Integrated Solutions to USB Type-C Port Implementation Challenges

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Highly integrated solutions for USB 3.2 data switching, USB Power Delivery and USB Battery Charging control, and transient protection help designers unleash the full potential of the USB Type-C interface

The USB Type-C® (USB-C®) interface supports the latest USB single-lane (USB 3.2 Gen 1 aka SuperSpeed USB 5Gbps, and USB 3.2 Gen 2 aka SuperSpeed USB 10Gbps) and dual-lane (USB 3.2 Gen 2x2 aka SuperSpeed USB 20Gbps, USB4™ 20Gbps, and USB4 40Gbps) specifications, in parallel with USB 2.0. USB-C also supports the USB Power Delivery (USB PD) specification.

As such, the USB Type-C interface has many more connections than the conventional well-known USB Type-A, Type-B, Mini, and Micro connectors. USB-C includes two sets of differential data channels, the USB 2.0 D+ and D- channels, and power connections that include two sets of power and ground pins with a communication channel for connected devices to negotiate their power-consumption demands and power-supply capabilities. There are also additional side band use (SBU) contacts to allow for future performance enhancements and new features.

At the same time, the USB-C connection is physically small and, unlike its predecessors, is not polarized. Moreover, the same connector style is intended for use on all devices, which reduces the number of different cable types users require to connect devices in any desired configuration and creates the opportunity for easy dual-role device flexibility. Hence USB Type-C cables are reversible, USB Type-C plugs are flippable, and devices equipped with a USB-C port can independently negotiate their roles as host or device or as power consumer or supplier.

To support the extra power and data connections, as well as catering for the additional flexibility when interconnecting devices and providing backwards-compatibility with USB 2.0, the USB Type-C connector has 24 pins. These are assigned as shown in Figure 1. By supporting USB PD, a USB-C port can supply devices ranging from legacy 5V USB-powered equipment to devices consuming up to 100 Watts at 20V.

