Improving USB System Reliability With a Transient Suppressor

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ABSTRACT

Existing universal serial bus (USB) system designs contain minimal electrostatic discharge (ESD) protection. Increased system reliability is possible through system immunity to higher ESD levels. This application note discusses the benefits of adding the SN75240/SN65240 /SN65220 universal serial bus port transient suppressor to existing USB designs to improve system reliability and robustness. Device properties, application, and ESD protection are discussed for the SN75240/SN65240/SN65220.

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1 Introduction

The universal serial bus (USB) has become a popular solution to connect PC peripherals. USB allows devices to be hot-plugged in and out of the existing PC system without rebooting or turning off the PC. Because frequent human interaction with the USB system occurs as a result of its attractive hot-plugging ability, there is the possibility for large ESD strikes and damage to crucial system elements. The ESD protection included on the existing hardware is typically in the 2-kV to 4-kV range for the human body model (HBD) and 200-V to 300-V for the machine model (MM). The ESD voltage levels found in a normal USB operating environment can exceed these levels. The SN75240/SN65240/SN65220 (‘220/240) will increase the robustness of the existing USB hardware to ESD strikes common to the environment in which USB is likely to be used.

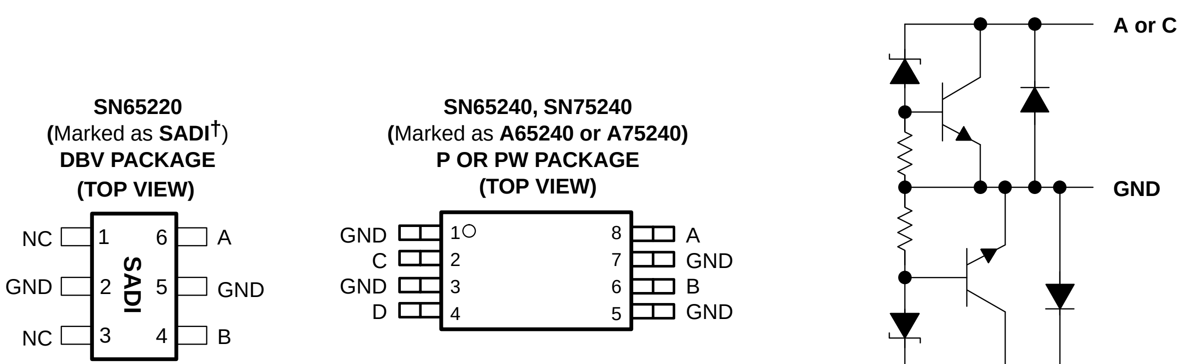
2 The SN75240/SN65240/SN65220 USB Transient Suppressor

The ‘220/240 USB port transient suppressor provides additional transient voltage protection for a USB port. USB port hardware typically is implemented in 3V or 5V digital CMOS with some level of built-in ESD protection. However, voltage transients of sufficient magnitude and duration can penetrate the on-chip ESD protection and damage the USB port hardware. The ’220/240 protects submicron 3-V or 5-V silicon from voltage transients and applies to high- and low-speed USB, hub, or peripheral ports.

3 Application

The schematic and package pin-out for the ‘220/240 are included in Figure 1. The SN65220 contains a single-port suppressor, and the SN65240/SN75240 contain dual-port suppressors. For the ‘240, pins 2, 4, 6 and 8 provide inputs to the two suppressors, and pins 1, 3, 5 and 7 are grounds for the device package. For the ‘220, pins 6 and 4 are inputs to the suppressors, and pins 2 and 5 are ground. The schematic in Figure 1 is for the ‘220 and shows both suppressors connected to the same ground. The ‘240 has two of the circuits pictured in Figure 1.

The multiple ground pins are provided to lower connection resistance to ground. In order to improve circuit operation, a connection to all ground pins must be provided on the system printed circuit board. Without proper device connection to ground, the speed and protection capability of the device will be degraded.



NC – No internal connection
† When read horizontally, pin 1 is the bottom left pin.
NOTE: All four GND terminals should be connected to ground.

Figure 1. Device Packages and Internal Schematic

Figure 2 illustrates a typical USB system and application of the ‘220/240. Connections to pin A from the D+ data line, pin B from the D– data line, and the device grounds from the GND line that already exists are all that are necessary to increase the amount of ESD protection provided to the USB port.

