USB-C Power Delivery Data Lines Demand Enhanced Protection

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Abstract

USB Type-C and USB-C power delivery raise voltage and power levels. A new reversible connector with a tighter pin pitch than that of the USB Micro-B increases the risk of short circuits. In conjunction with the ever-increasing complexity of portable devices, this leads to enhanced electrostatic discharge (ESD), surge, and overvoltage (OV) protection requirements. This article presents a design solution that has a compact, full-featured protection IC. This lowers the BOM and takes up less space on the PCB.

Introduction

The USB Type-C® (USB-C) cable and connector specification makes it easy to link and power electronic gadgets, such as digital cameras and ultrathin tablets (Figure 1). The specification supports USB-C charging applications up to 15 W. The USB-C power delivery (PD) extends charging up to 100 W and includes interchangeable charging across a wide variety of devices.

With USB Type-C connectivity, there are new design challenges in protecting the system. The new connector has a smaller pitch than that of the USB Micro-B, which leads to increased risk of mechanical shorts to V_{BUS}. Additionally, due to the high voltages associated with USB PD, more robust protections are needed. And finally, the ever-increasing complexity of the electronic loads demand enhanced protection from ESD and voltage surges. This article reviews the USB Type-C PD architecture and the challenges associated with D+/D– data signal protection. It then proposes a highly integrated 2× SPDT switch that can address these challenges with minimum BOM and PCB occupancy.

Figure 1. A digital camera connected to a tablet via a USB-C cable.

USB-C PD System

Figure 2 illustrates a typical portable power management device front end equipped to connect to a USB-C cable and powered by a lithium-ion (Li+) battery.

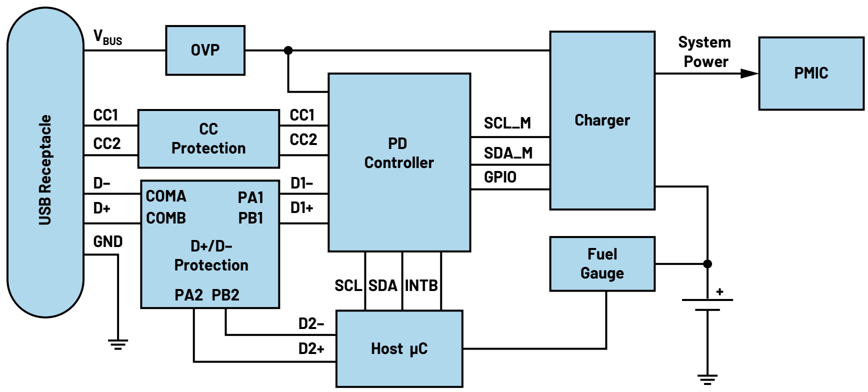

Figure 2. The USB PD power management system.

When the V_{BUS} is present, it powers the charger, the system, and the rest of the blocks. In this phase, the battery is charged. When the V_{BUS} is disconnected, the battery powers the system. With the USB-C cable, the CC1 and CC2 pins determine port connection, cable orientation, role detection, and port control. The D+/D– lines are the standard USB-C communication lines handling data with a speed of 480 Mbps and are protected by the D+/D– protection device. The PD controller implements the power delivery protocol.

The Protection Challenge

Electric surges and ESDs in a power supply are common and can interfere with or cause damage to electronic loads and equipment. The transfer of static electrical charge from a body to an electronic circuit causes ESD. ESD is a big concern for handheld electronics. Electrical surges can be caused by lightning or induced by long cables laying in proximity of a lightning strike. Switches or relays can cause surges during on and off operation. A load dump is a surge generated by cutting the battery connection off on an automobile. A good data line protection IC should offer adequate protection without significant data degradation.

Integrated Solution

As an example, the MAX20334 is a 2× SPDT switch with overvoltage protection intended for use with portable devices (Figure 3). The IC protects the downstream data line from a high voltage short, ESD, or surge event. It combines low on-capacitance and low on-resistance necessary for high performance switching applications in portable electronics. The IC features internal positive overvoltage and surge protection. The device handles USB low/full/high speed signaling and operates from a 2.7 V to 5.5 V supply. It is available in a 12-ball (1.23 mm × 1.63 mm) wafer-level package (WLP) and operates over the –40°C to +85°C extended temperature range.

