USB (Universal Serial Bus)
Silicon & PolySwitch Solutions
Application Note

Overcurrent Protection and Power Switch Design Criteria

The Universal Serial Bus connection offers a standard interface for attaching computer peripherals to a host system. USB is a bus-powered interface on which circuit protection is a requirement. Per the 1.1 and 2.0 USB specifications, high-power devices can source up to 0.5A current, while low-power devices can source up to 0.1A current. Circuit protection minimum requirements stem from UL, IEC, CSA, and other regulatory agencies. As an example, UL60950 states that current must be limited to 5A within 60 seconds if a short is applied across the bus. These requirements can easily be met with the appropriate application of PolySwitch devices. However, tighter requirements can be driven by system limitations. Raychem Circuit Protection offers both PolySwitch and protected power switch devices to meet all design requirements.

USB Hub Design

The first criterion is meeting the USB Specification where the following is given in Table 1.

Additional design considerations include:
- Cost
- System Functionality
- Ganged/Individual Protection or Switching
- Component Long-Term Reliability

PolySwitch Protection

The most important design requirements for Hosts/Self-powered Hubs are low cost, high system reliability, and overcurrent protection implementation; power switching is optional. The low-cost, reliable, resettable overcurrent protection is achieved with a PolySwitch PPTC device.

Raychem Circuit Protection's PolySwitch devices offer designers the broadest range of products to select from, including the lowest resistance and smallest size packages. Depending on the

design criteria, Raychem Circuit Protection has a device which fits the specific requirements. Table 2 is a selection guide for PolySwitch devices for USB.

Implementation examples are offered in Figures 1 and 2.

Protected Power Switch Protection

With the advent of portable PCs and energy conservation, some USB system implementations have become extremely power sensitive. In low-power designs, voltage droop on the main system bus can disable a system. Therefore, for reliable system operation, extremely fast and accurate fault correction on the USB bus is required. In addition, voltage drop between the system Vcc and the USB port must be minimized. Finally, these requirements must be met at a reasonable cost.
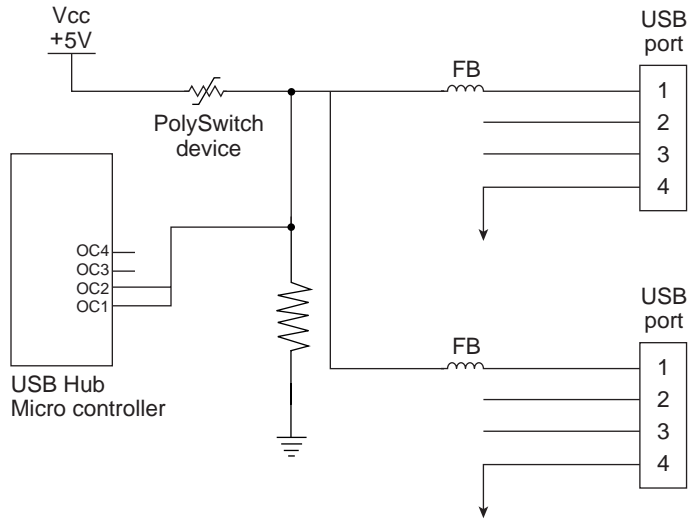
Table 1. Protection Criteria

Host	Overcurrent Protection*	Power Switching*
Self-powered hub	Required	Optional
Bus-powered hub	Optional	Required

