

USB Devices







By

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USB Versions & Data Rates (Speed)

USB VERSION	RELEASE DATE	NAME	TRANSFER RATES
USB 1.0	January 1996	Full speed	12 Mbps
USB 1.1	August 1998	Full speed	12 Mbps
USB 2.0	April 2000	High Speed	480 Mbps
USB 3.0	November 2008	SuperSpeed	5 Gbps
USB 3.1	July 2013	SuperSpeed+	10 Gbps
USB 3.2	September 2017	SuperSpeed+	20 Gbps
USB-4 v1.0	August 2019		20/40/80 Gbps
USB-4 v2.0	September 2022		120Gbps

USB Versions & Other Details

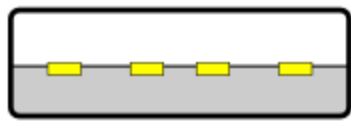
Rate Name	Old Name	First publication (Standard)	Encoding	Data pairs	Nominal Rate	USB-IF Marketing Name	Logo
Low-Speed		USB 1.0	NRZI	1 <u>HDx</u>	1.5 Mbit/s	Basic-Speed USB	
Full-Speed					12 Mbit/s		
High-Speed		USB 2.0			480 Mbit/s	Hi-Speed USB	
USB 3.2 Gen 1x1	USB 3.0; USB 3.1 Gen 1	USB 3.0	8b/10b	2 FDx	5 Gbit/s	SuperSpeed USB 5Gbps	
USB 3.2 Gen 2x1	USB 3.1 Gen 2	USB 3.1	128b/132b	2 FDx	10 Gbit/s	SuperSpeed USB 10Gbps	
USB 3.2 Gen 1x2		USB 3.2	8b/10b	4 FDx x2	10 Gbit/s	—	
USB 3.2 Gen 2x2			128b/132b	4 FDx x2	20 Gbit/s	SuperSpeed USB 20Gbps	
USB4 Gen 2x1		<u>USB4</u>	64b/66b	2 FDx	10 Gbit/s	—	
USB4 Gen 2x2			64b/66b	4 FDx x2	20 Gbit/s	USB4 20Gbps	
USB4 Gen 3x1			128b/132b	2 FDx	20 Gbit/s	—	
USB4 Gen 3x2			128b/132b	4 FDx x2	40 Gbit/s	USB4 40Gbps	

USB Device Types & Roles

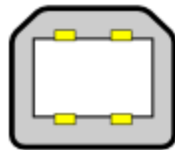
USB Device Type	Device Role	Role Negotiation
USB Host Controller Device	USB Host Controller	Role fixed. No role negotiation.
USB Slave Device	USB Slave Device	Role fixed. No role negotiation.
USB OTG (On-The-Go) Device	USB Host Controller or USB Slave Device	Role negotiated at Hardware level
USB DR (Dual-Role) Device	USB Host Controller or USB Slave Device	Role negotiated at Software level (also chosen by the user)