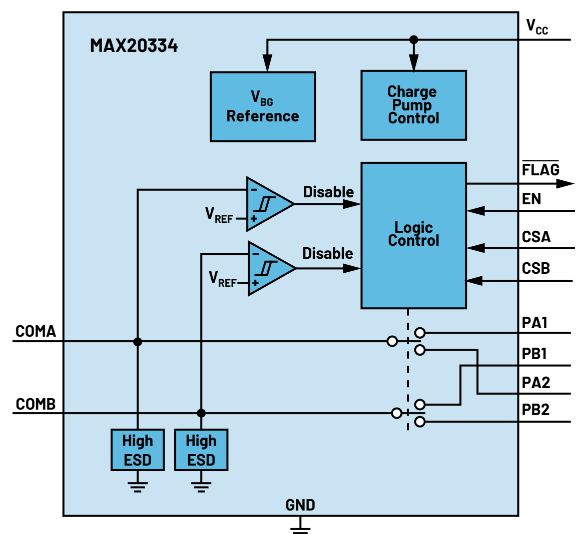

Figure 3. A 2× SPDT switch with extended protection.

Extended Protection

ESD protection structures are incorporated on all pins to protect against electrostatic discharges up to ±2 kV (human body model) encountered during handling and assembly. COMA and COMB (Figures 2 and 3) are further protected against ESD up to ±15 kV (human body model), ±15 kV (air gap discharge method described in IEC 61000-4-2), and ±8 kV (contact discharge method described in IEC 61000-4-2) without damage. The ESD structures withstand high ESD, both in normal operation and when the device is powered down. After an ESD event, the IC continues to function without latch-up. The IC is surge-protected from –30 V to +45 V (IEC 61000-4-5) and overvoltage protected up to +20.5 V.

Figure 4 compares the PCB layout of this highly integrated, extended protection solution with a typical competitor device offering positive-only surge protection and lower OV and ESD protections. The latter will require additional circuitry to meet ESD/surge/OV specifications, leading to a more costly BOM and a 5× bigger PCB active area occupancy.

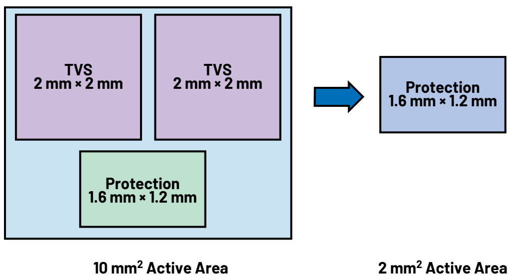

Figure 4. Extended protection advantage.

Data Integrity

The eye diagram in Figure 5 shows at a glance the good level of integrity of the data signal. The curved blue lines maintain a close-to-maximum distance from the forbidden red zone. The high bandwidth of the protection IC causes a minimum slowdown of the signal rise and fall times and jitter, resulting in a good margin for error. This is important to pass USB compliance tests.

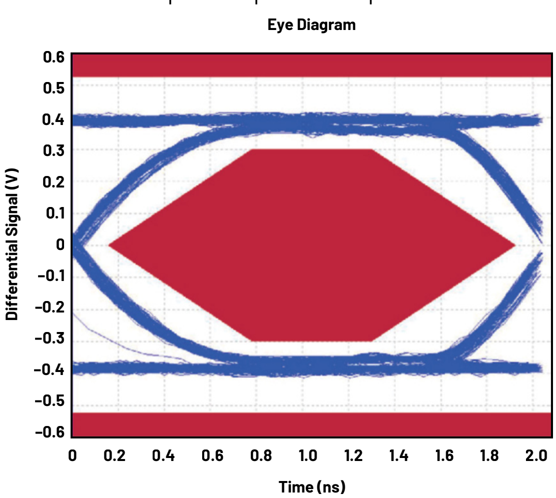

Figure 5. D+/D– eye diagram.

Conclusion

With USB Type-C come new challenges in interconnecting, powering, and protecting our electronics. The new connector has a smaller pitch than that of the USB Micro-B, leading to an increased risk of mechanical shorts to V_{BUS}. Additionally, due to the high voltages associated with USB PD, more robust protections are needed. And finally, the ever-increasing complexity of the electronic loads demands enhanced protection from ESD and voltage surge. An enhanced protection device with up to ±15 kV ESD, –30 V to +45 V surge, and +20.5 V overvoltage protection can protect data lines and meet ESD/surge/OV specifications while lowering BOM costs.

About the Authors

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