Note: *Overcurrent protection and power switching may be designed in either a ganged or individual port format.
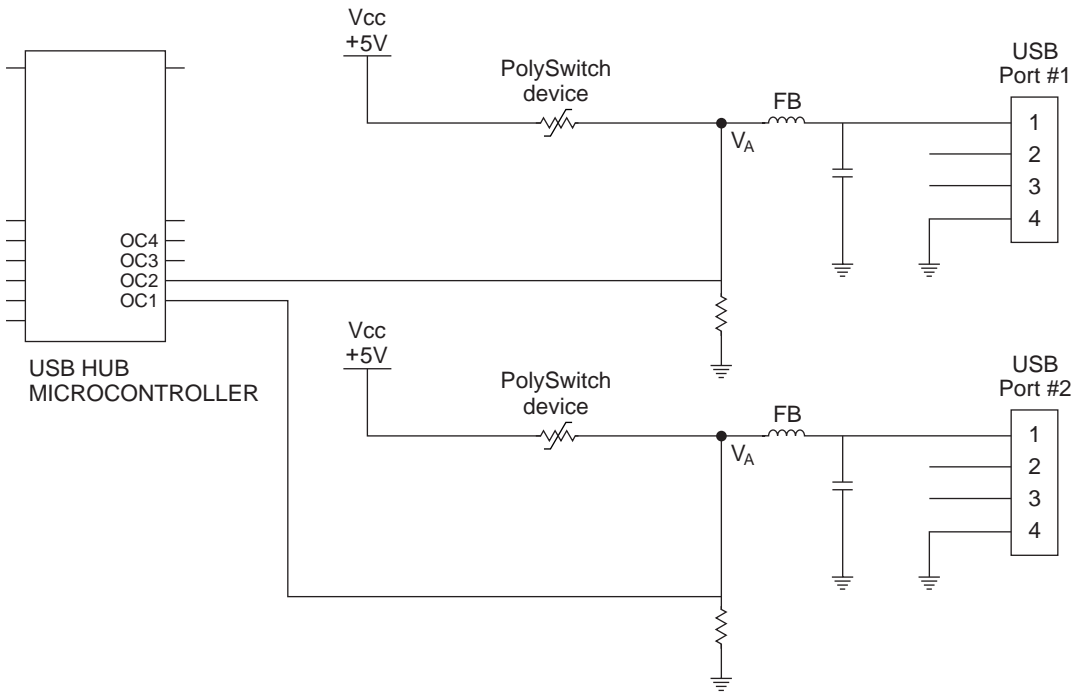
Table 2. Selection Guide for PolySwitch Devices for USB

	Device Selection Criteria		
	Small Size	Low Resistance	Fast Time-to-Trip
1 port (individ.)	nanoSMDC075	microSMD150	nanoSMDC075
2-port ganged	nanoSMDC150	microSMD150	nanoSMDC100
3-port ganged	miniSMDC200	miniSMD200	miniSMDC200
4-port ganged	miniSMDC260	miniSMDC260	miniSMDC200

Figure 1. Ganged Port Protection (two-port example)

Vcc +5V

PolySwitch device

USB port
1
2
3
4

FB

OC4
OC3
OC2
OC1

USB Hub
Micro controller

USB port
1
2
3
4

FB

3

Figure 2. Low-active Overcurrent Pin Fault Reporting for Individual Port Protection

Vcc +5V

PolySwitch device

FB

V_A

USB Port #1
1
2
3
4

OC4
OC3
OC2
OC1

USB HUB MICROCONTROLLER

Vcc +5V

PolySwitch device

FB

V_A

USB Port #2
1
2
3
4

Raychem Circuit Protection has developed a line of active silicon protected power switches to meet these requirements. These power switches offer:
• Extremely fast trip time
• Extremely sensitive overcurrent sensing

• Low series resistance that drops with input voltage
• Individual port control
• Integrated anti-nuisance tripping circuitry
• Integrated off-board components
• UL recognition

A selection guide for Raychem Circuit Protection's protected power switches is offered in Table 3. Implementation examples are offered in Figures 3 and 4.

Table 3. Selection Guide to Protected Power Switches

| Host	No. of ports	Device
Self-Powered Hub	1 / 2	RYC8600 Series
	2	RYC8600 Series
Bus-Powered Hub	2	RYC8600 Series
Peripheral Devices	1	RYC8600 Series

