



## Overview

The USBHub3+ is an 8-port software-programmable USB 3.1 (Gen1; 5 Gbps) hub designed for demanding industrial environments where advanced control and monitoring of USB ports is required. Ideal for testing or development environments where standard “always-on” behavior of a consumer-grade USB hub is not desirable.

Software control of the USBHub3+ is established and maintained over one of two available upstream-facing host ports or via a dedicated Control Port connection.

The USBHub3+ can be used to enable/disable individual USB ports, measure current or voltage on downstream USB ports, set programmable current limits, set USB charging protocol behavior and otherwise automate USB port behaviors in development and testing.

Typical applications include:

- USB device manufacturing
- USB device validation and development
- Plug/unplug cycle testing
- Functional testing
- Battery charging
- USB device resets
- USB power monitoring
- Controlling USB device enumeration sequence

## Features

- Supports USB hosts and devices up to USB 3.1 (5Gbps)
- Individually enable/disable any of 8 downstream ports
- Measure voltage and current on each downstream port
- Hi-Speed data, SuperSpeed data and power lines can be separately enabled for each downstream port
- Set programmable current limits for each downstream port (up to 4A)
- Dedicated Control Port for software control; independent of the selected upstream port

- Automatic or programmed selection for either of 2 upstream-facing host port connections
- All ports support USB link speeds up to 5Gbps
- Detect established link speed on each port: SuperSpeed (5Gbps) or Hi-Speed (480Mbps)
- Selectively enable USB charging mode behaviors: SDP (Standard Downstream Port) or CDP (Charging Downstream Port) modes<sup>1</sup>
- Deliver up to 4.0A per port (in CDP mode)
- Set enumeration delay for discovery of attached downstream devices
- Backward compatible with USB 2.0 and USB 1.x devices
- Boost USB 2.0 upstream and downstream signal levels
- DIN-rail mountable
- Alternate Euro-style terminal block power input connector
- Certified to +/-15kV ESD strikes (IEC61000-4-2 level 4)
- Overvoltage and reverse-current protected  $V_{bus}$  outputs

## Description

The USBHub3+ gives engineers advanced flexibility and configurability over USB ports in testing and development applications.

The USBHub3+ hub architecture consists of two layers of internal hubs to achieve true 8-port hub functionality.

Each downstream USB channel implements separately and independently switched data lines and current-limited power lines. USB power, data and SS data can be independently disconnected for advanced USB testing applications. Pin interfaces are protected against reverse polarity and over-voltage. Connections are designed to operate from 0°C to 50°C ambient with no external cooling or fans.

Each USBHub3+ is uniquely addressable and controllable from a host PC via the selected USB host input or through a dedicated Control Port. Acroname’s BrainStem™ link is then established over the USB input and allows a connection to the on-board controller in the USBHub3+. USBHub3+ can be controlled via a host running BrainStem APIs or alternately, it can operate independently by running locally embedded, user-defined programs based on Acroname’s BrainStem Reflex language.

<sup>1</sup> See [http://www.usb.org/developers/docs/devclass\\_docs/](http://www.usb.org/developers/docs/devclass_docs/) under the category Battery Charging for full details.

## Absolute Maximum Ratings

Stresses beyond those listed under ABSOLUTE MAXIMUM RATINGS can cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under RECOMMENDED OPERATING CONDITIONS is not implied. Exposure to absolute-maximum rated conditions for extended periods affects device reliability and may permanently damage the device.

| Parameter   | Minimum | Maximum | Units |
|---|---------|---------|-------|
| Input Voltage, $V_{\text{supply}}$                            | 0.0     | 36.0    | V     |
| Input Power   |         | 85      | W     |
| $V_{\text{bus}}$ Output Power                                 |         | 65      | W     |
| Voltage on any $V_{\text{bus}}$ line, upstream and downstream | 0.0     | 5.1     | V     |
| Voltage on any USB D+/D-, upstream and downstream             | -0.3    | 5.1     | V     |

Table 1: Absolute Maximum Ratings

## Handling Ratings

| Parameter                                 | Conditions/Notes                                | Minimum | Typical | Maximum | Units |
|---|---|---------|---------|---------|-------|
| Ambient Operating Temperature, $T_A$      | Non-Condensing                                  | 0.0     | 25.0    | 50.0    | °C    |
| Storage Temperature, $T_{\text{STG}}$     |   | -10.0   | -       | 85.0    | °C    |
| Electrostatic Discharge, $V_{\text{ESD}}$ | Meets IEC 61000-4-2, level 4, air-discharge     | -15     | -       | +15     | kV    |
|   | Meets IEC 61000-4-2, level 4, contact-discharge | -8      | -       | +8      | kV    |

Table 2: Handling Ratings

## Recommended Operating Ratings

Values presented apply to the full operating temperature range.

| Parameter   | Conditions/Notes                 | Minimum | Typical | Maximum | Units |
|---|----------------------------------|---------|---------|---------|-------|
| Input Voltage, $V_{\text{supply}}$                        |                                  | 9.0     | 12.0    | 24.0    | V     |
| USB $V_{\text{bus}}$ Voltage, all downstream-facing ports | Hub powered; Port power enabled  | 4.5     | 5.0     | 13.2    | V     |
|   | Hub powered; Port power disabled | 0.0     | 0.0     | 13.2    | V     |

