



# Universal Serial Bus (USB)

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# Introduction

- **Universal Serial Bus (USB)** is a serial bus standard to interface devices
- USB was designed to allow many peripherals to be connected using a single standardized interface socket and to improve the plug-and-play capabilities by allowing devices to be connected and disconnected without rebooting the computer (hot swapping)
- Other convenient features include providing power to low-consumption devices without the need for an external power supply and allowing many devices to be used without requiring manufacturer specific, individual device drivers to be installed
- The USB "trident" Icon:



## USB Interface

- a serial data-transmission system that uses cables to connect peripheral equipment to PCs
- USB system is master-slave type bus
- The PC is the master that supplied power to the bus and controls the bus operation
- The peripheral equipment connected to USB bus just follow the PC controlling
- USB system -complicated, to interface something to USB, need practically always use special ICs designed for USB interfacing
- Those ICs typically include USB controllers and general purpose microcontrollers with built-in USB controllers.

## Lecture 02

- A USB system has an asymmetric design, consisting of a host, a multitude of downstream USB ports, and multiple peripheral devices connected in a tiered-star topology
- Additional USB hubs may be included in the tiers, allowing branching into a tree structure, subject to a limit of 5 levels of tiers
- USB host may have multiple host controllers and each host controller may provide one or more USB ports
- Up to 127 devices, including the hub devices, may be connected to a single host controller

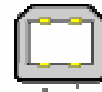


A conventional USB hub

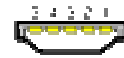
# Types of USB Connectors



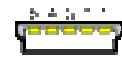
Type A



Type B

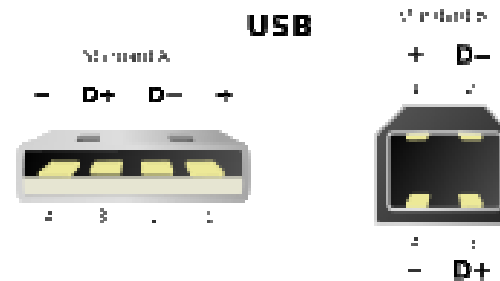


Mini-A



Mini-B

Pin configuration of the USB connectors  
Standard A/B, viewed from face of plug:



# USB TYPES

The data slots in A-Plug are actually farther in the plug than the outside power wires to prevent data errors by powering the device first, then transferring data

- Standard-A  
≈ 4 x 12 mm

Standard -A

- Standard-B  
≈ 7 x 8 mm

Standard -B

Mini-B, Micro-A, Micro-B, and Micro-AB

- Micro-A and Micro-B plugs approximately 2 by 7 mm
- are used for smaller devices such as PDAs, mobile phones or digital cameras

## USB Cables

- The maximum length of a standard USB cable is 5.0 meters (16.4 ft)
- The primary reason for this limit is the maximum allowed round-trip delay of about 1500 ns
- If a USB device does not answer to host commands within the allowed time, the host considers the command to be lost
- When USB device response time, delays from using the maximum number of hubs and delays from cables connecting the hubs, host and device are summed, the maximum delay caused by a single cable turns out to be 26 ns
- The USB 2.0 specification states that the cable delay must be less than 5.2 ns per meter, which means that maximum length USB cable is 5 meters long
- However, this is also very close to the maximum possible length when using a standard copper cable

