Application Report
SLVA800–July 2016

Effective System ESD Protection Guidelines TPS251x USB Charging Port Controllers

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ABSTRACT

IEC 61000-4-2 electro-static discharge (ESD) protection of USB charging ports is a necessary system requirement for most products. The USB D+ and D– signals from the charging port controller make direct contact with a potentially charged USB cable and the discharge of energy from the cable to the product can damage the controller. The controller D+, D–, and even VBUS signals must have some form of ESD protection added to the application circuit. This document discusses the design and printed circuit board (PCB) layout of the ESD protection circuitry.

1 Description

The TPS251x family (TPS2511/11Q1, TPS2513/13A/13AQ1, TPS2514/14A/14AQ1) of USB charging port controllers do not incorporate internal IEC 61000-4-2 ESD protection. In order to meet IEC 61000-4-2, level 4, external circuitry must be used. In some cases, protection of the D+ and D– signals starts with a transient voltage suppressor (TVS) and may include a choke. Protection of VBUS can usually be accomplished through the use of the USB-required VBUS capacitor, C_{PORT}. The basic protection scheme is shown in Figure 1.

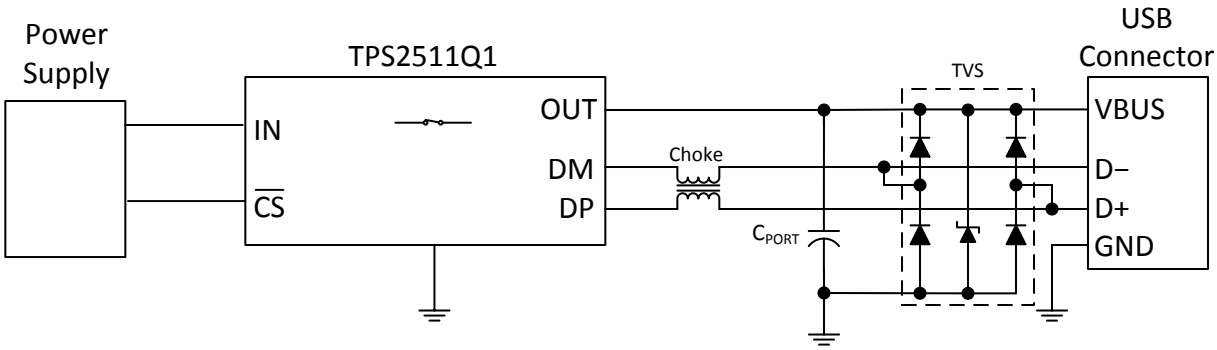

Figure 1. Basic USB ESD Protection Circuit

2 Choosing the TVS

The absolute maximum voltage rating of the TPS251x DP_IN and DM_IN pins with respect to GND ranges from –0.3 V to the lower of V_{IN} + 0.3 V or 5.7 V. For example, if V_{IN} = 5 V, then the maximum rating is 5.3 V. The TVS should clamp the voltage on DP_IN and DM_IN within this voltage range for reliable operation in the presence of ESD surges.

The TVS configuration shown in Figure 1 is one example of an ESD diode array which can clamp D+ and D– between GND and VBUS. The TPD2E001 is used on TPS2513EVM-527 and benefits from the connection of the TPD2E001 VCC pin to VBUS (and C_{PORT}). For this case, the clamping voltage between GND and VBUS depends on the forward voltage drop of the clamping diodes at peak surge current.

There are alternative options such as the TPD2E2U06 which rely on the clamping voltage of the internal clamp only and do not benefit from a connection to VBUS (and C_{PORT}). An example is shown in Figure 2. The internal clamping voltage of this configuration may not protect the TPS251x as the clamping voltage is above the absolute maximum voltage rating of the TPS251x DP_IN and DM_IN pins.

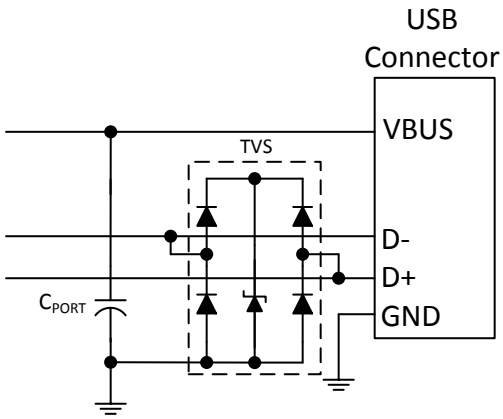

Figure 2. Clamp Type USB ESD Protection Circuit

3 Data Line Choke

In some cases where the signal trace length is far away from the USB connector and TVS, a data line choke such as Coilcraft 0805USB-372ML or Wurth 744231371 may be used. This can provide additional ESD margin above IEC 61000-4-2, level 4 (±8-kV contact and ±15-kV air discharge). The data line choke also helps suppress EMI generated by the local dc/dc converter.

4 PCB Layout and Routing

4.1 TVS Placement and Hookup

The TVS should be placed close to the downstream USB connector so that ESD energy is shunted back to chassis ground before it can find a discharge path within the internal circuitry of the end product. The TVS should be directly connected to the TPS251x DP_IN/DM_IN pins without any vias. Placing the TVS on the same side of the PCB as the TPS251x can help minimize any impedance between the TVS pin and TPS251x pin. Figure 3 shows a poor, good, and best method for connecting the TPS251x, TVS, and USB connector.

