Technical Article

Power Tips: How to Protect a USB Type-C Controller from Legacy Adapters

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Other Parts Discussed in Post: TPD2S300

In the last couple of years, more and more portal devices such as notebooks and smartphones have employed USB Type-C™ as the interface port. The USB Type-C connector is a totally new USB connector. It has a set of great profile, power rating and data transmission speed improvements. But the most important change about this charging protocol is that USB Type-C introduces a new pin, the configuration channel (CC) pin, to negotiate between different devices.

Legacy adapters use D+/D– lines to perform a handshake between two devices. The most common legacy adapters, as shown in Figure 1, usually have a Type A port as output so that different cables can be match with different phones; for example, an A-uB cable for Android phones, an A-lighting cable for iPhones, etc. USB Type-C also has an A-C cable so that it can be charged by legacy adapters.

Figure 1. A Legacy USB Adapter

To give users the best usage experience, some USB Type-C product manufacturers have designed their USB Type-C products to support both the new USB Type-C charging protocols via CC as well as existing charging protocols. Employing D+/D- in current USB products, some of the charging protocols cannot be used for USB Type-C connectors (see Section 4.8 of the USB Type-C Cable and Connector Specification, Revision 1.2).

There lies the problem. A USB Type-C connector has an A-C cable to be compatible with legacy adapters and there is an internal pull-up resistor (Rp) inside the USB Type-C plug (see Section 3.5 of the USB Type-C specification) to enable the detection of a USB Type-C device. Once there is a DC voltage existing at V_{BUS} and the USB Type-C plug is inserted to the USB Type-C device, V_{BUS} will pull up the voltage level of the CC pin to notify the USB Type-C controller, as shown in Figure 2.

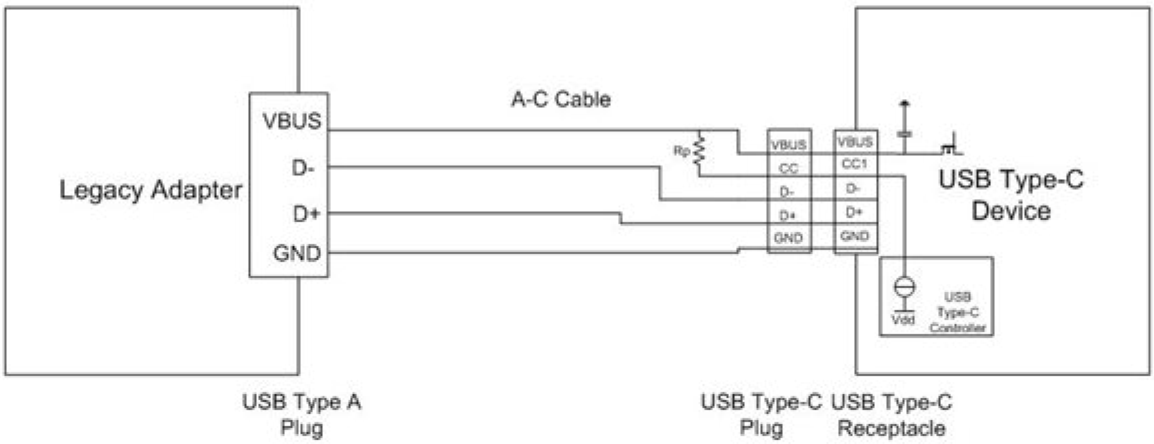

Figure 2. Legacy Adapter to a USB Type-C Product Connection

Even the fast –charging protocols such as QC are not compatible in a USB Type-C connector, the irregular USB Type-C products, as mentioned above, are still going to support these high voltage protocols. In this case, the V_{BUS} may increase to 9V or 12V after a successful handshake with a legacy adapter via D+/D- lines. This high voltage will be applied to the CC pin of the USB Type-C controller via Rp. Unfortunately, the most common USB Type-C controllers cannot handle such high voltage, because it is out of the USB Type-C specification. To prevent the USB Type-C controller from being damaged in the case of being tied to VBUS via Rp requires a compliant USB Type-C device.

One simple way to protect the USB Type-C controller is to add a Zener diode between the CC pin of the USB Type-C controller and ground. This Zener diode can clamp the CC line's voltage within a safe range. But I need to highlight two things:

- The clamping voltage of the Zener diode should be higher than the normal voltage of the CC pin and lower than the maximum rating voltage. But because a Zener diode's breakdown voltage always varies with its own current (in this case, proportional to the V_{BUS} voltage) and temperature, selecting a proper Zener diode won't be easy.
- The current flowing from V_{BUS} to ground via the Zener diode brings additional losses. This current may be up to several milliamps in the worst case (given that V_{BUS} may be up to 20V and Rp is lower than 10KOhm).

Another way to protect the USB Type-C controller is to use a blocking field-effect transistor (FET) , labeled as QB in Figure 3,QB to isolate the USB Type-C controller from V_{BUS}. The QB is inserted between the USB Type-C receptacle and USB Type-C controller. It can be off when an overvoltage event occurs at the CC pin of the USB Type-C receptacle so that the USB Power Delivery controller does not see such a high voltage. However, this will bring an additional path consisting of a pull-down resistor (RD in Figure 3) and its control FET (QD in Figure 3). QD will be ON to perform the RD on CC pin in the event of a dead battery. The additional logic circuit for QD may also sacrifice some board space.

A good choice is to adopt a USB Type-C port protection integrated circuit (IC) such as the TPD2S300, which integrates all of the necessary functions for a USB Type-C device. This IC requires no additional protection and logic circuitry. Electrostatic discharge (ESD) protection is integrated as well. Figure 3 shows a typical circuit using the TPD2S300.

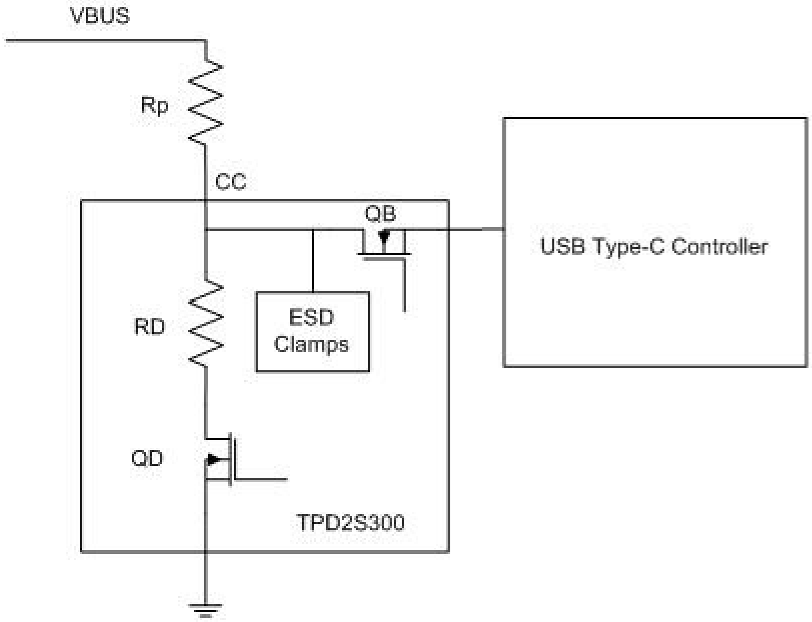

Figure 3. TPD2S300 Circuit for the CC Pin

To protect the USB Type-C devices, such as power banks or smartphones, from irregular adapters or chargers on the market, additional protection for the USB Type-C port is necessary with Zener diodes, blocking FETs or protection ICs.