

ESD Protection of USB Type-C Interfaces

One of the most recent connectors, USB Type-C, is distinctly different from previous versions in terms of physical size as well as how it connects to host and peripheral devices. Designed to be reversible, USB Type-C can be inserted either face up or down and consists of same set of 12 pins on both upper and lower side, making it a total 24 pins. As for data transfer, USB Type-C supports up to 10Gbps and can deliver up to 100W of power with the help of USB power delivery (USB PD). The VBus voltage is 5V like the previous USB versions. However, using USB PD, peripheral devices can select a VBus voltage of up to 20V. The maximum current has been increased to 5A, making the maximum deliverable power to $20 \times 5 = 100\text{W}$. With the USB PD feature, devices can be charged at a much faster rate. This faster charging feature of USB Type-C has made it very popular for charging cellular phones, wireless headphones, drones and some of the latest notebook models. If USB PD is not required for any application, the VBus can support 5V at 3A, making it 15W deliverable power. USB Type-C can also work with prior USB versions including USB 2.0 and USB 3.0, connecting with an adaptor and also supporting display protocols like DisplayPort and HDMI, connecting through Alternate Mode.

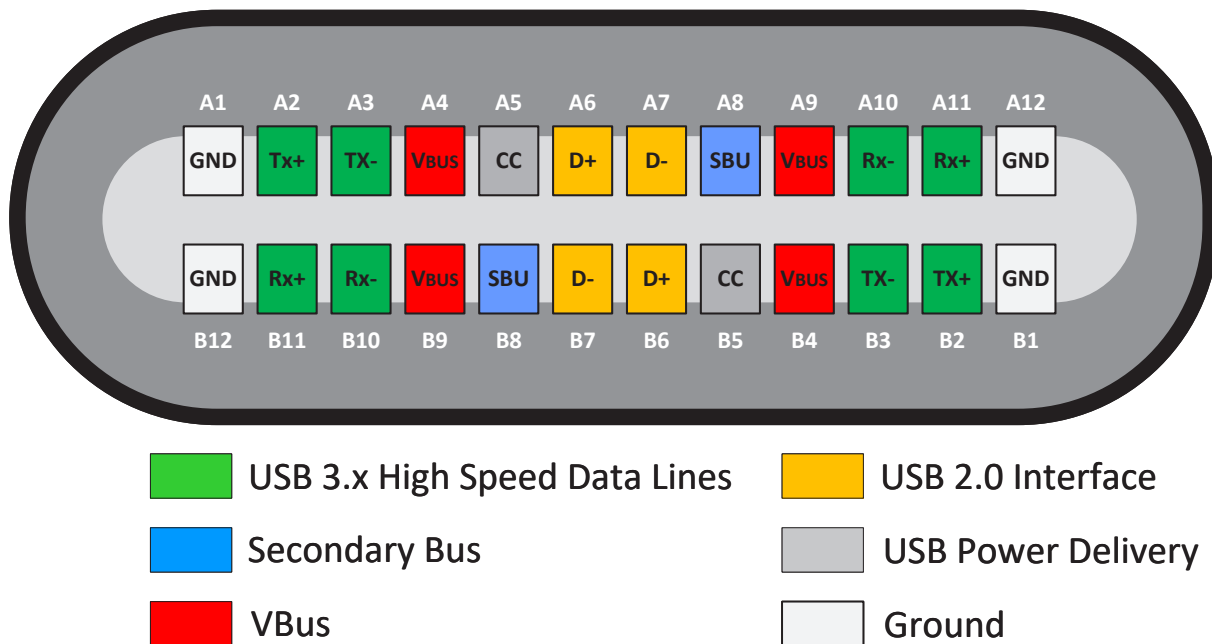


Figure 1. USB Type C pin configurations

Pin Configurations of USB Type-C

Figure 1 shows the pin configurations of USB Type-C. There are two differential pairs (D+ and D-), four pairs of SuperSpeed+ transmitter and receiver data buses (Tx+/Tx- and Rx+/Rx-), two Configuration Channel (CC) pins, two Side Band Use (SBU) pins, four VBus pins and four Ground pins (refer to Table 1 below).

