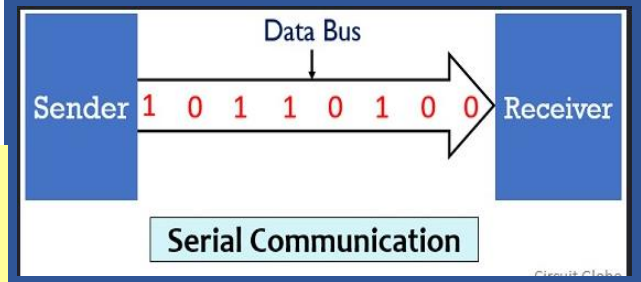
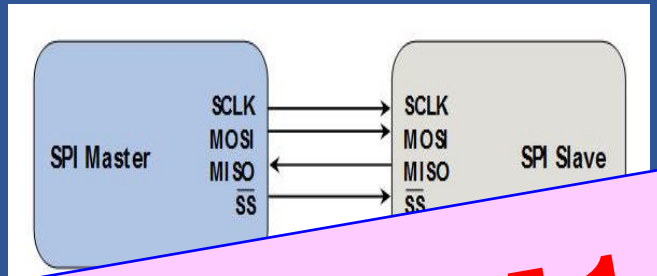
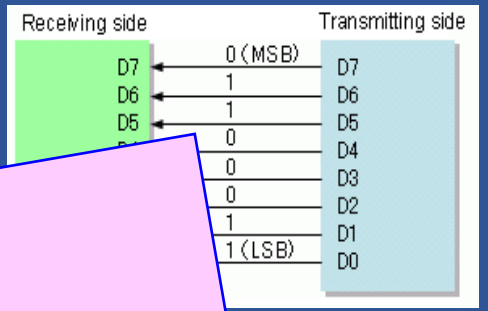
Vishwakarma Institute of Technology

FY - Department of Engineering, Sciences and Humanities



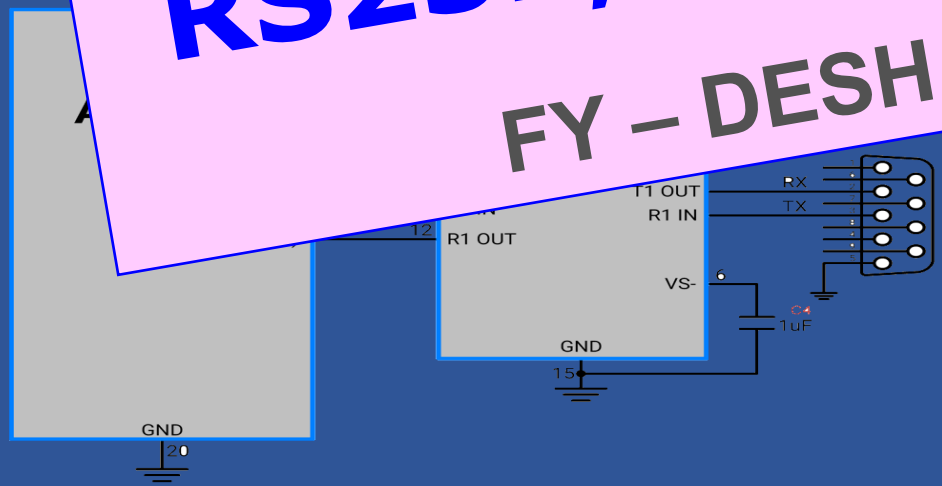


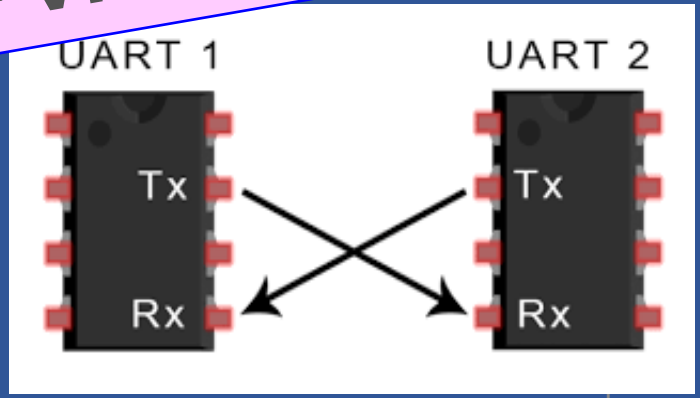


Communication – 5.1

RS232, SPI and I2C

FY – DESH – VIT





WHAT IS A COMMUNICATION ?

Communication is the act of conveying meanings from one entity or group to another through the use of mutually understood signs, symbols, and semiotic rules.

Communication is a process by which information is exchanged between individuals through a common system of symbols, signs, or beheaviour.

…….Webster's Dictionary

WHAT IS A COMMUNICATION? : General

DATA COMMUNICATION

DATA essentially means; information coded in digital form, that is, **0s and 1s.**

Sending such DATA from one point to the other either directly or through a network in a systematic and organized manner is known as **Data Communication.**

PROTOCOLS

- During the data Communication, in order to have proper interaction between the data transmitter (the device needing to start data communication) and the data receiver (the system which has to receive the data) there has to be some **set of rules** which all the interested parties must obey are better known as **PROTOCOLS.**

- **DATA COMMUNICATION STANDARDS** are evolved from Protocols.

DATA COMMUNICATION : STANDARD

Data communication standard comprises -

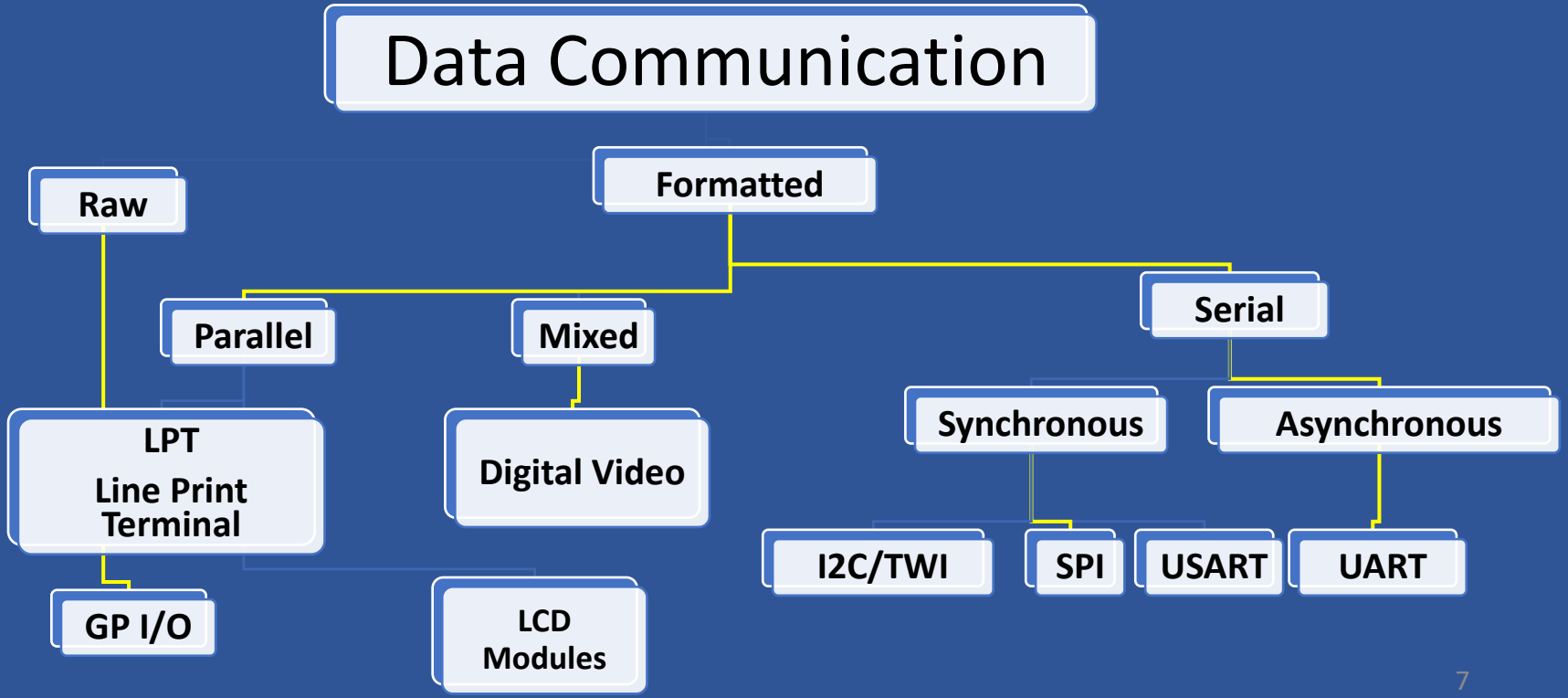
- The protocol.
- Signal/data/port specifications for the devices or additional electronic circuitry involved.

All the data communication systems follow some specific set of standards defined for their communication capabilities so that the systems are **not Vendor specific** but for each system the user has the advantage of selecting the device and interface according to his own choice of make and range.

What is meaning of Vendor specific ?