Table 3: Recommended Operating Ratings



**Block Diagram**

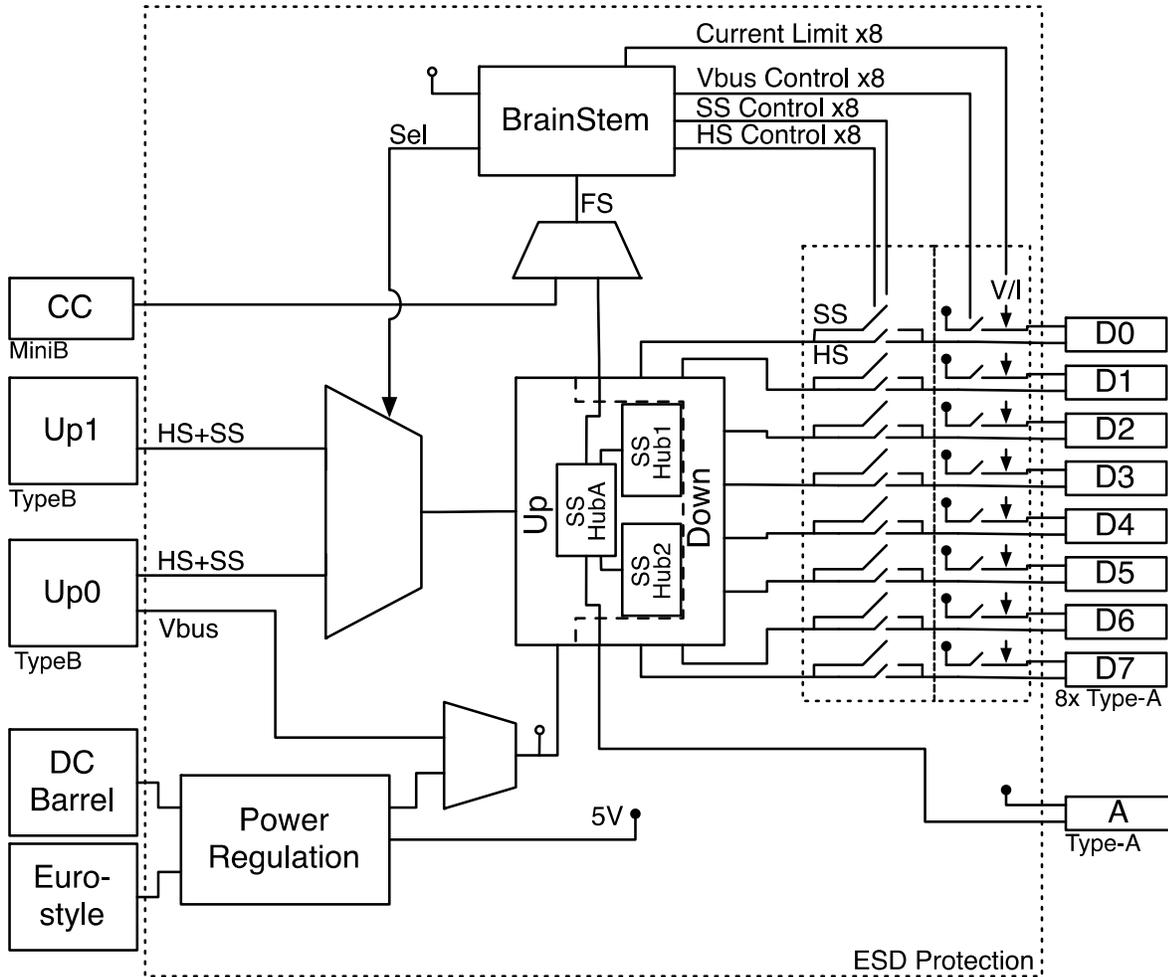


Figure 1: USBHub3+ Block Diagram

## Typical Performance Characteristics

Values presented apply to the full operating temperature range.

| Parameter  | Conditions/Notes   | Min   | Typ. | Max  | Units         |
|--|--|-------|------|------|---------------|
| Input Power, $W_{\text{supply}}$ , no downstream devices attached  |  | -     | 2.2  | -    | W             |
| $V_{\text{supply}}$ Under Voltage Lockout (UVLO)                   |  | 7.5   | 8.0  | 8.2  | V             |
| $V_{\text{supply}}$ Over Voltage Lockout (OVLO)                    |  | 26.0  | 26.8 | 27.8 | V             |
| Wide Input Range System Efficiency                                 | At 12.0V input, nominal 8A load <sup>2</sup>                       | 84    | -    | 92   | %             |
| USB Downstream Output Voltage, $V_{\text{bus}}$                    | No load on downstream USB ports                                    | 4.947 | 5.10 | 5.25 | V             |
| $V_{\text{bus}}$ Measurement Resolution                            |  | -     | 8.0  | -    | mV            |
| $V_{\text{bus}}$ Measurement Accuracy                              |  | -2.0  | -    | 2.0  | %             |
| $V_{\text{bus}}$ Short-circuit Trip Current, $I_{\text{limit}}$    |  | 4.8   | 5.0  | 5.4  | A             |
| $V_{\text{bus}}$ Short-circuit Trip Time, $t_{\text{limit}}$       |  | -     | 0.7  | -    | $\mu\text{S}$ |
| $V_{\text{bus}}$ Short-circuit Average Current, $I_{\text{short}}$ | After trip   | 0.3   | 0.5  | 2.0  | A             |
| $V_{\text{bus}}$ Current Measurement Resolution                    |  | -     | 1.0  | -    | mA            |
| $V_{\text{bus}}$ Current Measurement Accuracy                      | $V_{\text{bus}}$ current < 4.00A                                   | -1.0  | -    | 1.0  | %             |
| $V_{\text{bus}}$ Current Measurement Range                         |  | 0     | -    | 4095 | mA            |
| $V_{\text{bus}}$ Current Limit Trip Point Range                    | Software programmable  | 0     | -    | 4095 | mA            |
| $V_{\text{bus}}$ Current Limit Trip Point Resolution               |  | -     | 1.0  | -    | mA            |
| $V_{\text{bus}}$ Overcurrent Trip Time $t_{\text{trip}}$           | Time from overcurrent load to port power switch disconnect.        | -     | 5.0  | 7.5  | ms            |
| USB SuperSpeed Data Rate   | May depend on host or devices                                      | -     | -    | 5    | Gbps          |
| USB Hi-Speed Data Rate   | May depend on host or devices                                      | -     | -    | 480  | Mbps          |
| $V_{\text{bus}}$ Current Supply (SDP mode)                         | USB 2.0 data lines disabled or no USB host present, device limited | -     | 100  | -    | mA            |
| $V_{\text{bus}}$ Current Supply (SDP mode)                         | USB 2.0 data lines enabled and USB host present, device limited    | -     | 500  | -    | mA            |
| $V_{\text{bus}}$ Current Supply (CDP mode)                         | USB 2.0 data lines enabled, USB host present, device limited       | -     | 1500 | -    | mA            |
| $V_{\text{bus}}$ Current Supply (DCP mode)                         | USB 2.0 data lines enabled, no USB host present, device limited    | -     | 5000 | -    | mA            |
| Input current CH0 upstream port, $I_{V_{\text{bus}}}$              | No $V_{\text{supply}}$ present, USB 2.0 type-B cable               | -     | 180  | -    | mA            |
| Input current CH0 upstream port, $I_{V_{\text{bus}}}$              | No $V_{\text{supply}}$ present, USB 3.0 type-B cable               | -     | 425  | -    | mA            |
| Input current measurement resolution, $I_{\text{supply}}$          | Through barrel jack or Euro-style connector only                   | -     | 4.0  | -    | mA            |
| $I_{\text{supply}}$ accuracy                                       |  | -2.0  | -    | 2.0  | %             |
| Input voltage measurement resolution, $V_{\text{supply}}$          | Through barrel jack or Euro-style connector only                   | -     | 8.0  | -    | mV            |
| $V_{\text{supply}}$ measurement accuracy                           |  | -2.0  | -    | 2.0  | %             |

Table 4: Typical Performance Characteristics

<sup>2</sup> Representative 8A load based on 8 USB downstream devices running in CDP mode consuming approximately 1.0A each.

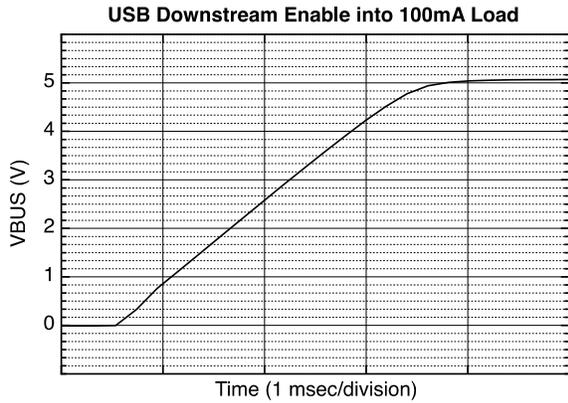


Figure 2:  $V_{bus}$  rise time after with 100mA constant load.

