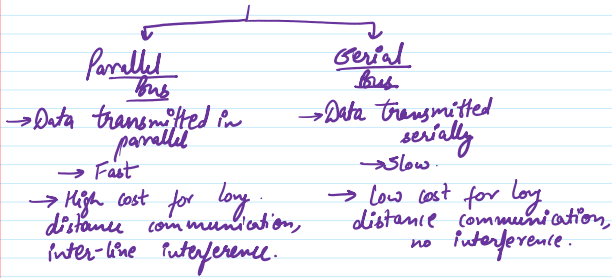


A bus is a collection of wires and connectors through which data is transmitted.

Bus = address bus + data bus.



USB :- most popular external bus standard.

keyboard, mouse, printers, scanners, mobile phones, disks, pen drives, etc

- USB 1.1 (1998): upto 12 Mbps
- USB 2.0 (2000): upto 480 Mbps
- USB 3.0 (2008): upto 5 Gbps
- USB 3.1 (2013): upto 10 Gbps
- USB 4 : upto 20 Gbps

History of USB :-

In 1994 7 companies :-

- 1) COMPAQ
- 2) DEL
- 3) IBM
- 4) Intel
- 5) Microsoft
- 6) NEC
- 7) Nortel

developed USB standard.

→ To simplify the problem of connecting external devices.

→ In USB there is a mechanism of automatic detection of the type of device connected by the system software.

Data Transmissions:-

Differential NRZI Encoding

Bits to be sent	Previous Line state	New line state
0	0	1
0 ←	1 ←	0 ←
1	0	0
1	1	1

NRZI

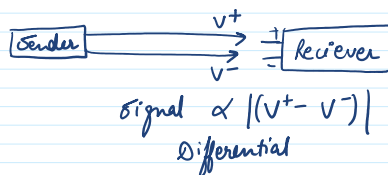
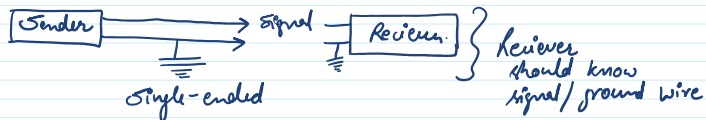
Let data to be transmitted is

0000 1111 ← data.

Let previous line 1 0 1 0 1 1 1 1

Advantage of NRZI encoding :-

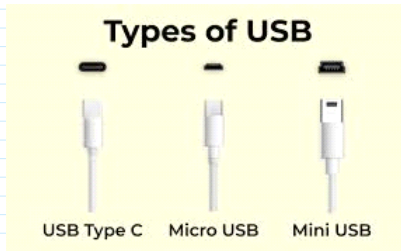
Single-ended v/s differential encoding



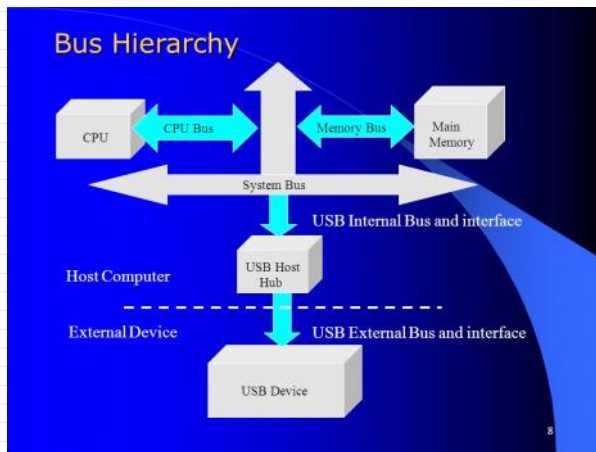
There is always some transition going on.  
Even if the line is long stream of 0's there is some tran-  
sition in serial communication as receiver can  
easily synchronize itself.

OR bit stuffing :-

Whenever there is a sequence of six consecutive 1's/0's  
then transmitter will forcibly insert 0/1.



Bus hierarchy in USB :-



USB host hub is inside the motherboard.