What is USB ?

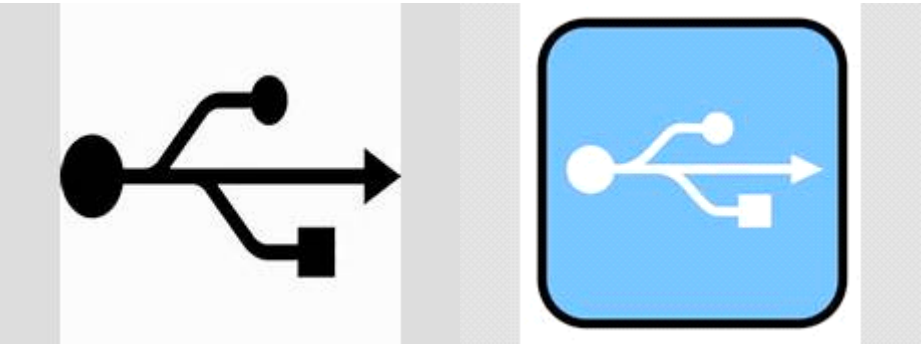

fig : Logo of USB

Short for Universal Serial Bus, USB (pronounced yoo-es-bee) is a plug-and-play interface that allows a computer to communicate with peripheral and other devices. USB-connected devices cover a broad range; anything from keyboards and mice, to music players and flash drives. For more information on these devices, see our USB devices section.

USB may also be used to send power to certain devices, such as smartphones and tablets, as well as charge their batteries. The Universal Serial Bus industry standard was established in 1995, and then quickly adopted by Intel, Compaq, Microsoft and other companies.

Who invented the USB ?

The team that created the universal serial bus included Ajay Bhatt, Bala Cadambi, Shelagh Callahan, Shaun Knoll and Jeff Morriss. Though Ajay Bhatt is best known for the invention, he credits his entire team for their collaborative effort.

Short History of USB :

The Universal Serial Bus (USB) is standard interface for linking peripheral devices to a host computer. The peripheral bus standard originally began development in 1994 by seven core companies: Compaq, DEC, IBM, Intel, Microsoft, NEC and Northern Telecom. Their intent was to create a simple way to integrate computers and telephone, commonly referred to as computer-telephone-integration (CTI).

Later, the main goal of USB evolved into a way to make the addition of peripheral devices quick and easy. This would replace the multitude of cables and connectors required to connect peripheral devices to a host computer with a simpler architecture. It later expanded into a concept of easy integration of multiple peripherals to the host PCs.

The idea that you could Plug'n'Play your peripherals to a host computer was the vision. To accomplish this, all USB devices were designed to share some key characteristics. All USB devices are self-identifying, hot-pluggable, and can draw power from USB ports which eliminate the need for extra power adapters.

To maximize the ability of these diverse systems to work together, the USB standard defined all parts of the USB system from the mechanical, electrical, protocol, and software layer. This USB standard is revised and regulated by the USB Implementers Forum (USB-IF). All USB devices must pass a USB-IF compliance test in order to be considered in compliance and utilize the USB logo on their product.

The first edition of the USB standard, USB 1.0, was introduced in 1996, but was not widely adopted until 1998 with the first revision, USB 1.1. The second major revision, USB 2.0, was released in 2000 and has since become the existing standard for connecting devices to computers and beyond. In 2008, the USB specification was expanded with USB 3.0, also known as SuperSpeed USB. USB 3.0 represents the third significant change in the underlying operation of USB by the USB-IF. This edition improved on power management, bus power and current draw, and the rate of data transfer.

Where are the USB ports used?

All modern computers have at least one USB port, below are the typical locations you can find a USB port on a computer.

Desktop computer - A desktop computer usually has two to four ports in the front and two to eight ports in the back.

Laptop computer - A laptop computer has between one and four ports on the left, right, or both sides of the laptop.

Tablet computer - If a tablet has a USB port it is usually the same port as the charging port. A few laptops may have an additional port and if it is available it is on one of the sides of the tablet.

Smartphone - Not many smartphones have a USB port, but many use a USB port to charge the phone that can be used as a USB port when not being charged.