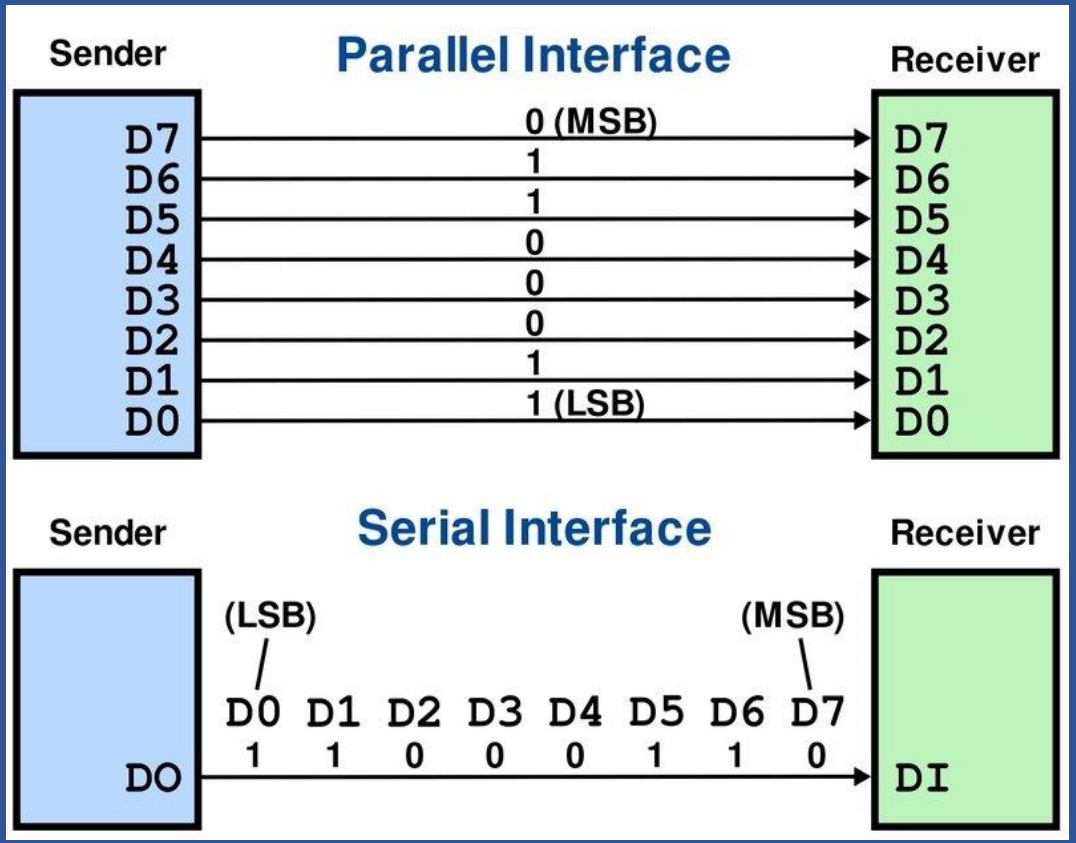
DATA COMMUNICATION : STRATEGY

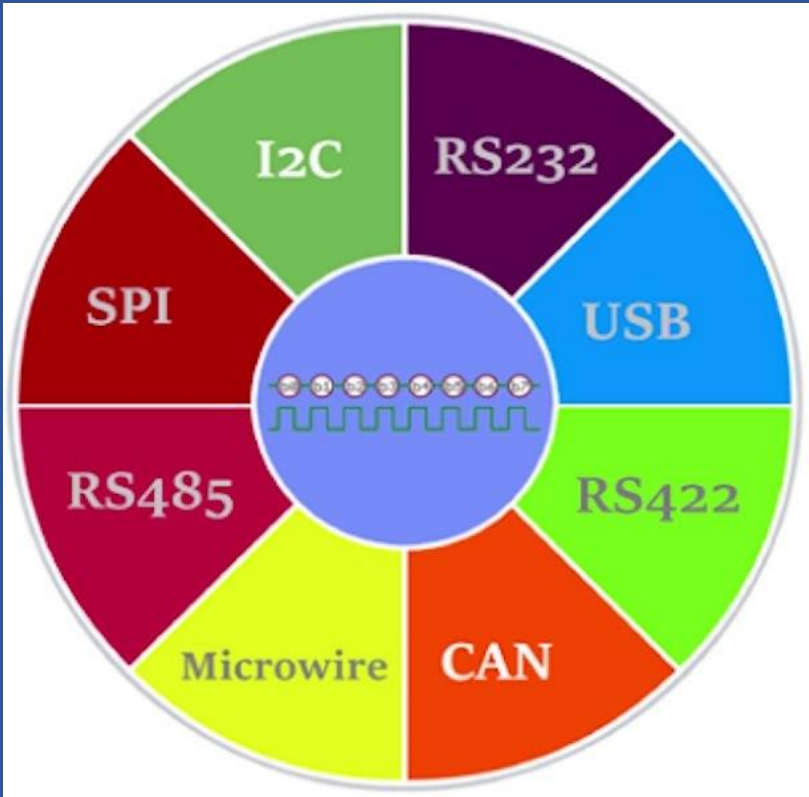
Depending on the requirement of applications, one has to choose the appropriate type of Data communication strategy. There are basically two major classifications, namely **SERIAL** and **PARALLEL**, each with its variants.



DATA COMMUNICATION: SERIAL AND PARALLEL

- There needs to be a sender and receiver of the signal for the complete communication process to take place.
- **Serial and parallel** communications are both ways of transferring data over networks. Both systems have a unique way of operating, with merits and demerits.

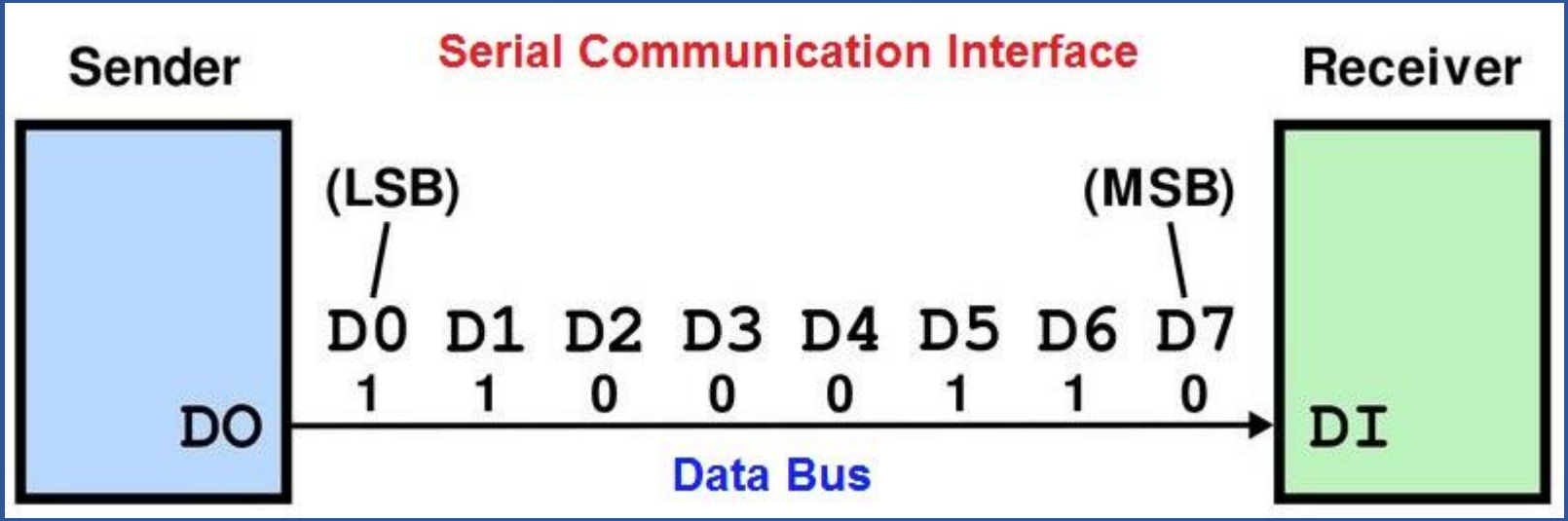


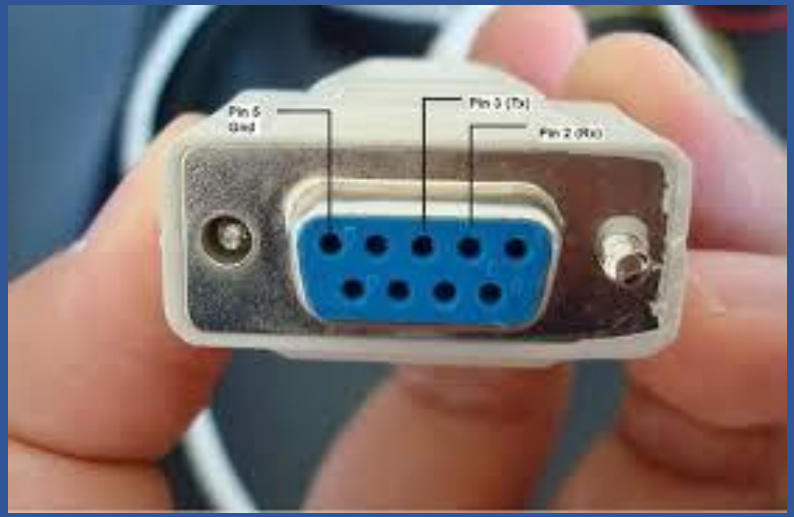


Serial Communication Protocols

SERIAL COMMUNICATION

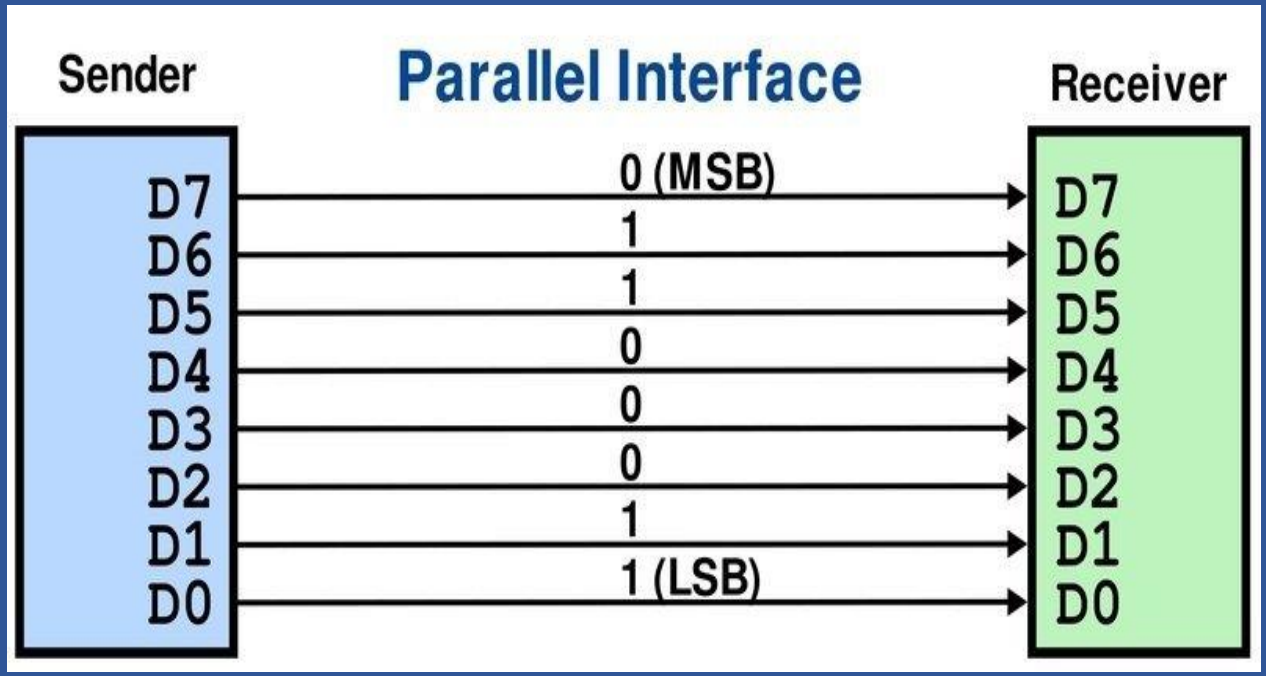
- Serial data communication is the most common low-level protocol for communicating between two or more devices.
- This is the primary mode of transfer in long-distance data communication.
- Serial communication involves sending one data bit at a time over a single data channel or bus



