Transition Existing Products from USB 2.0 OTG to USB Type-C™

TEXAS INSTRUMENTS

Michael Campbell
Systems Engineer
High Speed Interface
Texas Instruments

Transition your existing USB 2.0 On-The-Go (OTG) products with a micro-A/B receptacle to a Type-C receptacle using the USB Type-C™ specification.

The daunting task of analyzing the USB Type-C™ one hundred-plus page specification with references to other specifications like USB Power Delivery (PD), which is over 500 pages, in order to determine what changes are needed can be overwhelming. This paper details the minimum requirements of progressing from a USB 2.0 OTG product to a USB Type-C-compliant product.

Introduction

The USB Type-C™ cable, receptacle, and plug are designed to be more robust and user-friendly than existing USB cables (micro-A, Type-A and Type-B). Currently, for example, Type-A plugs only connect in one position to a Type-A receptacle. Type-C, however, allows you to plug in devices either upside down or downside up. This simple change eliminates the frustration of incorrectly inserting USB devices into a USB port.

With USB products consuming more power from V_{BUS} and the desire for faster charging, the USB Type-C standard enables power delivery to support products of today and well into the future. To take advantage of Type-C benefits, companies need to change their existing products to meet the Type-C standard. How to go about this process can be a formidable task, but it doesn't have to be that way. By following information detailed in this paper, you can easily transition your products.

USB 2.0 OTG

A USB 2.0 On-The-Go (OTG) product is a portable device, such as a cell phone or tablet, that can function either as a USB host or a USB peripheral. All USB 2.0 OTG products are required to use a micro-A/B receptacle. A portable product implementing USB 2.0 OTG determines its role as either a host or a peripheral by the state of the ID pin. With the ID pin at ground (GND), the OTG product functions as a USB host and provides V_{BUS} to the attached USB peripheral. Otherwise, the OTG device functions as a USB peripheral.

Table 1 shows the pin-out for both receptacle and plug. The plug's ID pin is either grounded or left unconnected to select either host or peripheral functionality.

Pin No.	Micro-A/B receptacle signal name	Micro-A plug signal name	Micro-B plug signal name
1	V_{BUS}	V_{BUS}	V_{BUS}
2	D–	D–	D–
3	D+	D+	D+
4	ID	ID tied to GND	ID unconnected or connected to GND through greater than 100K resistor.
5	GND	GND	GND

Table 1. Micro-A/B receptacle and plug pin assignment

When acting as a USB peripheral, the portable USB 2.0 OTG product monitors V_{BUS} to determine when it is connected to a USB host or external charger (for example, a cell phone plugged into a wall charger). By using USB battery charging 1.2 (BC1.2) or a proprietary method, a portable product can request higher than the USB 2.0 default of 2.5 Watts to enable faster charging times.

USB Type-C

The USB Type-C specification defines a receptacle along with a cable that allows users to plug in their products and cables without caring about the connector's position (upside down or downside up). The cable can have the same Type-C plug on each end of the cable or, if desired, have a legacy USB plug (micro-A, Type-A or Type-B, to mention a few) on one end of the cable. In order to accommodate higher bandwidth applications, the USB Type-C specification adds multiple USB 3.1 pairs to the connector.

Figure 2 shows the receptacle pin assignment for supporting a full-featured Type-C cable. A full-featured cable supports both USB 2.0 and USB 3.1.

When migrating from a USB 2.0 OTG product to a Type-C product, USB 3.1 signals are not needed. These signals should be left unconnected (electrically isolated) on the PCB. ***Figure 3*** shows the USB 3.1 contacts as no-connects in a Type-C receptacle.

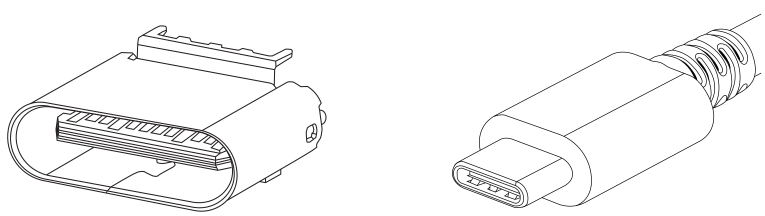

Figure 1. USB Type-C receptacle and plug
Source: Courtesy of USB Type-C specifications

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
GND	TX1+	TX1-	VBUS	CC1	D+	D-	SBU1	VBUS	RX2-	RX2+	GND
GND	RX1+	RX1-	VBUS	SBU2	D-	D+	CC2	VBUS	TX2-	TX2+	GND
B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1

Figure 2. USB Type-C full-featured receptacle pin map (front view)
Source: Courtesy of USB Type-C specifications

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
GND	NC	NC	VBUS	CC1	D+	D-	SBU1	VBUS	NC	NC	GND
GND	NC	NC	VBUS	SBU2	D-	D+	CC2	VBUS	NC	NC	GND
B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1

Figure 3. Receptacle pin map with only USB Type-C USB 2.0 (front view)
Source: Courtesy of USB Type-C specifications

The pin map in ***Figure 3*** has two sets of D+ and D– contacts. These two sets of pins do not imply that there are two independent USB 2.0 paths. In fact, a Type-C cable has only one wire for D+ and one wire for D–. The purpose of these two sets of D+/D– contacts is to support the flippable feature. Products should connect the two D+ contacts on their PCB, and also connect the two D– contacts on their PCB. When tying these contacts together on a PCB, creating a stub is unavoidable. As such, be careful that the stub length does not exceed 2.5 mm. Otherwise, signal integrity issues may be observed on the USB 2.0 interface.

