What Is USB Type-C?

- Vision – Seamless Connectivity
- USB Evolution
  - High Data Speed
  - High Power Rating
  - Multi-function Connector
USB Evolution (1/3) – Data Speed

USB 1.1 (1998)
Full Speed, 12M bps

USB 2.0 (2000)
High Speed, 480M bps

USB 3.0 (2008) →→ **USB 3.1 Gen 1 (2015)**
Super Speed, 5G bps

Super Speed +, 10G bps, 4K UHD video

Hewlett-Packard, **Intel**, Microsoft, Renesas, ST-Ericsson, Texas Instruments

**Competition:**
- **Data:** Thunderbolt (v1: 10G, v2: 20G, v3: 40G bps)
- **Video:** Thunderbolt w/ DisplayPort, MyDP, HDMI, MHL 3.0
# USB Evolution (2/3) – Power Rating

<table>
<thead>
<tr>
<th>USB Charging and Powering</th>
<th>Voltage</th>
<th>Current</th>
<th>Max. Wattage</th>
<th>USB Plug/Receptacle</th>
<th>Handshake</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB 1.x/2.0 (1996/2000)</td>
<td>5V</td>
<td>0.5A</td>
<td>2.5W</td>
<td>Type-A, B, C</td>
<td>no</td>
</tr>
<tr>
<td>USB 3.0/3.1 (2008/2013)</td>
<td>5V</td>
<td>0.9A</td>
<td>4.5W</td>
<td>Type-A, B, C</td>
<td>no</td>
</tr>
<tr>
<td>USB Battery Charging 1.0/1.1/1.2 (2007/2009/2011)</td>
<td>5V</td>
<td>0.5/1.5A</td>
<td>7.5W</td>
<td>Type-A, B, C</td>
<td>D+/D- voltage</td>
</tr>
<tr>
<td>USB Type-C 1.0/1.1 (2014/2015)</td>
<td>5V</td>
<td>0.5/0.9/1.5A/3A</td>
<td>15W</td>
<td>Type-C</td>
<td>CC voltage</td>
</tr>
<tr>
<td>USB Power Delivery 1.0/2.0 (2012/2014)</td>
<td>5V/12V/20V</td>
<td>1.5/2/3/5A</td>
<td>10/18/36/60/100W</td>
<td>Type-A, B, C</td>
<td>yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Apple iPhone/iPad</th>
<th>Voltage</th>
<th>Current</th>
<th>Max. Wattage</th>
<th>USB Plug/Receptacle</th>
<th>Handshake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5V</td>
<td>1A/2.1A/2.4A</td>
<td>12W</td>
<td>Type-A, B, C</td>
<td>D+/D- voltage</td>
</tr>
</tbody>
</table>

| Qualcomm Quick Charge 1.0 (2013) | 5V | 2A | 10W | Type-A, B | yes |
| Qualcomm Quick Charge 2.0 (2014) | 5V/9V/12V/20V | 3A | 60W | Type-A, B, C | yes |
| Qualcomm Quick Charge 3.0 (2015) | 3.6V to 20V (variable) | 3A | 60W | Type-A, B, C | yes |
USB Evolution (3/3) – Connector

Thunderbolt, DisplayPort, HDMI, and MHL could also run via Type-C

- Reversible plug orientation
- Reversible cable direction
- Slim industrial design
USB Type-C
A new connector to support reversible plug orientation
# Type-C Signals Summary

<table>
<thead>
<tr>
<th>Signal Group</th>
<th>Signal</th>
<th>Description</th>
</tr>
</thead>
</table>
| USB 3.1       | SSTXp1, SSTXn1, SSRXp1, SSRXn1 | SuperSpeed USB serial data interface: one transmit diff pair and one receive diff pair  
Two pin sets to enable plug flipping |
|               | SSTXp2, SSTXn2, SSRXp2, SSRXn2 |                                                                             |
| USB 2.0       | Dp1, Dn1, Dp2, Dn2      | USB 2.0 serial data interface  
Two pin sets to enable plug flipping                          |
| Configuration | CC1, CC2 (receptacle), CC (plug) | CC channel in the plug used for connection detect, interface configuration and VCONN |
| Auxiliary signals | SBU1, SBU2               | Sideband Use                                                                 |
| Power         | VBUS                    | USB cable bus power                                                        |
|               | VCONN (plug)            | USB plug power                                                              |
|               | GND                     | USB cable return current path                                              |