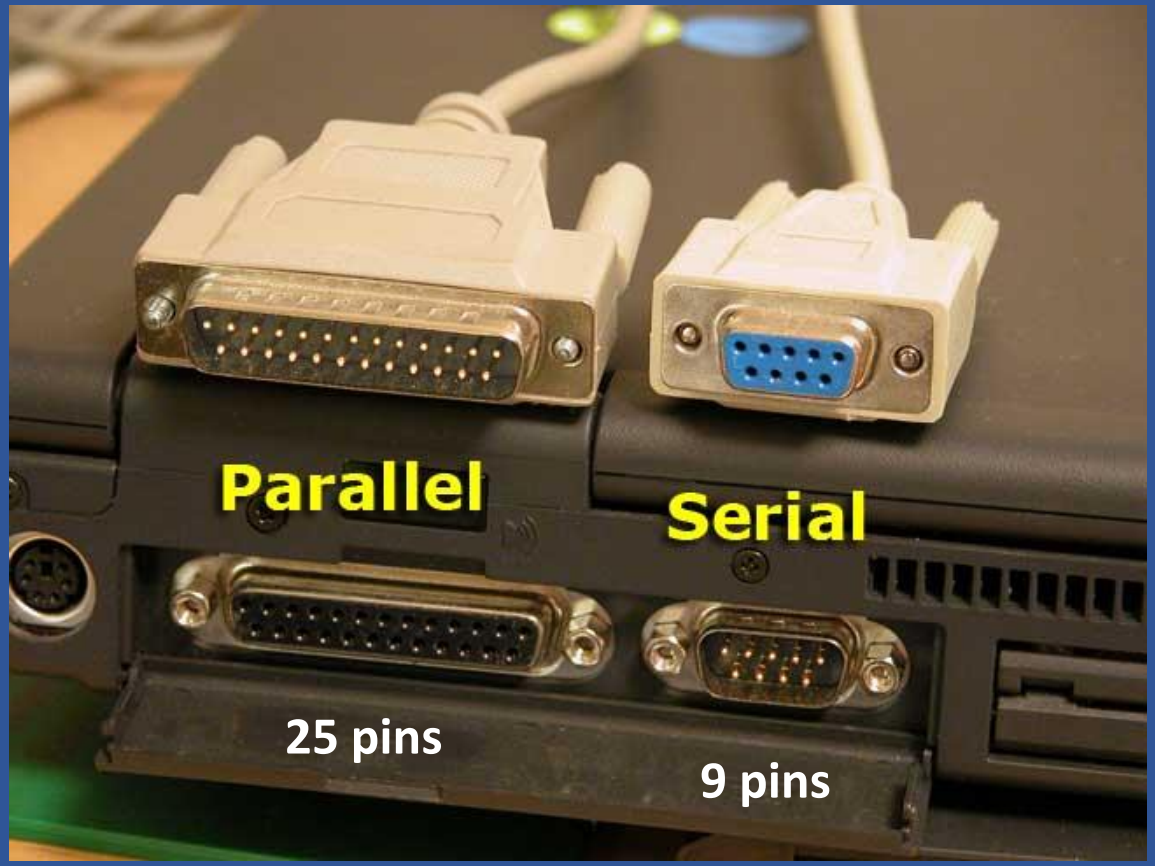


RS232 - DB9 type connectors
Male and Female type

PARALLEL COMMUNICATION



For the transmission of 8-bit of data, 8 separate communication links are utilized. Sequential but Simultaneous data transmission is achieved.


Parallel
Serial
25 pins
9 pins

SERIAL COMMUNICATION : ADVANTAGES

- Reduced cost of cabling : Lesser number of wires are required as compared to parallel connection.
- Reduced cross talk : Lesser number of wires result in reduced cross talk.

  (unwanted signals generated in a neighboring cable because of leakage of interference signals)
- Many devices are inherently serial in nature.
- Long distance data communication is possible at lower cost. e.g. Computer and a Modem.
- Examples --- Morse Code, RS232, RS422, RS485, USB, RJ45 etc.

Serial communication

Concept of Simplex, Half Duplex and Full Duplex.

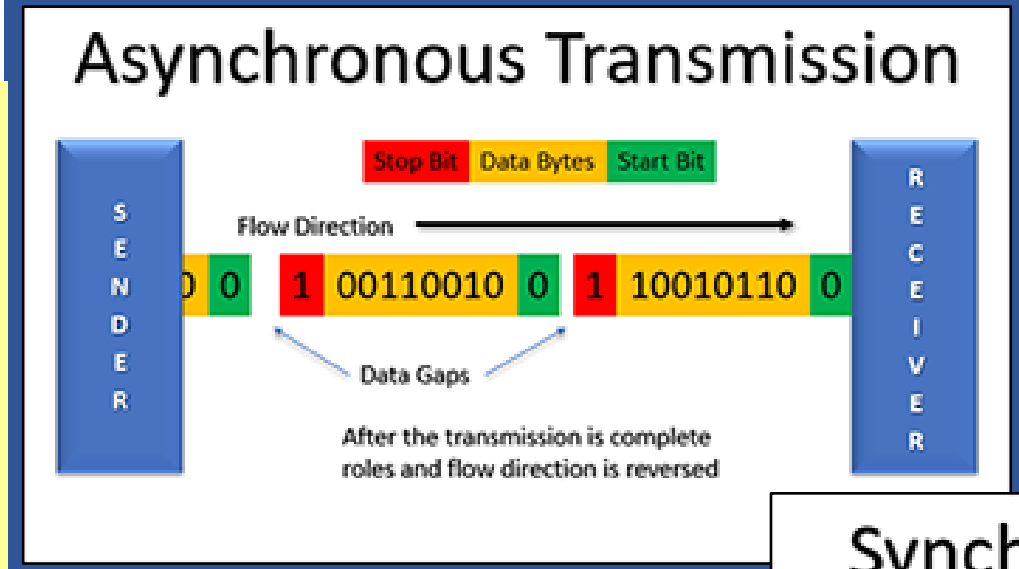
Asynchronous

- Data is transmitted in small sizes in the form of bytes or characters.
- It is half duplex type and gaps are present between data.
- Not very efficient because of large overhead.
- Slow and Economical system.
- Tight synchronization between T and R clocks NOT required.
- External clock is not required.
- START bit, STOP bit and Parity bits are added along with the data.

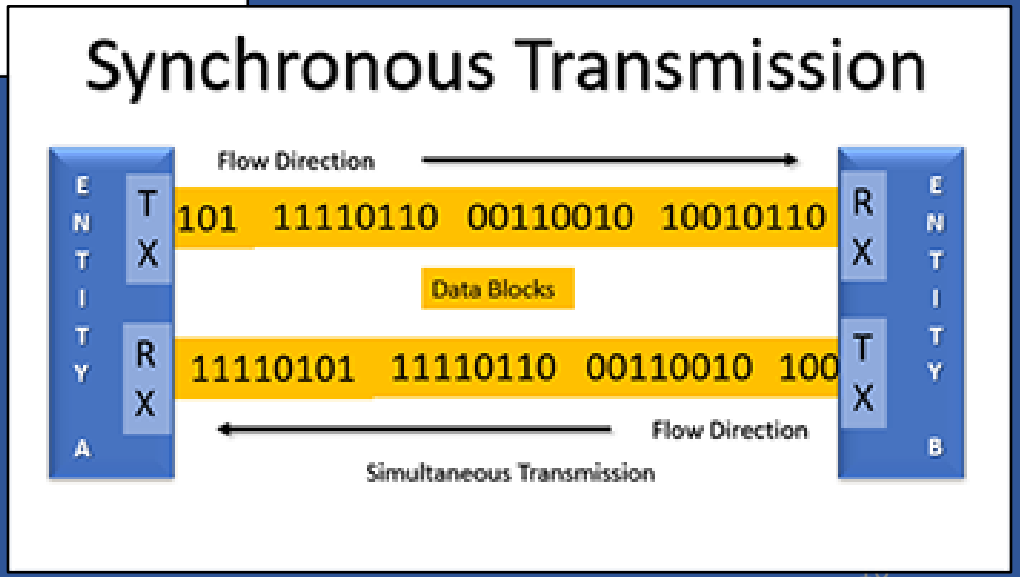
Synchronous

- Blocks or frames with large number of bits are sent at a time.
- It is fully duplex and gaps are NOT present between data.
- More efficient and reliable system.
- Fast and Costly system.
- Requires TIGHT synchronization between T and R clocks.
- External clock is a must.

Asynchronous and Synchronous serial communication



Half Duplex



Full Duplex

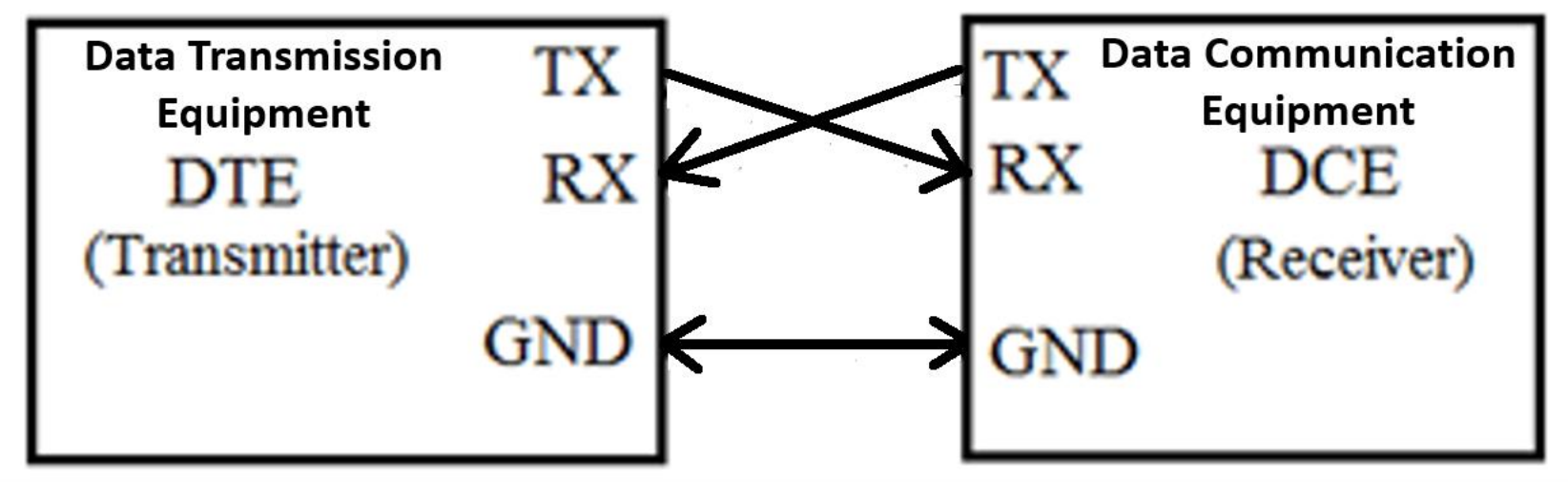
RS-232 interface

RS-232 was first introduced in 1960 by the Electronic Industries Association (EIA).

- RS232 stands for "**Recommended Standard 232**"
- Oldest one but still popular in applications.
- It is a type of asynchronous serial communication.
- Used for medium range distance upto 15 meters (50 feet - upto 130 max.).
- Technical names are EIA 232 (Electronic Industry Association) or TIA 232 (Telecommunication Industry Association)

- RS232 is a standard protocol used for serial communication, it is used for connecting computer and its peripheral devices to allow serial data exchange between them. e.g. Mouse, Modem etc.

