

a very long

^ Tech Moment

USB (United States Bank?)



By Tom Thorpe

What we know about USB

- It connects peripherals to your computer ✓
- You need cables with the right connectors ✓
- Devices work as soon as they are plugged in ✓
- Some devices don't require external power ✓
- You can charge some devices via USB ✓

Agenda

- Overview / Operation
- Apple Products
- Specifications
- Connectors
- Cables
- Device Power

Overview

- USB = Universal Serial Bus
- Began in 1994 by Compaq, DEC, IBM, Intel, and Microsoft
- It was intended to standardize the way peripherals are connected to various computers

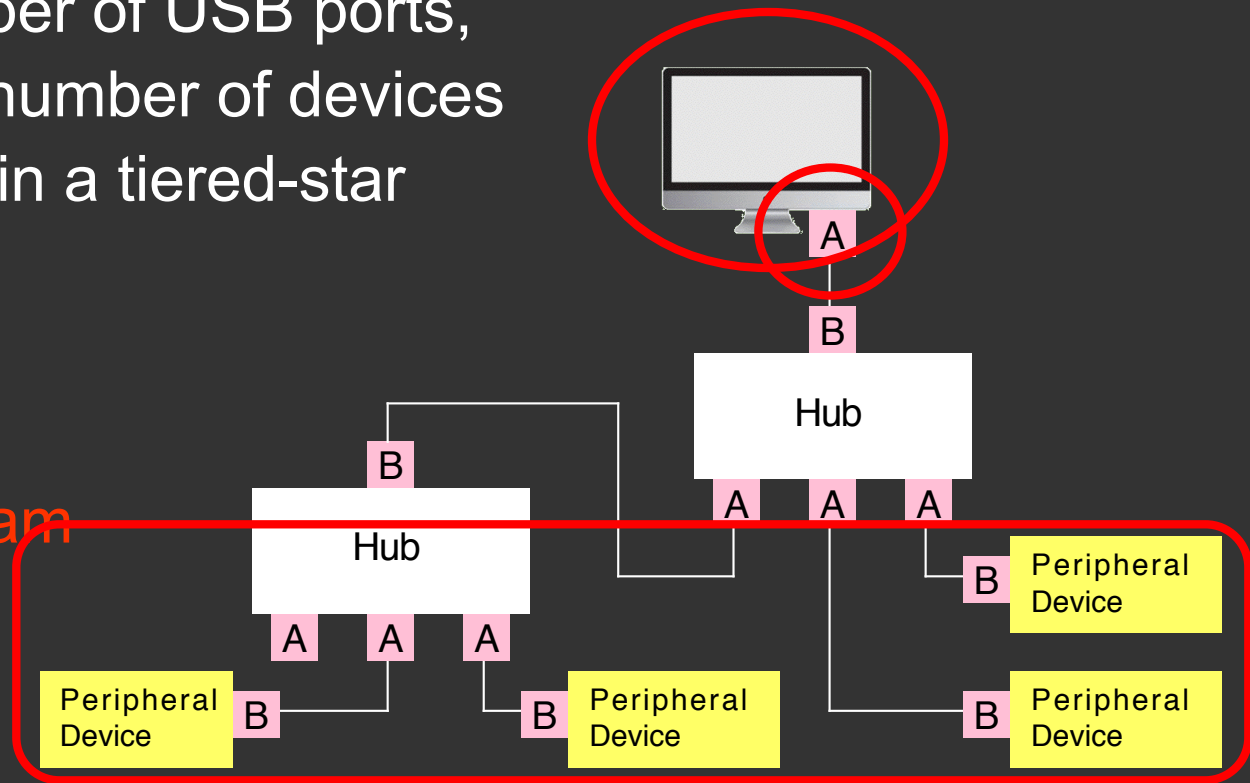
Overview

- A USB system is made up of a host, some number of USB ports, and some number of devices connected in a tiered-star topology