Source: USB-IF

24 pins
USB Type-C
A new connector for various industries
USB Type-C Hazards & Faults

Over-Voltage
Over-Current
Over-Temperature
Hazards Present and Fault Scenarios

- **Over-voltage**
  - Human touch causes ESD
  - Hot plugging/unplugging causes surge

- **Over-current**
  - Faulting pins
  - Faulting cables

- **Over-temperature**
  - Lint, water, dirt, dust in connector
ESD Stress Everywhere
IEC 61000-4-2 ESD Immunity test

IEC 61000-4-2 Testing and measurement techniques – Electrostatic Discharge (ESD) Immunity test

This standard defines test procedures to evaluate equipment ESD resistibility performance.

Table 3.30  Test Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Contact discharge</th>
<th>Air discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Voltage</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2 kV</td>
<td>2 kV</td>
</tr>
<tr>
<td>2</td>
<td>4 kV</td>
<td>4 kV</td>
</tr>
<tr>
<td>3</td>
<td>6 kV</td>
<td>8 kV</td>
</tr>
<tr>
<td>4</td>
<td>8 kV</td>
<td>15 kV</td>
</tr>
<tr>
<td>X</td>
<td>Special</td>
<td>Special</td>
</tr>
</tbody>
</table>

"x" is an open level, to be specified in dedicated equipment specification

Figure 3.8  ESD generator schematic
8kV ESD Strike with 30A Peak Current
**V_{BUS} Voltage Transient**

- Caused by USB connector plugging/unplugging
- IEC61000-4-5 (Surge)
  - Four open circuit voltage levels: 0.5kV, 1kV, 2kV, and 4kV
  - Current waveform (t_{p}=8/20\mu s) will vary depending on port (data or power) being tested as the generator source impedance is varied
Over-Current Fault

- Short circuit at bent pins
- Short circuit at worn cable
Over-Temperature Fault

- Contamination in connector causes overheating
  - Lint, water, dirt, dust
Protection Solutions

TVS Diode Arrays
Resettable PTCs
Different ESD Protection Components in Littelfuse

<table>
<thead>
<tr>
<th>Protection Technology</th>
<th>Data Rate Span</th>
<th>Peak/Clamp (8KV)</th>
<th>ESD Level</th>
<th>Discrete Options</th>
<th>Array Options</th>
<th>Applications and Circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multilayer Varistor (MLVs)</td>
<td>&lt; 125Mbps</td>
<td>Good</td>
<td>30KV</td>
<td>0402 0600 0606 1206</td>
<td>1206</td>
<td>Keypad/switch, audio, analog video, USB1.1, RS232</td>
</tr>
</tbody>
</table>

- 0.1 pF for 10Gb/s
- ~30pF

| TVs Diode Arrays (SPA® Diodes) | 0 - > 5Gbps | Excellent | 30KV |

| PULSE-GUARD® ESD Suppressors  | 100Mbps -> 5Gbps | Good | 30KV |

0.04pF

3 ESD protection components (MLV/SPA/PGB) are benchmarked.
Littelfuse TVS Diode Arrays

- **SP3012 Series**
  - 4 channel and 6 channel options
  - 0.5pF of capacitance
  - 12kV contact ESD
  - $R_{\text{DYN}}$ value of 0.4Ω

- **SP3030 Series**
  - 1 channel, discrete option
  - 0.5pF of capacitance
  - 20kV contact ESD
  - $R_{\text{DYN}}$ value of 0.8Ω
Ensuring USB 3.1 Type-C Compliance

