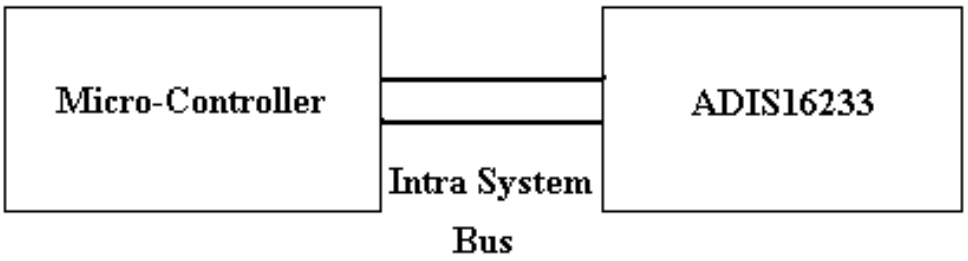
The wired communication is divided into two categories:

- *INTERNAL SYSTEM PROTOCOLS*
- *EXTERNAL SYSTEM PROTOCOLS*

The **Internal system protocol** is used to communicate between two devices within the circuit board. This category of protocols is majorly used for the peripherals present inside micro-controllers and devices similar to it.



Different categories of protocols in Inter system protocols are:

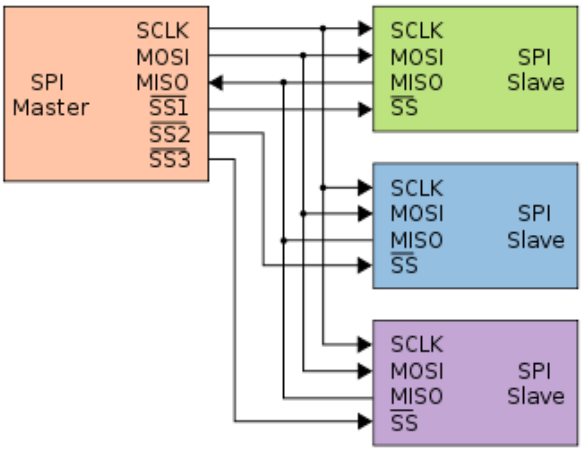
- SPI Protocol
- I2C Protocol

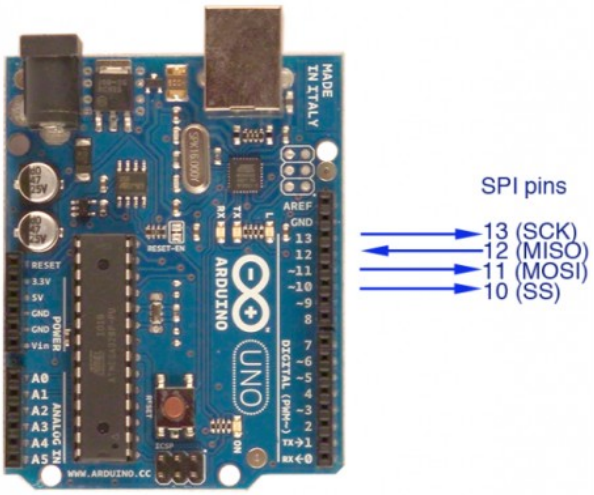
We'll discuss them one by one starting with:

SPI:

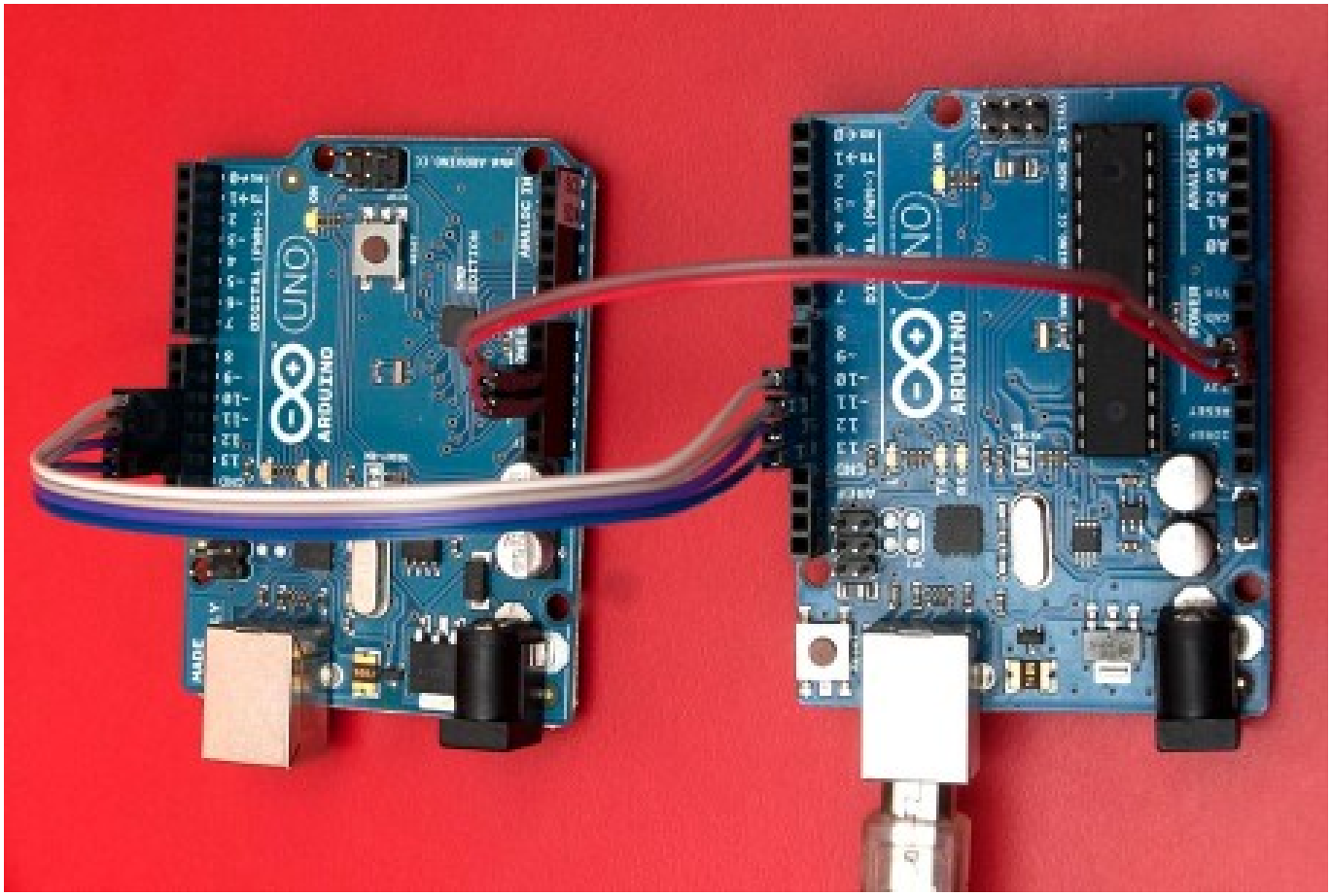
The Serial Peripheral Interface bus (SPI) is a synchronous serial communication specifically used for short distance communication, primarily in embedded systems. Sometimes SPI protocol is also called a 4-wire protocol. It requires four wires **MOSI, MISO, SS**, and **SCLK**. SPI protocol used to communicate the master and slave devices.

Applications for this type of communications are Secure Digital cards and liquid crystal displays.





The master selects only one slave at a time. It is a full-duplex communication protocol.



Advantages and Disadvantages of SPI:

Advantages:

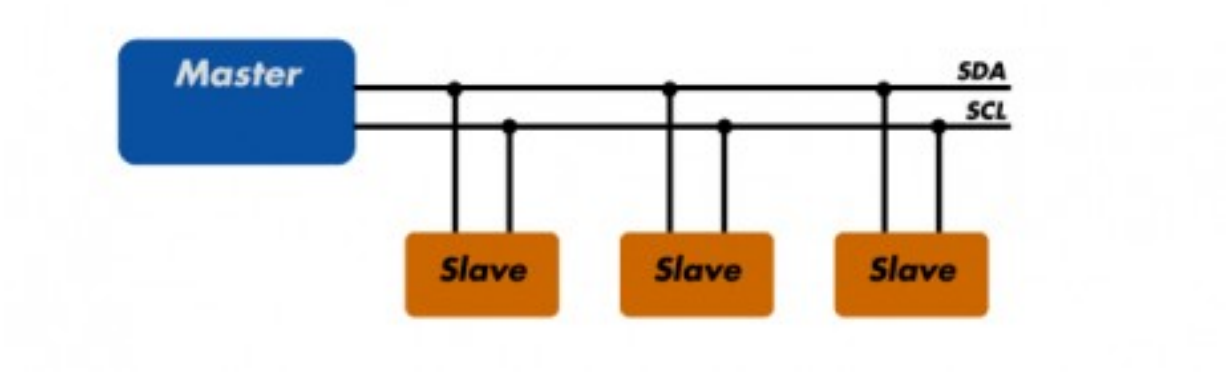
- It’s faster than asynchronous serial communication
- The receiving hardware can be a simple shift registers
- It supports multiple slaves