“A” = Upstream

“B” = Downstream

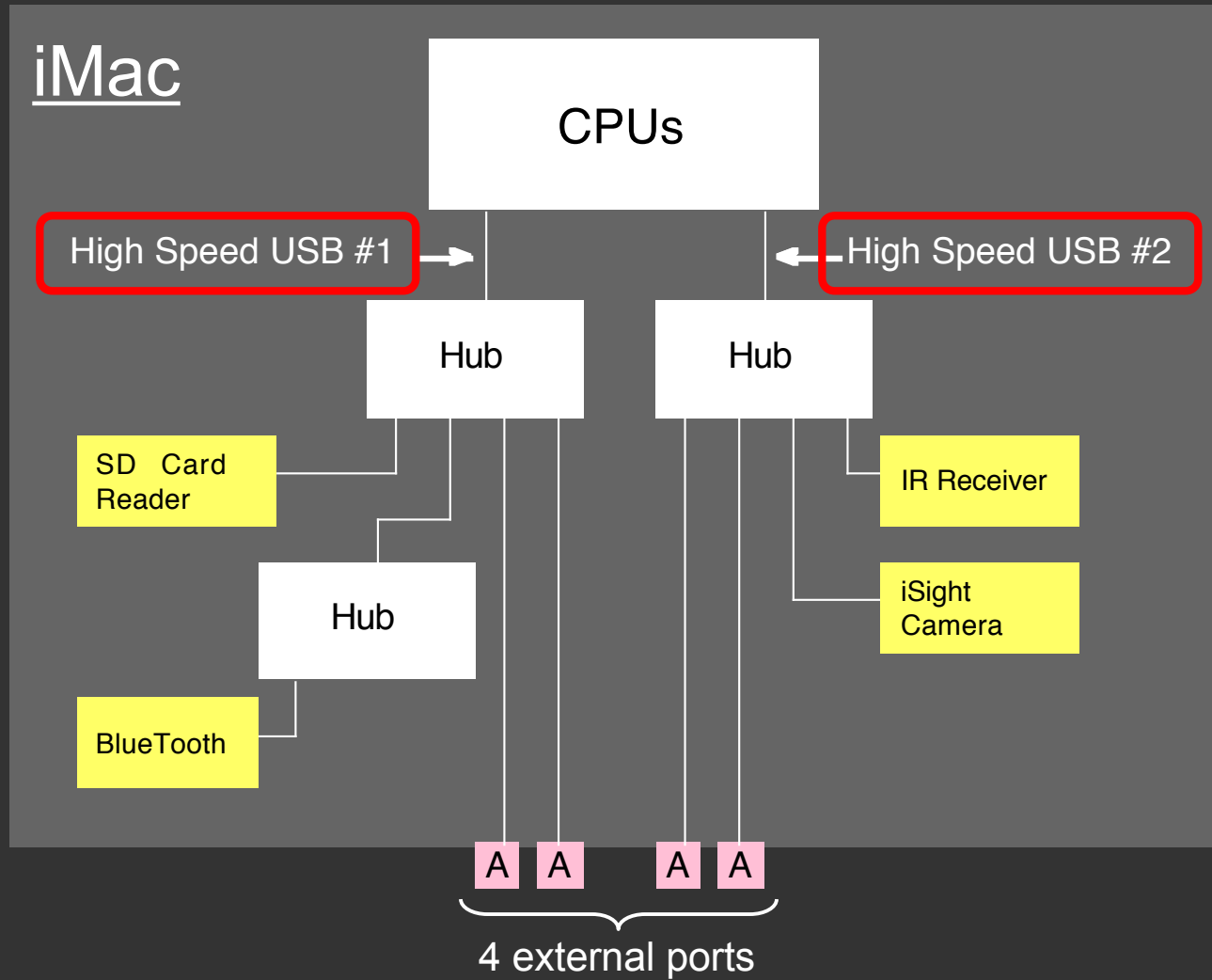
A-B cables are very common



Overview

- To expand the number of ports use a hub
 - Up to five tier levels
- Up to 127 devices
 - Keyboards, mice, printers, cameras, scanners, storage devices, etc.
- USB allows hot swapping
 - When plugged in, everything configures automatically

Example

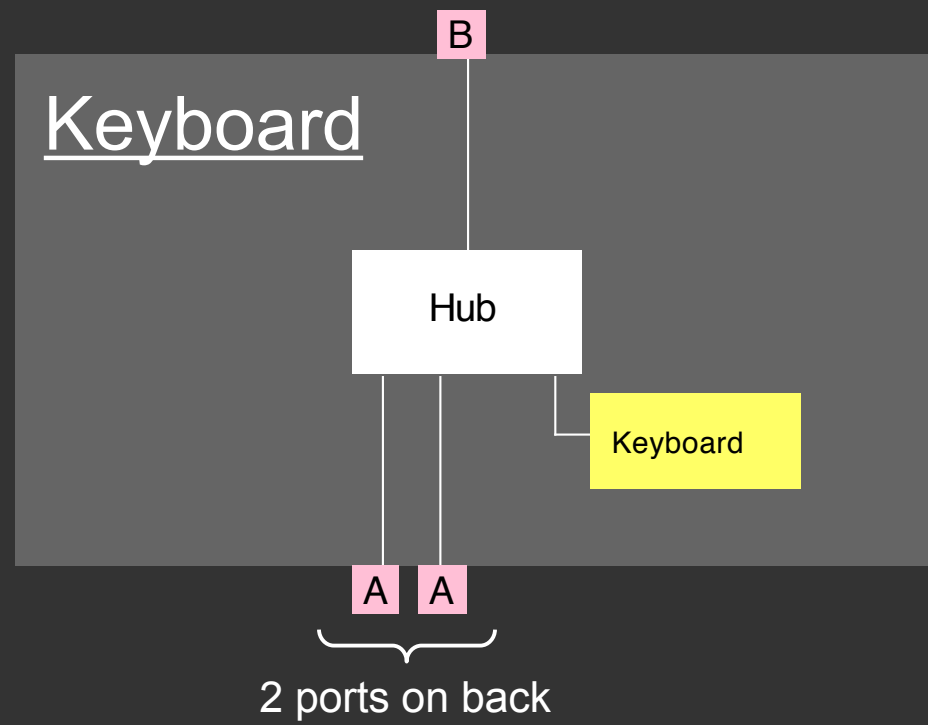


Q. Who uses a USB hub?

Q. Who has a USB mouse?

Q. Who has a USB keyboard?

Example



Operation

- When the host powers up it polls each of the devices in turn and:
 - assigns each one a unique address
 - finds out the device speed and data transfer types
 - finds out if the device requires extra DC power
- This process is called enumeration and it also takes place whenever a device is plugged into an active bus

Operation

- The host controls and schedules all communication activities on this bus
 - A device must wait to be asked to transfer data

