USB 2.0 advanced protection solutions
Where do you stand with USB protection?

**Beginner?**
I am not familiar with this subject. I am in the discovery phase and would like an overview and a basic understanding of the technology.

**Intermediate?**
I have a basic understanding of this subject. I would like to go deeper in details and tackle more aspects of this subject.

**Advanced?**
I am very familiar with this subject. I would like to deepen my knowledge and become an expert.
USB stands for Universal Serial Bus

It is very popular and present on most electronic devices

It is a serial bi-directional bus that is hot-pluggable and supports Plug and Play.

3 data lines:
- D+
- D-
- ID (for USB On-The-Go only)

1 power line: $V_{BUS}$

3 standards:
- Low speed (1.5 Mbit/s)
- Full speed (12 Mbit/s)
- High speed (480 Mbit/s)
## USB 2.0 basics (2)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Low speed</th>
<th>Full speed</th>
<th>High speed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data rate</strong></td>
<td>Up to 1.5 Mbit/s</td>
<td>Up to 12 Mbit/s</td>
<td>Up to 480 Mbit/s</td>
</tr>
<tr>
<td><strong>Termination</strong></td>
<td>Not terminated</td>
<td>Not terminated</td>
<td>90 Ω differential</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>45 Ω to ground</td>
</tr>
<tr>
<td><strong>Signaling – Logical low level</strong></td>
<td>$V_{D^+} = 0$ to $+0.3$ V</td>
<td>$V_{D^+} = 0$ to $+0.3$ V</td>
<td>$V_{D^+} = -10$ to $+10$ mV</td>
</tr>
<tr>
<td></td>
<td>$V_{D^-} = 2.8$ to $3.6$ V</td>
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</tr>
<tr>
<td><strong>$V_{BUS}$ voltage</strong></td>
<td>From 4.4 V to 5.5 V</td>
<td>From 4.4 V to 5.5 V</td>
<td>From 4.4 V to 5.5 V</td>
</tr>
<tr>
<td><em>(standard downstream port)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>$V_{BUS}$ max current</strong></td>
<td>500 mA</td>
<td>500 mA</td>
<td>500 mA</td>
</tr>
<tr>
<td><em>(standard downstream port)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Focus on power: charging ports

• Purpose: Charging batteries through the $V_{BUS}$ pin.

• Need for a current rate higher than 500 mA for the standard downstream port.

• The USB Battery Charging Specification (first release in 2007) defined a new type of port called charging port.

• Even if the maximum current is 5.0 A for safety, most USB cables are rated up to 1.5 A, thus creating a limitation.

<table>
<thead>
<tr>
<th></th>
<th>Standard downstream port (SDP)</th>
<th>Charging downstream port (CDP)</th>
<th>Dedicated charging port (DCP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>USB Battery Charging Specification Revision 1.2 (released in 2010)</td>
<td>Yes (max. current 900 mA on $V_{BUS}$ during high speed transfer)</td>
<td>No (D+ and D- shorted)</td>
</tr>
<tr>
<td>Data transfer enabled</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum current on $V_{bus}$</td>
<td>500 mA @ 5V</td>
<td>1.5 A @ 5V (USB cables rated at 1.5A only)</td>
<td>5A with voltage &gt; 2V (USB cables rated at 1.5A only)</td>
</tr>
</tbody>
</table>
Focus on power: USB Power Delivery

• To further develop the “power” aspect of USB ports, the USB Power Delivery (PD) specification was released in July 2012.

• 6 power profiles are defined extending the supply voltages (Profile 0 is reserved)

• This requires new cables withstanding voltages higher than 5 V and currents higher than 1.5 A.

• Profile 4 is the limit for micro-B/AB connectors.

<table>
<thead>
<tr>
<th>Profile</th>
<th>5 V</th>
<th>12 V</th>
<th>20 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2.0 A, 10 W</td>
<td>1.5 A, 18 W</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2.0 A, 10 W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>3.0 A, 36 W</td>
<td>3.0 A, 60 W</td>
</tr>
<tr>
<td>5</td>
<td>5.0 A, 60 W</td>
<td>5.0 A, 60 W</td>
<td>5.0 A, 100 W</td>
</tr>
</tbody>
</table>
The need for ESD protection devices

Advanced technology with very **thin lithography** and gate oxides are highly vulnerable to ESD.

Integrated electronics systems with **high-component-density PCBs** facilitate ESD coupling and propagation.

