharge Current of HBM ESD

Voltage (kV)	Peak Current (A)
±0.5	±0.33
±1	±0.67
±2	±1.33
±4	±2.67
±8	±5.33

Due to the large electrostatic voltage and large discharge current, the ESD zap circuit is integrated in IC to prevent IC damaged by ESD. With the ESD zap circuit, the peak voltage is clamped, and the discharge current goes through the zap circuit.

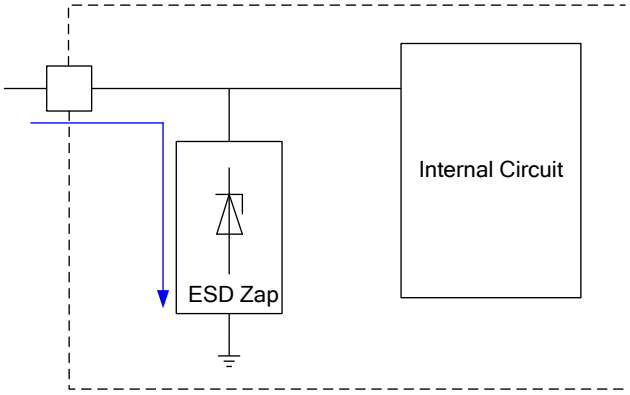

Figure 3: ESD Zap Circuit

System Level ESD (IEC61000-4-2)

Some fan product needs to pass system level ESD test following the IEC61000-4-2. Two different methods, air discharge and contact discharge, the contact discharge is first choice for test, unless contact discharge test is not available. The level and test voltage is shown in table 2

Table 2 ESD Voltage and Level

Contact Discharge		Air Discharge	
Level	Voltage (kV)	Level	Voltage (kV)
1	±2	1	±2
2	±4	2	±4
3	±6	3	±8
4	±8	4	±15

The IEC61000-4-2 set the equivalent circuit as figure 4

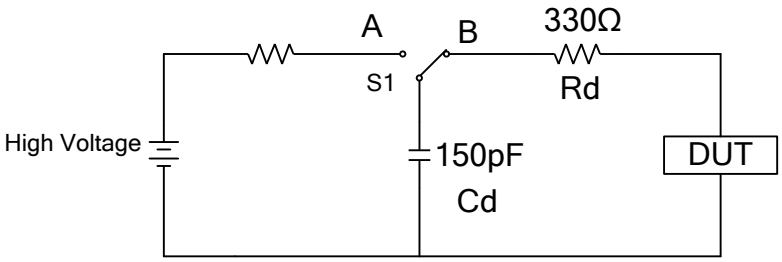

Figure 4 Equivalent Circuit of System Level ESD

Comparing with HBM, the discharge capacitance is larger than human body effective capacitance, and the discharge resistor of IEC is much smaller. Therefore, the peak discharge current of system level ESD is almost 5 time of HBM's. To pass IEC61000-4-2 system level ESD, external circuit may needed to enhance the ESD capability.

Recommended Circuit of System Level ESD

Four wire fan is common in fan products. Usually the four terminals are VIN, GND, FG, and PWM. The following ESD test is needed

1. Apply ESD test between VIN and GND, contact discharge
2. Apply ESD test between PWM and GND, contact discharge
3. Apply ESD test between FG and GND, contact discharge
4. …

Take MP6517B typical application circuit (fig. 5) for example. Because of the large input capacitor, no risk of VIN terminal ESD. However, the FG and PWM terminal don't have such of input capacitors, for ESD consideration, we suggest customer to add external circuit for ESD protection.

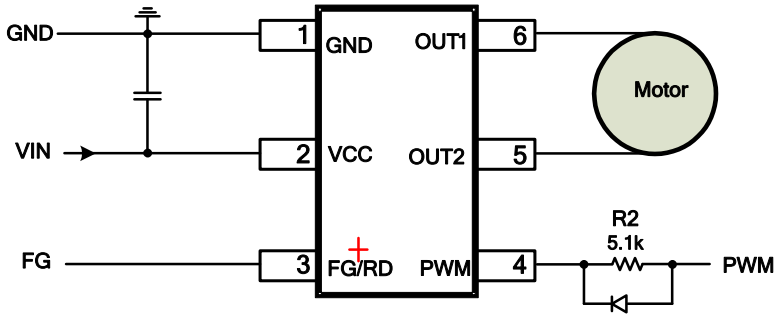

Figure 5 Typical Application Circuit of MP6517B

Two solutions are recommended to pass system-level ESD.

1. Add TVS on FG and PWM terminal as following, the TVS clamps the voltage apply on FG and PWM terminal, prevents the FG/RD pin and PWM pin from being damaged by ESD. A 13V TVS with SOD-123 package is recommended for each terminal.

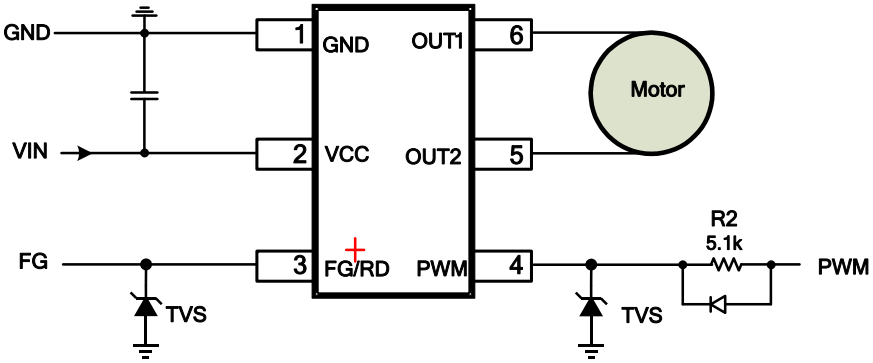

Figure 6 ESD Solution with TVS

2. In additional, if customers also can use a zener diode with a resistor can be used as the following figure 7. A 15V zener diode and a 0603 resistor are recommended for each terminal.

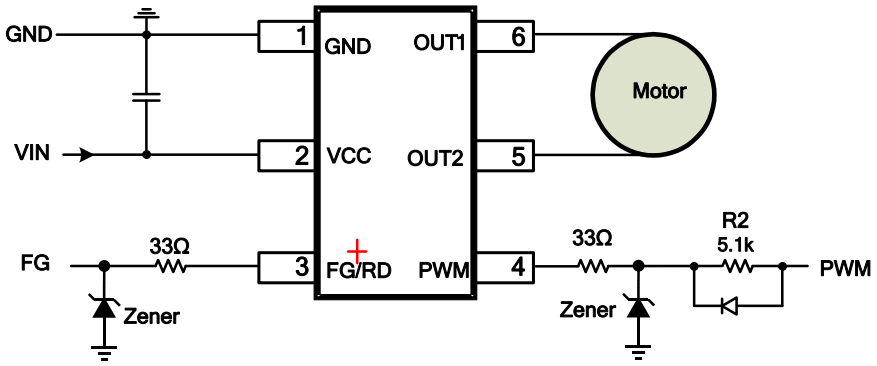

Figure 7 ESD Solution with Zener Diode and Resistor

The test result is showing in table 3

Table 3 Test result with different solutions

	Part Number	Package	ESD Test Result
TVS Solution	SMF13A	SOD123-FL	>=8kV
Zener+Resistor Solution	MM5Z15VT1G	SOD523	>=8kV
	BZT52C15	SOD123	6kV