Disadvantages:

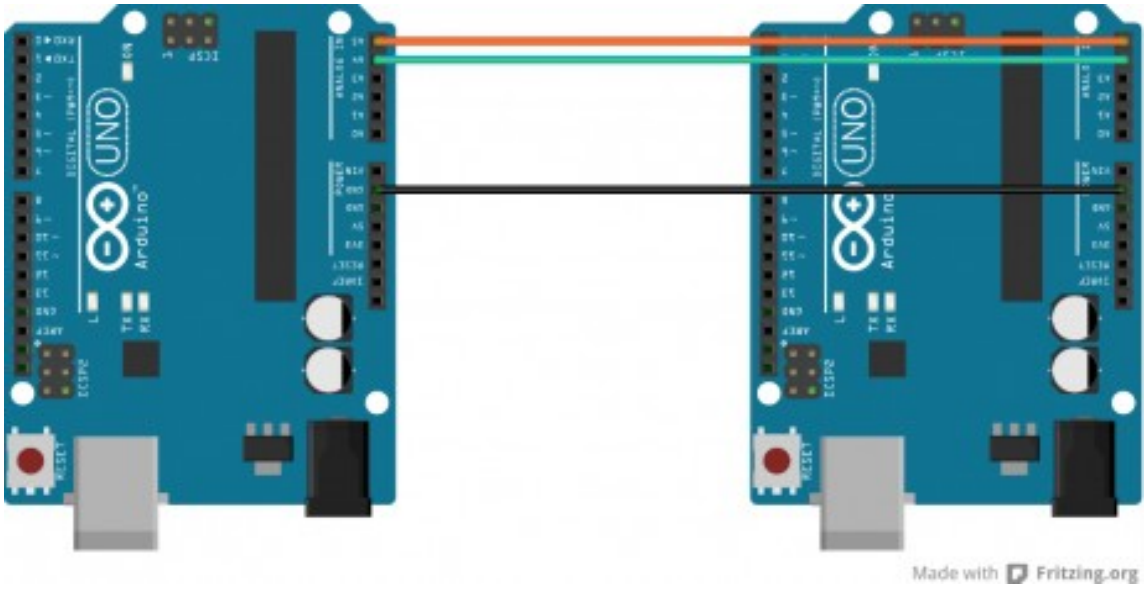
- It requires more signal lines (wires) than other communications methods
- The communications must be well-defined in advance.
- The master must control all communications (slaves can't talk directly to each other)

I2C

- I2C, therefore, stands for "Inter-integrated circuit" connections.
- I2C is one of the most popular protocols used in industry for many purposes. Here we will see the technical details of this protocol with its advantages and disadvantages.



- It is a master-slave communication protocol.
- It can also be used as **a multi-master protocol (**meaning there may be more than one master present in this types of communication**).**
- In I2C devices processors, EEPROMs, sensors, real-time clocks are used as a control interface.
- There are 3 types of I2C based on speed: **Slow (under 100 Kbps)**, **Fast (400 Kbps)**, **High-speed (3.4 Mbps)**.



There are two wire lines: Serial Data (SDA) and Serial Clock (SCL).

Advantages and Disadvantages of I2C:

Advantages:

- Occasional communication of devices is easy to implement
- I2C requires only two wires connecting all peripherals to a microcontroller
- Addressing scheme allows multiple devices
- Interconnection without additional wires

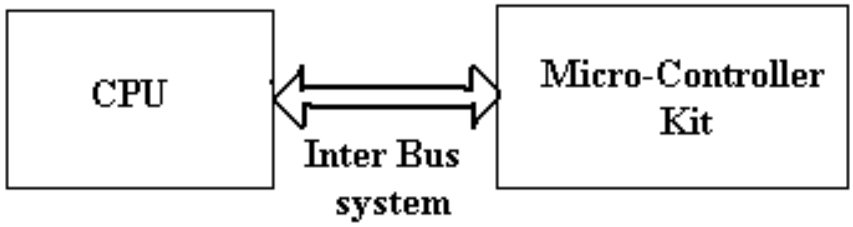
Disadvantages:

- Hardware and especially software implementation is more complicated than the SPI Half-duplex.
- Not scalable for a large number of devices.