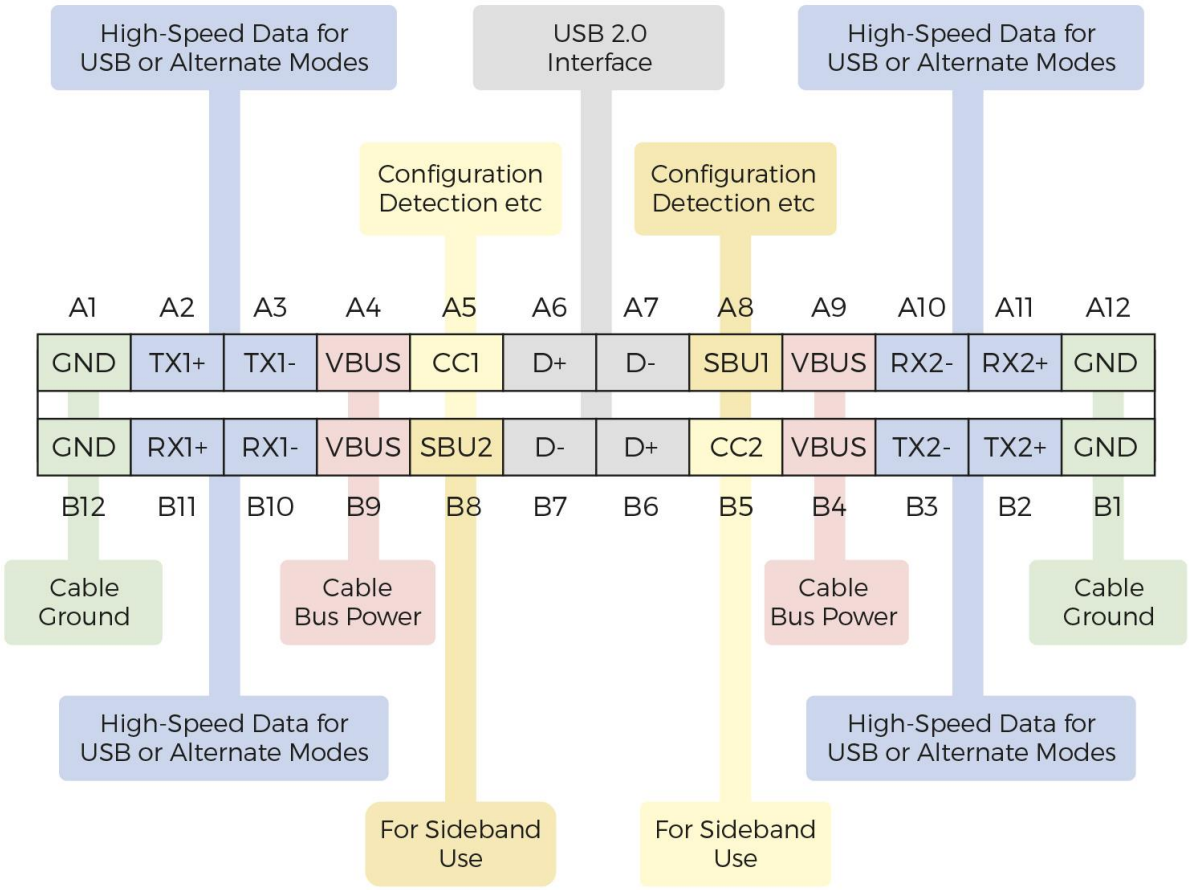

Figure 1. Pin Assignments in the USB-C Connector

With the larger number of connectors and greater flexibility, the USB-C interface is complex and incorporates important new features and capabilities. These include configuration-control logic, which is needed to classify devices as downstream facing port (DFP or source), upstream facing port (UFP, or Sink), or dual role port (DRP) able to both source and sink data and power. Circuitry is also needed to detect the plug-in orientation of the cable, correctly switch signals such as USB 3.2 and DisplayPort™ to the USB-C connector while maintaining signal integrity, and to multiplex USB 2.0 signals. Transient voltage protection is also required.

The best way to implement the desired functionality differs depending on the type of equipment. A notebook PC or tablet, for example, must typically be able to handle USB 3.2 and multimedia data and support full USB PD functionality. Figure 2 shows how suitable data switches and TVS diodes are likely to be combined to create a fully functioning USB-C interface.

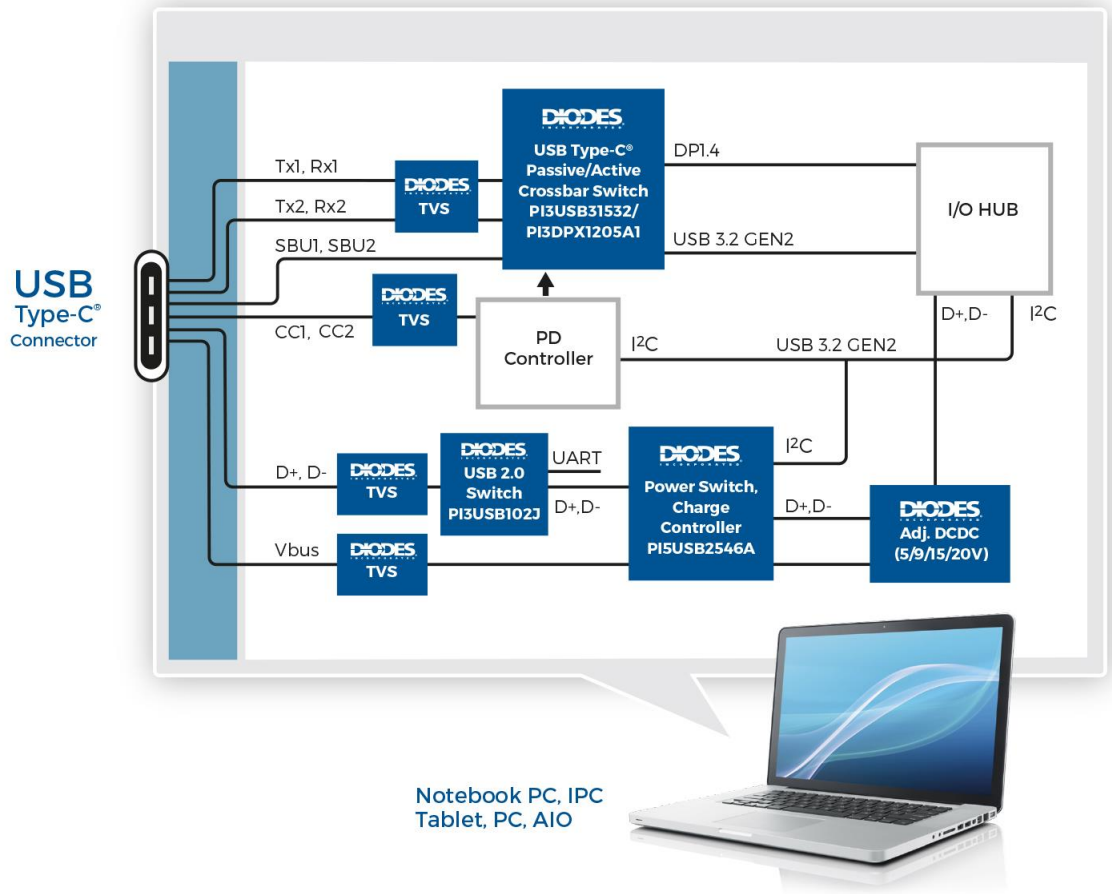

Figure 2. Notebook or Tablet USB-C Interface Supporting USB 3.2, Multimedia, and USB PD.