PIN	SIGNAL	DESCRIPTION
A4, B4, A9, B9	VBus	Power
A7, B7	D-	USB2.0 Data
A6, B6	D+	USB2.0 Data
A1, B1, A12, B12	GND	Ground
A10, B10	SSRx-	SuperSpeed Receiver
A11, B11	SSRx+	SuperSpeed Receiver
A3, B3	SSTx-	SuperSpeed Transmitter
A2, B2	SSTx+	SuperSpeed Transmitter
A5	CC	Configuration Channel
B5	CC(VCONN)	Configuration Channel (Alt Mode)
A8	SBU2	Side Band Use
B8	SBU2	Side Band Use

Table 1: Pin configuration of USB Type-C

The SBU pins correspond to low-speed signal paths and are used in the operation of the alternate mode (Alt Mode). In Alt Mode, USB Type-C can directly connect to HDMI or Display port devices and transport display signals through USB Type-C cable. This feature of USB Type-C facilitates several popular data transmission systems in a single reversible tiny port without any additional electrical circuitry.

The Configuration Channel (CC) pins correspond to communication, configuration of plug orientation and connection management. The communication of power delivery (USB PD) option is done through the CC pins, also referred to as VCONN pins. One of the two CC pins in the USB Type-C port is used for orientation detection and the other one is used for initiating power delivery.

ESD Protection of USB Type-C

It is very important to protect USB interfaces from electrostatic discharges (ESD). ESD events can be generated either from a user (human body) or from stored charge on a cable. The electrostatic spike can reach up to tens of thousands of volts – easily capable of damaging the sensitive CMOS structures of the USB transceiver. Hence, ESD protection for each individual USB pin is not just important, it is essential. Considering the small size of the USC Type-C port and close proximity of its 24 pins, protecting the port from ESD can be quite challenging. The two opposite sets of 12 pins are designed in such close proximity to one another that a short circuit can occur when plugging the port in the device. It can also occur if conductive particle happens to form an unintended connection across the pins. Additional transient protection is always required to safeguard against this short circuit condition.

SBU and CC pins protection: Considering the tiny size of the USB Type-C plug and close positioning of its pins, discrete single-line TVS diodes are well suited to protect the port from ESD event. Moreover, discrete TVS diodes are also easier for the designer to layout and trace route. Referring to the pin configurations in Figure 1, note that the CC pin and SBU pin are next to the VBus pin. The VBus pin voltage can reach up to 20V. Therefore, if a short circuit condition occurs, the CC pin and SBU pin will be exposed to 20V. TVS diodes are not designed to protect against the short condition so in this case, a TVS diode with a minimum working voltage of 20V is required to protect the CC and SBU pins. Semtech’s μ Clamp2411ZA is capable of withstanding high ESD with voltages ranging from ± 20 kV (Air), and ± 17 kV (Contact) as per IEC 61000-4-2. It maintains an operating voltage of 24V. μ Clamp2411ZA is a bi-directional TVS diode with a low dynamic resistance of 1Ω and comes in an ultrasmall 0201 package.

VBus pin protection: As previously mentioned, the VBus voltage can reach up to 20V, thus protecting VBus pin requires a TVS diode with a minimum 22V working voltage. Low capacitance is not a consideration for the protection of VBus line as it is generally not sensitive to additional capacitance. The TDS2221PW from Semtech’s SurgeSwitch® family is ideally suited to safeguard the VBus pin of the Type-C connector. TDS2221PW has an operating voltage of 22V to protect the USB-PD controllers during ESD and surge events. It offers a minimum breakdown voltage of 23V, maximum clamping voltage of 28V, and a peak pulse current of 22A ($t_p=8/20\mu s$). TDS2221PW provides transient protection as per the specification in IEC 61000-4-2 (ESD) at ± 30 kV (Air), ± 15 kV (Contact). This part is available in a DFN package with a 1.6 x 1.0 x 0.55 mm nominal dimension. Figure 2 shows the TVS protection options for VBus, CC and SBU pins.