RS232 communication :

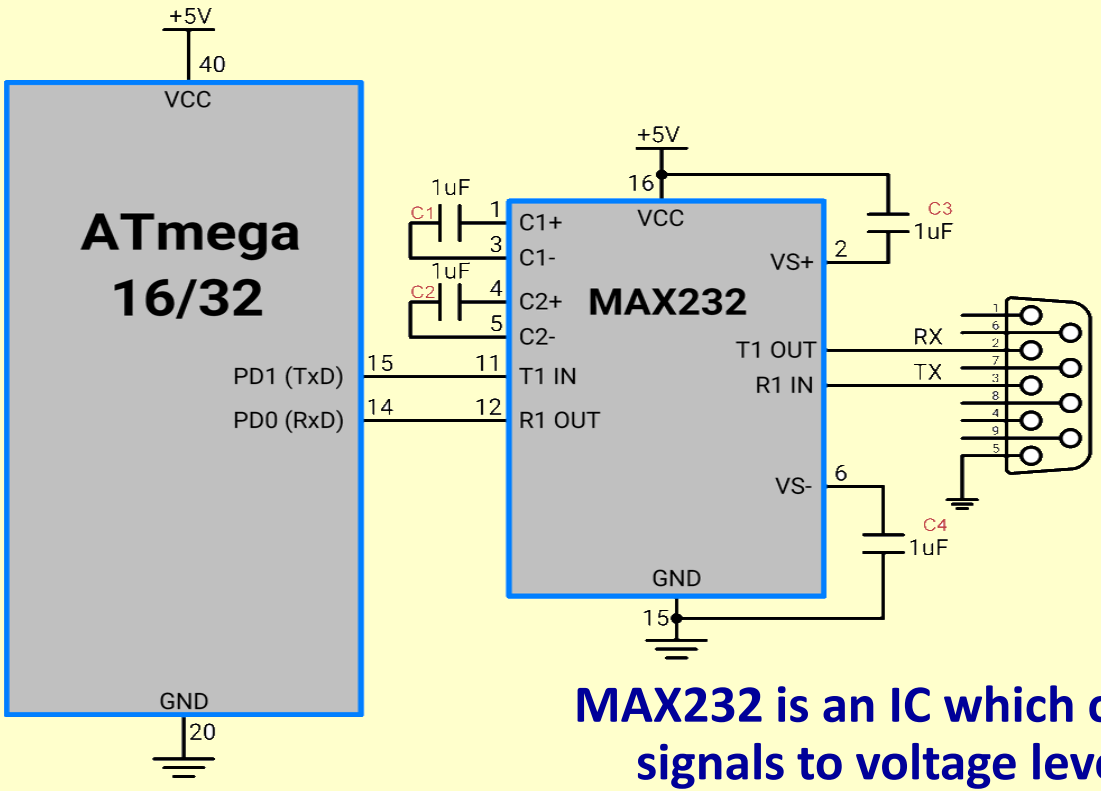


RS232 : 3 main pins for data transfer

MuC connection to Computer – Role of IC MAX232

TTL	
LOGIC 0	0 V
LOGIC 1	5 V

RS232	
LOGIC 0	+3 to +25 V
LOGIC 1	-3 to -25 V

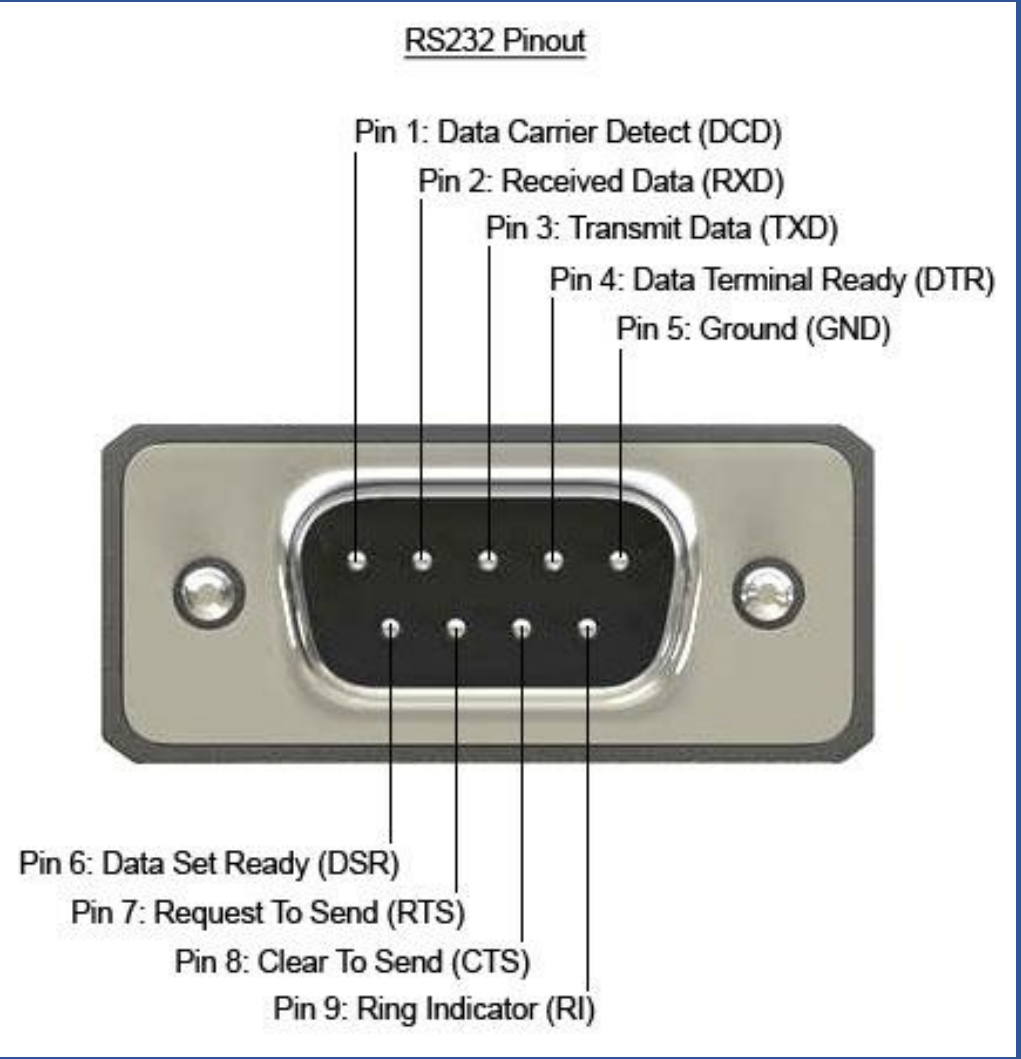


MuC works at voltage levels of 0-5 V. Whereas PC works at voltage levels of – 15 V to + 15 V.

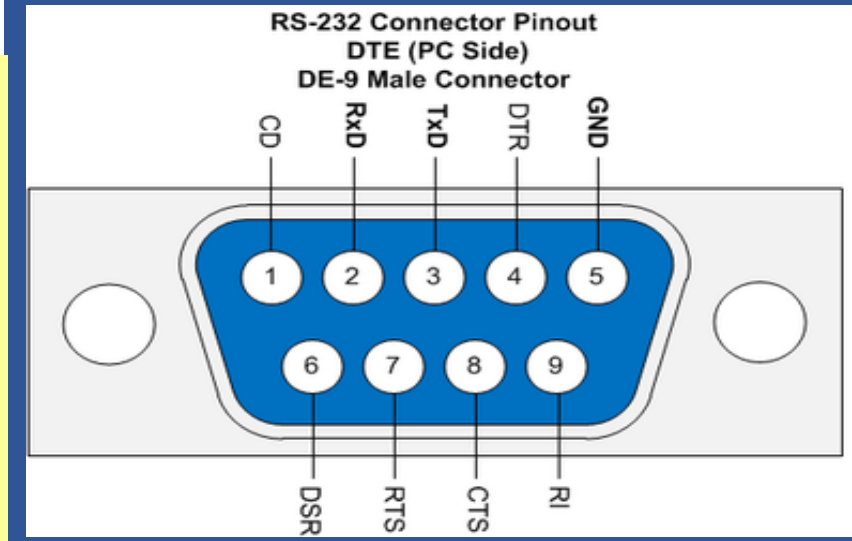
Thus a direct connection between PC and MuC is not possible.

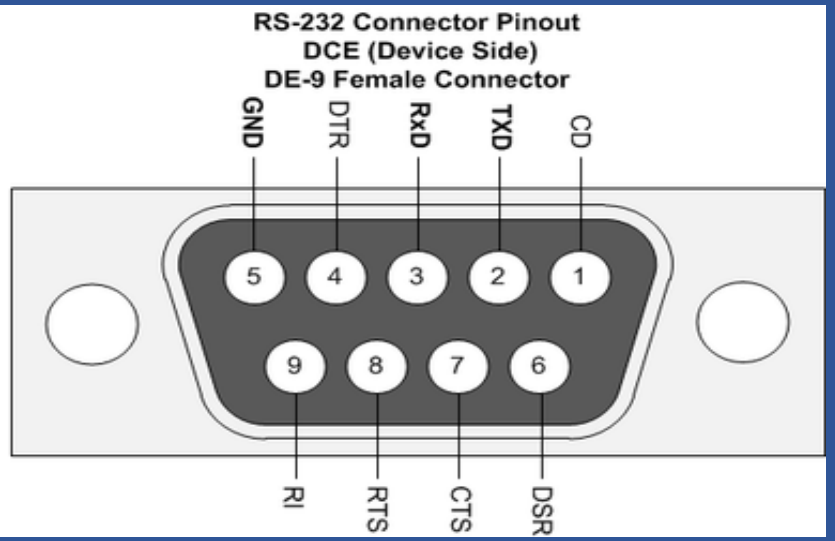
MAX232 is an IC which converts TTL /CMOS signals to voltage levels of 5 V and 0 V suitable for RS232 communication of MuC.

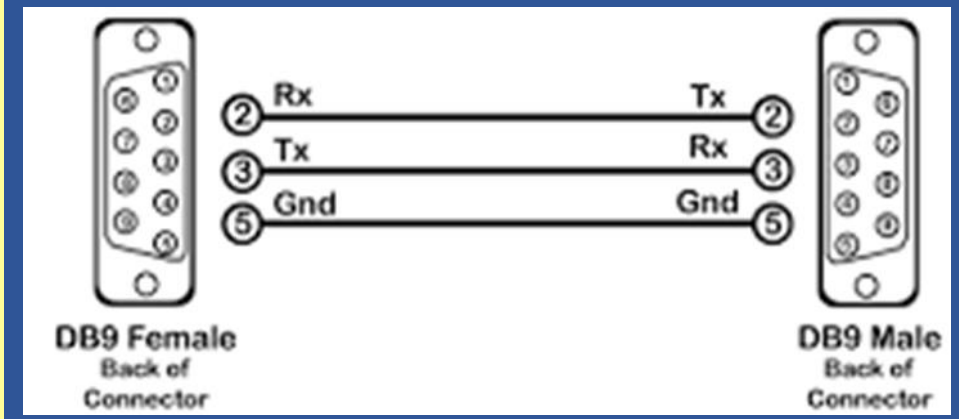
RS232 pinout of DB9 connector



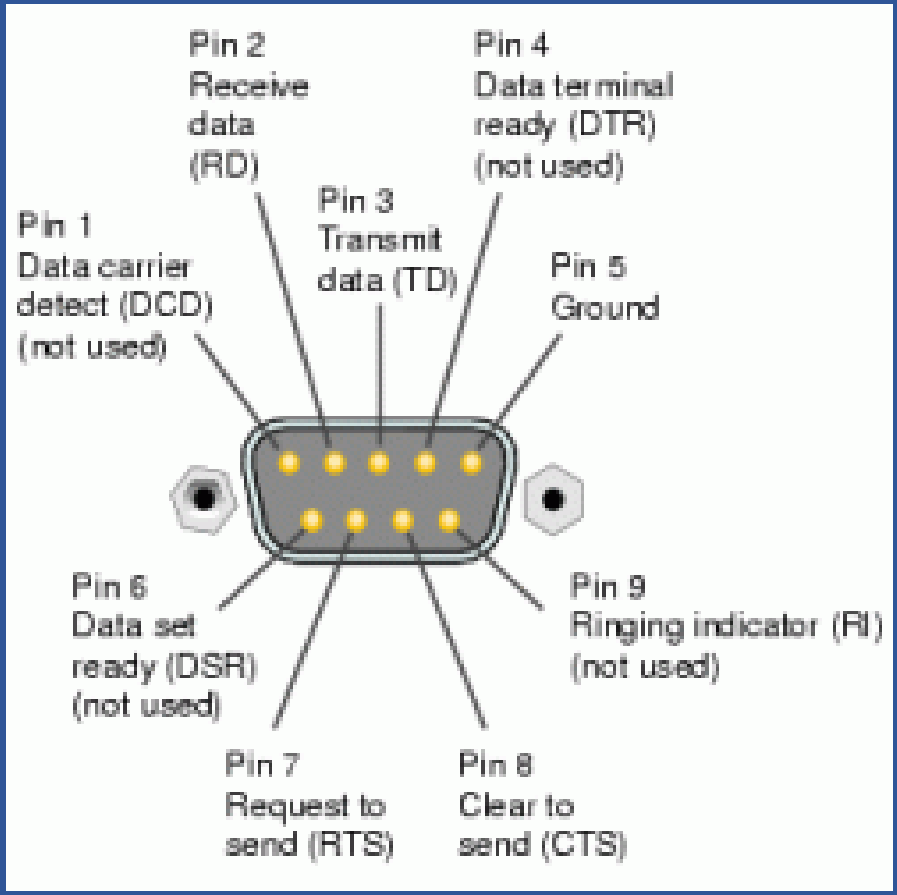
Minimum Connections (RS232)