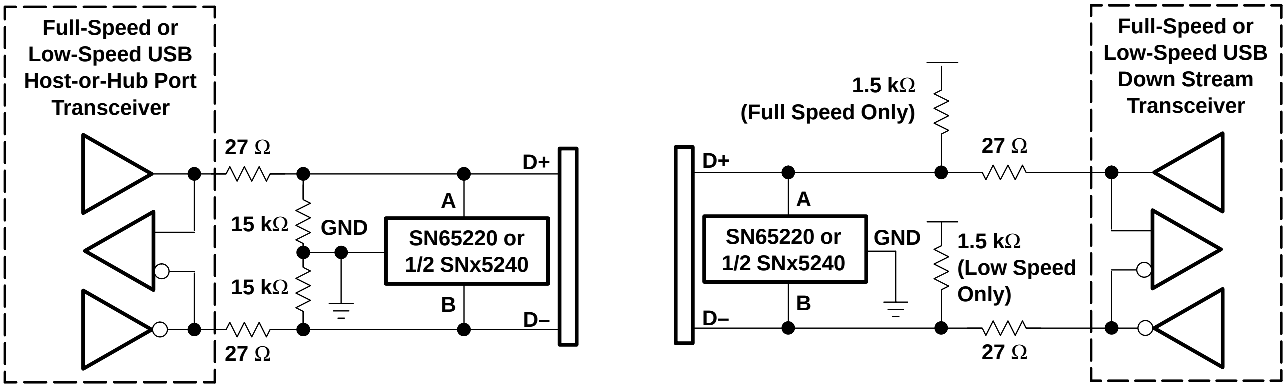


Figure 2. Application Schematic

The design of the suppressor gives it very low maximum current leakage of 1µA, a very low typical capacitance of 35 pF, and a stand off voltage minimum of 6 V. Because of these levels, the ‘220/240 devices will provide added protection to the USB system hardware during ESD events without introducing the high capacitance and current leakage levels typical of external transient voltage suppressors. ‘220/240-device addition is beneficial to both full-speed and low-speed USB 1.1 bandwidth standards.

4 ESD Protection

USB peripherals are attractive to users because of the ability to plug and unplug necessary USB peripherals at will without turning off the PC or re-booting the operating system. Most PCs are used in an office or home environment with little or no protection from ESD strikes, and therefore a robust system design is necessary to withstand the possible ESD events. ESD events can be simulated by testing the system with the following ESD models: HBM, MM, and IEC1000-4-2 compliance test.

The HBM accurately simulates one of the most common causes of ESD damage. When one moves around or walks across a floor, electrostatic charge accumulates on the body. Any contact with the pins on a device allows that accumulated charge to discharge, possibly causing damage to the internals of the device. This test is important because of the frequent human interaction with the USB port on the PC. The ‘220/240 was tested for HBM suppression, and demonstrates transient protection through 15 kV.

Another ESD event is the MM discharge. It is similar to the HBM, but is different in that it simulates a strike from a charge conductive object like a metal surface instead of a charged resistive object like a human. This model simulates the USB system environment by simulating a discharge from a charge conductive object that would come into contact with the bus pins of the USB system like the charged cable of the system bus. The ‘220/240 was tested to MM suppression. The sample parts tested protected through 4 kV. (The data sheet specifies a MM protection of 2 kV)

The final test related to the USB system is the IEC1000-4-2 specification test. It tests the system latch-up (freezing and unresponsiveness) due to transient ESD strikes to the system bus while the system is active. The results from this test are almost entirely dependent upon system design. The HBM and MM tests are done on the individual devices themselves; the IEC1000-4-2 test is a system level test.

IEC1000-4-2 testing was administered by attaching a Texas Instruments USB2036 USB evaluation module to a working USB system and discharging both air and contact discharges into the shielding around the USB system bus cable connectors. The system had to survive a particular voltage level for a minimum of ten strikes to each system bus cable connector.

The test method employed to determine IEC1000-4-2 specification performance measures the characteristics of the evaluation module, not the peripherals attached downstream. Failure was determined to be the point where the USB evaluation module latches up and freezes USB system operation. During testing, the electronics in the connected peripherals intermittently latch up and freeze operation of the system. If unplugging and plugging these peripherals back into the system without resetting the evaluation module allows functionality of those peripherals to return, then the evaluation module has passed the test. Unplugging and plugging the peripherals is allowable because it does not reset the evaluation module. It allows the frozen (latched-up) peripheral to return to a functional state. This proves that the evaluation module is sufficiently protected for that ESD level.

5 Test Results

Tests for the IEC1000-4-2 specification were performed on the TI USB2036 USB evaluation module with and without the ‘220/240 transient voltage suppressor implemented on the PCB. Compliance with the IEC1000-4-2 Specification at the component level does not assure compliance of the equipment.

The ‘220/240 improved performance for the IEC1000-4-2 specification for susceptibility of the system to latch-up in the case of the TI USB2036 evaluation module. No degradation in the susceptibility level or functionality of the system was detected by including the ‘220/240 on the evaluation board. Table 1 displays the results from the IEC1000-4-2 testing on the evaluation module. Table 2 displays the results of the HBM and MM tests. This shows that an increase in ESD protection up to 15 kV for HBM and 4 kV for MM is possible with the addition of the ‘220/240 transient voltage suppressor to USB system architecture.

Table 1. Test Results for IEC1000-4-2

TEXAS INSTRUMENTS EVALUATION MODULE	WITHOUT SN75240	WITH SN75240
USB2036	Passes = 2 kV	Passes = 8 kV

Table 2. HBM and MM Component Test Results

TEXAS INSTRUMENTS TRANSIENT VOLTAGE SUPPRESSOR	HUMAN BODY MODEL	MACHINE MODEL
SN75240	Passes = 15 kV	Passes = 4 kV
SN65220	Passes = 15 kV	Passes = 4 kV

6 Conclusion

The ESD protection included on typical USB devices ranges from 2 kV to 4 kV for the human body model and from 200 V to 300 V for the machine model. The ESD voltage levels found in a normal USB operating environment can exceed these levels and possibly damage system hardware. The ‘220/240 transient voltage suppressor can improve the human body model to 15kV protection and the machine model to 4 kV of protection. Depending on the USB system design, the ‘220/240 also can improve system susceptibility to latch-up. Adding the ‘220/240 transient voltage suppressor increases the robustness of the existing USB hardware to ESD strikes by providing another path for ESD strikes to travel to ground.

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