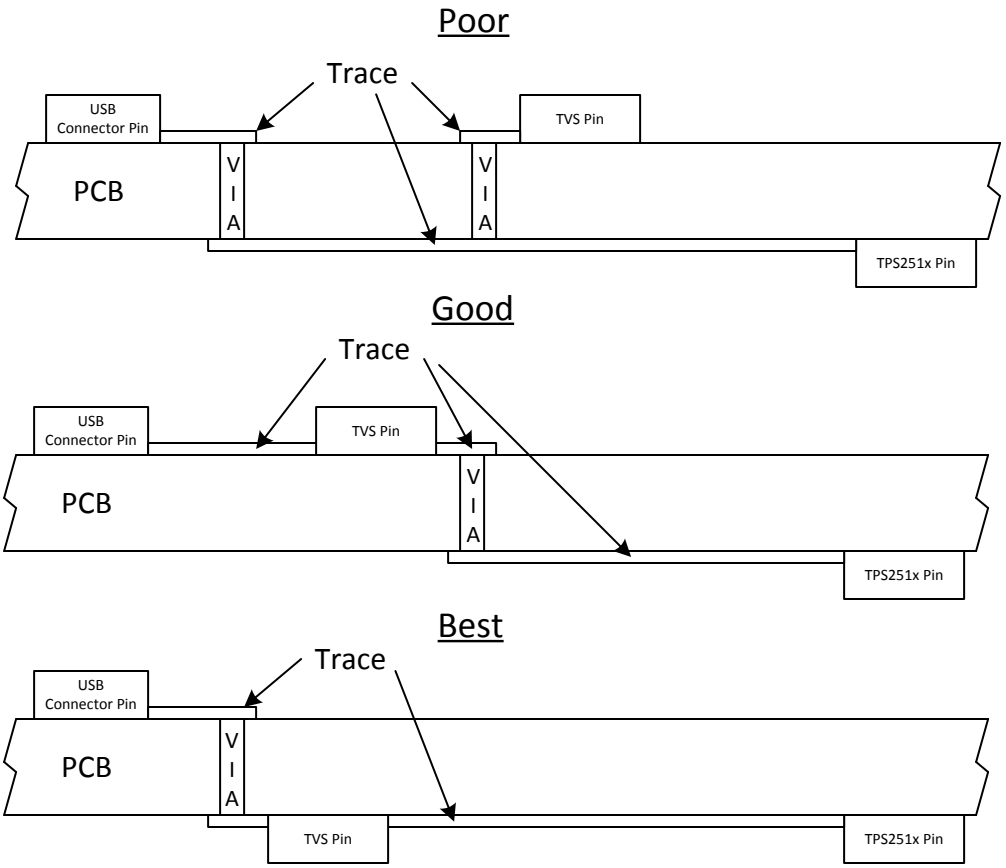

Figure 3. Examples of TVS Placement and Connectivity

Use a heavy connection from TVS, VCC, and GND pins to VBUS and ground plane, respectively. Use multiple vias to make the connection when VBUS and ground are on internal layers.

5 Extended ESD Performance

For a dedicated charging port, ESD performance can be extended beyond level 4 because there are no high-speed USB signal integrity concerns. The configurations shown in Figure 4 have been tested successfully up to ±12-kV contact and ±20-kV air discharge.

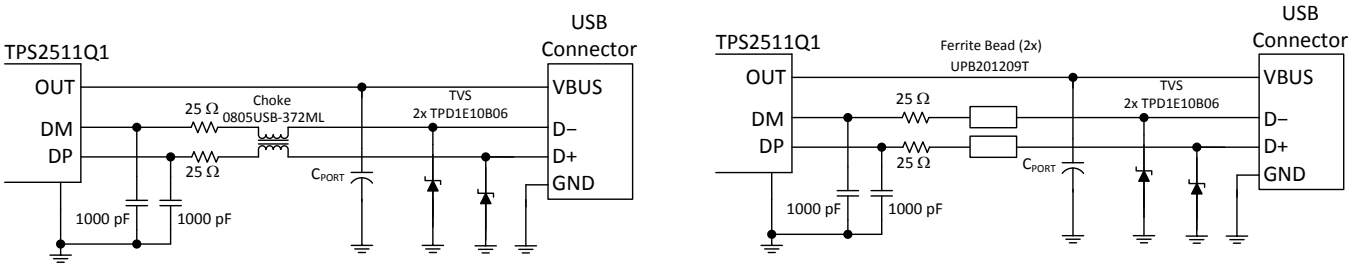

Figure 4. Extended ESD Protection Circuit Examples

6 Conclusion

The guidelines in this application report provide a robust solution for ESD suppression in USB charging based devices. Protection up to and above ±8-kV contact and ±15-kV air discharge are achieved by proper PCB layout and choice of the TVS. Additionally, two examples are shown which can extend ESD performance beyond level 4.

7 References

1. Data Sheet: TPS2513 USB Dedicated Charging Port Controller (SLVSBY8)
2. Application Report: *ESD Protection Layout Guide* (SLVA680)
3. Application Report: *Design Considerations for System-Level ESD Circuit Protection* (SLYT492)
4. User Guide: TPS2513EVM-527 (SLVU910)

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