Pin 1	CD	（Carrier Detect）
Pin 2	RXD	（Receive）
Pin 3	TXD	（Transmit）
Pin 4	DTR	Data Terminal Ready）
Pin 5	GND	（Ground）
Pin 6	DSR	（Data Set Ready）
Pin 7	RTS	Request To Send）
Pin 8	CTS	（Clear to Send）
Pin 9	RI	（Ring Indicator）



Pin details in RS232 DB9 set up

1) Pin no. 1 = CD = (Data) Carrier Detect = Used for Modem to Modem communication.

2) Pin no. 2 = RXD = Receive Data = Data is received at this pin.

3) Pin no. 3 = TXD = Transmit Data = Data is transmitted from this pin.

4) Pin no. 4 = DTR = Data Terminal Ready = Pin goes high to indicate terminal is ready for transmission.

5) Pin no. 5 = GND = Ground Reference Terminal = System Ground.

6) Pin no. 6 = DSR = Data Set Ready = Pin goes high to indicate Terminal is ready for reception.

Steps followed in RS232 communication

7) Pin no. 7 = RTS = Request To Send = Pin goes high to request actual sending of the Data (by the Transmitter)

8) Pin no. 8 = CTS = Clear To Send = Pin goes low to indicate permission to send the Data. (by the Receiver)
Also, understands a low frequency of Data and alerts Data Terminal but continues the transmission.

9) Pin no. 9 = RI = Ring Indicator = Sends a signal to DTE if there is an external call ringing from outside.

Steps followed in RS232 communication

- Data is generated by the sender and put in a buffer.
- If there is no receiver, sender will not send.
- This is ensured by DTR (Data terminal ready) and DSR (Data set ready). Receiver sets a proper voltage at its terminals to ensure this.
- To ensure the correct Baud rate, RTS (Ready to send) and CTS (Clear to send). Receiver sets a proper voltage to ensure this.
- It operates in full duplex mode as there are separate lines for Tx and Rx.
- But can be converted to half duplex mode if required.

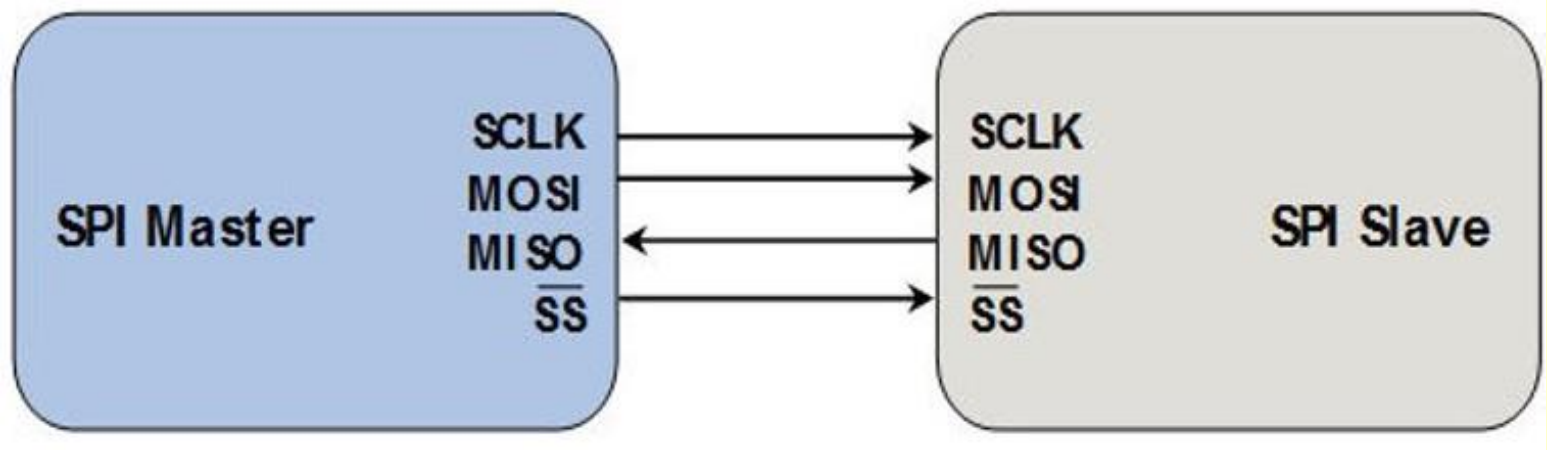
Serial Peripheral Interface (SPI)

• The Serial Peripheral Protocol (SPI) was first introduced with the first microcontroller deriving from the same architecture as the popular Motorola 68000 microprocessor, announced in 1979.

- Full duplex – serial communication interface.
- Developed by Motorola in 68000 MuP in 1976-79.
- Synchronous type.
- Single Master – Multi Slave protocol.
- Four wires used.
- For short distances.
- First Bit travel is programmable.

SPI :-

• A master is the microcontroller, and the slave can be an ADC, DAC, LCD, Card reader or a sensor like Temperature sensor, or another MuC etc.



Four conductors are …..

1) Data receiving and 2) Data sending – MOSI and MISO

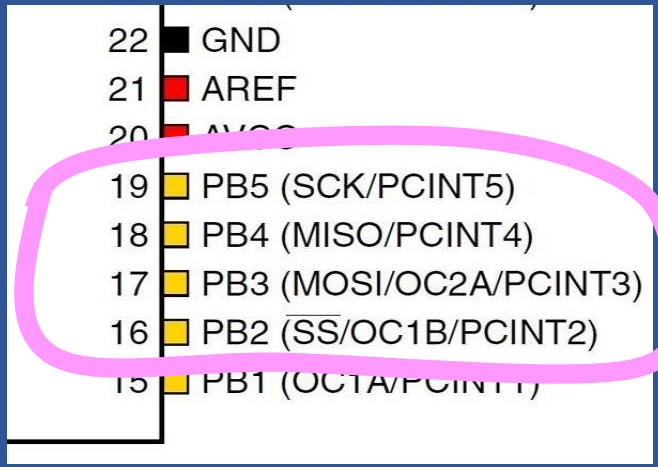
3) SCLK / SCK – Serial Clock signal – for Synchronization

4) SS – Slave Select (active low)

SPI Communication in ATmega328 :-

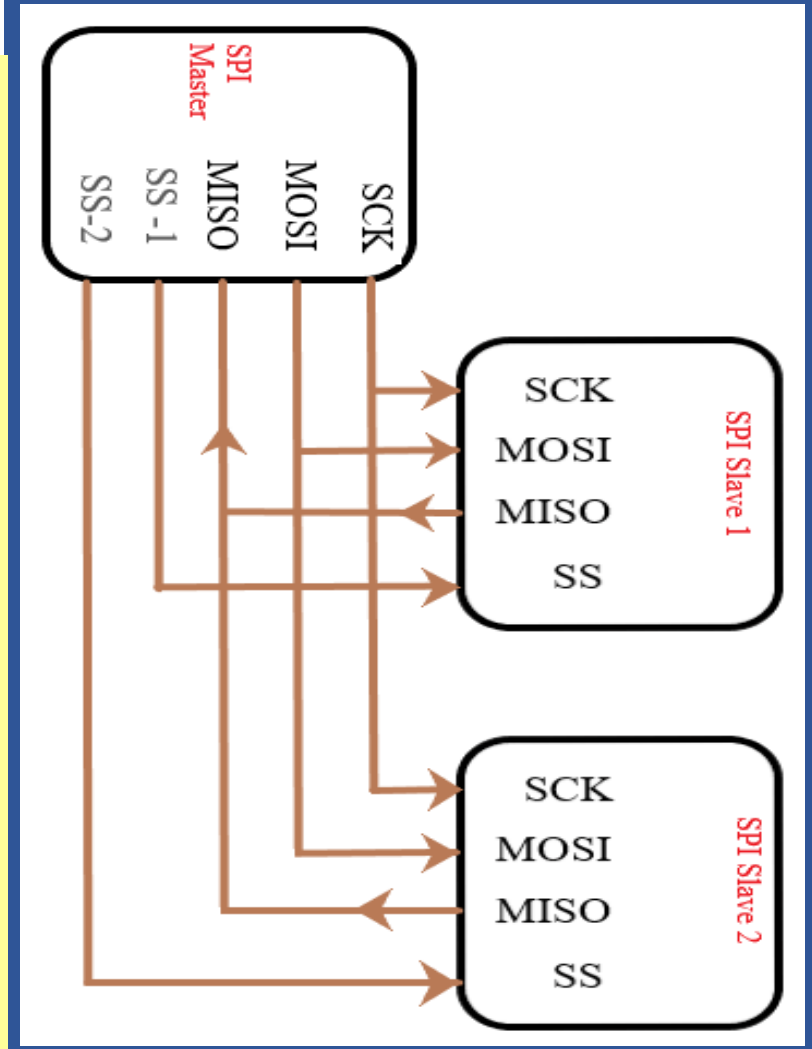
- ATmega328p has an inbuilt SPI module.
- It can act as a master or a slave SPI device.

(pin 16 to 19 – Port B – PB2 to PB5)



- MOSI (Master Out & Slave In) - The Master transmits data and the slave receives data through this pin.
- MISO (Master In & Slave Out) - The Master receives data and the slave transmits data through this pin.
- SCK (Serial Clock) - The Master generates this clock for the communication, which is used by the slave. Serial clock is initiated by the Master only.
- $\overline{SS}$ (Slave Select) - Master can select slaves using this pin. Default high pin. SS is made low to select slave. Active Low pin.