## USB Cable

Pin	Function
1	Vbus 4.75 - 5.25 V
2	Data -
3	Data +
4	Ground
Shell	Screen

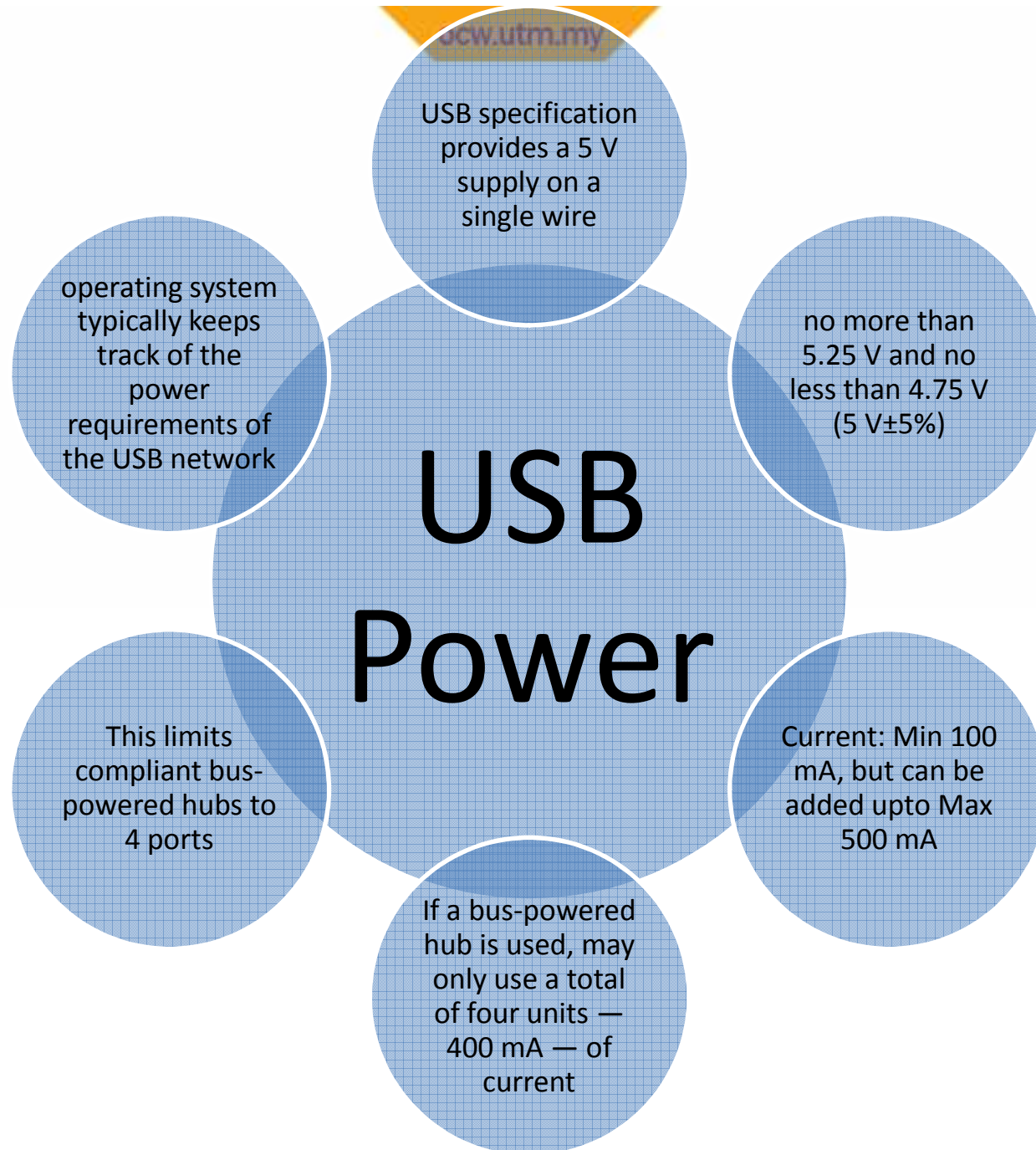
USB cable pin assignments

## Data Cable

- The data cables are a twisted pair to reduce noise and crosstalk





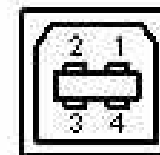


## USB Connectors

- All devices have an upstream connection to the host and all hosts have a downstream connection to the device
- Upstream and downstream connectors are not mechanically interchangeable, thus eliminating illegal loopback connections at hubs such as a downstream port connected to a downstream port
- There are commonly two types of connectors, called type A and type B which are shown below
- Type A plugs always face upstream
- Type A sockets will typically find themselves on hosts and hubs
- For example type A sockets are common on computer main boards and hubs



Type A USB Connector



Type B USB Connector

## Lecture 02

- Type B plugs are always connected downstream and consequently type B sockets are found on devices
- It is interesting to find type A to type A cables wired straight through and an array of USB gender changers in some computer stores
- This is in contradiction of the USB specification
- The only type A plug to type A plug devices are bridges which are used to connect two computers together
- Other prohibited cables are USB extensions which has a plug on one end (either type A or type B) and a socket on the other
- These cables violate the cable length requirements of USB
- USB 2.0 included errata which introduces mini-usb B connectors
- The reasoning behind the mini connectors came from the range of miniature electronic devices such as mobile phones and organisers. The current type B connector is too large to be easily integrated into these devices

## Power ( $V_{BUS}$ )

- One of the benefits of USB is bus-powered devices - devices which obtain its power from the bus and requires no external plug packs or additional cables
- However many leap at this option without first considering all the necessary criteria
- A USB device specifies its power consumption expressed in 2mA units in the configuration descriptor
- A device cannot increase its power consumption, greater than what it specifies during enumeration, even if it loses external power
- There are three classes of USB functions
  - Low-power bus powered functions
  - High-power bus powered functions
  - Self-powered functions
- Low power bus powered functions draw all its power from the  $V_{BUS}$  and cannot draw any more than one unit load
- The USB specification defines a unit load as 100mA

## Data Signaling Rate

- Another area which is often overlooked is the tolerance of the USB clocks
- This is specified in the USB specification
  - High speed data is clocked at 480.00Mb/s with a data signalling tolerance of  $\pm 500$ ppm
  - Full speed data is clocked at 12.000Mb/s with a data signalling tolerance of  $\pm 0.25\%$  or 2,500ppm
  - Low speed data is clocked at 1.50Mb/s with a data signalling tolerance of  $\pm 1.5\%$  or 15,000ppm
- This allows resonators to be used for low cost low speed devices, but rules them out for full or high speed devices

THANK YOU