Widely used USB Connector Diagrams

USB 1.0 - 2.0



A



B



Mini-A



Mini-B

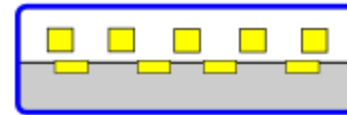


Micro-A

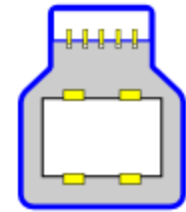


Micro-B

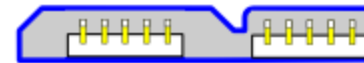
USB 3.0 - 3.1



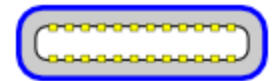
A



B



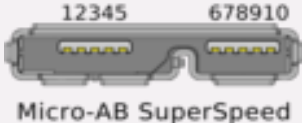


Micro-B



C

Rarely used USB Connector Diagrams

	USB 2.x	USB 3.x
Mini	 Mini-AB	
Micro	 Micro-AB	 Micro-AB SuperSpeed

USB-1.x/2.x Physical Connectors & Pins



USB-1.x/2.x Physical Connectors: Std, Mini & Micro



USB-1.x/2.x Physical Connectors

USB-1.x/2.x Std-A & Std-B Connectors



USB-1.x/2.x Mini-A & Mini-B Connectors



USB-1.x/2.x Micro-A Connector



USB-1.x/2.x Micro-B Connector



USB-3.x Physical Connectors

USB Type-C Connector



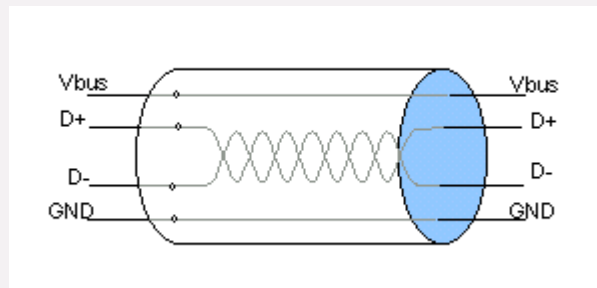
USB-3.x Micro-B Connector



USB-3.x B Connector



USB Connector Pins (Half-Duplex)



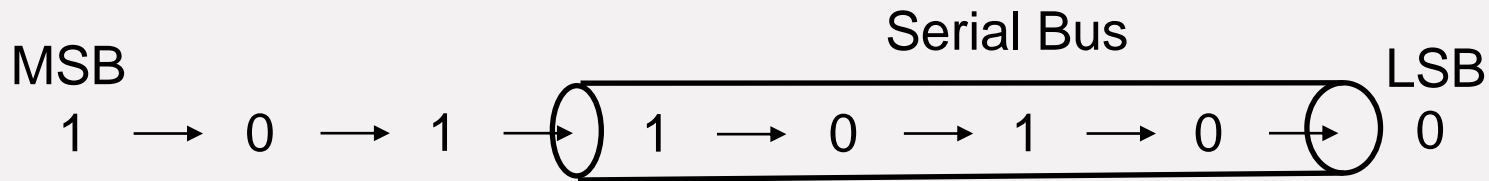
USB Standard - A & B : Pins, Signals & Wires

Contact / Pin Number	Signal Name	Typical Wire Colour
1	VBUS	Red or Orange
2	D-	White or Gold
3	D+	Green
4	GND	Black or Blue
Shell	Shield	Drain Wire

USB Mini/Micro - A & B : Pins, Signals & Wires

Contact / Pin Number	Signal Name	Typical Wire Colour
1	VBUS	Red
2	D-	White
3	D+	Green
4	ID	No Connection
5	GND	Black
Shell	Shield	Drain Wire

USB Data Transfer Order



Serial Transmission of binary number 10110100

USB Host Controller Interface Types

Four Types of Host Controller Interfaces:

- OHCI
- UHCI
- EHCI
- XHCI

USB OHCI (Open Host Controller Interface)

- Compaq, Microsoft and National Semiconductors cooperated to produce this standard host controller specification for USB 1.0 and USB 1.1.
- It is a more hardware oriented version than UHCI.
- Low speed and full speed.

USB UHCI (Universal Host Controller Interface)

- Intel's more software-oriented version of a controller for USB 1.0 and USB 1.1.
- Requires a license from Intel.
- Low speed and full speed.

USB EHCI (Enhanced Host Controller Interface)

- When USB 2.0 appeared with its new high speed functionality, the USB-IF insisted on there being a single host controller specification, to keep device development costs down.
- The EHCI handles high speed transfers, and hands off low and full speed transfers to either OHCI or UHCI companion controllers.

USB XHCI (Extensible Host Controller Interface)

- eXtensible Host Controller Interface (xHCI) is a computer interface specification that defines a register-level description of a host controller for Universal Serial Bus (USB).
- Capable of interfacing with USB 1.x, 2.0, and 3.x compatible devices.
- The specification is also referred to as the USB 3.0 host controller specification.