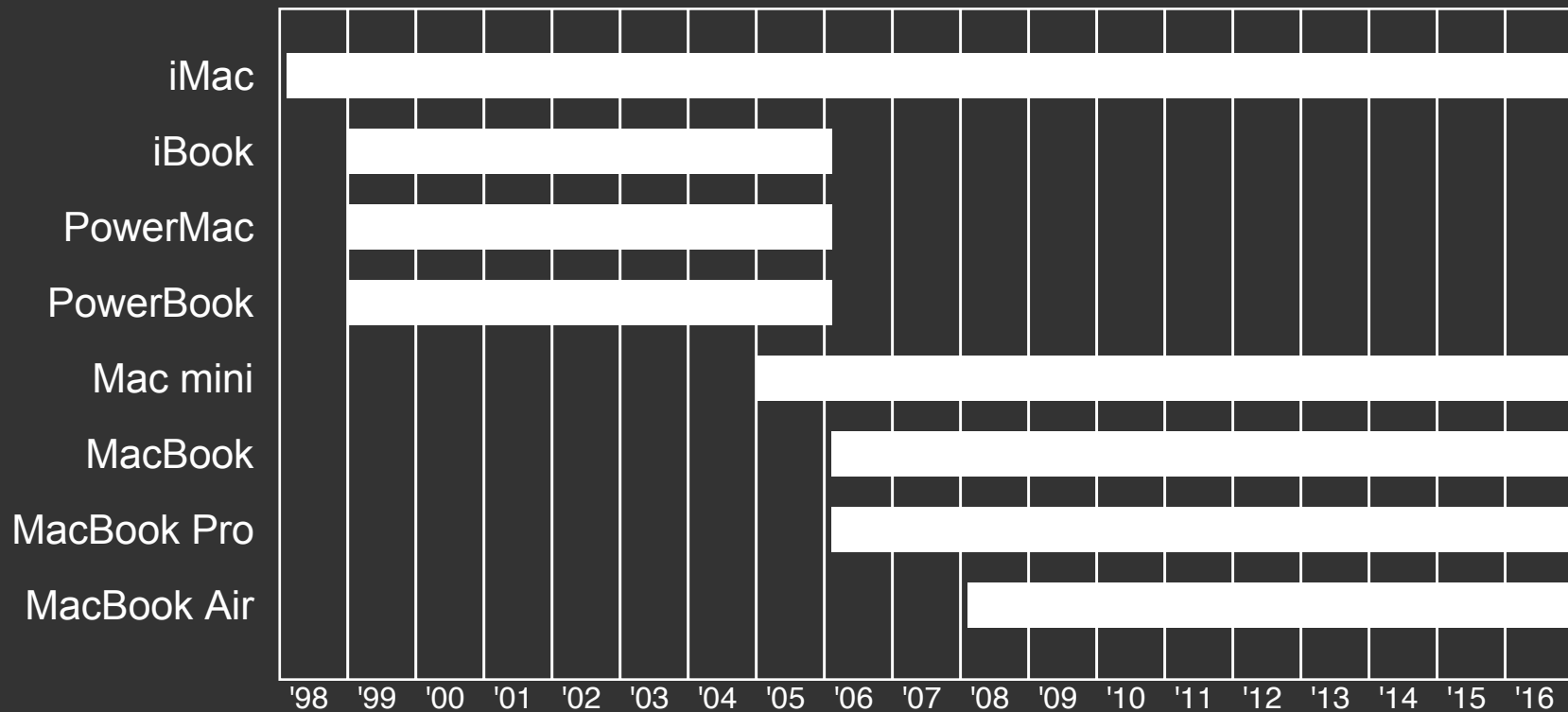
Note: There can be no communication directly between USB devices

Q. How often does the host talk to each device?

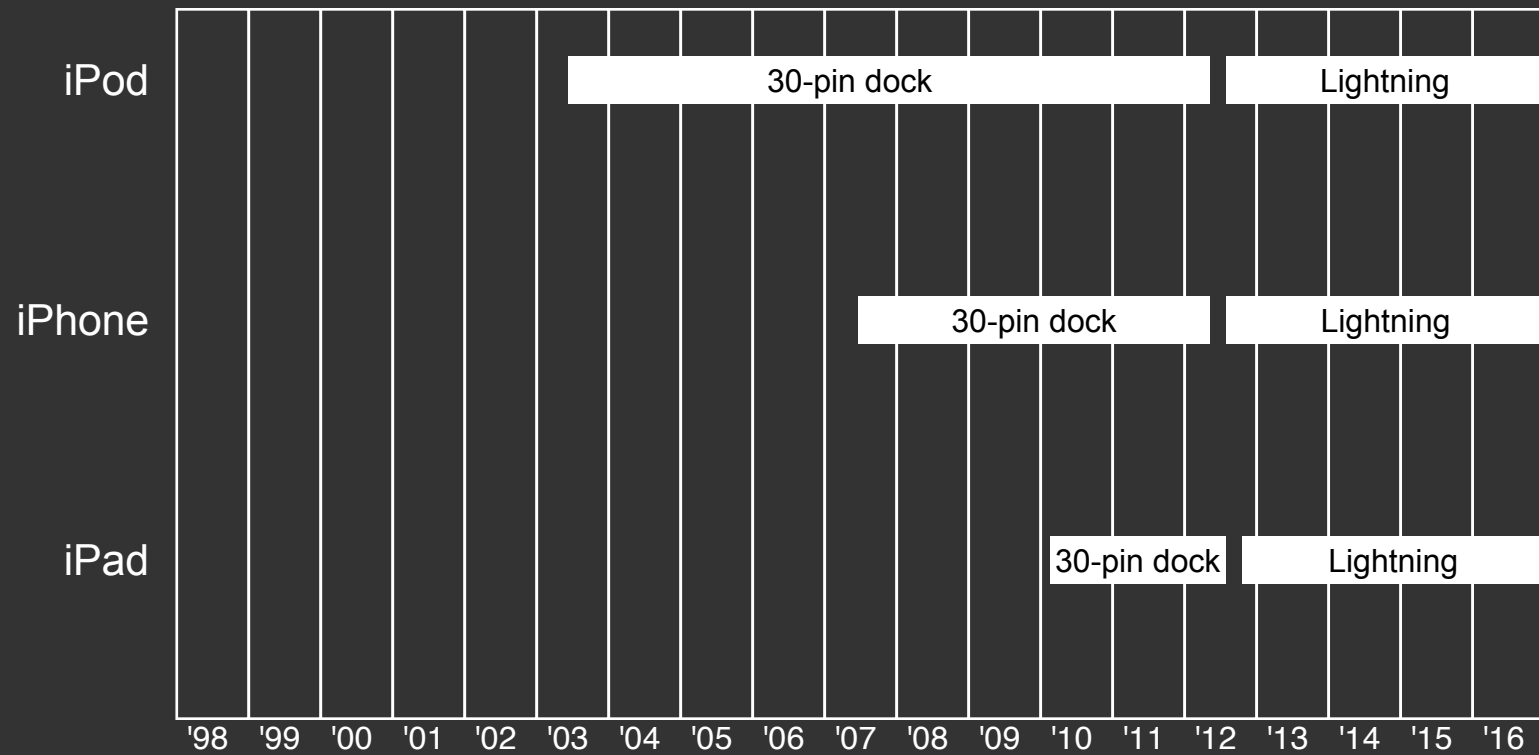
A. 1000 times per second

Apple Products

Macs with USB Interfaces



Other Products



iPod / iPhone / iPad

- 30-pin dock connector
 - USB device, via an adapter cable
 - Only iTunes can talk to it
 - ~~USB host~~
 - Cannot connect a USB device
 - No power
 - No Apple support
 - There are some third party devices that can be connected

iPod / iPhone / iPad

- Lightning connector
 - Introduced September 2012
 - Similar to the 30-pin dock connector except
 - Can connect a camera
 - iPad with Retina display and subsequent
 - iPhone 5 and subsequent