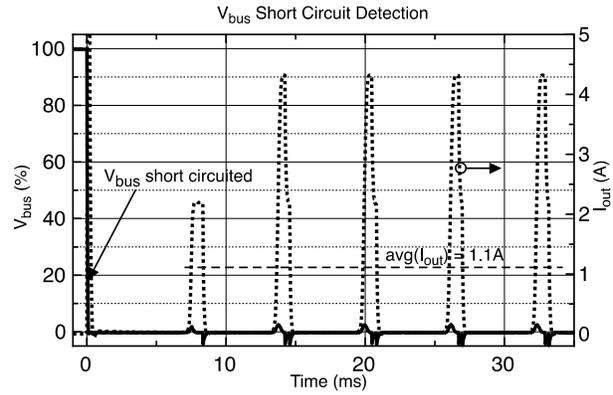


Figure 4:  $V_{bus}$  short-circuit mode behavior.

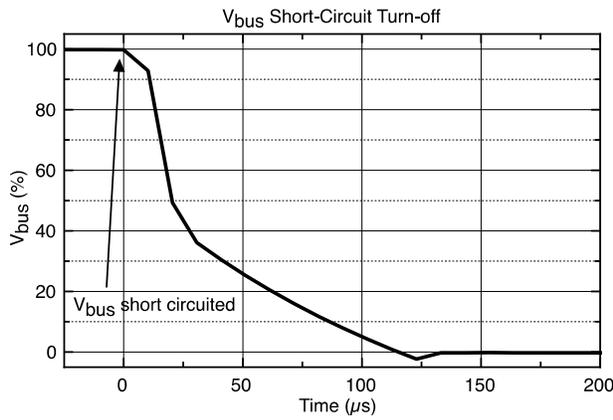


Figure 3:  $V_{bus}$  turn-off time after short-circuit.

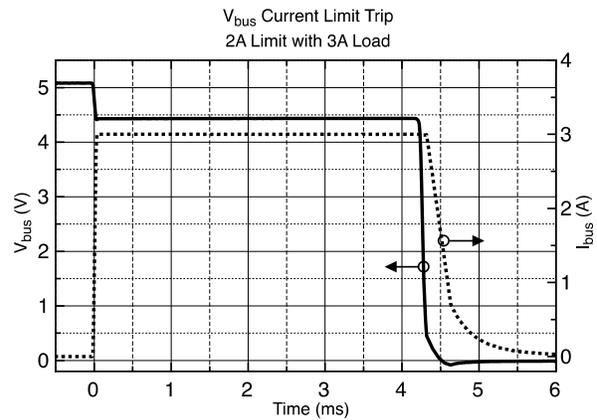


Figure 5:  $V_{bus}$  programmable current limit response.

### Overview

With advanced programmable control features, the USBHub3+ is targeted at industrial and production systems requiring software and embedded control of USB devices. It is ideal for manufacturing test of consumer electronics and control of industrial systems.

#### Power Subsystem

An over-voltage, under-voltage, over-temperature, current limited switch mode power supply regulated input supply power to generate  $V_{bus}$  for all downstream ports as well as the USBHub3+'s system power. As noted in the system block diagram, the system power can also come from Up0's  $V_{bus}$ . However, if powering the system from Up0, no downstream port power is available. This feature is useful for programming and testing the hub's features without the need of an external power supply.

#### Grounding

USB is sensitive to grounding and ground loops. It is important to understand your system's grounding strategy to ensure the USB shield or ground is not the primary ground current return path. The USBHub3+ shorts USB shield and ground and provides an earth ground connection point. Instructions for separating shield and earth ground from USB and system ground can be obtained by contacting Acroname support.

Ground isolation methods such as optical isolators and isolated power supplies have been demonstrated to work well with the USBHub3+.

#### Current Limiting Behavior

There are two current limits in the USBHub3+: the programmable limit and short-circuit limit. The programmable current limit sets a circuit-breaker style trip point which disables the port if the current goes above the set limit.  $V_{bus}$  current is sampled over  $140\mu s$  and averaged over 4 samples for the programmable current trip point (total averaging period of  $560\mu s$ ). When a port trips, the USBHub3+ sets the overcurrent flag (see USB Port Error Status Mapping) and disables the port after  $t_{trip}$ . A device is allowed to draw up to the short-circuit current limit until the port is disabled. This behavior is detailed in Figure 5.

A short-circuit on  $V_{bus}$  is current limited to  $I_{limit}$ . Any current over  $I_{limit}$  will cause  $V_{bus}$  to enter short-circuit mode after  $t_{limit}$ . Higher current may flow within  $t_{limit}$ . After entering short-circuit mode, assuming the programmable current limit is not tripped, the port will supply an average of  $I_{short}$ . The short-circuit behavior is detailed in Figure 3 and Figure 4. Short-circuit mode will

continue until the short-circuit is removed or the load current drops below  $I_{limit}$ .

### Software Control

#### Device Drivers

The USBHub3+ leverages operating system user space interfaces that do not require custom drivers for operation on modern operating systems.

Some older operating systems may require the installation of a BrainStem USB driver to enable software control. Installation details on installing USB drivers can be found within the BrainStem Development Kit under the "drivers" folder. For example, Windows 7 requires the supplied INF to communicate with BrainStem USB devices.

#### Capabilities and Interfaces

The USBHub3+ is built on Acroname's BrainStem system, which provides simple high level APIs, a real-time embedded runtime engine and modular expandability. Functionality details unique to the USBHub3+ are described in the following sections. Please refer to for a complete list of all available API functionality. All shortened code snippets are loosely based on the C++ method calls and meant to be pseudocode – Python and Reflex are virtually the same. Please consult the BrainStem Reference for implementation details.<sup>3</sup>

### System Entities

Every BrainStem module includes a single System Entity. The System Entity allows access to configuration settings such as the module address, input voltage, control over the user LED and many more.

#### Serial Number

Every USBHub3+ is assigned a unique serial number at the factory. This facilitates an arbitrary number of USBHub3+ devices attached to a host computer. The following method call can retrieve the unique serial number for each device.

```
stem.system.getSerialNumber(serialNumber)
```

<sup>3</sup> See BrainStem software API reference at <https://acroname.com/reference/> for further details about all BrainStem API methods and information.

### Module Default Base Address

BrainStems are designed to be able to form a reactive, extensible network. All BrainStem modules come with a default network base address for identification on the BrainStem network bus. The default module base address for USBHub3+ is factory-set as 6, and can be accessed with:

```
stem.system.getModule(module)
```

### Saving USB Entity Settings

Some entities can be configured and saved to non-volatile memory. This allows a user to modify the startup and operational behavior for the USBHub3+ away from the factory default settings. Saving system settings preserves the settings as the new default. Most changes to system settings require a save and reboot before taking effect. For example, upstream and downstream USB Boost settings will not take effect unless a system save operation is completed, followed by a reset or power cycle. Use the following command to save changes to system settings before reboot:

```
stem.system.save()
```

Pressing the reset button two times within 5 seconds will return all settings to factory defaults: all ports' data (HS and SS) and power enabled, CDP mode, enumeration delay of 0, 4095mA current limit.

| Saved Configurations             |                             |
|----------------------------------|-----------------------------|
| Software Offset                  | I2C Rate                    |
| Router Address                   | Port Enumeration Delay      |
| Boot Slot                        | Downstream Boost            |
| Port Mode (SDP, CDP) – each port | Current Limit – per port    |
| Upstream Boost                   | Port state (data and power) |

Table 5: Saved Parameters

## USB Entity

The usb entity provide a mechanism to control all functionality for the upstream and downstream USB ports.