<table>
<thead>
<tr>
<th>Interface</th>
<th>Part Number</th>
<th>Order Number</th>
<th>Package</th>
<th>Channels</th>
<th>Usage</th>
<th>Size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB 2.0 I/O's</td>
<td>SP3012-06UTG</td>
<td>DFN-14</td>
<td>6</td>
<td>1 per</td>
<td>3.5x1.45x0.5mm</td>
<td>Shown above</td>
<td></td>
</tr>
<tr>
<td>USB 2.0 I/O's</td>
<td>SP3012-04UTG</td>
<td>DFN-10</td>
<td>4</td>
<td>1 per</td>
<td>2.5x1.0x0.52 mm</td>
<td>Alternative to SP3012-06UTG if Vbus protected otherwise or if routing allows all USB 3.1 Super Speed traces to be routed to the same device</td>
<td></td>
</tr>
<tr>
<td>USB 3.1 I/O's</td>
<td>SESD1004Q4UG-0030-088</td>
<td>RF3923-000</td>
<td>DFN-10</td>
<td>4</td>
<td>1 per</td>
<td>2.5x1.0x0.52mm</td>
<td></td>
</tr>
<tr>
<td>USB 3.1 I/O's</td>
<td>SESD0402Q2UG-0030-088</td>
<td>RF3925-000</td>
<td>SOD-883</td>
<td>2</td>
<td>2 per</td>
<td>1.0x0.6x0.4mm</td>
<td>Shown above</td>
</tr>
<tr>
<td>Type-C overcurrent</td>
<td>2016L500</td>
<td>-</td>
<td>2016</td>
<td>-</td>
<td>1 per</td>
<td>5.0x4.0x1.2mm</td>
<td>Shown above (PTC)</td>
</tr>
</tbody>
</table>
USB 3.1 Connector, USB 2.0 Type Speeds

Part Number | Package | Channels | Usage | Size
--- | --- | --- | --- | ---
SP3012-06UTG | uDFN-14 | 6 | 1 per | 3.5x1.45x0.5mm
SP3012-04UTG | uDFN-10 | 4 | 1 per | 2.5x1.0x0.52 mm
2016L500 | 2016 | - | 1 per | 5.0x4.0x1.2mm
USB Type-C Super Speed (+) Interfaces
4 Pairs (8 Lines)

ESD air/contact : +/-22KV
USB Type-C Hi-Speed Interfaces (USB2.0)
One Pair (2 Line)

- Capacitance = 0.35 pF
- Reverse Voltage = 5.3V
- Package: 0402/0201
- ESD air/contact: 30/20 KV
- SP3022-01WTG

USB 2.0
• Bi Directional
• SP3022-01WTG
• 2 Placements

Female USB 3.1 Connector
USB Type-C Low Speed Interfaces

**Female USB 3.1 Connector**

- **CC1/CC2**
  - Logic, slow
  - Uni Directional
  - SP1003-01ETG
  - SP1006-01UTG

**SP1003**
**SP1005**
**SP1006**

**30pF**
**0201/0402**
**VR=5~6V**

**SBU1/2**
- DisplayPort Usage Only
- Low Speed
- SP1003-01ETG
- SP1006-01UTG
USB Type-C Default Power & PD ($V_{BUS}$)

- **Female USB 3.1 Connector**

- **PTC**

- **30pF**
  - 0201/0402
  - $V_r=5\sim24\,V$

### PoweredUSB

<table>
<thead>
<tr>
<th>0402</th>
<th>0201</th>
<th>Voltage</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP1003-01ETG</td>
<td>SP1005-01UTG</td>
<td>5 V</td>
<td>2 A</td>
</tr>
<tr>
<td>SPHV15/200W</td>
<td>SP15-01WTG-HV</td>
<td>12 V</td>
<td>5 A</td>
</tr>
<tr>
<td>SPHV24/200W</td>
<td>SP24-01WTG-HV</td>
<td>20 V</td>
<td>5 A</td>
</tr>
</tbody>
</table>
# Stylized USB 3.1 Type C Interface

<table>
<thead>
<tr>
<th>A Row</th>
<th>B Row</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSTXp1</td>
<td>SSRXp1</td>
</tr>
<tr>
<td>SSTXn1</td>
<td>SSRXn1</td>
</tr>
<tr>
<td>V_Bus</td>
<td>V_Bus</td>
</tr>
<tr>
<td>CC1</td>
<td>SPHVL</td>
</tr>
<tr>
<td>Dp1</td>
<td>SP0201B-ULC-01UTG (x4)</td>
</tr>
<tr>
<td>Dn1</td>
<td>SP3022</td>
</tr>
<tr>
<td>SBU1</td>
<td>SP1006</td>
</tr>
<tr>
<td>V_Bus</td>
<td>SPHVL</td>
</tr>
<tr>
<td>SSRXn1</td>
<td>SSTXn2</td>
</tr>
<tr>
<td>SSRXp1</td>
<td>SSTXp2</td>
</tr>
</tbody>
</table>