USB Data Transfer Priority

Transfer Type	Priority
Interrupt	1 (Highest)
Isochronous	2 (Medium)
Bulk	3 (Low)

USB Interrupt Transfer - 1

- Short packets with CRC.
- Scheduled at fixed periodic intervals.
- While the interrupt transfer may be running every frame, interrupt transfers could be scheduled to run on intervals of frames, such as every 10 frames.
- Interrupt transfers will always occur regardless of whether or not there is any data to be transferred.

USB Interrupt Transfer - 2

Interrupt Transfer

Benefits	High-reliability data transfers with the fixed response time.
Drawback	Bandwidth may be limited (64 KBytes for Full-Speed USB).
Typical Use	Mice, Keyboards, and Medical Devices
Notes	<ul style="list-style-type: none">• Up to 90% of the frame can be allocated for Interrupt endpoints.• The maximum length of the transfer depends upon the frame size used.

USB Isochronous Transfer - 1

- Longer packets without CRC.
- Isochronous transfers are scheduled at fixed periods.
- The frame bandwidth is released by the Host if communication with the endpoint is not needed.

USB Isochronous Transfer - 2

Isochronous Transfer

Benefits	High bandwidth
Drawback	<ul style="list-style-type: none">• No CRC hardware. If a CRC is needed it must be done in software.• Long packets can limit the number of devices being enumerated.
Typical Use	Audio/Video streaming, serial port emulation
Notes	<ul style="list-style-type: none">• Up to 90% of the frame can be allocated for interrupt endpoints.• When not in use the bandwidth used will be released.• The maximum length of the transfer depends upon the frame size used.

USB Bulk Transfer - 1

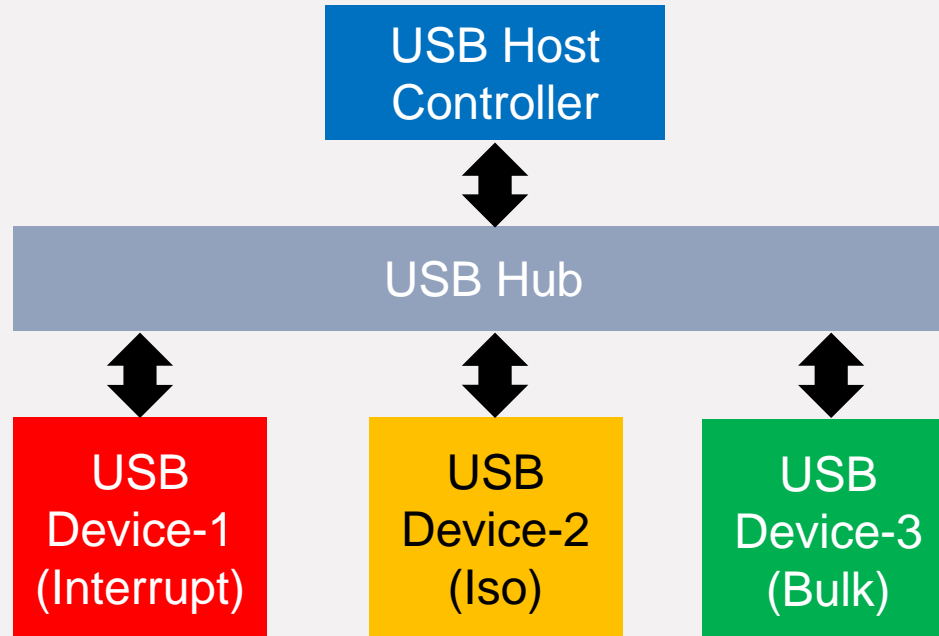
- Short packets with CRC.
- Bulk transfers are not scheduled, they run when there is available bandwidth in the frame.
- Multiple Bulk transfers can run in a single frame if there is bandwidth available.