### USB Downstream Channels

Downstream USB channels can be manipulated through the usb entity command to enable and disable USB data and  $V_{bus}$  lines, measure current, measure  $V_{bus}$  voltage, boost data line signals, and measure temperature.

Manipulating Hi-Speed data, SuperSpeed data, and  $V_{bus}$  lines simultaneously for a single port can be done by calling the following methods with channel in [0-7] being the port index:

```
stem.usb.setPortEnable(channel)
stem.usb.setPortDisable(channel)
```

Manipulating Hi-Speed data and SuperSpeed data lines while not affecting the  $V_{bus}$  lines simultaneously for a single port can be done by calling the following method with channel [0-7]:

```
stem.usb.setDataEnable(channel)
stem.usb.setDataDisable(channel)
```

Manipulating just the USB 2.0 Hi-Speed data lines for a single port can be done by calling the following method with channel [0-7]:

```
stem.usb.setHiSpeedDataEnable(channel)
stem.usb.setHiSpeedDataDisable(channel)
```

Manipulating just the USB 3.1 SuperSpeed data lines for a single port can be done by calling the following method with channel [0-7]:

```
stem.usb.setSuperSpeedDataEnable(channel)
stem.usb.setSuperSpeedDataDisable(channel)
```

Manipulating just the USB  $V_{bus}$  line for a single port can be done by calling the following method with channel [0-7]:

```
stem.usb.setPowerEnable(channel)
stem.usb.setPowerDisable(channel)
```

To affect multiple ports and lines simultaneously, see `usb.setHubMode()` later in this section.

The USB  $V_{bus}$  voltage, as well as the current consumed on  $V_{bus}$ , can be read for each channel by calling the following methods with channel [0-7], where the second variable passed into the method is the location for the measurement result:

```
stem.usb.getPortVoltage(channel, μV)
stem.usb.getPortCurrent(channel, μA)
```

Current-limit trip point settings can be accessed for each port by calling the following methods with channel [0-7], where the second variable passed into the method is either the set value or the write location of the result:

```
stem.usb.getPortCurrentLimit(channel, μA)
stem.usb.setPortCurrentLimit(channel, μA)
```

The enumeration state and speed of each downstream port can be read with

```
stem.usb.getDownstreamDataSpeed(ch, speed)
```

with ch in [0-7] and speed values returned as:

- 0 – N/A (device not enumerated)
- 1 – Hi-Speed device
- 2 – SuperSpeed device

### **USB Downstream Operational Mode**

The USB port operational mode controls the behavior of each downstream port's charging behavior. Each port can be setup to support different modes in the USB Battery Charge Specification 1.2 (BC1.2). Standard Downstream Port (SDP) mode will cause BC1.2 compliant or older USB devices to consume 500mA or less. Configuring a port as a Charging Downstream Port (CDP) will cause the hub signal to downstream devices that devices may consume up to 5A, the maximum allowed by BC1.2. If there is no upstream USB host connected to the hub, downstream ports set to CDP will behave as Dedicated Charging Ports (DCP).

The actual current consumed by the device is controlled by the downstream device and not the USBHub3+. Devices which are not compliant with BC1.2 or the previous USB power specifications may draw more current than specified above.

The operational mode is set or read by calling the methods:

```
stem.usb.setPortMode(channel, mode)  
stem.usb.getPortMode(channel, mode)
```

Available options for Downstream Operational Mode are:

- 0 – Standard Downstream Port (SDP)
- 1 – Charging Downstream Port (CDP)

### **USB Downstream Enumeration Delay**

Once a USB device is detected by the USBHub3+ it is possible to delay its connection to an upstream host computer and subsequent enumeration on the USB bus. The enumeration delay can mitigate or eliminate host kernel instabilities by forcing devices to enumerate in slow succession, allowing a focus on validation of drivers and software. The enumeration delay is configured in milliseconds, representing the time delay between enabling each successive downstream port from 0 to 7. Enumeration delay is applied when the hub powers on or when a new upstream connection is made.

```
stem.usb.setEnumerationDelay(delay)  
stem.usb.getEnumerationDelay(delay)
```

### **USB Boost Mode**

Boost mode increases the drive strength of the USB 2.0 Hi-Speed data signals (SuperSpeed data and power signals are

not changed). Boosting the data signal drive strength may help to overcome connectivity issues when using long cables or connecting through relays, "pogo" pins or other adverse conditions. This setting is applied after a `system.save()` call and reset or power cycle of the hub. The system setting is persistent until changed or the hub is hard reset. After a hard reset, the default value of 0% boost is restored. A hard reset is done by pressing the "Reset" button on the back of the hub while the hub is powered.

Boost mode can be applied to both the upstream and downstream USB ports with the follow methods:

```
stem.usb.getDownstreamBoostMode(setting)  
stem.usb.setDownstreamBoostMode(setting)  
stem.usb.getUpstreamBoostMode(setting)  
stem.usb.setUpstreamBoostMode(setting)
```

The setting parameter is an integer that correlates to the following:

- 0 – normal drive strength
- 1 – 4% increased drive strength
- 2 – 8% increased drive strength
- 3 – 12% increased drive strength

### **USB Hub Upstream Channels**

The USBHub3+ is perfect for environments where multiple devices need to be shared or switched between two host computers using two host (upstream) connections via USB standard-B connectors. The upstream connection can be automatically detected or specifically selected using the following methods:

```
stem.usb.getUpstreamMode(mode)  
stem.usb.setUpstreamMode(mode)
```

The mode parameter can be defined as the following:

- 0 – select upstream port 0  
(usbUpstreamModePort0)
- 1 – select upstream port 1  
(usbUpstreamModePort1)
- 2 – automatically detect upstream port  
(usbUpstreamModeAuto)
- 255 – disconnect both upstream ports  
(usbUpstreamModeNone)

Predefined C++ macros for these can be found in `aProtocoldef.h`, and Python's built-in help interface.

The default operational mode is to auto detect which upstream USB port is selected. Automatic detection uses the presence of  $V_{bus}$  on the USB type-B upstream connector to determine presence of a host. i.e. if a host is connected to the Up0 port, then channel 0 will be selected as the upstream USB connection (see Figure 7 for more detail).

Note: if the Hub Upstream Mode is set to disconnect both upstream ports, the only path available to control the USBHub3+ will be via a host connected to the BrainStem Control Port.