Different versions of USB :

Release name	Release date	Maximum transfer rate
USB 1.1	August 1998	
USB 2.0	April 2000	High Speed (480 Mbit/s)
USB 3.0	November 2008	SuperSpeed (5 Gbit/s)
USB 3.1	July 2013	SuperSpeed+ (10 Gbit/s)

As USB technology advanced the new version of USB are unveiled with time. Let us now try to understand more about the different versions of the USB.

USB1.0:

Version 0.7 of the USB interface definition was released in November 1994. But USB 1.0 is the original release of USB having the capability of transferring 12 Mbps, supporting up to 127 devices. And as we know it was a combined effort of some large players on the market to define a new general device interface for computers. This USB 1.0 specification model was introduced in January1996. The data transfer rate of this version can accommodate a wide range of devices, including MPEG video devices, data gloves, and digitizers. This version of USB is known as full-speed USB.

Since October-1996, the Windows operating systems have been equipped with USB drivers or special software designed to work with specific I/O device types. USB got integrated into Windows 98 and later versions. Today, most new computers and peripheral devices are equipped with USB.

USB1.1:

USB 1.1 came out in September 1998 to help rectify the adoption problems that occurred with earlier versions, mostly those relating to hubs.

USB 1.1 is also known as full-speed USB. This version is similar to the original release of USB; however, there are minor modifications for the hardware and the specifications. USB version 1.1 supported two speeds, a full speed mode of 12Mbits/s and a low speed mode of 1.5Mbits/s. The 1.5Mbits/s mode is slower and less susceptible to EMI, thus reducing the cost of ferrite beads and quality components.

USB2.0:

Hewlett-Packard, Intel, LSI Corporation, Microsoft, NEC, and Philips jointly led the initiative to develop a higher data transfer rate than the 1.1 specifications. The USB 2.0 specification was released in April 2000 and was standardized at the end of 2001. This standardization of the new device-specification made backward compatibility possible, meaning it is also capable of supporting USB 1.0 and 1.1 devices and cables.

Supporting three speed modes (1.5, 12 and 480 megabits per second), USB 2.0 supports low-bandwidth devices such as keyboards and mice, as well as high-bandwidth ones like high-resolution Web-cams, scanners, printers and high-capacity storage systems.

USB 2.0, also known as hi-speed USB. This hi-speed USB is capable of supporting a transfer rate of up to 480 Mbps, compared to 12 Mbps of USB 1.1. That's about 40 times as fast! Wow!

USB3.0:

USB 3.0 is the latest version of USB release. It is also called as Super-Speed USB having a data transfer rate of 4.8 Gbit/s (600 MB/s). That means it can deliver over 10x the speed of today's Hi-Speed USB connections.

The USB 3.0 specification was released by Intel and its partners in August 2008. Products using the 3.0 specifications are likely to arrive in 2009 or 2010. The technology targets fast PC sync-and-go transfer of applications, to meet the demands of Consumer Electronics and mobile segments focused on high-density digital content and media.

USB 3.0 is also a backward-compatible standard with the same plug and play and other capabilities of previous USB technologies. The technology draws from the same architecture of wired USB. In addition, the USB 3.0 specification will be optimized for low power and improved protocol efficiency.

USB connectors & the power supply:

Connecting a USB device to a computer is very simple -- you find the USB connector on the back of your machine and plug the USB connector into it. If it is a new device, the operating system auto-detects it and asks for the driver disk. If the device has already been installed, the computer activates it and starts talking to it.

The USB standard specifies two kinds of cables and connectors. The USB cable will usually have an "A" connector on one end and a "B" on the other. That means the USB devices will have an "A" connection on it. If not, then the device has a socket on it that accepts a USB "B" connector.

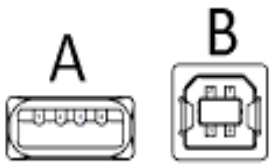

Fig 3: USB Type A & B Connectors

The USB standard uses "A" and "B" connectors mainly to avoid confusion:

1. "A" connectors head "upstream" toward the computer.
2. "B" connectors head "downstream" and connect to individual devices.

By using different connectors on the upstream and downstream end, it is impossible to install a cable incorrectly, because the two types are physically different.