**SuperSpeed + Lines Unidirectional**
**SuperSpeed+ Lines Unidirectional**

**Power 5V-20V, 2-5 AMP**
**Config Control PoweredUSB**
**Sideband 2 DisplayPort Enable**

**USB2.0 240 MHz**

**Sideband 2 DisplayPort Enable**
**Config Control PoweredUSB**
**Power 5V-20V, 2-5 AMP**

Focused on Signal Integrity, 0201 is best solution for SuperSpeed+ lines, as it offers lowest parasitic inductance SP0201U-ULC-01UTG
# Component Suggestions

## TVS Diode Arrays (SPA® Diodes)

<table>
<thead>
<tr>
<th>Function</th>
<th>Designators</th>
<th>Ordering Number</th>
<th>ESD Level</th>
<th>I/O Cap.@ Op. Freq. (Signal Integrity)</th>
<th>Operating Voltage</th>
<th>Standard Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>SuperSpeed+, USB 2.0</td>
<td>SSx SSx, D+D-</td>
<td>SP0201B-U1C-01UTG</td>
<td>±20kV</td>
<td>0.15 pF</td>
<td>&lt;5V</td>
<td>0201 DFN</td>
</tr>
<tr>
<td>Logic</td>
<td>SBU1/2, CC1/2</td>
<td>SP1003-01ETG / SP1006-01UTG</td>
<td>±30kV</td>
<td>30pF / 25pF</td>
<td>&lt;5V</td>
<td>SOD-882 / 0201 DFN</td>
</tr>
<tr>
<td>Charging</td>
<td>Vbus1, Vbus2</td>
<td>SPHV24-01ETG / SP24-01WTG-C</td>
<td>±24kV</td>
<td>17pF</td>
<td>from 5V thru 24V</td>
<td>SOD-882 / 0201 DFN</td>
</tr>
</tbody>
</table>

## PTC

<table>
<thead>
<tr>
<th>Function</th>
<th>Designators</th>
<th>Ordering Number</th>
<th>Power</th>
<th>Voltage</th>
<th>Current</th>
<th>Vmax(Vdc)</th>
<th>Ihold 20-C(A)</th>
<th>Ihold 60-C(A)</th>
<th>R1max (Ω)</th>
<th>Footprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inline Overcurrent Protection</td>
<td>Vbus1, Vbus2</td>
<td>0805L300SLWR</td>
<td>10 Watt</td>
<td>5V</td>
<td>2.0 A</td>
<td>6</td>
<td>3</td>
<td>2.13</td>
<td>0.03</td>
<td>0805</td>
</tr>
<tr>
<td></td>
<td></td>
<td>miniSMDC260F/16</td>
<td>18 Watt</td>
<td>12V</td>
<td>1.5 A</td>
<td>16</td>
<td>2.6</td>
<td>2</td>
<td>0.05</td>
<td>1812</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2920L500/16MR</td>
<td>36 Watt</td>
<td>12V</td>
<td>3.0 A</td>
<td>16</td>
<td>5</td>
<td>3.5</td>
<td>0.025</td>
<td>2920</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2920L500/24MR</td>
<td>60 Watt</td>
<td>20V</td>
<td>3.0 A</td>
<td>24</td>
<td>5</td>
<td>3.3</td>
<td>0.015</td>
<td>2920</td>
</tr>
<tr>
<td>Inline Protection at Connector/Cable</td>
<td>Vbus</td>
<td>nanoSMD400LR-2</td>
<td>15 Watt</td>
<td>5V</td>
<td>3.0A</td>
<td>6</td>
<td>4</td>
<td>2.8</td>
<td>0.01</td>
<td>1206</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nanoSMD500LR-2</td>
<td>20 Watt</td>
<td>5V</td>
<td>4.0A</td>
<td>6</td>
<td>5</td>
<td>3.7</td>
<td>0.008</td>
<td>1206</td>
</tr>
</tbody>
</table>
Cable Insertion Loss

Cable Assembly Insertion Loss Requirements

- USB 3.1 Gen 2 Type-C to Type-C cable assembly is allocated with \(-5.8\) dB loss at 5 GHz, supporting a cable about 1-meter long
  - Control the loss at 10 GHz (20 GHz) to be \(\leq -11\) dB for future scalability
- USB 3.1 Gen 1 Type-C to Type-C cable assembly is allocated with \(-7\) dB loss at 2.5 GHz, supporting a cable about 2-meter long

Raw cable may be coax or twisted pairs

Insertion loss

-5.8 dB
Frequency Response (S21)