### USB Hub Upstream State

The USBHub3+ can provide status information on which upstream port is actively selected as data path to the downstream ports:

```
stem.usb.getUpstreamState()
```

This command returns a 32-bit value which indicates:

- 0 – upstream port 0 is actively selected
- 1 – upstream port 1 is actively selected
- 2 – no upstream port selected

### BrainStem Control Port

The USBHub3+ also has a dedicated control channel on the USB mini-B connector. This is a full-speed USB 2.0 connection for BrainStem interface only. No USB hub traffic can flow on this connection. When a cable is connected to the mini-B connector, the BrainStem device will be controlled only through the Control Port, independent of the selected upstream port. The USB 3.0 type-B connectors are then used only for USB hub traffic to connect downstream USB devices. When no host is connected to the Control Port, BrainStem control is available through the selected upstream port.

### USB Hub Operational Mode

In addition to targeting individual downstream USB ports, a bit-mapped hub state interface is also available. This interface allows the reading or setting of all USB downstream ports in one functional call.

```
stem.usb.getHubMode(mode)
stem.usb.setHubMode(mode)
```

The value mode is 32-bit word, defined as the following:

| Bit | Hub Operational Mode Word Definition  |
|-----|---------------------------------------|
| 0   | USB Ch 0 USB Hi-Speed Data Enabled    |
| 1   | USB Ch 0 USB V <sub>bus</sub> Enabled |
| 2   | USB Ch 1 USB Hi-Speed Data Enabled    |
| 3   | USB Ch 1 USB V <sub>bus</sub> Enabled |
| 4   | USB Ch 2 USB Hi-Speed Data Enabled    |
| 5   | USB Ch 2 USB V <sub>bus</sub> Enabled |
| 6   | USB Ch 3 USB Hi-Speed Data Enabled    |
| 7   | USB Ch 3 USB V <sub>bus</sub> Enabled |
| 8   | USB Ch 4 USB Hi-Speed Data Enabled    |
| 9   | USB Ch 4 USB V <sub>bus</sub> Enabled |
| 10  | USB Ch 5 USB Hi-Speed Data Enabled    |
| 11  | USB Ch 5 USB V <sub>bus</sub> Enabled |

|    |                                       |
|----|---------------------------------------|
| 12 | USB Ch 6 USB Hi-Speed Data Enabled    |
| 13 | USB Ch 6 USB V <sub>bus</sub> Enabled |
| 14 | USB Ch 7 USB Hi-Speed Data Enabled    |
| 15 | USB Ch 7 USB V <sub>bus</sub> Enabled |
| 16 | USB Ch 0 USB SuperSpeed Data Enabled  |
| 17 | Reserved                              |
| 18 | USB Ch 1 USB SuperSpeed Data Enabled  |
| 19 | Reserved                              |
| 20 | USB Ch 2 USB SuperSpeed Data Enabled  |
| 21 | Reserved                              |
| 22 | USB Ch 3 USB SuperSpeed Data Enabled  |
| 23 | Reserved                              |
| 24 | USB Ch 4 USB SuperSpeed Data Enabled  |
| 25 | Reserved                              |
| 26 | USB Ch 5 USB Super Speed Data Enabled |
| 27 | Reserved                              |
| 28 | USB Ch 6 USB SuperSpeed Data Enabled  |
| 29 | Reserved                              |
| 30 | USB Ch 7 USB SuperSpeed Data Enabled  |
| 31 | Reserved                              |

Table 6: Hub Operational Mode Result Bitwise Description

### USB Port State

Each downstream port reports information regarding its operating state represented in bit-packed results from:

```
stem.usb.getPortState(channel, state)
```

where channel can be [0-7], and the value status is 32-bit word, defined as the following:

| Bit   | Port State: Result Bitwise Description |
|-------|--|
| 0     | USB V <sub>bus</sub> Enabled           |
| 1     | USB2 Data Enabled                      |
| 2     | Reserved                               |
| 3     | USB3 Data Enabled                      |
| 4:10  | Reserved                               |
| 11    | USB2 Device Attached                   |
| 12    | USB3 Device Attached                   |
| 13:18 | Reserved                               |
| 19    | USB Error Flag                         |
| 20    | USB2 Boost Enabled                     |
| 23    | Device Attached                        |
| 24:31 | Reserved                               |

Table 7: Port State: Result Bitwise Description

### USB Port Error Status Mapping

Error states for all downstream ports are bit-packed in 32-bit words available from:

```
stem.usb.getPortError(channel)
```

where channel is [0-7].

Errors can be cleared on each individual channel by calling the following method:

```
stem.usb.clearPortErrorStatus(channel)
```

Calling this command clears the port-related error bit flags (see Table 7) in the port error state. Global bits for hub errors cannot be cleared by this command.

Details about the port error status 32-bit word are as follows:

| Bit  | Port Error Status (channel) Result Bitwise Description |
|------|--|
| 0    | USB port current limit exceeded                        |
| 1    | USB port back-drive condition detected                 |
| 2    | Hub external power not present                         |
| 3    | Hub overtemperature condition                          |
| 4:31 | Reserved   |

Table 8: Port Error Status Result Bitwise Description

### **USB System Temperature**

The temperature of the USB subsystem in the USBHub3+ can be measured with:

```
stem.temperature(0).getTemperature( $\mu$ C)
```

where temperature is in micro-degrees Celcius.

## USBHub3+ Supported Entity Methods Summary

Detailed entity class descriptions can be found in the BrainStem Reference (<https://acroname.com/reference/entities/index.html>). A summary of USBHub3+ class options are shown below. Note that when using Entity classes with a single index (aka, 0), the index parameter can be dropped. For example:

```
stem.system[0].setLED(1) → stem.system.setLED(1)
```

| Entity Class | Entity Option   | Variable(s) Notes |
|--------------|-----------------|-------------------|
| store[0-1]   | getSlotState    |                   |
|              | loadSlot        |                   |
|              | unloadSlot      |                   |
|              | slotEnable      |                   |
|              | slotDisable     |                   |
|              | slotCapacity    |                   |
|              | slotSize        |                   |
| system[0]    | save            |                   |
|              | reset           |                   |
|              | setLED          |                   |
|              | getLED          |                   |
|              | setSleep        |                   |
|              | setBootSlot     |                   |
|              | getBootSlot     |                   |
|              | getInputVoltage |                   |
|              | getInputCurrent |                   |
|              | getVersion      |                   |
|              | setHBInterval   |                   |
|              | getHBInterval   |                   |
|              | getModule       |                   |
|              | getSerialNumber |                   |
|              | getModel        |                   |
|              | temperature[0]  | getTemperature    |
| timer[0-8]   | getExpiration   |                   |
|              | setExpiration   |                   |
|              | getMode         |                   |