Specifications

USB Specification v1.1

- Released August 1998, 325 pages, free
- Two speeds
 - 1.5 Mbps LOW Speed
 - and
 - 12 Mbps FULL Speed
 - 9.7 Mbps useable
- Up to 2.5W of power
- 3.5 meter maximum cable length

USB Specification v2.0

- Released in April 2000, 650 pages, free
- Same as v1.1 and added:
 - HIGH Speed, 480 Mbits/sec
 - 425 Mbps useable
- 5 meter maximum cable length

USB Specification v3.0

- Released May 2011, 530 pages, free
- Same as v2.0 and added:
 - 5 Gbps, “SuperSpeed”
 - 3.2 Gbps useable
 - Dual-simplex, 4-wire differential signals
 - Separate from USB 2.0 signaling
 - Increased power from 2.5W to 4.5W
- 5 meter maximum cable length
 - 3 meters recommended

USB Specification v3.1

- Released in July 2013, 630 pages, free
- Same as v3.0 and added:
 - 10 Gbps, “SuperSpeed+”
 - 6.4 Gbps useable

Speed Summary

Low speed USB 1.1 1.5 Mbps

Full speed USB 1.1 12 Mbps

High speed USB 2.0 480 Mbps

SuperSpeed USB 3.0 5 Gbps

SuperSpeedPlus USB 3.1 10 Gbps



Terminology

SuperSpeed
SuperSpeed USB
USB 3.0
USB 3.1 Gen 1

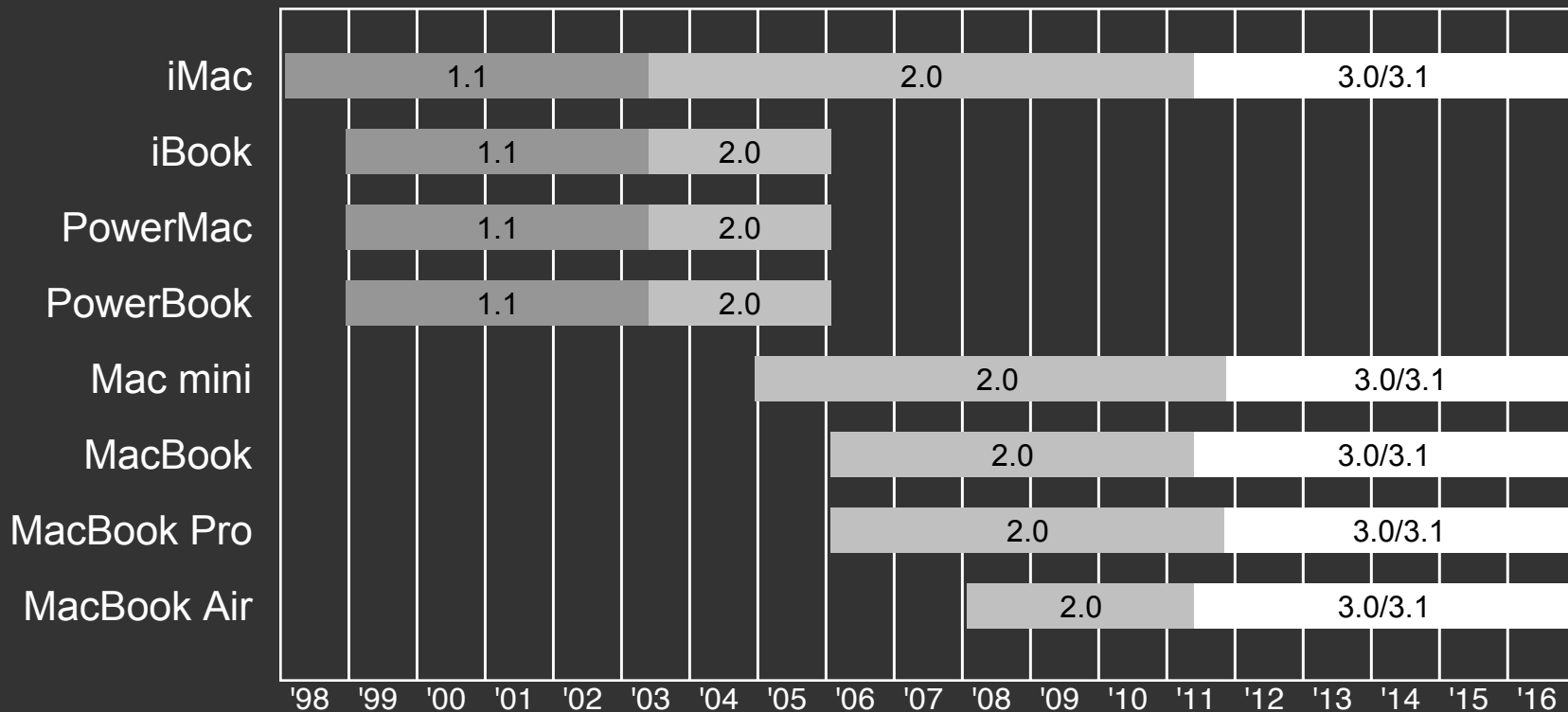
} 5 Gbps

SuperSpeed+
SuperSpeedPlus
SuperSpeed USB 10 Gbps
USB 3.1
USB 3.1 Gen 2

} 10 Gbps

Spec Compliance

USB Specs



Spec Compliance

USB Specs



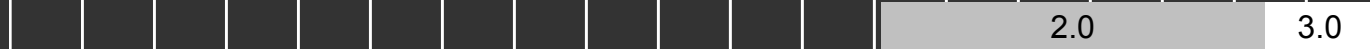
iPod



iPhone



iPad



'98 '99 '00 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 '12 '13 '14 '15 '16