Differences Between the Internal System Protocols:

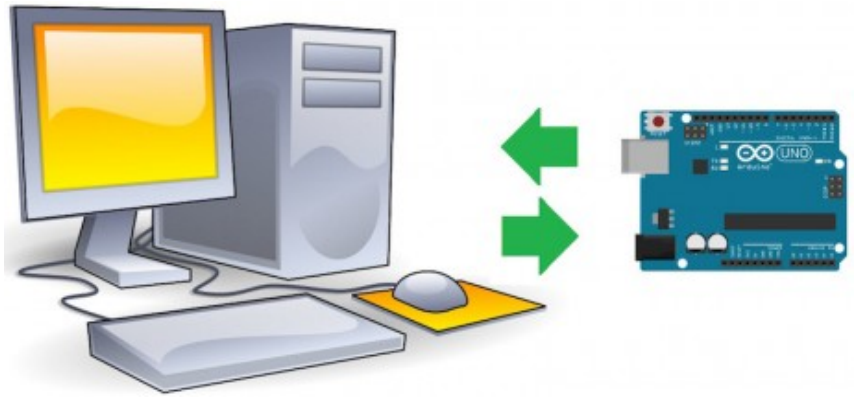
I2C	SPI
1. I2C stands for inter Integrated circuit.	1. SPI stands for serial peripheral Interface.
2. It is developed by the Philips.	2. It is developed by the Motorola.
3. It is a Half Duplex protocol	3.It is a full duplex protocol
4. Syncronization	4. Synchronization
5. It is two wire protocols SCL and SDL.	5. It is a four wire protocol SCL and MISO/MOSI, SS
6. It is multi master protocol	6. It is single master protocol
7. With in the circuit board	7. With in the circuit board

The **external system protocol** is used to communicate between two different devices, like communication happening between a computer to microcontroller kit.



For e.g. when plugging in your pen drive into the computer.

or, connecting Arduino with a computer.



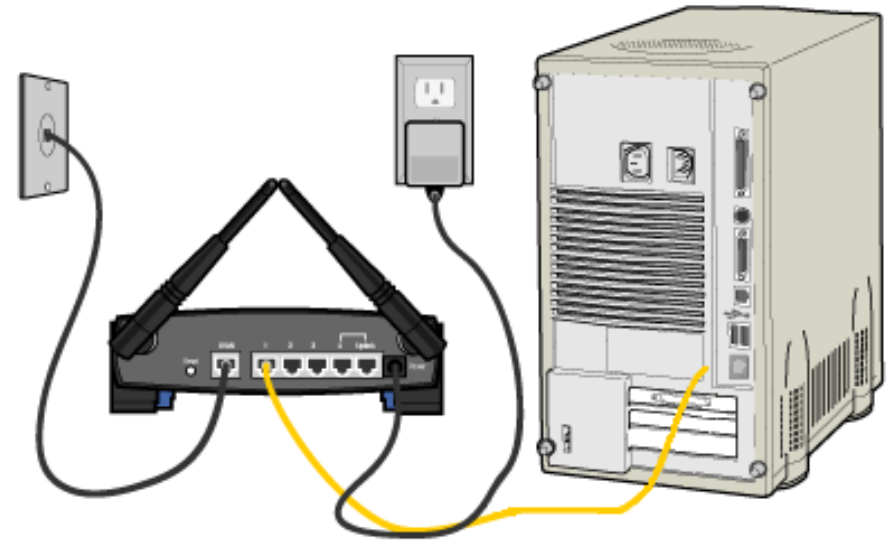
The protocols which are there for this communications are:

- **Ethernet**
- **UART Protocol**
- **USART Protocol**

Ethernet:

Ethernet is a type of connection between computers forming Local Area Networks (LAN). It also serves as one of the main methods for connecting a computer or network to an Internet hub. Ethernet cables that connect to a central hub or router in order to network several computers together.

A system for connecting a number of computer systems to form a local area network, with protocols to control the passing of information and to avoid simultaneous transmission by two or more systems.



Advantages and Disadvantages of Ethernet:

Advantages:

- Network start with it and end with it.
- Reliable and can be used within a building, doesn’t matter how many floor.

- It will be needed to switch to keep the network.
- It is basically used for making LAN.