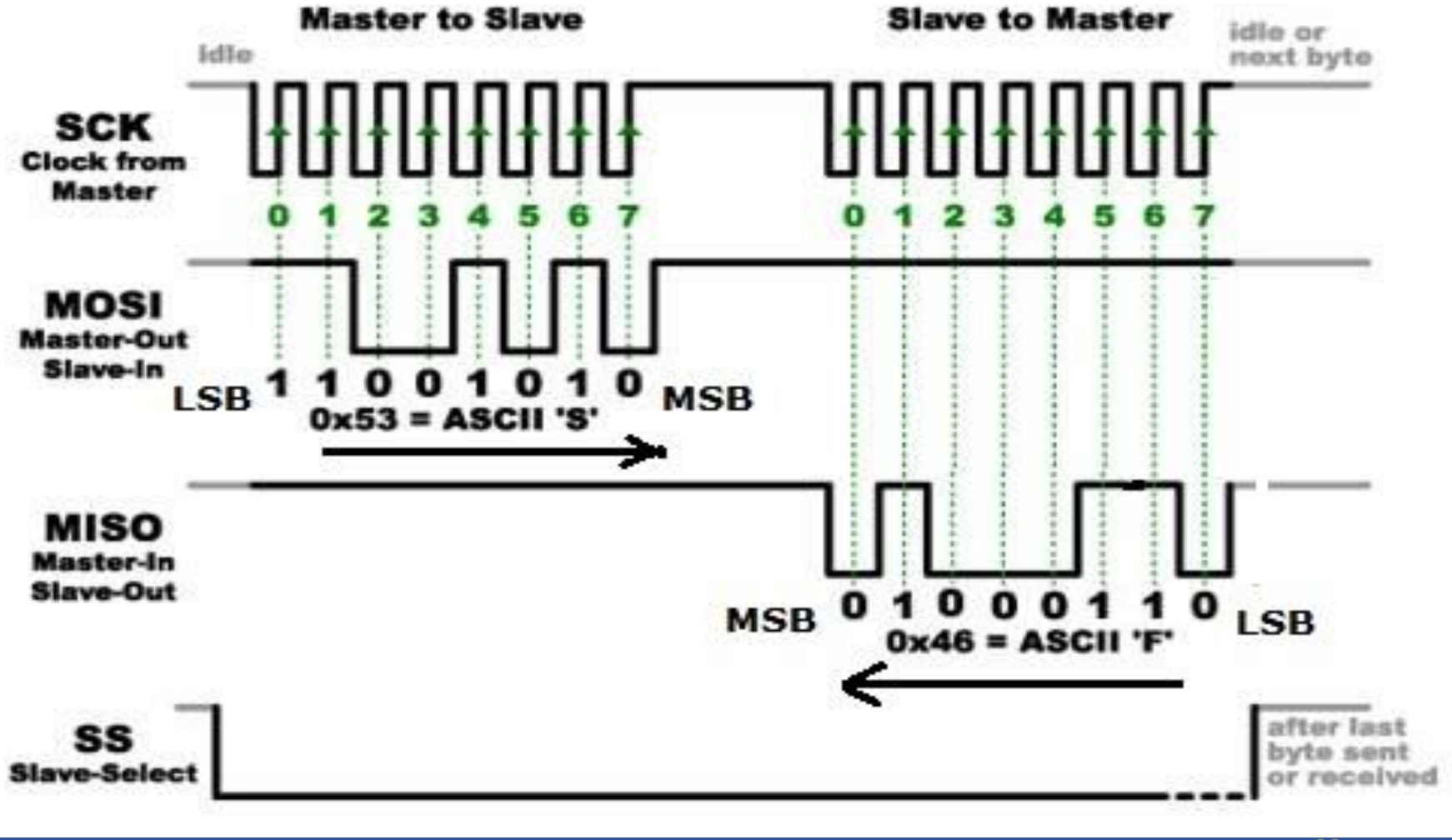
SPI :-



Operations details – steps followed

1) Activates the clock signal at a clock frequency.
2) Selects the Slave by pulling the corresponding SS line low.
3) The master transmits information onto MOSI line.
4) The master receives signal on the MISO line.

Timing diagram :-



SPI :-

There are 4 modes of operation in SPI.

1) Mode 0 – SCK = Low and sampling on immediate (Rising edge)
2) Mode 1 – SCK = Low and sampling after 180^0 (Falling edge)
3) Mode 2 – SCK = High and sampling on immediate (Falling edge)
4) Mode 3 – SCK = High and sampling after 180^0 (Rising edge)

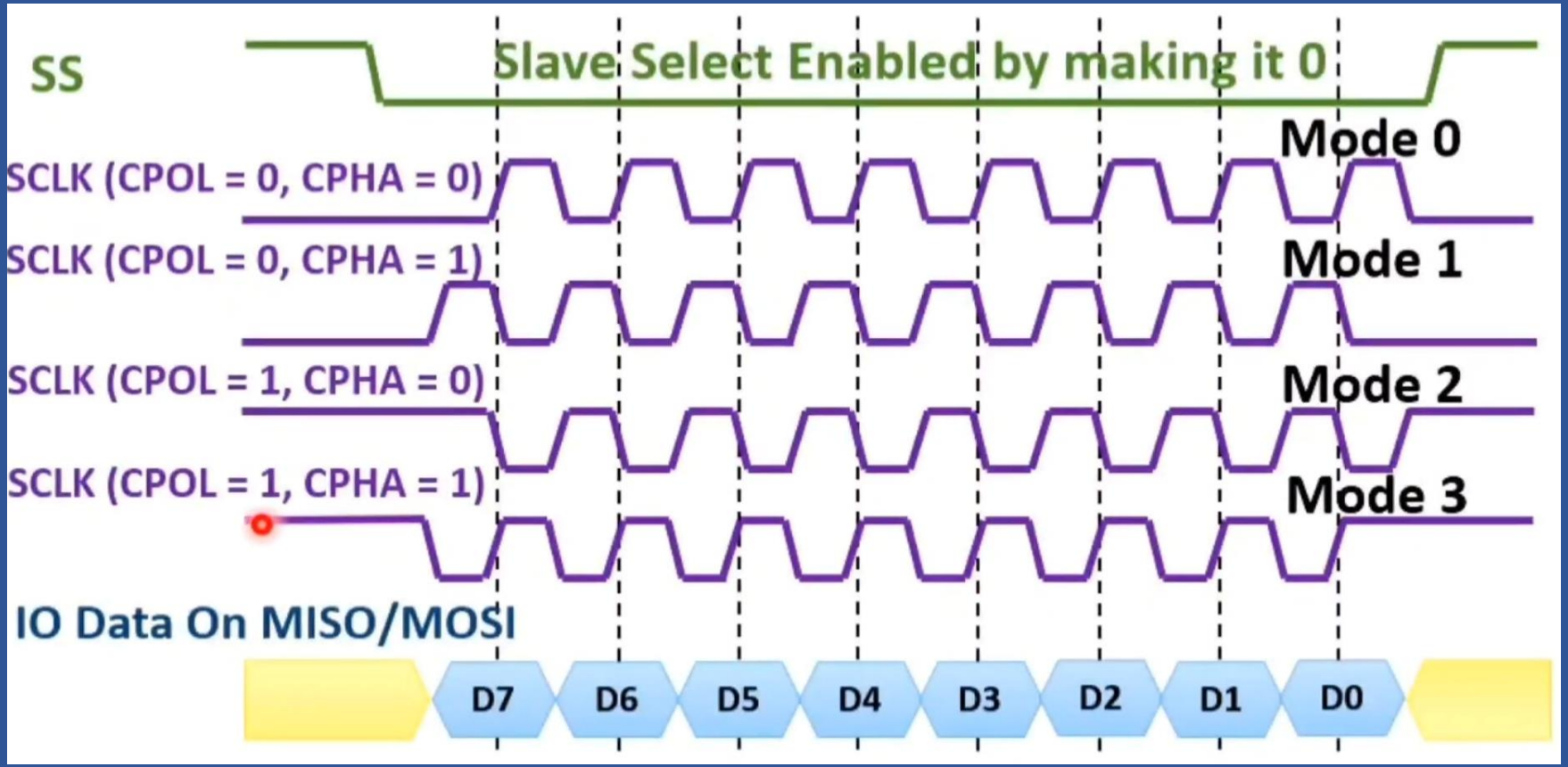
→ Data must be available before rising or falling edge

Clock Polarity (CPOL) = Start of clock signal.

Initially Low = 0 and Initially High = 1

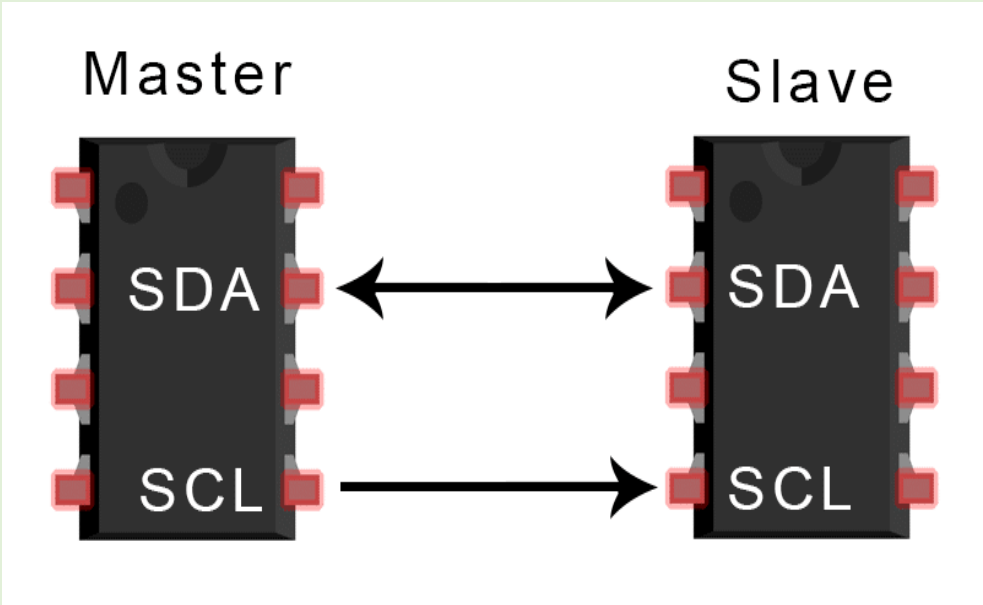
Clock Phase (CPHA) = Sampling on immediate (0) or after 180^0 (1)

SPI :-


SS
Slave Select Enabled by making it 0
SCLK (CPOL = 0, CPHA = 0)
Mode 0
SCLK (CPOL = 0, CPHA = 1)
Mode 1
SCLK (CPOL = 1, CPHA = 0)
Mode 2
SCLK (CPOL = 1, CPHA = 1)
Mode 3
IO Data On MISO/MOSI
D7
D6
D5
D4
D3
D2
D1
D0

Inter-Integrated Circuit (IIC = I2C)

- **The I2C bus was developed in the early 1980's by Philips Semiconductors.**
- **Its original purpose was to provide an easy way to connect CPU to multiple chips in a TV set using just 2 wires.**