Individual USB cables can run as long as 5 meters for 12Mbps connections and 3m for 1.5Mbps. With hubs, devices can be up to 30 meters (six cables' worth) away from the host. Here the high-speed cables for 12Mbps communication are better shielded than their less expensive 1.5Mbps counterparts. The USB 2.0 specification tells that the cable delay to be less than 5.2 ns per meter

Inside the USB cable there are two wires that supply the power to the peripherals-- +5 volts (red) and ground (brown)-- and a twisted pair (yellow and blue) of wires to carry the data. On the power wires, the computer can supply up to 500 milliamps of power at 5 volts. A peripheral that draws up to 100ma can extract all of its power from the bus wiring all of the time. If the device needs more than a half-amp, then it must have its own power supply. That means low-power devices such as mice can draw their power directly from the bus. High-power devices such as printers have their own power supplies and draw minimal power from the bus. Hubs can have their own power supplies to provide power to devices connected to the hub.

Pin No:	Signal	Color of the cable
1	+5V power	Red
2	- Data	White / Yellow
3	+Data	Green / Blue
4	Ground	Black/Brown

Table - 1: USB pin connections

USB Data Transfer Types :

The USB device (function) communicates with the host by transferring data through a pipe between a memory buffer on the host and an endpoint on the device. USB supports four different transfer types. A type is selected for a specific endpoint according to the requirements of the device and the software. The transfer type of a specific endpoint is determined in the endpoint descriptor.

The USB specification provides for the following data transfer types:

Control Transfer :

Control Transfer is mainly intended to support configuration, command and status operations between the software on the host and the device. This transfer type is used for low-, full- and high-speed devices.

Each USB device has at least one control pipe (default pipe), which provides access to the configuration, status and control information.Control transfer is bursty, non-periodic communication. The control pipe is bi-directional – i.e., data can flow in both directions.

Control transfer has a robust error detection, recovery and retransmission mechanism and retries are made without the involvement of the driver. The maximum packet size for control endpoints can be only 8 bytes for low-speed devices; 8, 16, 32, or 64 bytes for full-speed devices; and only 64 bytes for high-speed devices.

Isochronous Transfer :

Isochronous Transfer is most commonly used for time-dependent information, such as multimedia streams and telephony. This transfer type can be used by full-speed and high-speed devices, but not by low-speed devices. Isochronous transfer is periodic and continuous.

The isochronous pipe is unidirectional, i.e., a certain endpoint can either transmit or receive information. Bi-directional isochronous communication requires two isochronous pipes, one in each direction.

USB guarantees the isochronous transfer access to the USB bandwidth (i.e., it reserves the required amount of bytes of the USB frame) with bounded latency, and guarantees the data transfer rate through the pipe, unless there is less data transmitted.

Since timeliness is more important than correctness in this type of transfer, no retries are made in case of error in the data transfer. However, the data receiver can determine that an error occurred on the bus.

Interrupt Transfer :

Interrupt Transfer is intended for devices that send and receive small amounts of data infrequently or in an asynchronous time frame. This transfer type can be used for low-, full- and high-speed devices.

Interrupt transfer type guarantees a maximum service period and that delivery will be re-attempted in the next period if there is an error on the bus. The interrupt pipe, like the isochronous pipe, is unidirectional and periodical.

The maximum packet size for interrupt endpoints can be 8 bytes or less for low-speed devices; 64 bytes or less for full-speed devices; and 1,024 bytes or less for high-speed devices.

Bulk Transfer :

Bulk Transfer is typically used for devices that transfer large amounts of

non-time sensitive data, and that can use any available bandwidth, such as printers and scanners. This transfer type can be used by full-speed and high-speed devices, but not by low-speed devices. Bulk transfer is non-periodic, large packet, bursty communication.

Bulk transfer allows access to the bus on an "as-available" basis, guarantees the data transfer but not the latency, and provides an error check mechanism with retries attempts. If part of the USB bandwidth is not being used for other transfers, the system will use it for bulk transfer.

Like the other stream pipes (isochronous and interrupt), the bulk pipe is also unidirectional, so bi-directional transfers require two endpoints.

The maximum packet size for bulk endpoints can be 8, 16, 32, or 64 bytes for full-speed devices, and 512 bytes for high-speed devices.

Different USB devices:

Today, there are millions of different USB devices that can be connected to your computer. Below are just a few of the most common USB devices you'll likely find and use.

Digital Camera

External drive

iPod or other MP3 player

Keyboard

Keypad

Microphone

Mouse

Printer

Joystick

Jump drive aka Thumb drive

Scanner

Smartphone

Tablet

Webcams