Noticeably absent from the USB Type-C receptacle is the ID pin. The determination of host or peripheral functionality is handled differently in Type-C. Here, the host or peripheral detection is done through monitoring channel configuration (CC) pins (CC1/CC2) while toggling at a specific interval between a pull-up resistor and pull-down resistor. Depending on the voltage level detected on the CC pins after a defined de-bounce time, the device becomes either a host or a peripheral.

Type-C dual-role port

In the Type-C ecosystem, the USB 2.0 OTG device is referred as a dual-role port (DRP). A DRP is a device that can function either as a USB host or as a USB peripheral. In Type-C terminology, a USB host is called a downstream-facing port (DFP), and a USB peripheral is called an upstream-facing port (UFP).

In determining whether a DFP or UFP role, a DRP device must alternate between being a UFP and a DFP until a connection can be established. For easy reference, ***Figure 4*** depicts the same functional DRP model provided in the USB Type-C specification.

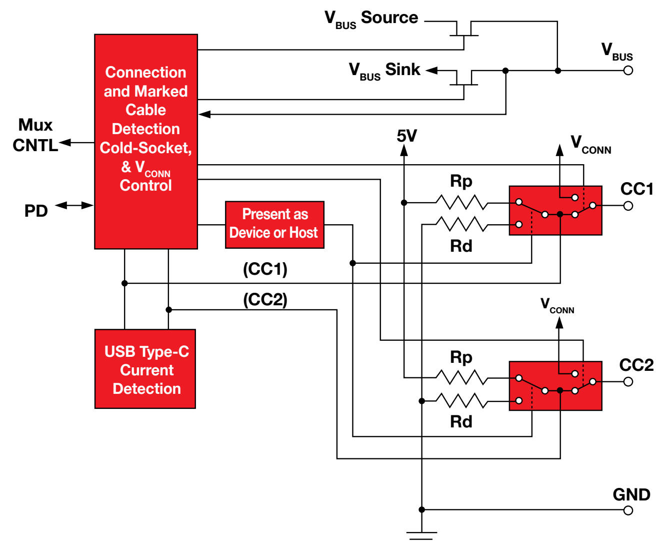

Figure 4. A functional mode of a dual-role port for CC1 and CC2
Source: Courtesy of USB Type-C specifications

A DFP has a pull-up resistor (Rp), and a UFP has a a pull-down resistor (Rd). ***Figure 4*** shows that the Rp and Rd on CC1/CC2 are controlled through a switch. When a connection occurs because an Rp is selected, the DRP device behaves as a DFP (host) and provides V_{BUS} to the attached peripheral. When a connection occurs with the Rd selected, the DRP device behaves as a UFP (peripheral) and monitors V_{BUS} to establish a data connection and/or power onboard circuits.

In cases where two DRP-capable products are connected, it is possible that one or both products have the capability to become a host or peripheral. For example, a cell phone and a tablet could both be DRP-capable. However, when connected, the cell phone becomes a peripheral while the tablet becomes a host. What should not happen is for a cell phone to host a tablet and provide V_{BUS} to it. In other words, your cell phone should not be charging your tablet.

The Type-C specification has optional paths in the DRP's connection and role-detection method that allows a device to select a preference for a specific role. These option paths are called Try.SRC and Try.SNK. Implementing these two optional features is critical for portable devices. A tablet may want to implement Try.SRC so that it can become a host when attached to another DRP. A cell phone may want to implement Try.SNK so that it can be a peripheral when attached to another DRP.

Figure 4 also shows a V_{CONN} switch. V_{CONN} (5 V at min of 1 Watt) is intended to power cables with active circuitry. In Type-C these cables are known as *active cables*. V_{CONN} is typically used for powering a USB 3.1 signal conditioning device within the cable. For a product that only supports USB 2.0, support for V_{CONN} is not required.

One chip solution

One possible solution for transitioning a USB 2.0 OTG product that uses a micro-A/B receptacle to a Type-C receptacle is the Texas Instruments TUSB32x product line. This family of products can function as a UFP, DFP, or a DRP-based on a pin or value of an I^2C register. These devices handle all aspects of the Type-C connection process. These devices provide an ID pin that mirrors the micro-A/B ID pin behavior so that a host or peripheral role can be easily determined. When connected as a peripheral the TUSB32x family indicates the V_{BUS} current provided by the attached host through either I^2C registers or GPIO pins. When connected as a host, these devices advertise V_{BUS} current to the attached peripheral.

Note: At the time of this writing, Try.SNK has not been approved as a engineering change notice (ECN) to the USB Type-C 1.1 specification.

References

- For more information, please visit: ti.com/usb-c
- Download datasheets from these product folders:
  - TUSB320
  - TUSB321
  - TPS65982
  - HD3SS3212
  - HD3SS460