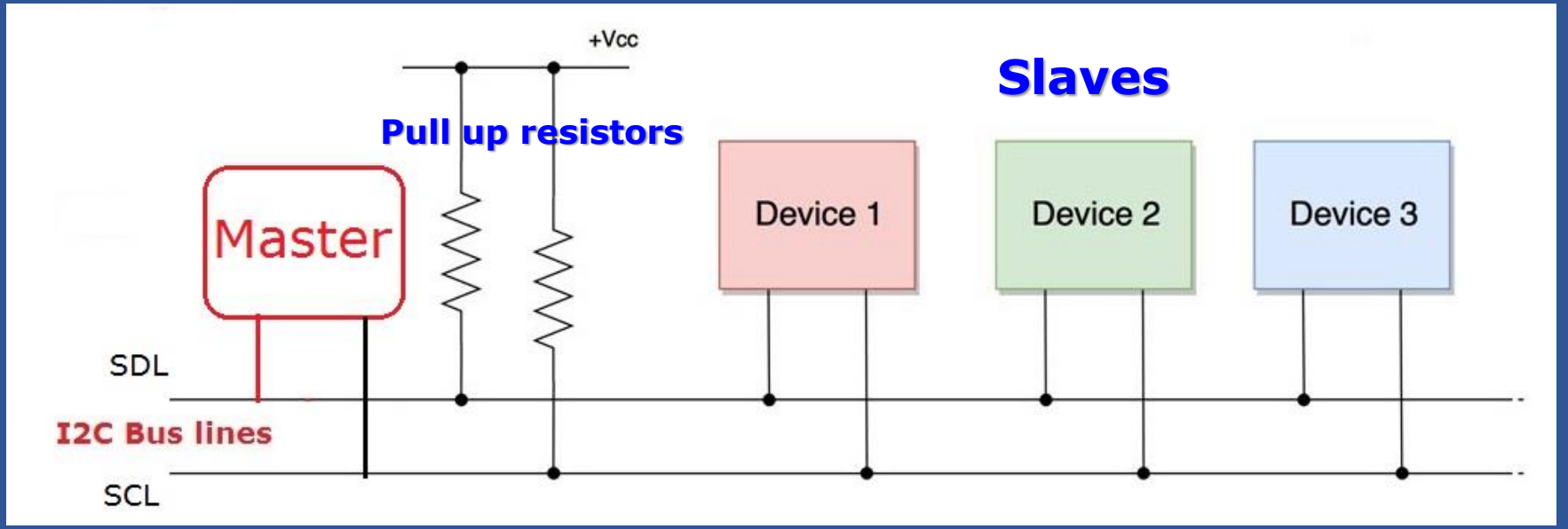
Features of I2C :-

- I2C is a **synchronous** serial communication protocol.
- Only 2 wires are required. But it is a **Half Duplex** system.
- Reference clock is required.
- Data is transferred bit by bit.
- I2C is a **Multi Masters – Multi Slave** system.
- **But at a time only one Master and only one Slave is active.**
- Each slave is allotted a unique **7 bit address** like a password.

How many slaves can be there ?

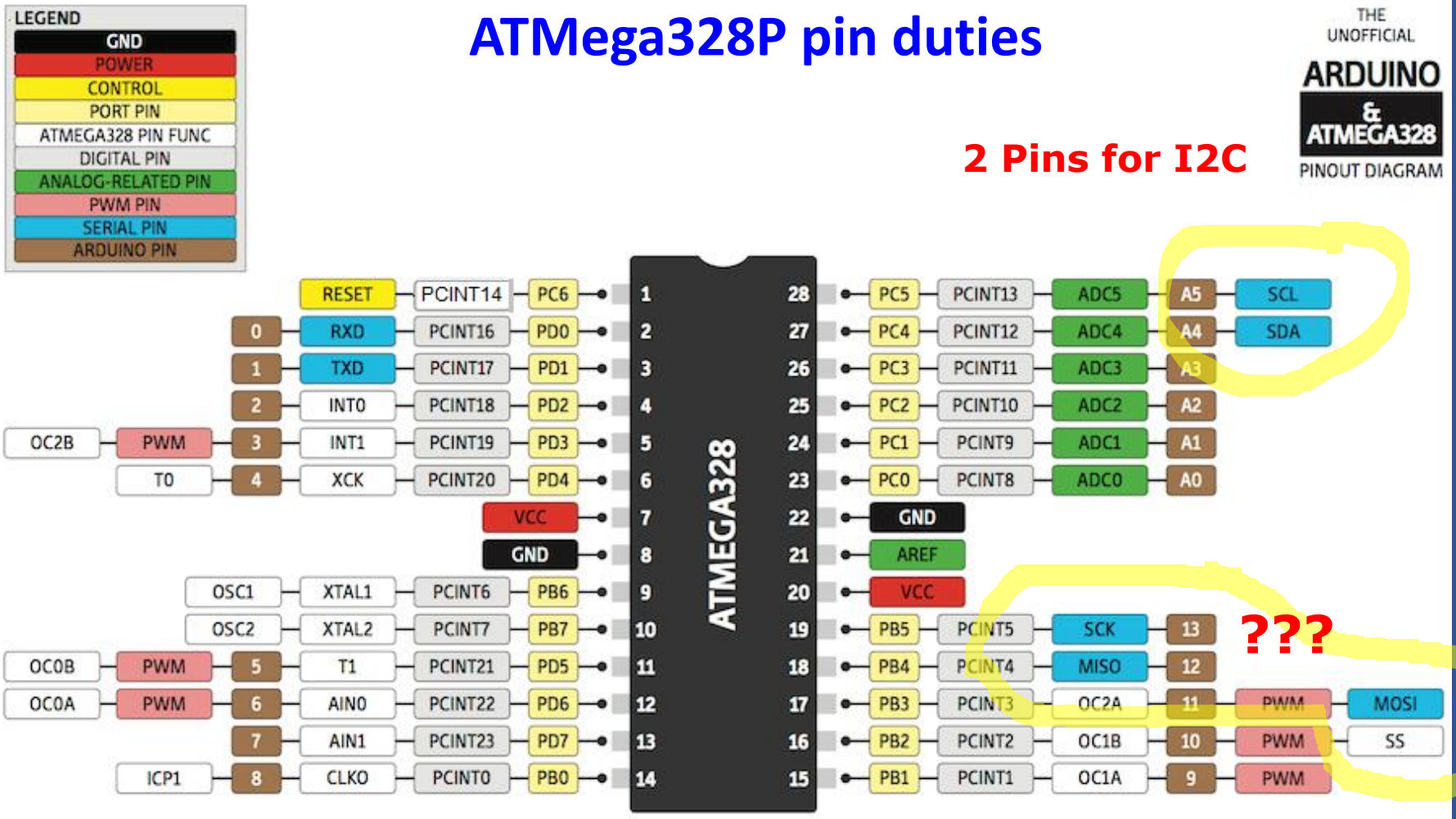
- Good system for upto 30-35 feet long distance.
- Data can be transferred at variable speed. This is called as clock stretching. Generally required by the slave.

Working of I2C :-



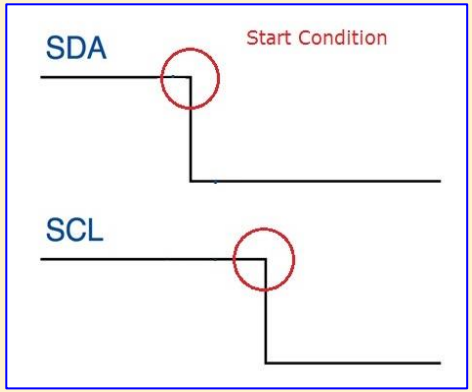
- Pin 27 and 28 on ATMega328P for SDA and SCL resply.

ATMega328P pin duties



Working of I2C :-

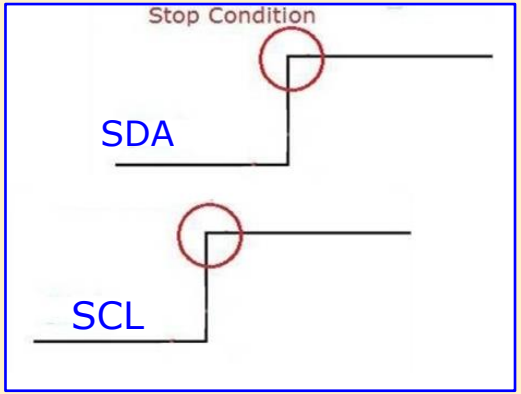
- The 2 wires used are = SDA (Serial Data Line) and SCL (Serial Clock Line).
- START :- Master sends a START bit = 0 i.e. SDA LOW from HIGH and after that SCL starts with LOW. (Both are HIGH before – pulled up)



- All slave devices get active and wait for the address bits.
- Master sends a 7 bit address to decide which slave should work.
- All slaves compare this address with their individual address.
- Thus only one slave is finalised.

Working of I2C :-

- R/W bit - Direction of data transfer is decided by direction bit.
- “0” for Master to Slave and “1” for Slave to Master. **Read = ? Write = ?**
- ACK /NACK bit is sent by slave :– Acknowledge or Not Acknowledge bit. If the address matches, this bit = “0” otherwise bit = “1”.
- Data Transfer :– 8 bits are sent by the Master to the slave.
- This is again followed by an ACK bit. If the data is received by the Receiver, ACK = “0”, else “1”.
- This process is repeated until all the data is sent.
- STOP :– Once the data transfer process is over,



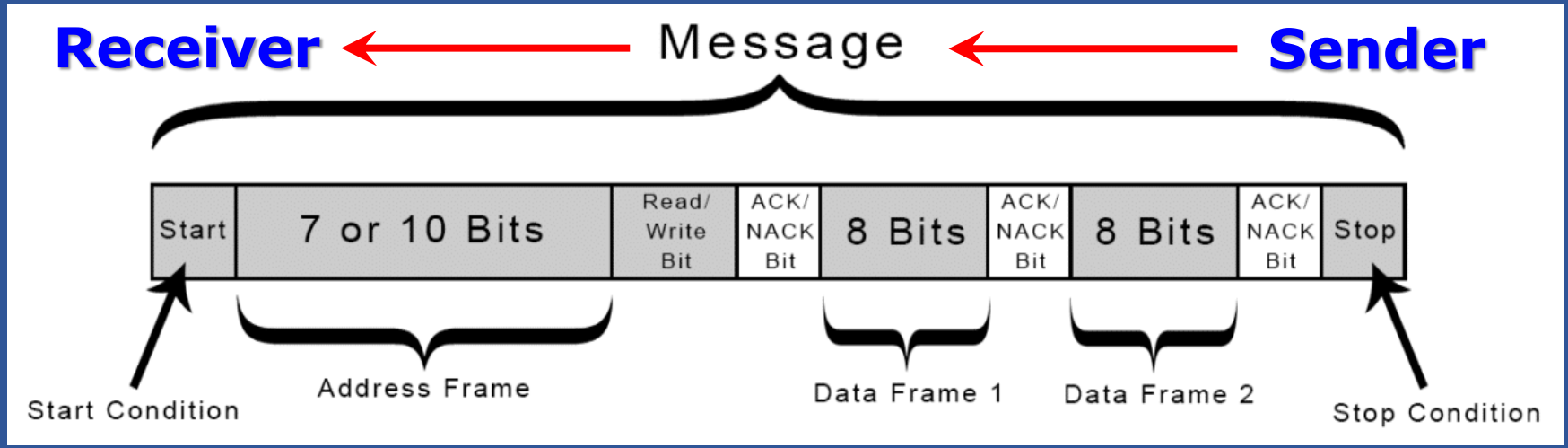
Master will send …. 1) STOP bit = 0

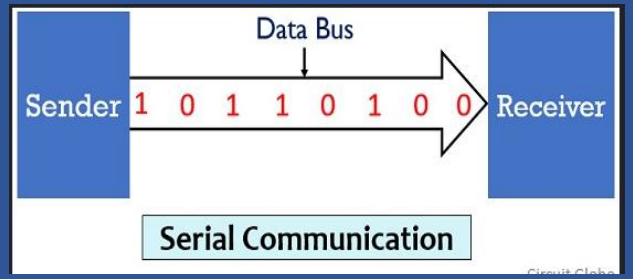
2) SCL = HIGH

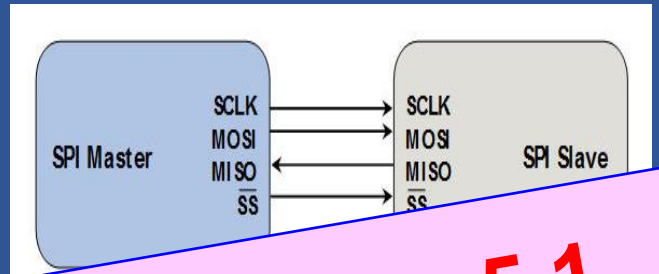
3) SDA = HIGH to end the process.