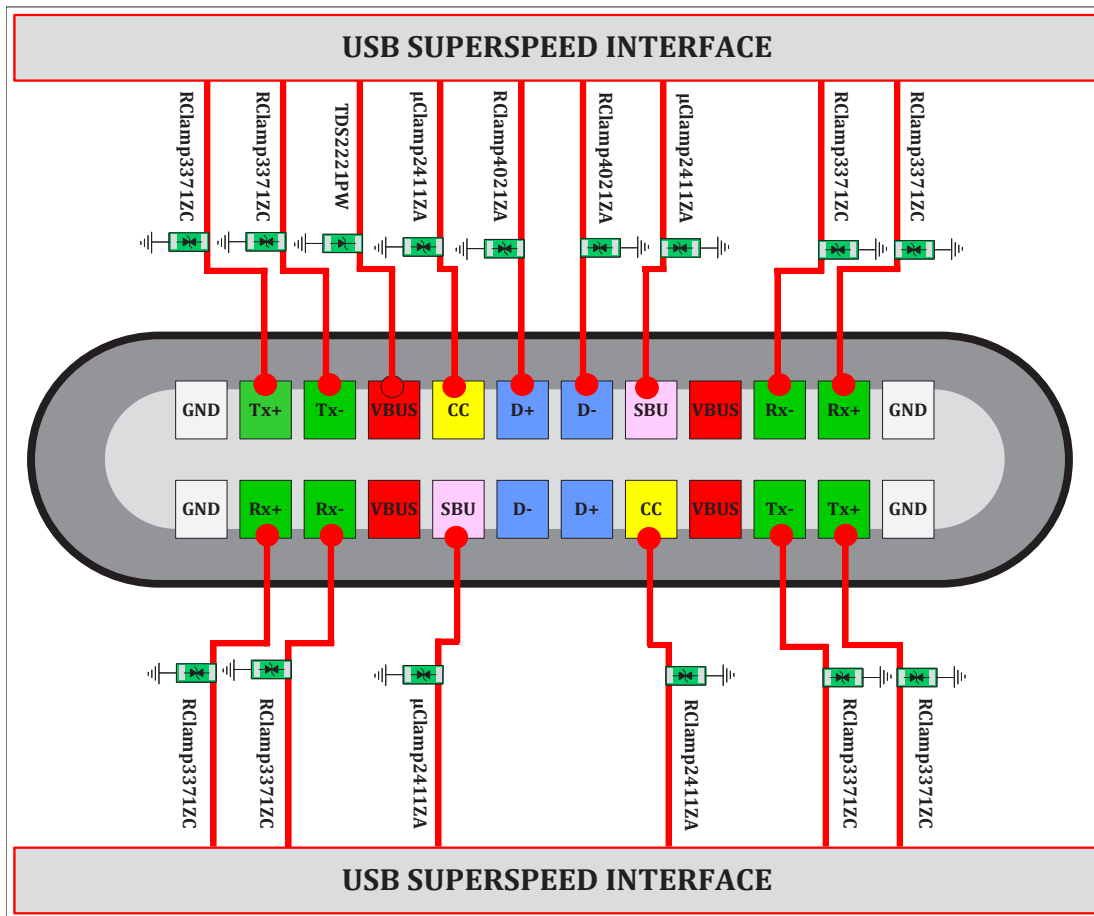


Figure 2. ESD Protection of USB Type-C port

High-Speed Differential Lines Protection: Tx+/Tx- and Rx+/Rx- lines are used for super speed interfaces and alternate modes. Transmitter and receiver lines support 10Gbps of data transfer so it is clear that an ultrasmall junction capacitance is critical to preserve signal integrity. Semtech's RClamp3371ZC is characterized by a high ESD withstand voltage of $\pm 17\text{kV}$ (Air), $\pm 10\text{kV}$ (Contact) per IEC 61000-4-2, and a working voltage of 3.3V maintaining a maximum capacitance of 0.25pF. It comes in a tiny 0201 (0.6 x 0.3 x 0.25mm) package.

D+/D- Lines protection: D+/D- lines are used for USB 2.0 interfaces. These lines can be protected by using Semtech's RClamp4021ZA diodes. The RClamp4021ZA is a 4V TVS diode with a maximum junction capacitance of 0.55pF and low dynamic resistance of 0.12Ω (typical). It comes in an ultrasmall 0201 (0.6 x 0.3 x 0.25mm) package. Figure 2 shows the ESD protection options for all differential lines.

The USB Type-C interface with its ultrafast data transfer speed and superior power delivery capacity is immensely popular on consumer, handheld and industrial electronic devices. With their popularity, these ports are routinely exposed to fast rise-time ESD spikes. As such, it is essential that USB ports are well safeguarded from the dangers of ESD threats. Semtech's TVS products protect many of the world's most popular electronics devices. These solutions are ideal for safeguarding USB 2.0 and USB Type-C interfaces enabling consumers to enjoy a smooth uninterrupted experience interfacing their high-performance electronic gadgets.