Connectors

USB 1.1 or 2.0

Type A

Type B



USB 1.1 or 2.0

Mini A

Mini B



USB 1.1 or 2.0

Micro A

Micro B




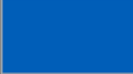


USB 3

Type A

Type B



Insert Color-Coding

	Color	Description
	Black or white	Type-A or type-B
	Blue	Type-A or type-B, SuperSpeed
	Teal blue	Type-A or type-B, SuperSpeed+
	Yellow, orange or red	Ports only. High-current or sleep-and-charge

USB 3

Type A

Type B



USB 3

Mini A

Mini B



USB 3

Micro A

Micro B

?



“USB Type-C Cable and Connector Specification” v1.2

- Supplement to the existing USB specs
- Originally released August 2014, 200 pages, free
- It adds another connector to the mix
 - Flippable (like the Lightning connector)
 - Reversible (end-for-end)
- Compatible with USB 1.1 through 3.1
 - Type C does not imply speed!

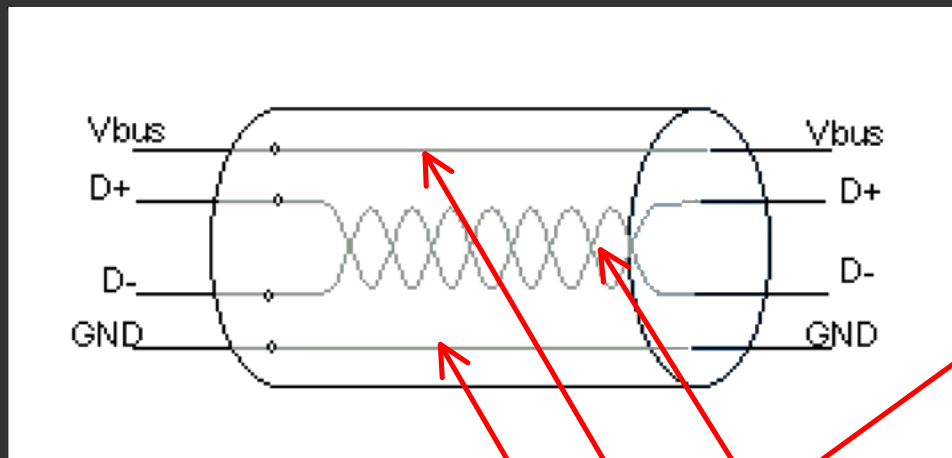
USB 1.1, 2, or 3

Type C

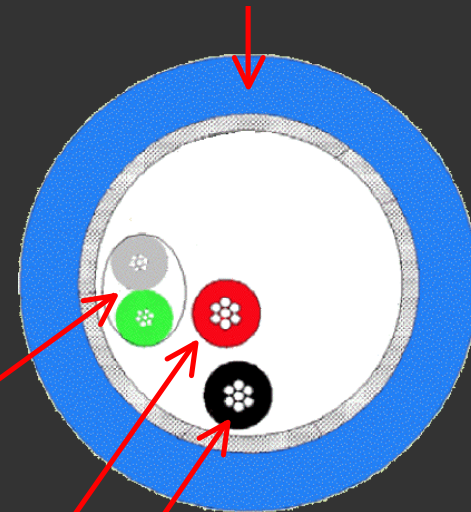


Cable Wiring

USB 1.1 and 2



Insulation



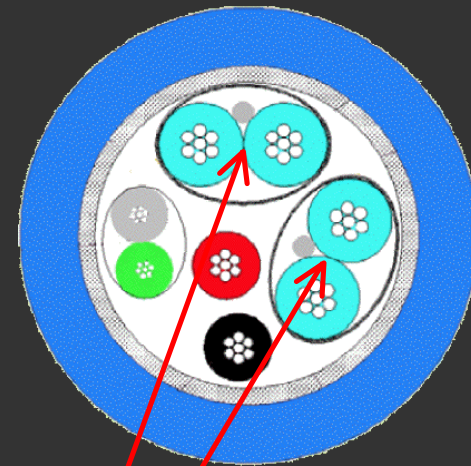
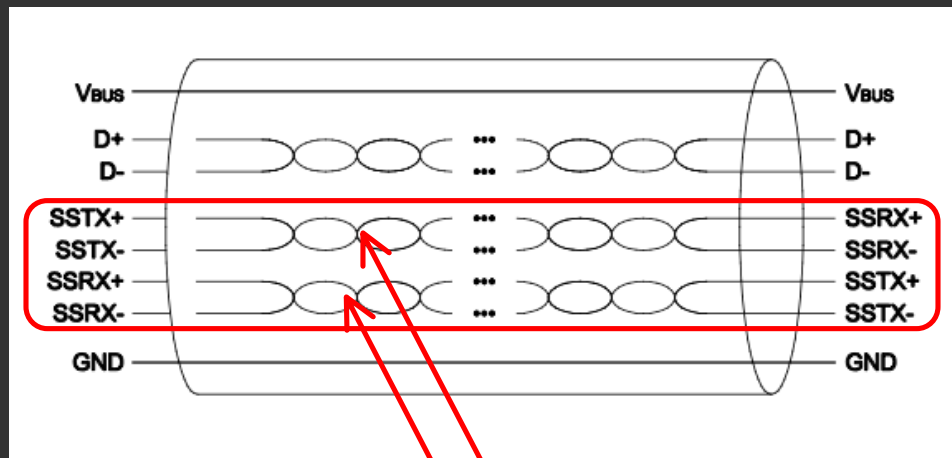
Signal pair

Power (5V)

Power return

Cable Wiring

USB 3



High speed signal pair #1

High speed signal pair #2

Cable Possibilities

10 different connectors

Plug vs. socket

At least 7 different lengths

At least 6 different jacket colors

Straight vs. right angle connector

Standard finish vs. gold finish

Over 3,000 different cables!