USB Bulk Transfer - 2

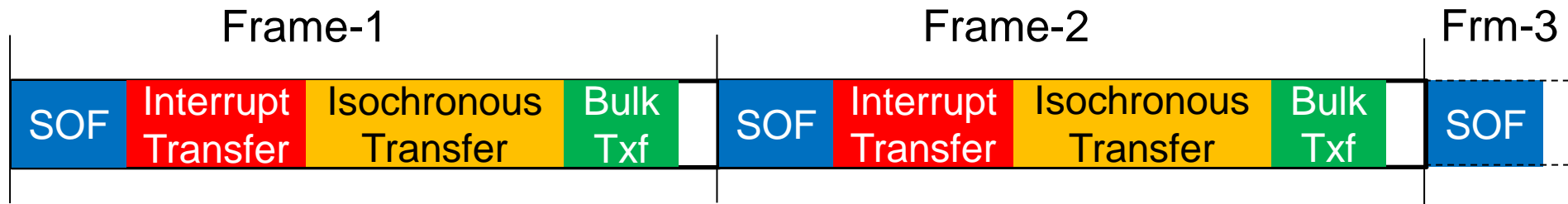
Bulk Transfer

Benefits	High reliability with the potential for high bandwidth.
Drawback	Bandwidth may vary depending upon the number of interrupt endpoints enumerated and the activity of enumerated Isochronous endpoints.
Typical Use	Mass Storage Device (USB-drive) and Printers
Notes	<ul style="list-style-type: none">• Will take advantage of unused Isochronous bandwidth.• The maximum length of the transfer depends upon the frame size used.

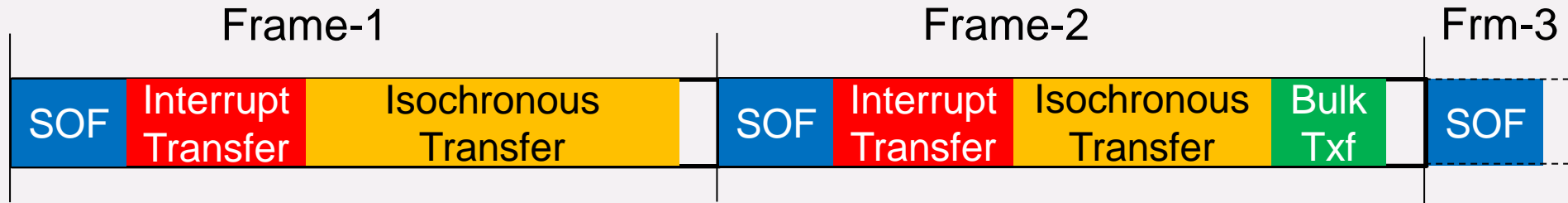
Typical USB Bus Topology



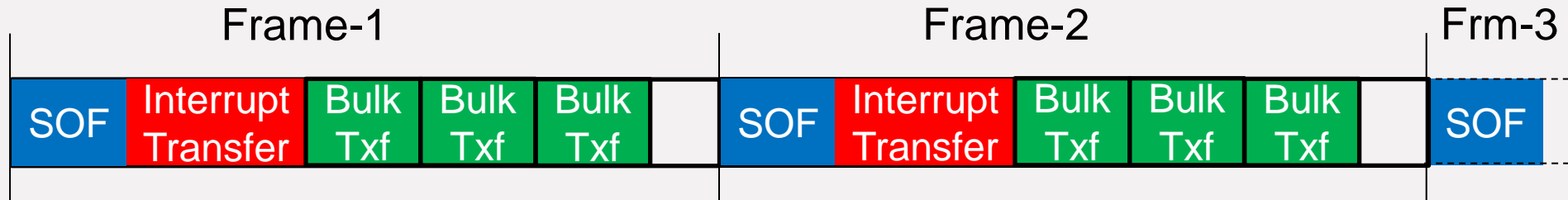
USB Transfer Schedule – Intr, Iso & Bulk