Insertion Loss Diagram - Unidirectional

-4dB

10GHz

5GHz

Insertion Loss Diagram - Bidirectional

-3dB

10GHz

5GHz
Compliant Eye Diagrams for Popular Interfaces

Figure SE5
USB 3.0 EYE DIAGRAMS
5.0 Gb/s, 100mV differential, CPPO Compliant Test Pattern
Without SEID Device
With SEID Device

Figure SE6
DISPLAYPORT EYE DIAGRAMS
5.4 Gb/s, 800mV differential, PRBS7 Compliant Test Pattern, DSC Enabled
Without SEID Device
With SEID Device

Figure SE7
HDMI EYE DIAGRAMS
3.4 Gb/s, 990 mV differential, TMDS Data
Without SEID Device
With SEID Device
USB Type-C Active Cable

- **E-Marker IC**
  - Identifying cable type/length, current rating, data speed, VID/PID, etc.

- **Re-Driver IC**
  - Signal conditioning

- **Authentication IC**
  - Preventing counterfeit products

ESD protection is needed to protect ICs from ESD threats coming from both ends of cable.
### Littelfuse PTC Solutions – Per PD Profile Type

Select PTC P/N based on Power Delivery Profile P1~P5.

For Profile #P5 (100W/20V/5A), over-current protection could be through-hole PTC or surface mount PTC by 2 in parallel or surface mount fuse.

#### Table: PTC Solutions

| P1 | P2 | P3 | P4 | P5 | Voltage | Current | PTC p/n | Footprint | Vmax (Vdc) | Ihold 20C (A) | Ihold 60C (A) | 8A trip (sec), 20C | R1max (ohms) |
|----|----|----|----|----|---------|---------|--------|-----------|------------|-------------|-------------|-------------|---------------|-------------|
| v  | v  | v  | v  | v  | 10W     | 5V      | 0805L300SL | 0805      | 6          | 3           | 2.13         | 5            | 0.03          |
| v  |     | 18W | 12V | 1.5A | 1812L260/12 | 1812    | 12       | 2.6       | 2            | 5            | n/a          | 0.055         |
|     | v  | 36W | 12V | 3.0A | 2920L500/16 | 2920    | 16       | 5          | 3.5          | n/a          | 0.025         |
| v  |     | 60W | 20V | 3.0A | 2920L500/24SL | 2920   | 24       | 5          | TBD          | n/a          | 0.015         |
| v  |     | 60W | 12V | 5.0A | 2920L700/12SL | 2920   | 12       | 7          | TBD          | n/a          | 0.11          |
| v  |     | 100W| 20V | 5.0A | 30R800       | Through Hole | 30     | 8          | 5.44         | n/a          | 0.02         |

**Alternative surface mount PTC to through-hole PTC**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
<th>PTC p/n</th>
<th>Footprint</th>
<th>Vmax (Vdc)</th>
<th>Ihold 20C (A)</th>
<th>Ihold 60C (A)</th>
<th>8A trip (sec), 20C</th>
<th>R1max (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100W</td>
<td>20V</td>
<td>5.0A</td>
<td>2920L500/24SL by 2</td>
<td>2920 by 2</td>
<td>24</td>
<td>10</td>
<td>TBD</td>
<td>n/a</td>
</tr>
</tbody>
</table>

**Alternative surface mount fuse to through-hole PTC**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Current</th>
<th>Fuse p/n</th>
<th>Footprint</th>
<th>Vmax (Vdc)</th>
<th>Fuse rating (A)</th>
<th>Melting i2t (A2s)</th>
<th>8A trip (sec), 20C</th>
<th>R (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100W</td>
<td>20V</td>
<td>5.0A</td>
<td>4400008</td>
<td>1206</td>
<td>32</td>
<td>8</td>
<td>12.95</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Problem Condition: USB-C Plug

- Smaller Pin-to-Pin Spacing
  - Type-C pin pitch (0.5 mm)
  - Micro-B (0.65 mm)

- Easier for contamination and worn/deformed pins to cause resistive fault

- USB-PD up to 100W
  - Increasing likelihood of overheating faults
Thermal Events of Smart Phone During Charging

As charging current increases, the incidents of thermal runaway are happening more frequently at charging port side.

Finding an economical protection solution to such events is important at initial design stage.