Miscellaneous

- Cable extensions are not allowed!
- Personal opinion
 - Stick to one cable if:
 - High power device, or
 - High speed (USB 3)
 - May sneak in an extension if:
 - Low power device, and
 - Within the total length limit

Device Power

USB 1.1 or 2 Power

- A device can only consume power from its upstream port
- A device which draws its power from the bus is called a 'bus-powered' device
 - In normal operation it may draw up to 0.1A (0.5W)
 - Or, if permitted to do so by its upstream host, up to 0.5A (2.5W)
 - Devices requiring more than 0.5A are self-powered

USB 1.1 or 2 Power

- If a host stops talking to a device it will suspend itself
 - It must reduce its current to less than 0.0025A (<0.02W)

Q. How long will a device tolerate no activity?

A. 3/1000 of a second

USB 3 Power

- The maximum numbers increase
 - Normal operation from 0.1A to 0.15A (0.75W)
 - High-power operation from 0.5A to 0.9A (4.5W)
- Everything else is pretty much the same

Power Summary

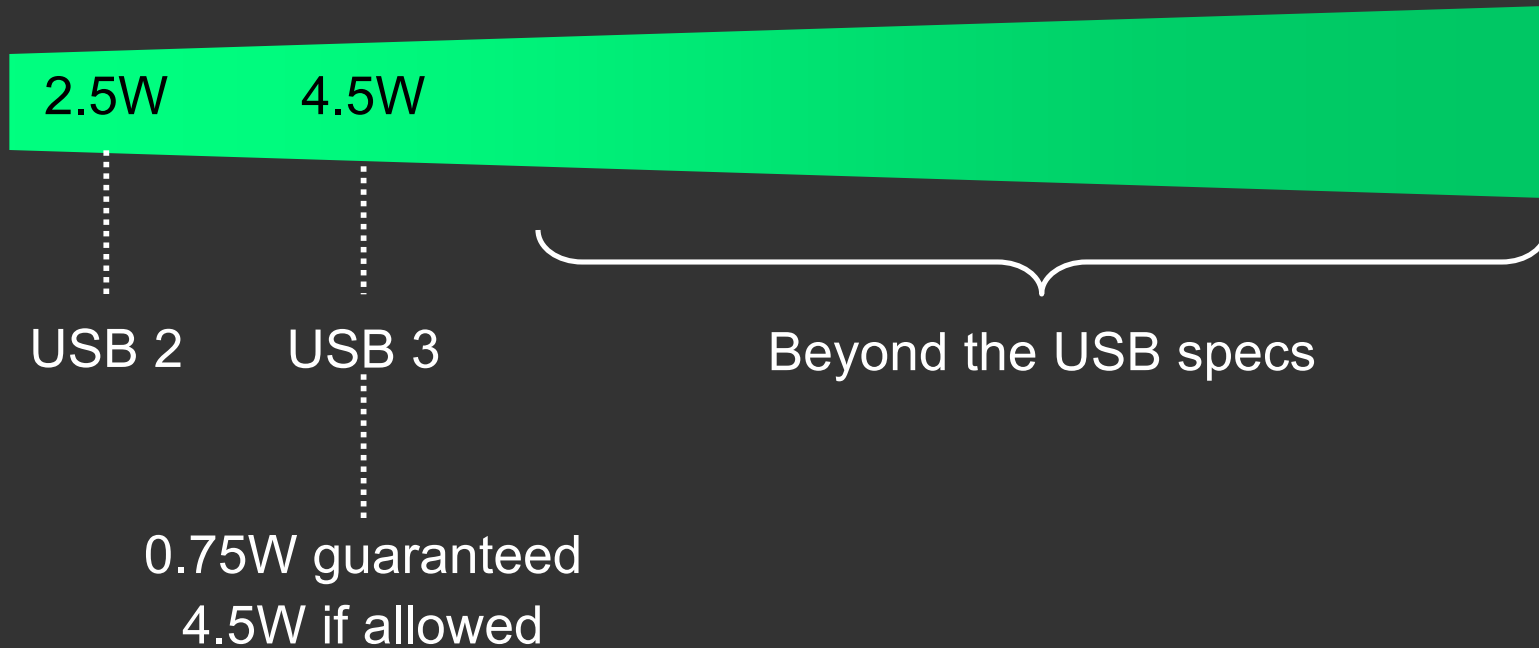


2.5W

USB 2

0.5W guaranteed
2.5W if allowed

Power Summary



Battery Charging Specification v1.2

- Released in December 2010, 70 pages, free
- Defines a charging port as:
 - Charging Downstream Port <-- active USB 2 port
 - Dedicated Charging Port <-- power cube, etc.
 - Accessory Charger Adaptor <-- connects USB port
and cube