Figure 3. Dual Port Power Switch in a Self-powered Hub*

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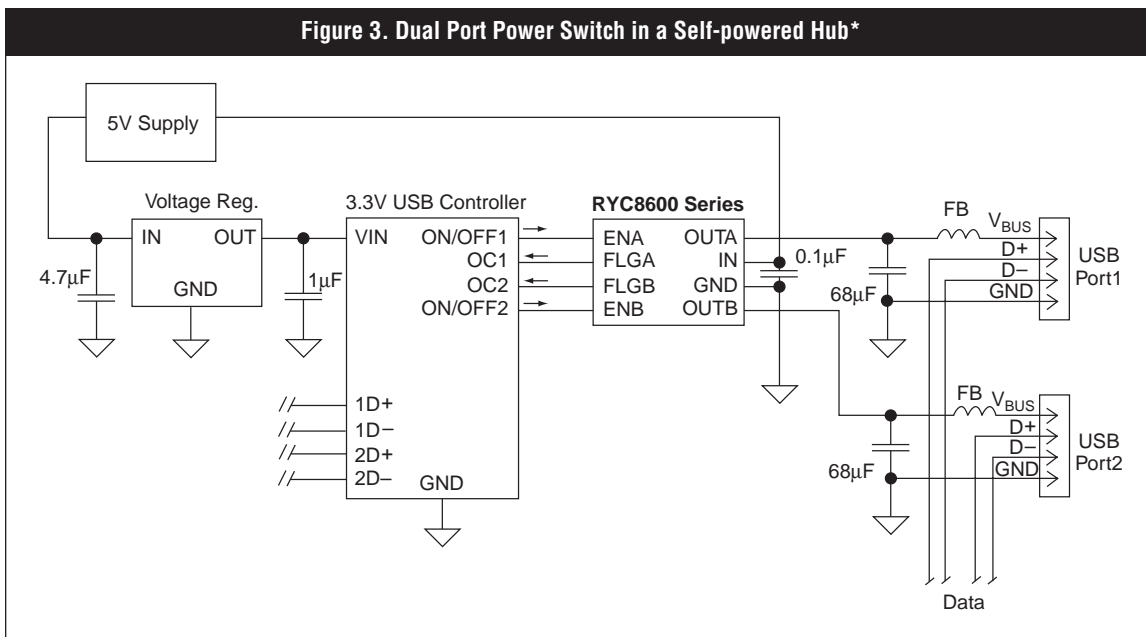
*This design is popular in Desktop PCs and Notebook PCs with two ports.

Figure 4. Dual Port Power Switch in a Bus-powered Hub

Figure 4. Dual Port Power Switch in a Bus-powered Hub
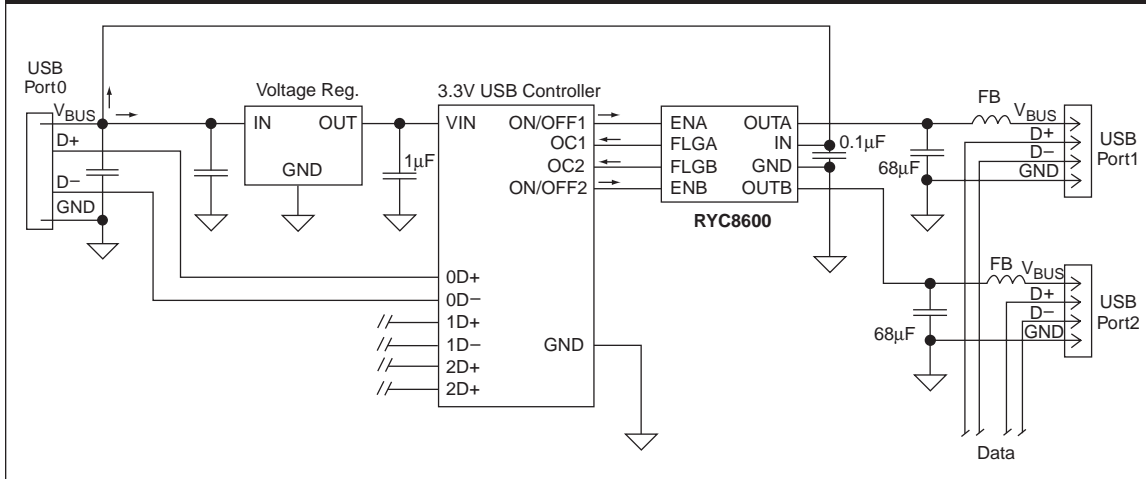
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USB Peripherals: In-Rush Limiting

Per the USB Specification 1.1, the maximum load that can be placed at the downstream end of a cable is 10µF in parallel with 44Ω. The 10µF capacitance represents any bypass capacitor directly connected across the V_{BUS} lines in the function plus any capacitive effects visible through the regulator in the device. The 44Ω resistance represents one unit load of current drawn by the device during connect. If more bypass capacitance is required in the device, then the device must incorporate some form of V_{BUS} surge current limiting, such that it matches the characteristics of the above load. The soft-start circuit below can be utilized to meet USB transient regulation specifications with large load capacitances (C_{BULK} >10µF). The RYC8600 series devices are typically used to provide in-rush current limiting for these applications.