Disadvantages:

- Can’t be used for long distance network. copper or Fiber will help here.
- In a building network, you have to connect Ethernet to switch and then Ethernet again which makes such network, a hell (with the presence of a lot of cables) which is very irritating and tough to manage.

Application of Ethernet:

- Cloud Computing
- Site to Site Access
- Video Applications
- Distributed Storage Area Networks
- CCTV
- Copper cable
- Fiber optic cable

Before we going to learn the Difference between UART and USART, we would discuss it one by one term used by UART and USART. As we all know, the full name of UART and USART is **Universal Asynchronous Receiver Transmitter** & **Universal Synchronous-Asynchronous Receiver Transmitter** respectively which includes main two words called Synchronous and Asynchronous. So this two word is the main philosophy used in serial communication.

Let us discuss it first

UART:

A **Universal Asynchronous Receiver/Transmitter**. It is a microcontroller peripheral that converts incoming and outgoing bytes of data into a serial bit stream. A start bit initiates the serial bit stream and a stop bit (or two) completes the data word. A UART also has the option of adding a parity bit to the stream to assist in detecting if a bit error occurs during transmission. The provided figure shows a standard example of what an engineer would expect to see from data transmitted through a UART.

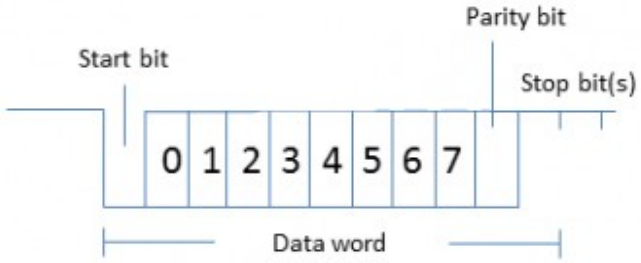


Figure – UART Serial Data

UART adds start and stops bits to the data packet being transferred. These bits define the beginning and end of the data packet to the receiving UART knows when to start reading the bits. When the receiving UART detects a start bit, it starts to read the incoming bits at a specific frequency known as the *baud rate.* Baud rate is a measure of the speed of data transfer, expressed in bits per second (bps).

Advantages and Disadvantages of UART:

Advantages:

- Single wire.
- Easy interface to PCs.
- The range of standard physical interfaces (TTL, RS232, RS422, RS485).

Disadvantages:

- Needs reasonable clock accuracy both ends.
- Max data rate in practice about 1mbit/sec (typically limited by UART capabilities).

Application of UART:

- Transmitting and receiving UARTs must be set for the same bit speed, character length, parity, and stop bits for proper operation.
- Very low-cost home computers or embedded systems dispense with a UART and use the CPU to sample the state of an input port or directly manipulate an output port for data transmission.
- Typical serial ports used with personal computers connected to modems use eight data bits.

USART

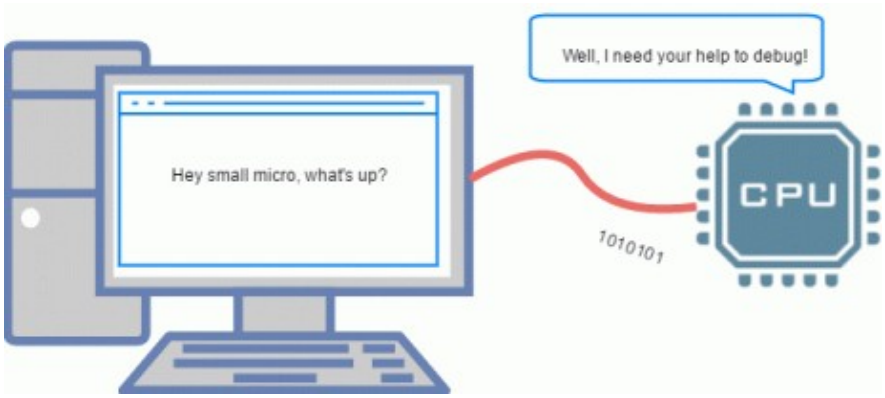
A **Universal Synchronous/Asynchronous Receiver/Transmitter** is a microcontroller peripheral that converts incoming and outgoing bytes of data into a serial bit stream.

Hmm. The definition of a USART is identical to that of a UART, but with "synchronous" added to the term.

The two-way communication as shown in the figure.

Surely there are some more meaningful differences? Otherwise, a USART would just be known as a UART.