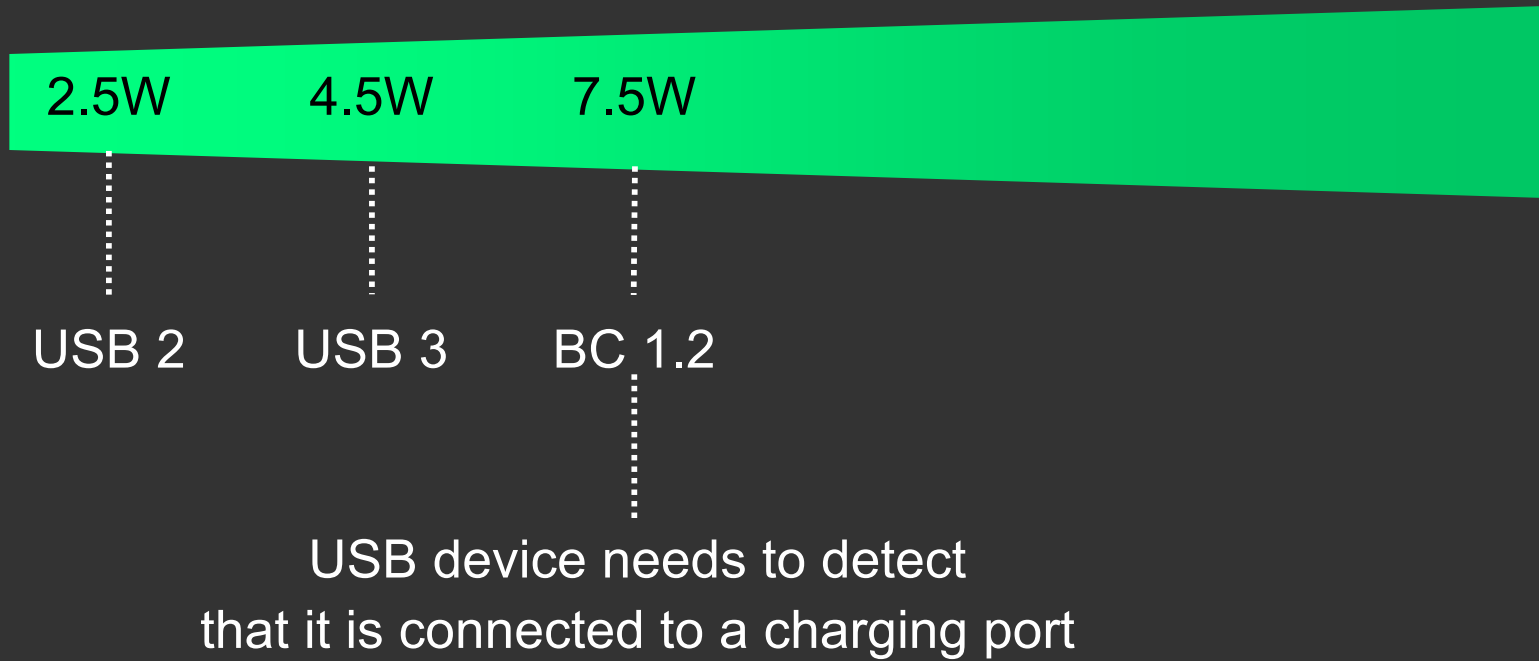
Battery Charging Specification v1.2

- The charging port adjusts the data lines so the downstream device can detect that they are connected to a charging port
- When the downstream device detects a charging port it is allowed to draw 1.5A (7.5W) without having to be configured or follow the rules of suspend

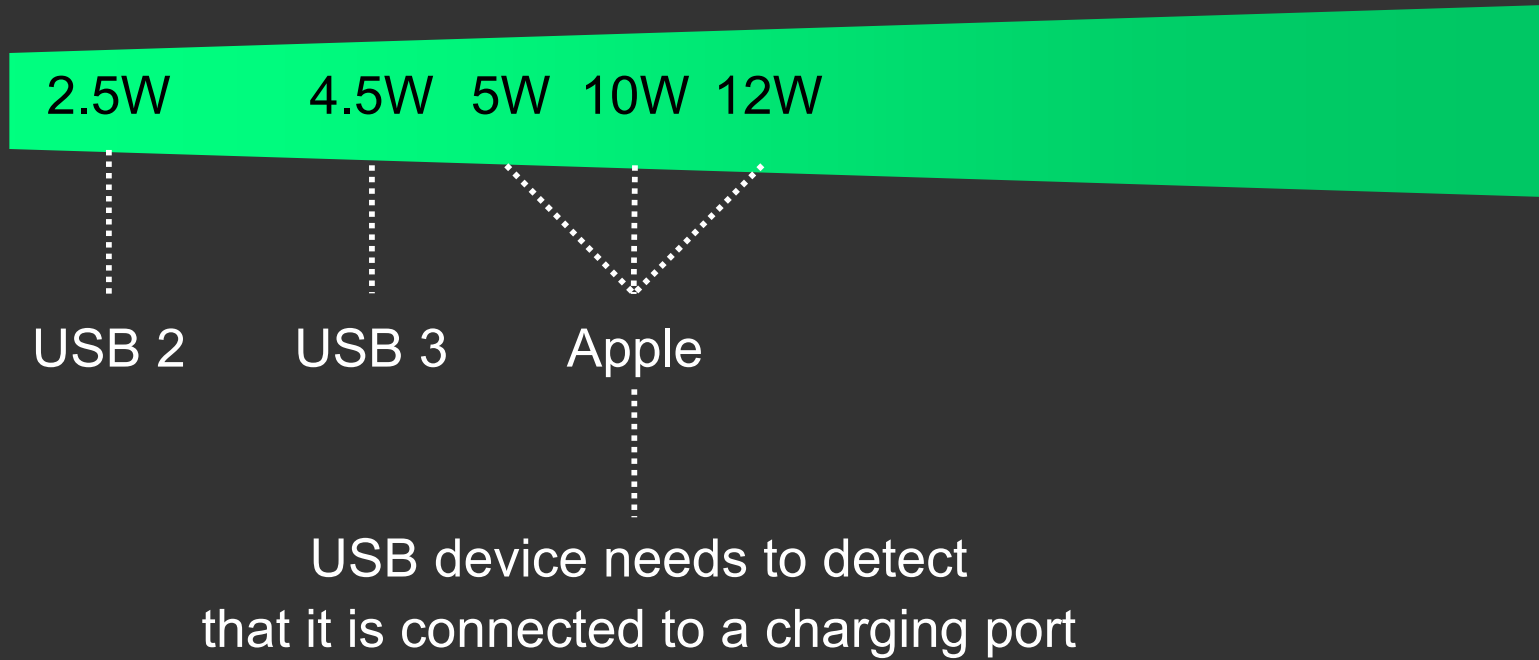
Apple Usage

- Best I can tell, Apple does not use BC 1.2
- They have their own proprietary approach
 - Very similar
 - But they adjust the data lines differently
 - Three options: 1A, 2A, and 2.4A (5W, 10W, 12W)