IC manufacturers are reluctant to make robust embedded ESD protection diodes that would take up a **significant active area of their advanced and expensive technology.**
Why ultra-low capacitance?

- The parasitic capacitance of ESD protection devices must be low enough to allow USB 2.0 high-speed signals (maximum data rate: 480 Mbit/s) to be transmitted without degradation.

- A high parasitic capacitance of the ESD protection devices would increase too much the signal rise/fall time and prevent communications.

*Example of the impact of parasitic capacitance on high-speed signal simulated with discrete capacitance*
EMI filtering & ESD protection for USB datalines

System-level ESD protection (IEC 61000-4-2 Level 4)

+ Common-mode filter (ECMF)

**Data rate (Gbit/s)**

- **10**
  - **ESDAXLC6-1BU2**
    - 1-line ESD
    - ST0201
    - 0.6 x 0.3 x 0.3 mm
  - **HSP051-4N10**
    - 4-line ESD
    - QFN 1.85 x 0.95 x 0.32 mm

- **5**
  - **USBULC6-2N4**
    - 2-line ESD
    - QFN 1.0 x 0.8 x 0.5 mm
  - **HSP051-4M10**
    - 4-line ESD
    - QFN 2.50 x 1.00 x 0.47 mm

- **0.48**
  - **USBLC6-2P6**
    - 2-line ESD + VBUS 6V
    - SOT-666
    - 1.6 x 1.6 x 0.53 mm
  - **USBLC6-4SC6**
    - 4-line ESD + VBUS 6V
    - SOT23
    - 2.92 x 1.62 x 1.17 mm

- **0.012**
  - **USBLC6-2SC6**
    - 2-line ESD + VBUS 6V
    - SOT23
    - 2.92 x 1.62 x 1.17 mm

**Click to know more about ECMF™**
Power Delivery - ESD & EOS protection

**VBUS (Typ.)**

- **SMALLEST**
  - **9 V**
    - NEW ESDA13P70-1U1M
      - Ipp = 70A, Ppp = 1300W
    - NEW ECMF02-4CMX8
      - 2-lane CMF + ID + \( V_{BUS} \) 16V
      - 2.50 x 1.20 x 0.50 mm
    - NEW ECMF2-0730V12M12
      - 2-lane CMF + ID + \( V_{BUS} \) 13V
      - 2.60 x 1.35 x 0.5 mm
  - **5 V**
    - NEW ESDA7P60-1U1M
      - Ipp = 60A, Ppp = 700W
    - HSP061-2M6
      - 2-line ESD + \( V_{BUS} \)
      - 1.45 x 1.00 x 0.55 mm

- **STONGEST**
  - SMM4F24A
    - Ipp = 60A, Ppp = 2300W
  - SMM4F13A
    - Ipp = 85A, Ppp = 2300W
  - SMM4F12AVCL
    - Ipp = 100A, Ppp = 2200W
  - SMM4F6.0A
    - Ipp = 170A, Ppp = 2300W

**SMALLEST INTEGRATION With USB 2.0 datalines**

1. **ESDA7P60-1U1M**
   - Ipp = 60A, Ppp = 700W

2. **ECMF02-4CMX8**
   - 2-lane CMF + ID + \( V_{BUS} \) 16V
   - 2.50 x 1.20 x 0.50 mm

3. **ECMF2-0730V12M12**
   - 2-lane CMF + ID + \( V_{BUS} \) 13V
   - 2.60 x 1.35 x 0.5 mm

4. **HSP061-2M6**
   - 2-line ESD + \( V_{BUS} \)
   - 1.45 x 1.00 x 0.55 mm

**NEW ECMF2-0730V12M12**

- **Package & Size**
  - **QFN**
    - 1610
    - 1.6mm x 0.55mm x 1.0mm
  - **SMA Flat**
    - 3.80mm x 0.85mm x 1.90mm
Let’s go further

**Basic information**

- ECMF™ series portfolio overview: common-mode filters embedding ESD protection - Product presentation
- HSP series portfolio overview: High-speed port ESD protection - Product presentation

**In-depth information**

- TVS short-pulse dynamic resistance measurements... Application note AN4022
- IEC 61000-4-2 standard testing - Application note AN3353
- Pspice models: ESD protection and ECMF™

**Selection & sampling**

- Our Protection devices & Integrated EMI filtering selection guide
- Our USB port protection product selector
- Our USB IPAD™ (including ECMF™) product selector