|        |                          |              |
|--------|--------------------------|--------------|
|        | setMode                  |              |
| usb[0] | setPortEnable            | Channels 0-7 |
|        | setPortDisable           | Channels0-7  |
|        | setDataEnable            | Channels 0-7 |
|        | setDataDisable           | Channels 0-7 |
|        | setHiSpeedDataEnable     | Channels 0-7 |
|        | setHiSpeedDataDisable    | Channels 0-7 |
|        | setSuperSpeedDataEnable  | Channels 0-7 |
|        | setSuperSpeedDataDisable | Channels 0-7 |
|        | setPowerEnable           | Channels 0-7 |
|        | setPowerDisable          | Channels 0-7 |
|        | getPortVoltage           | Channels 0-7 |
|        | getPortCurrent           | Channels 0-7 |
|        | getPortCurrentLimit      | Channels 0-7 |
|        | setPortCurrentLimit      | Channels 0-7 |
|        | setPortMode              | Channels 0-7 |
|        | getPortMode              | Channels 0-7 |
|        | getDownstreamDataSpeed   | Channels 0-7 |
|        | getHubMode               |              |
|        | setHubMode               |              |
|        | getPortState             | Channels 0-7 |
|        | getPortError             |              |
|        | getEnumerationDelay      |              |
|        | setEnumerationDelay      |              |
|        | clearPortErrorStatus     |              |
|        | getUpstreamMode          |              |
|        | setUpstreamMode          |              |
|        | getUpstreamState         |              |
|        | getUpstreamBoostMode     |              |
|        | setUpstreamBoostMode     |              |
|        | getDownstreamBoostMode   |              |
|        | setDownstreamBoostMode   |              |

*Table 9: Supported USBHub3+ BrainStem Entity API Methods<sup>4</sup>*

## Connections and LED Indicators

The front and back of the USBHub3+ have a set of connectors and LEDs to indicate control information and connectivity status. The meaning and location of each connector and LED are described in the following tables and diagrams.

| LED Name                         | Color                 | Description  |
|----------------------------------|-----------------------|--|
| Link Status LED                  | Yellow                | On once a host device has enumerated the BrainStem controller  |
| User LED                         | Blue                  | Can be manipulated through any of the available APIs   |
| Heartbeat LED                    | Green                 | Indicates active BrainStem connection; pulses at a rate determined by the system heartbeat rate  |
| Power/Watchdog LED               | Red and flashing blue | Solid red indicates the system is powered. Flashing blue is indication the internal watchdog is running and the USBHub3+ firmware is healthy |
| Upstream Operational Speed LED   | Yellow or green       | Upstream enumeration speed to host: green for SuperSpeed; yellow for Hi-Speed or lower USB 2.0 speeds.                                       |
| Upstream 0 LED                   | Green                 | Indicates an active connection on upstream port  |
| Upstream 1 LED                   | Green                 |  |
| Control Port LED                 | Yellow                |  |
| Downstream Operational Speed LED | Yellow or green       | Downstream device enumeration speed: green for SuperSpeed; yellow for Hi-Speed or lower USB 2.0 speeds; off when no device is enumerated     |
| Downstream Power LED             | Red                   | LED is on when downstream $V_{bus}$ is enabled   |

Table 10: LED indicators

| Connection Name        | Type               | Description   |
|------------------------|--------------------|---|
| Front Panel, 0-7       | USB 3.0 Type A     | Downstream-facing connections to USB devices<br>Each port is controlled and monitored by BrainStem API                    |
| Down A                 | USB 3.0 Type A     | Downstream-facing connection to USB devices<br>This port is always on and is not controlled or monitored by BrainStem API |
| Control Port           | USB 2.0 mini-B     | Dedicated BrainStem control command access  |
| Up0                    | USB 3.0 Type B     | Upstream-facing connections for a USB host to access downstream devices   |
| Up1                    | USB 3.0 Type B     | Selected UpX provides BrainStem control command access if Control Port is not connected                                   |
| Barrel Power Input     | Black Barrel-type  | External power input  |
| Euro-Style Power Input | Green Phoenix-type | External power input  |

Table 11: USBHub3+ External Connections

<sup>4</sup> See BrainStem software API reference at <https://acroname.com/reference/> for further details about all BrainStem API methods and information.

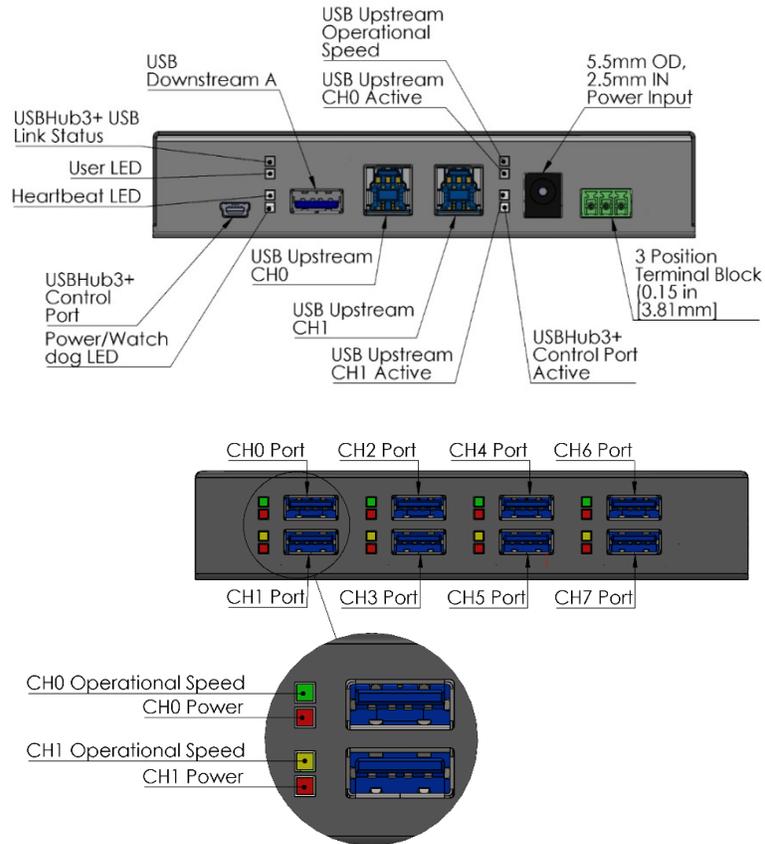


Figure 6: Connections and LED Indicators

### Using Multiple Hosts with USBHub3+

The two upstream-facing host ports can be connected to two different host computers. Due to limitations of USB specification and architecture, only one host computer can access downstream USB ports at any time. Through the BrainStem APIs, the upstream port used can be specifically selected, or the system can automatically select the upstream port (see USB Hub Upstream Channels). When automatically selecting the upstream port, the USBHub3+ will favor using Up0 if it is connected.

### BrainStem Control Access

A dedicated USB Control Port is available, which provides a constant connection to the BrainStem controller, independent of which upstream-facing USB host port is connected or selected. If the dedicated Control Port is not used, the BrainStem connection is accessed through the selected upstream port. Using the Control Port provides the ability to completely disconnect both USB upstream host connections while maintaining software control of the hub. Figure 7 details the decision flow used by the hub’s internal firmware for selecting the port used to receive BrainStem communications.