Well, there are differences – important ones. The first difference between a USART and a UART is the way in which the serial data may be clocked. A UART generates its data clock internally to the microcontroller and synchronizes that clock with the data stream by using the start bit transition. There is no incoming clock signal that is associated with the data, so in order to properly receive the data stream, the receiver needs to know ahead of time what the baud rate should be.



A USART, on the other hand, can be set up to run in synchronous mode. In this mode, the sending peripheral will generate a clock that the receiving peripheral can recover from the data stream without knowing the baud rate ahead of time.

Alternatively, the link will use a completely separate line to carry the clock signal. The use of the external clock allows the data rate of the USART to be much higher than that of a standard UART, reaching up to rates of 4 Mbps.

Are USARTs and UARTs the same?

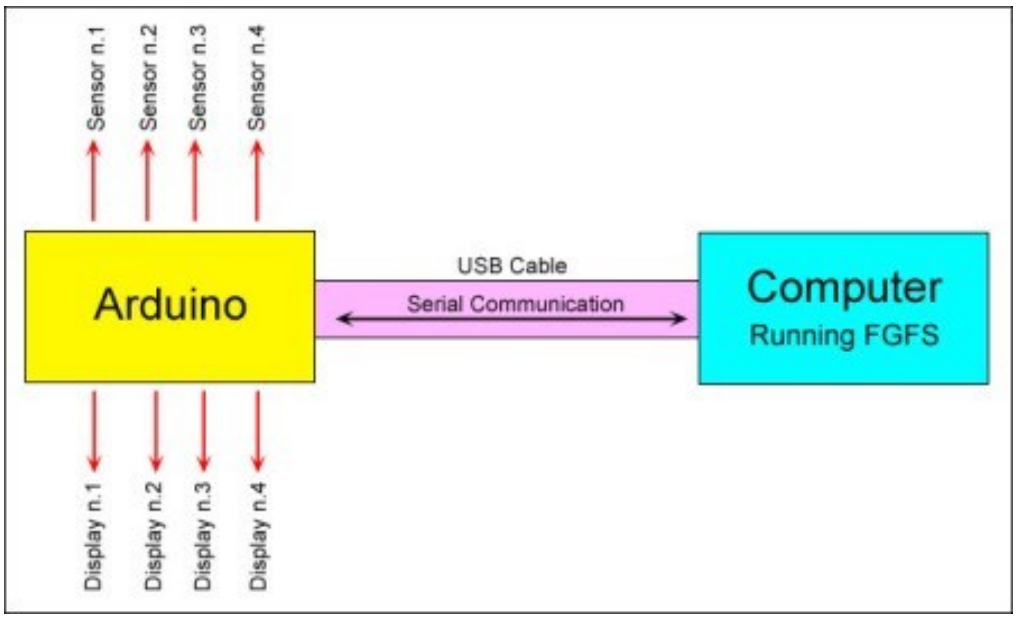
Technically the answer is no. A USART generally has more capabilities than a standard UART and the ability to generate clocked data allows the USART to operate at baud rates well beyond a UART's capabilities. A USART does encompass the capabilities of a UART, though, and in many applications, despite having the power of a USART, developers use them as simple UARTs, ignoring or avoiding the synchronous clock generation capability of these powerful peripherals. No wonder so many people use the terms as though they were synonyms.

USB:

It is a representative peripheral interface. USB stands for **Universal Serial Bus**. It provides a serial bus standard for connecting devices, usually to a computer, but it also is in use on other devices such as set-top boxes, game consoles, and PDAs.

USB Standard:

- USB 1.0 specification introduced in 1994
- USB 2.0 specification finalized in 2001: Became popular due to cost/benefit advantage.
- g. IEEE 1394 — high bandwidth, high cost
- Three generations of USB: USB 1.0 , USB 2.0, USB 3.0



Advantages and Disadvantages of USB:

Advantages:

- Flash drives use little power, have no fragile moving parts, and for most capacities are small and light.
- Data stored on flash drives is impervious to mechanical shock, magnetic fields, scratches, and dust.

Disadvantages:

- Flash drives can sustain only a limited number of write and erase cycles before the drive fails.
- A drawback to the small size is that they are easily misplaced, left behind, or otherwise lost.

Below Image differentiates between UART, CAN, and USB.

UART	CAN	USB
• Well Known • Cost Effective • Simple	• Secure • Fast	• Fast • Plug & Play HW • Simple • Low cost
• Limited functionality • Point to point	• Complex • Automotive oriented • Limited portfolio • Expensive firmware	• Powerful master required • No Plug & Play SW – Specific drivers required