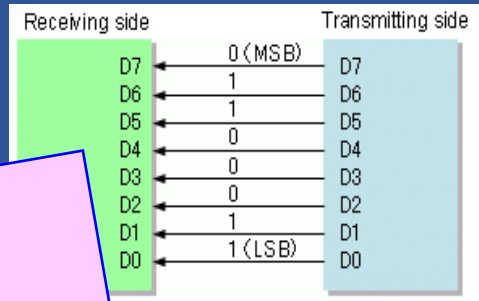
HOW I2C WORKS

- With I2C, data is transferred in number of Messages. Messages are broken up into frames of data.
- Each message has an address frame that contains the binary address of the slave, and one or more data frames that contain the data being transmitted.
- The message also includes start and stop conditions, read/write bits, and ACK/NACK bits between each data frame:









Communication – 5.1

SPI and I2C

Thanks !

FY – DESH – VIT

PWM – Pulse Width Modulation :-

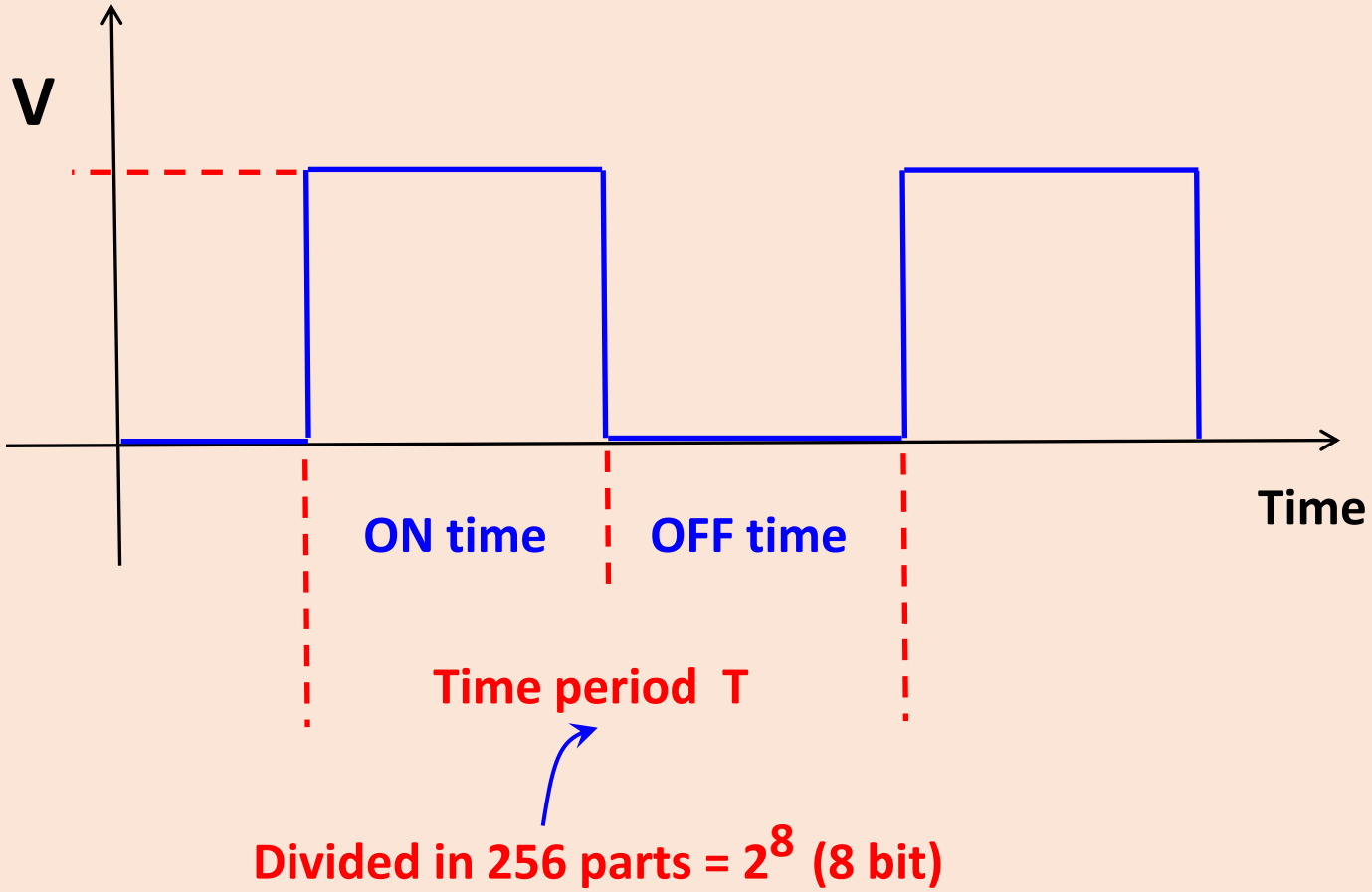
$$P = V \times I \ldots\ldots \text{Electrical (i/p)}$$

$$P = \text{Mechanical (o/p)} = ??? = T \times \omega$$

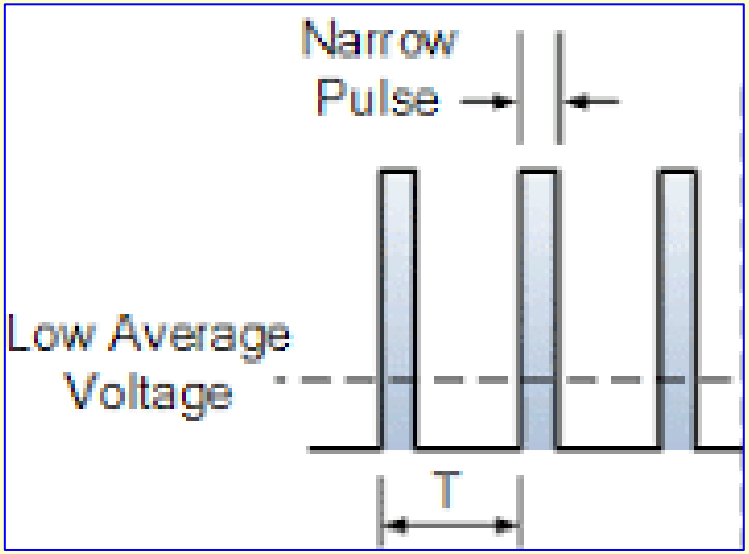
In PWM, average value of Voltage is controlled, and thus the Current as well !

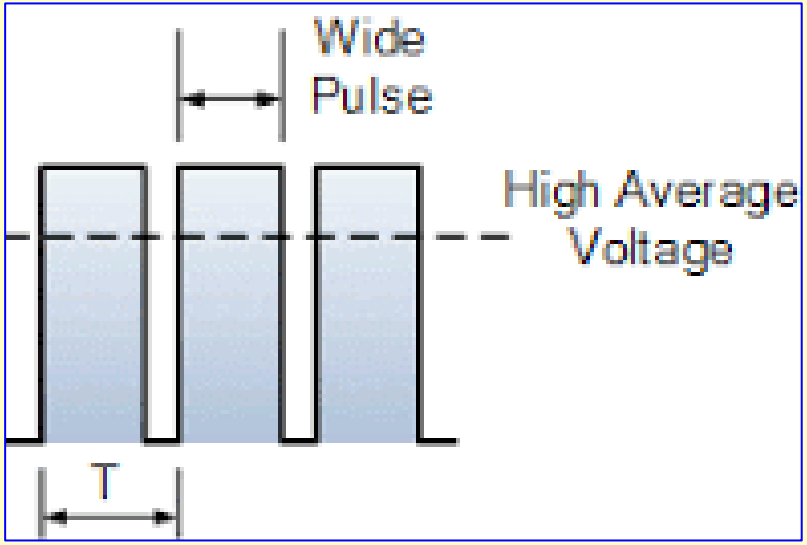
A very "Power"ful technique to Control the speed and torque of a motor.

PWM :- for speed control of motor

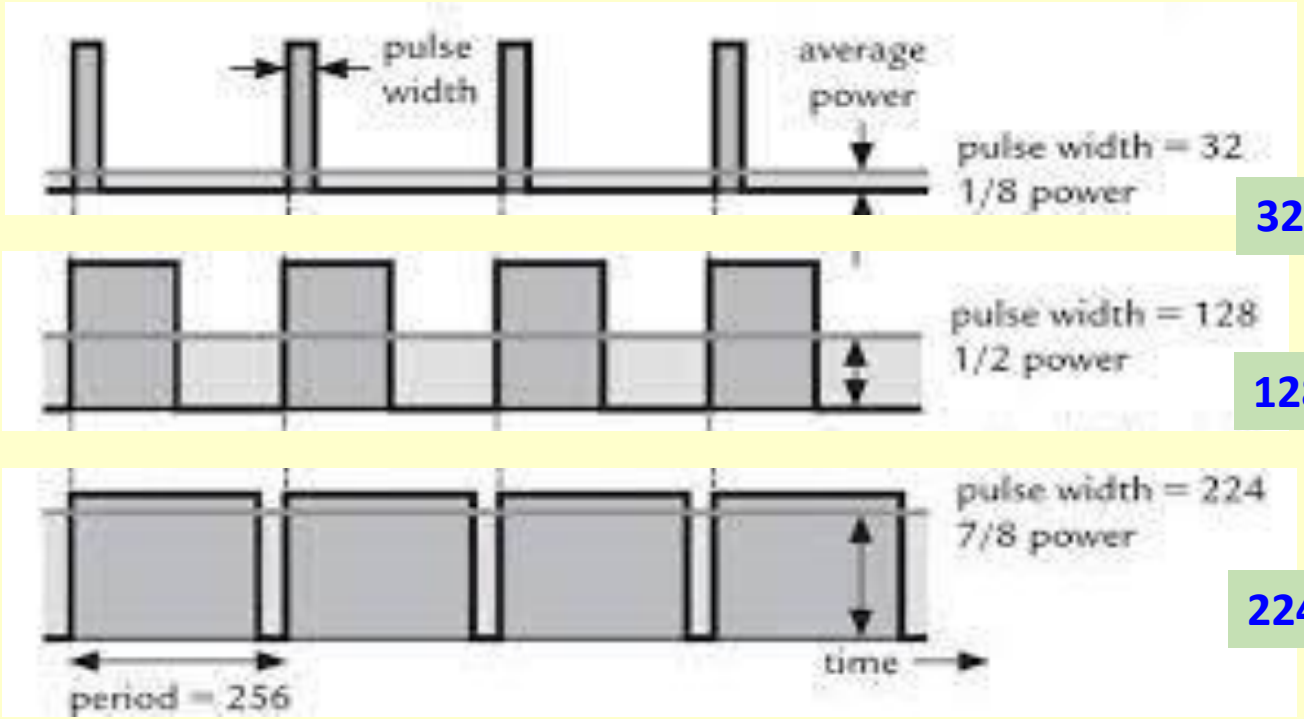


PWM – Pulse Width Modulation :-





PWM – Pulse Width Modulation :-



32/256 = 1/8 = 12.5%

128/256 = 1/2 = 50%

224/256 = 7/8 = 87.5%

How much can be maximum PWM % ? Why ?