Power Summary



Power Summary



USB Power Delivery Specification v1.2

- Released in July 2012, 550 pages, free
- Independent of other USB methods used to negotiate power
- Pairs of directly attached devices negotiate voltage, current and the direction of power flow

USB Power Delivery Specification v1.2

- Communicate via the VBUS wire or CC wire
- Via VBUS (normal power wire)
 - Binary Frequency Shift Keyed (BFSK) signaling
 - 23.2MHz carrier +/-500kHz, 300kHz bit rate
- Via CC wire (only available in Type C connector)
 - Biphase Mark Coding (BMC) signaling at 300Kbps

USB Power Delivery Specification v1.2

- The devices can negotiate a range of power options

5V at 1.5A = 7.5W

5V at 3A = 15W

9V at 3A = 27W

15V at 3A = 45W (Apple uses 14.5V at 2A = 29W)

20V at 5A = 100W

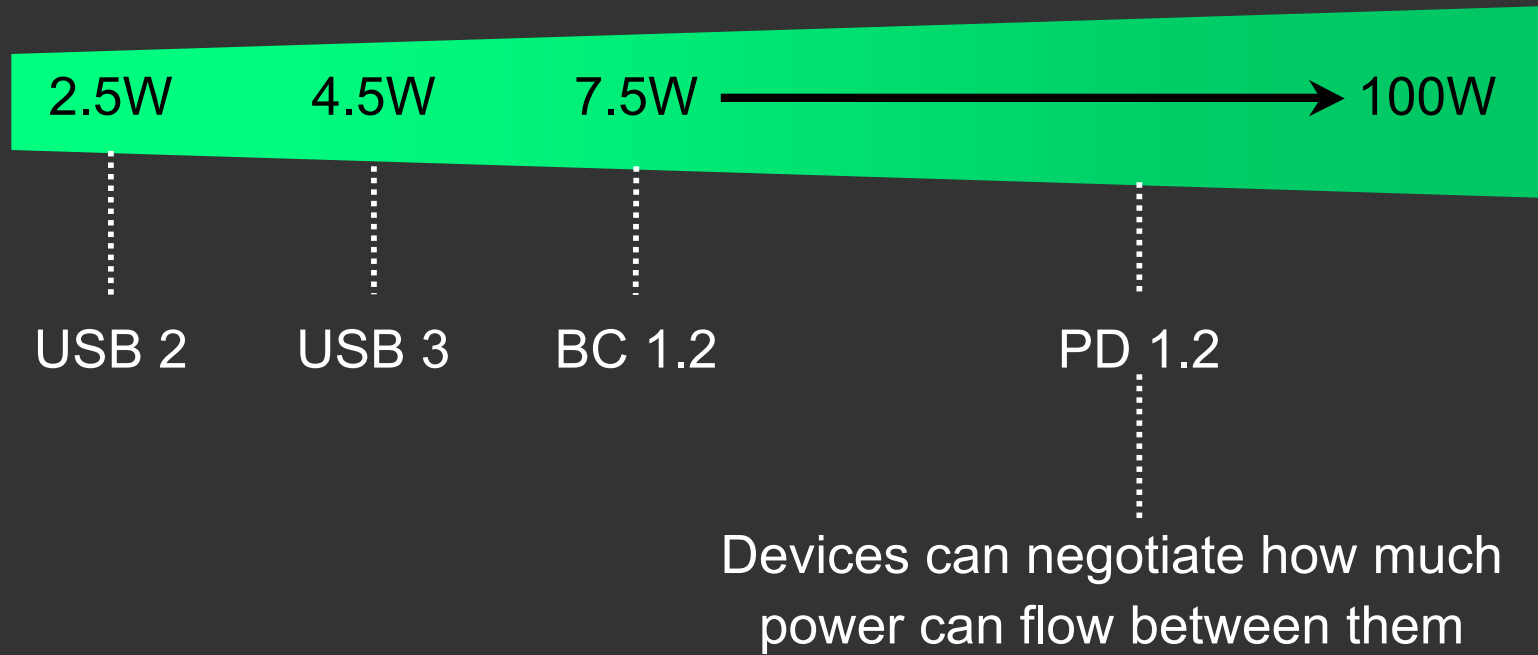
- Other voltages can be requested at up to 5A
- Again, power can flow either way!

Apple Usage

- Later MacBook computers feature a USB-C port
 - MacBook Retina, 12-inch, early 2015 and later
- iPad Pro
 - 2015 and later
- Both use 29W chargers

(iPhone and iPod probably don't make sense)

Power Summary



Spec Summary

Universal Serial Bus Specification v1.1

Universal Serial Bus Specification v2.0

Universal Serial Bus Specification v3.0












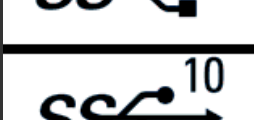
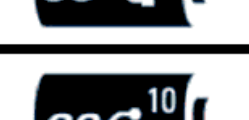
Universal Serial Bus Specification v3.1

USB Type-C Cable and Connector Specification v1.2

~~Battery Charging Specification v1.2~~

Universal Serial Bus Power Delivery Specification v1.2

Note: All are available at <http://usb.org/>

		Port Icon		
		Logo		+ Pwr Del
USB 1.1	1.5 Mbps			
USB 1.1	12 Mbps			
USB 2.0	480 Mbps			
USB 3.0	5 Gbps			
USB 3.1	10 Gbps			

If you see the icon, it conforms to the specs

Closing Thoughts

- USB 2
- USB 3
- Type C
- Apple is converting its product lines
- Power Delivery 1.2 is the coming thing
- Look for the logos and icons