Inner Mold: PVC (80-120°C)
## Root Cause Analysis of USB Connector Damage

### Diagram
- **Charging cable & (microUSB connector)**
- **Mobile phone female microUSB connector**
- **Vbus current**
- **GND**

### Table
<table>
<thead>
<tr>
<th>Damage Experienced</th>
<th>Possible Failure Locations</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connector Damaged due to significant heat ($I^2R$)</td>
<td>Contact Failure A</td>
<td>Contactor contamination, deformation, wearing, rust, etc.</td>
</tr>
<tr>
<td>Between $V_{BUS}$ and GND B</td>
<td>Small external items entering connector; metal particles, hair, fur, liquid, etc.</td>
<td></td>
</tr>
</tbody>
</table>
Over-Temperature Protection Using PTC

R:  Contact resistance increased due to contamination/deformation at contact pins

i:  Charging current increased to 3A/5A for USB Type-C

i^2R: Heat generated from contact pins

---

PTC inside USB plug
# SMD PTC Line-Up

Over-Temperature Protection for USB Plug/Cable

<table>
<thead>
<tr>
<th>Function</th>
<th>Designators</th>
<th>Ordering Number</th>
<th>I_{max} (A)</th>
<th>V_{max} (Vdc)</th>
<th>I_{hold} 20°C (A)</th>
<th>I_{hold} 60°C (A)</th>
<th>R_{1max} (Ω)</th>
<th>Footprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inline overtemperature Protection at Connector/Cable</td>
<td>Vbus</td>
<td>nanoSMD350LR-C-2</td>
<td>9</td>
<td>12</td>
<td>3.5</td>
<td>1.9</td>
<td>0.018</td>
<td>1206</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nanoSMD400LR-C-2</td>
<td>9</td>
<td>12</td>
<td>4.0</td>
<td>2.8</td>
<td>0.010</td>
<td>1206</td>
</tr>
<tr>
<td></td>
<td></td>
<td>microSMD450LR-C-2</td>
<td>12</td>
<td>12</td>
<td>4.5</td>
<td>3.2</td>
<td>0.010</td>
<td>1210</td>
</tr>
</tbody>
</table>

![inline overtemperature protection at connector/cable](image)
PTC in USB Type-C Plugs and Receptacles
Circuit Protection Example
Expansion Card with USB3.1 (Gen2) / PD (100W) / Type-C

<table>
<thead>
<tr>
<th>Function</th>
<th>Overcurrent Protection</th>
<th>ESD Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Delivery 100W</td>
<td>PTC Radial Leaded 8A 1 pcs per board</td>
<td>-</td>
</tr>
<tr>
<td>Type-C 15W</td>
<td>PTC Surface Mount 5A 2016L500 1 pcs per USB port</td>
<td>-</td>
</tr>
<tr>
<td>USB3.1</td>
<td>-</td>
<td>TVS Diode Array SP1004U 2 pcs per USB port</td>
</tr>
</tbody>
</table>
Circuit Protection Example
USB Type-C Cable for Smartphone Charging

PTC
Additional Literature and Tools
Additional Literature
Littelfuse iDesign™ Online Simulator

- The World’s First Comprehensive Fuse Selection Tool
  - On-line Fuse Design and Selection tool
  - For Beginners and Experts
  - Easy starting point for designing in fuses on boards
  - The users can go beyond the typical calculations
  - You can do a lot of modelling and simulation without the need for physical testing

https://littelfuse.transim.com/login.aspx?
utm_source=Littelfuse&utm_medium=Footer-Link&utm_campaign=iDesign
Additional Literature
Design and Selection Guides

- **Electronic Products Selection Guide**
  - Available on the Littelfuse website
  - Includes all Littelfuse technologies
  - Quick reference for all product specifications and applications

- **System Level ESD Design Guide**
  - Available on the Littelfuse website
  - Discusses multiple applications such as:
    - USB1.1/2.0/3.0
    - HDMI/DVI
    - Audio (Speaker/Microphone)
    - Keypad/Push button
    - And many more…

- **USB3.1 Type-C Protection Solutions Flyer**
  - Available on the Littelfuse website
  - Quick reference for PTC and TVS Diode Array solutions
Enables the ability to “drill down” based upon user selectable criteria
- Sorting/selections includes, interface, #channels, voltages, discrete/array
- Currently, 160 components in the database, number is expected to grow

Thank You for Your Attention! Any Questions?

https://www.speed2design.com/circuit-protection-for-led-lighting-applications/