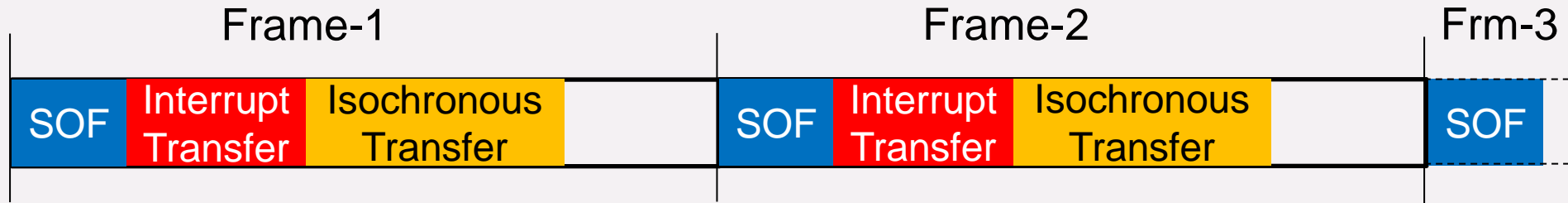
USB Transfer Schedule – Intr, Iso & Delayed Bulk



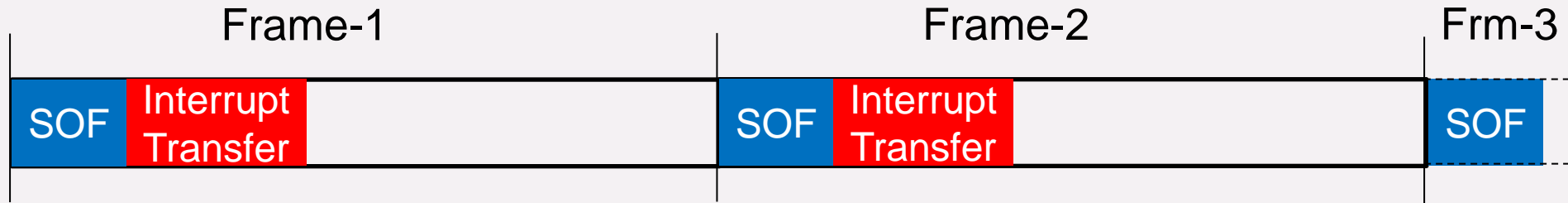
USB Transfer Schedule – Interrupt & Bulk



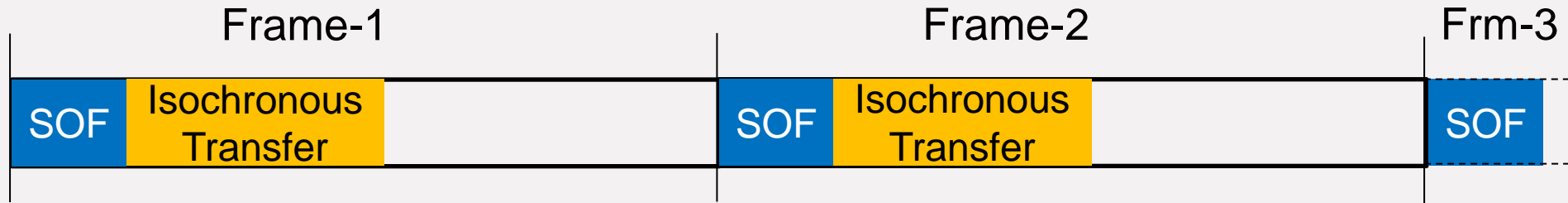
USB Transfer Schedule – Interrupt & Isochronous



USB Transfer Schedule – Only Interrupt



USB Transfer Schedule – Only Isochronous



USB References

- 1) <https://en.wikipedia.org/wiki/USB>
- 2) https://en.wikipedia.org/wiki/USB_hardware
- 3) <https://microchipdeveloper.com/usb:transfer>