The main functions of the high-speed data interface, shown in the upper portion of Figure 2, can be implemented using either the Diodes PI3USB31532 bidirectional matrix switch or the PI3DPX1205A 6-channel 4-lane active mux. The PI3USB31532 multiplexes USB 3.2 Gen2 (single-lane, 10Gbps SuperSpeed+) and/or up to four channels of DisplayPort 1.4 signals as well as auxiliary channels through the USB-C connector. With low insertion loss and a -3dB bandwidth of 8.3GHz, this device ensures signal fidelity at up to 10Gbps. The PI3DPX1205A1 integrates the same features with the addition of a ReDriver™ to drive longer distances. Also, with receive-side linear equalization integrated and by providing output settings for flat gain and equalization, this device ensures double the signal integrity of comparable CMOS ReDrivers.

The USB PD controller shown in the diagram handles delivering power up to 100W through the USB-C connector as well as enabling alternative modes of multimedia data, such as DisplayPort (DP) or Thunderbolt™, through the USB-C interface.

The PI5USB2546A is a combined 2.4A power switch and charging port controller that also handles the switching for USB 2.0 D+ and D- data lines. By supporting the charging downstream port (CDP) and dedicated charging port (DCP) modes of the USB Battery Charging 1.2 specification, the PI5USB2546A can be used in wall-charging adapters as well as host and hub devices.

Figure 3 shows how the interface may be implemented in a smartphone, leveraging features of the PI5USB31213A USB Type-C dual-role port controller and 10Gbps mux or the PI3EQX10312 USB 3.2 mux/demux linear ReDriver. Both devices provide USB-C configuration channel control along with USB 3.2 Gen2 10Gbps multiplexing function to enable the proper data to the non-polarized USB-C connector. Each also provides connector orientation detect, handles automatic configuration of host mode, device mode, or dual-role port based on the voltage levels detected on the CC pin, and negotiates charging current through the USB-C interface.