#### USBHub3+ API Control Message Path

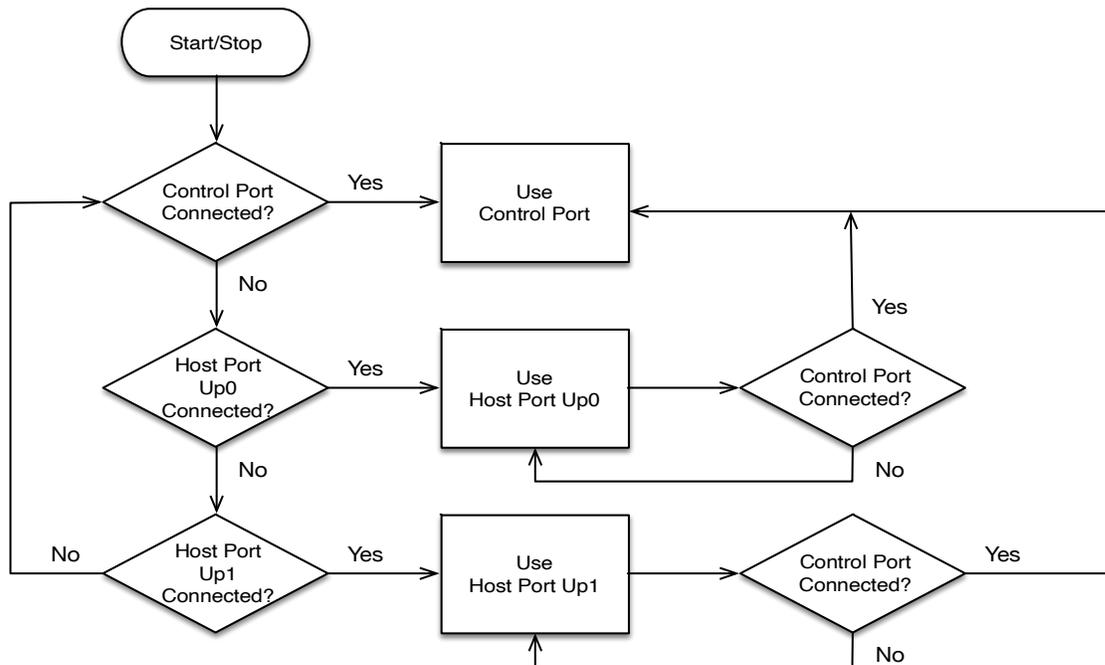


Figure 7: Determining connection used for BrainStem communications

### Mechanical

Dimensions are shown in inches [mm]. 3D CAD models available from <https://acroname.com>.

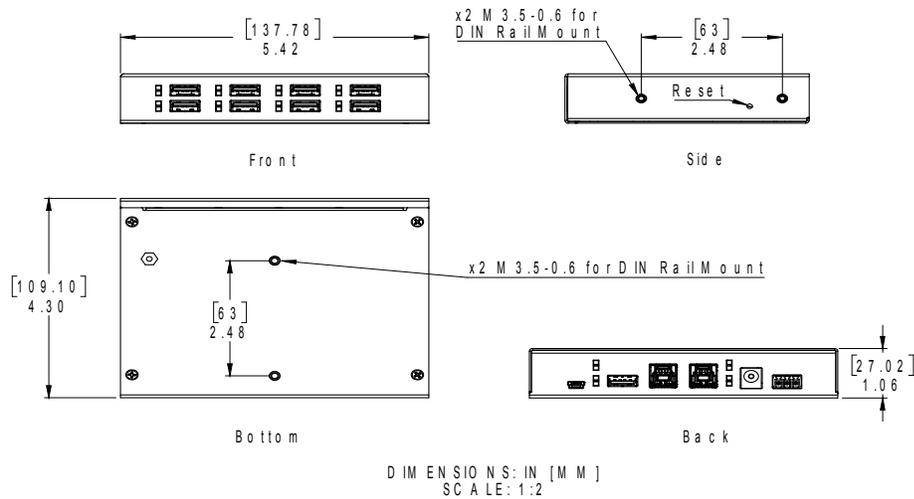


Figure 8: USBHub3+ Mechanical

### DIN Rail Mounting

DIN rail mounting provisions have been designed into the USBHub3+ case. Holes for a DIN rail clip/adaptor are provided to allow mounting of the USB3+ hub to standard DIN rails. Mounting clip hardware is available separately in a kit from Acroname: part number C31-DINM-1. The diagrams below illustrate USBHub3+ mounted in two orientations:

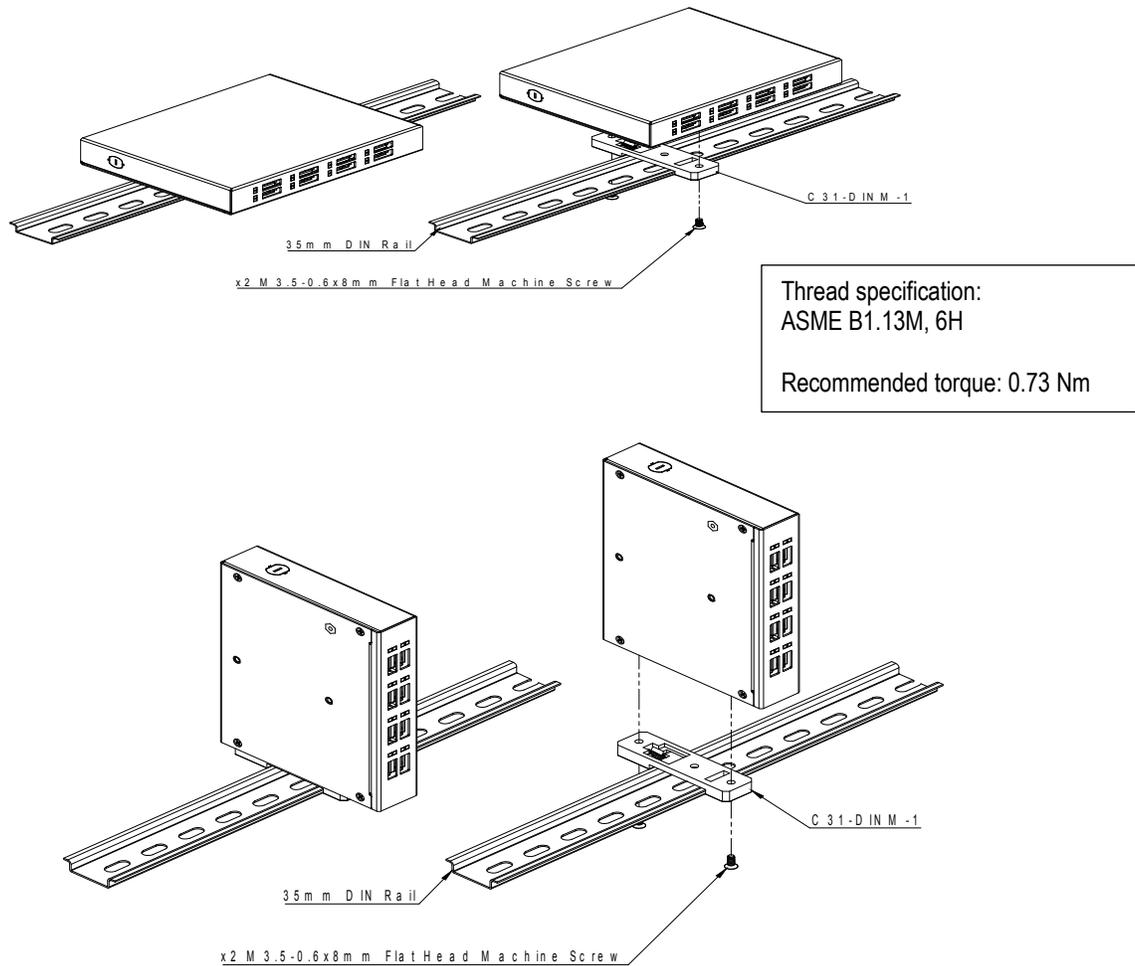


Figure 9: USBHub3+ DIN Rail Mount

**Important Note:** See instructions included in the C31-DINM-1 Kit. Acroname recommends using only the hardware provided in the C31-DINM-1 kit. Installing the DIN rail mount bracket without the included washers or with screws that are too long may damage the product and void any warranty.