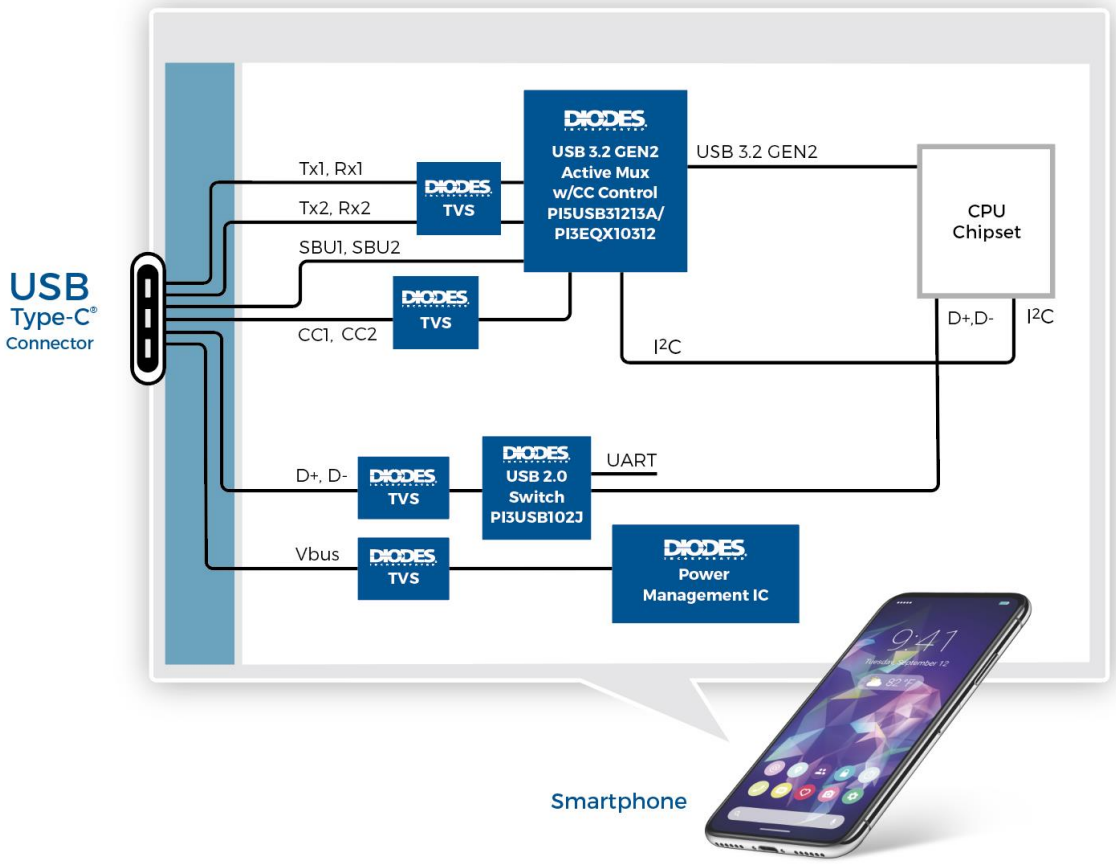

Figure 3. Highly Integrated and Protected USB-C Interface for Smartphones.

Finally, Figure 4 shows how a universal docking station may implement a single USB-C connection to an upstream host and provide DisplayPort, HDMI™, VGA, and multiple USB 3.2 output ports for downstream devices, such as a monitor, storage, and peripherals.

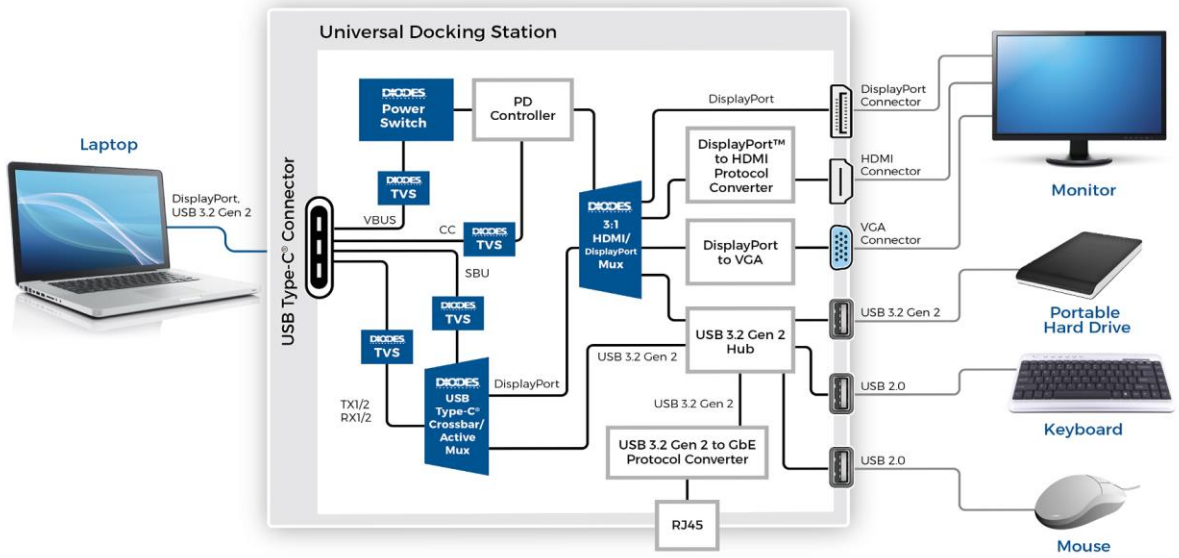

Figure 4. Universal Docking Station Featuring USB-C Host Connection.

The crossbar switch at the lower left of the diagram handles USB 3.2 and DisplayPort switching and can be a PI3USB31532 USB Type-C crossbar switch or PI3DPX1205A1 USB 3.2 Gen 2/DP1.4 active crossbar. The 3:1 HDMI/DisplayPort mux in the center is a PI3WVR31310A high-speed passive switch that can connect its output directly to the DP connector or through the HDMI or VGA converter to HDMI and VGA connectors respectively. The power switch shown on the left delivers power to the host computer through the VBUS pins.

Conclusion

The latest USB-C interface supports the most advanced USB power and data capabilities, including USB Power Delivery at up to 100W, USB 3.2 (and forthcoming USB4) data rates, and multi-protocol support. However, the expanded functionality presents complex engineering challenges.

Taking advantage of integrated solutions to handle functionality such as data switching, power switching, charging control, and cable-orientation detection helps to simplify design, save board space, and reduce bill-of-materials costs. Moreover, by easing product certification, these integrated solutions can also save development costs and accelerate time to market.