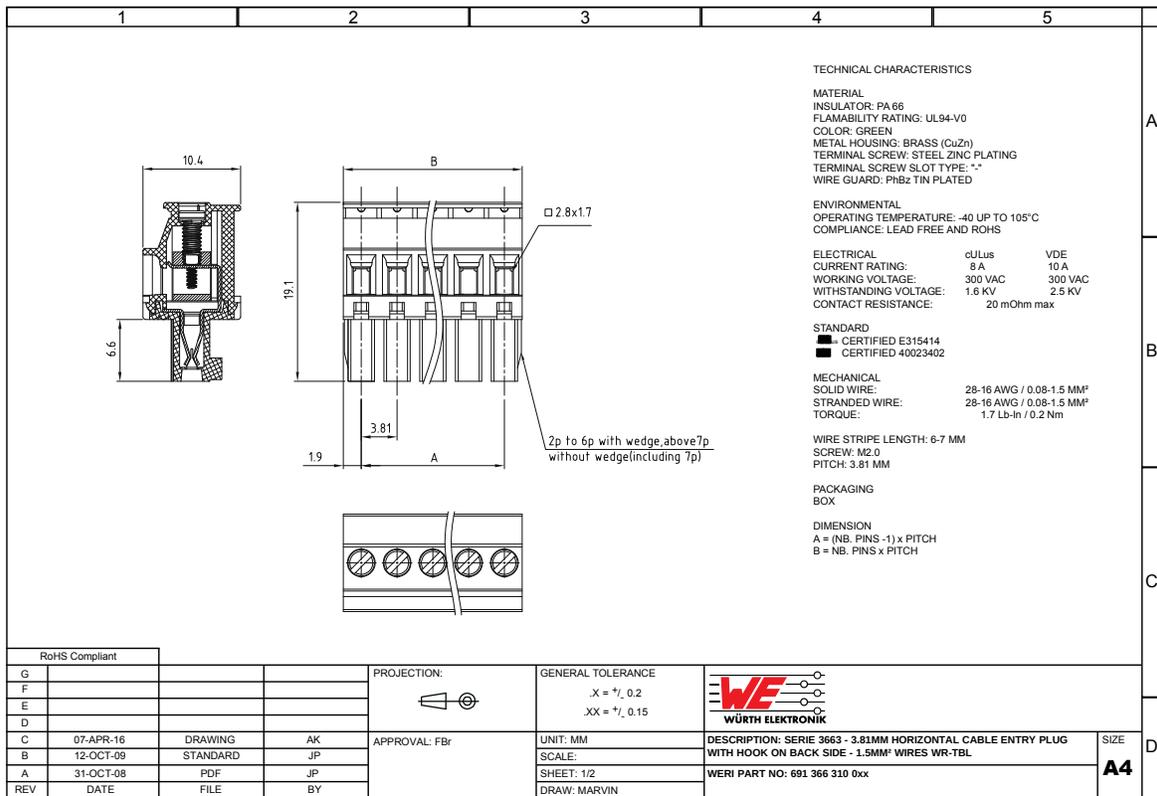
## Input Power Connections

The USBHub3+ can be powered in three ways: bus powered from upstream port 0; the DC “barrel-jack”; a “Euro-style” terminal block.

When bus-powered from upstream port Up0, the system’s BrainStem controller is powered and available, however all downstream ports are automatically disabled and cannot be enabled. This power mode is useful for testing while developing code without the need for an external power adapter. To enable downstream ports, external power must be supplied.

The DC barrel-jack is a standard 6.5mm outside diameter, 2.5mm inside diameter, 9.5mm mating length connector. The mating plug is a 5.5mm outside diameter, 2.5mm inside diameter plug. Many manufacturers make compatible mating plug connectors; one example is the DC barrel plug from CUI: part number PP3-002B (<https://www.cui.com/product/resource/pp3-002b.pdf>).

In addition to the standard barrel jack power input an alternative power input, a Euro-style 3-pin terminal block (“Euroblock”), is also provided. This connector provides the additional benefits of a dedicated earth connection and a higher current rating (8A) than the barrel connector (5A). Many manufacturers make compatible mating connectors; one example is the Würth Elektronik Serie 3663- 3.81mm Horizontal with Hook on Back Side WR-TBL, part number 691366310003 (see diagram below).



Source: [http://katalog.we-online.com/en/em/TBL\\_3\\_81\\_3663\\_HORIZONTAL\\_W\\_HOOK\\_ON\\_BACK\\_SIDE\\_69136631000X](http://katalog.we-online.com/en/em/TBL_3_81_3663_HORIZONTAL_W_HOOK_ON_BACK_SIDE_69136631000X)

## **FCC Compliance Statement**

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

This device complies with part 15 of FCC Rules. Operation is subject to the following two conditions; (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

## Document Revision History

All major documentation changes will be marked with a dated revision code

| Revision | Date           | Engineer | Description  |
|----------|----------------|----------|--|
| 1.0      | September 2016 | JTD      | Initial Release  |
| 1.1      | September 2016 | JLG      | Update block diagram   |
| 1.2      | October 2016   | LCD      | Update Overview, Features, Description Text  |
| 1.3      | October 2016   | LCD      | Update ESD compliance info   |
| 1.4      | January 2017   | JLG      | Add $V_{bus}$ overvoltage information; add voltage and current measurement accuracy  |
| 1.5      | February 2017  | JLG      | Add port state to saved parameters   |
| 1.6      | March, 2017    | JTD      | Updated DIN mount screw spec   |
| 1.7      | October, 2017  | JLG      | Update overvoltage and reverse current spec  |
| 1.8      | April 2018     | RMN      | Removed Hub State for Port State   |
| 1.9      | September 2018 | LCD      | Updated control path diagram   |
| 1.9.1    | October 2018   | LCD      | Updates to support online BrainStem API documentation  |
| 1.9.2    | October 2018   | LCD      | Added documentation on <code>usb.getUpstreamState()</code> ; other minor corrections   |
| 1.9.3    | November 2018  | LCD      | Improved Input Power Connections section; minor corrections  |
| 1.10     | March 2019     | JLG      | Added spec for DIN mount hole PEM nut and torque<br>Correct max current specification<br>Add details on current limit behavior |