Communication Protocols in Embedded Systems

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Serial Vs Parallel

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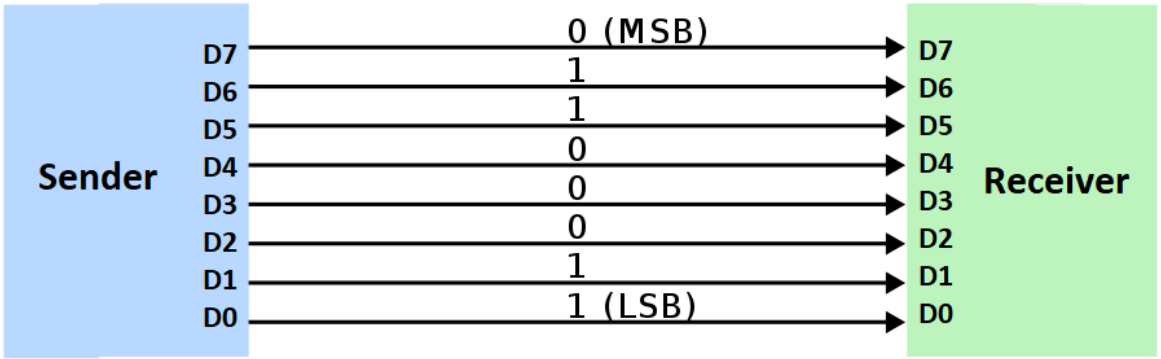

Figure: Parallel Communication

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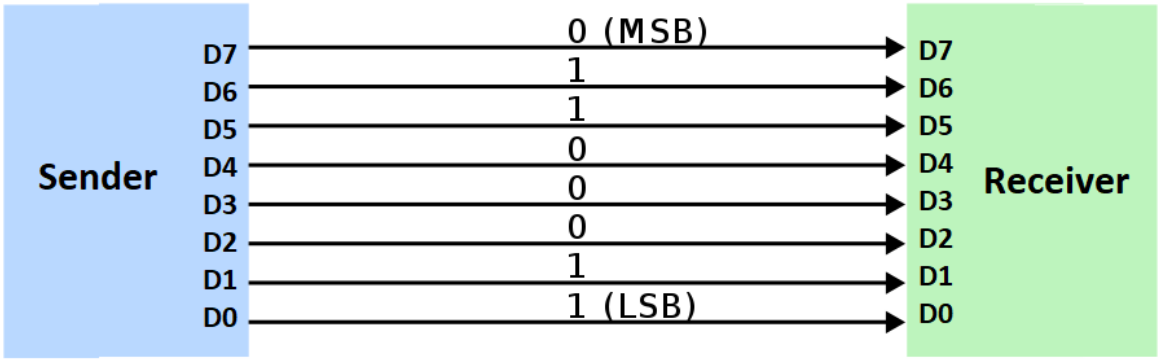

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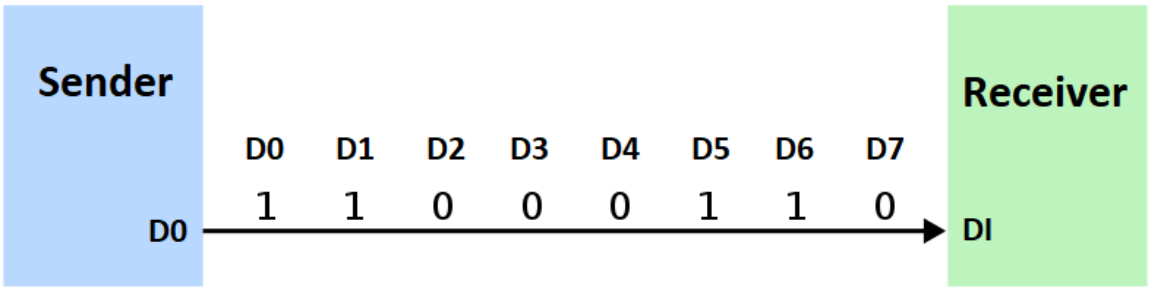

Figure: Serial Communication

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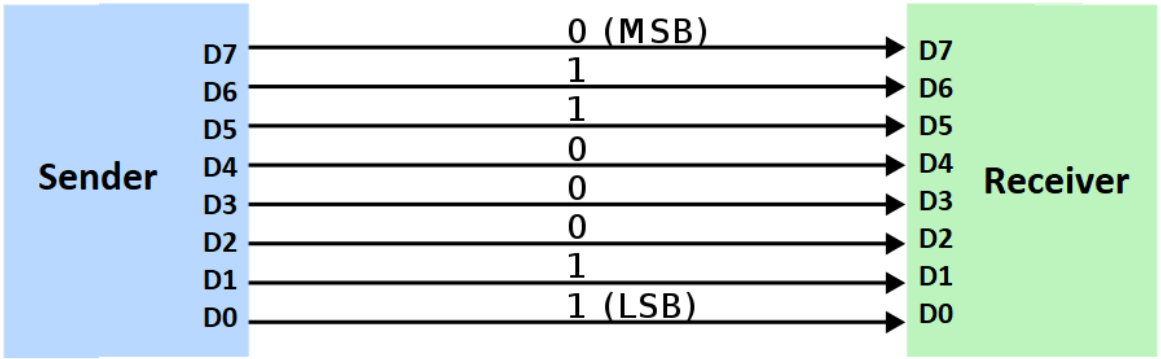

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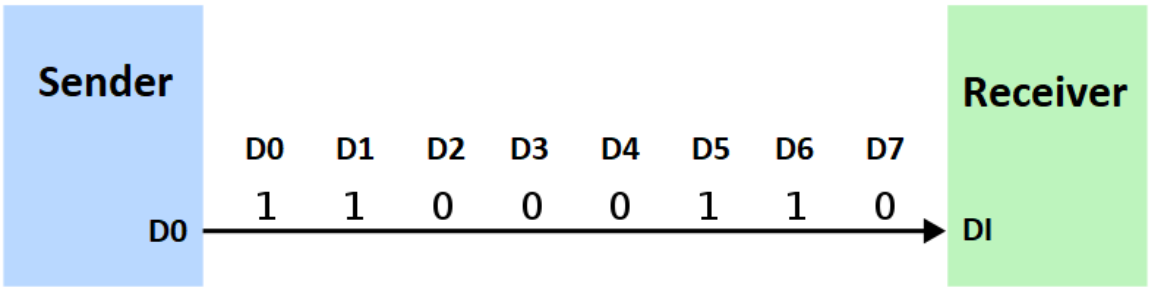

Figure: Serial Communication

One bit is sent at a time.

Simplex vs Duplex

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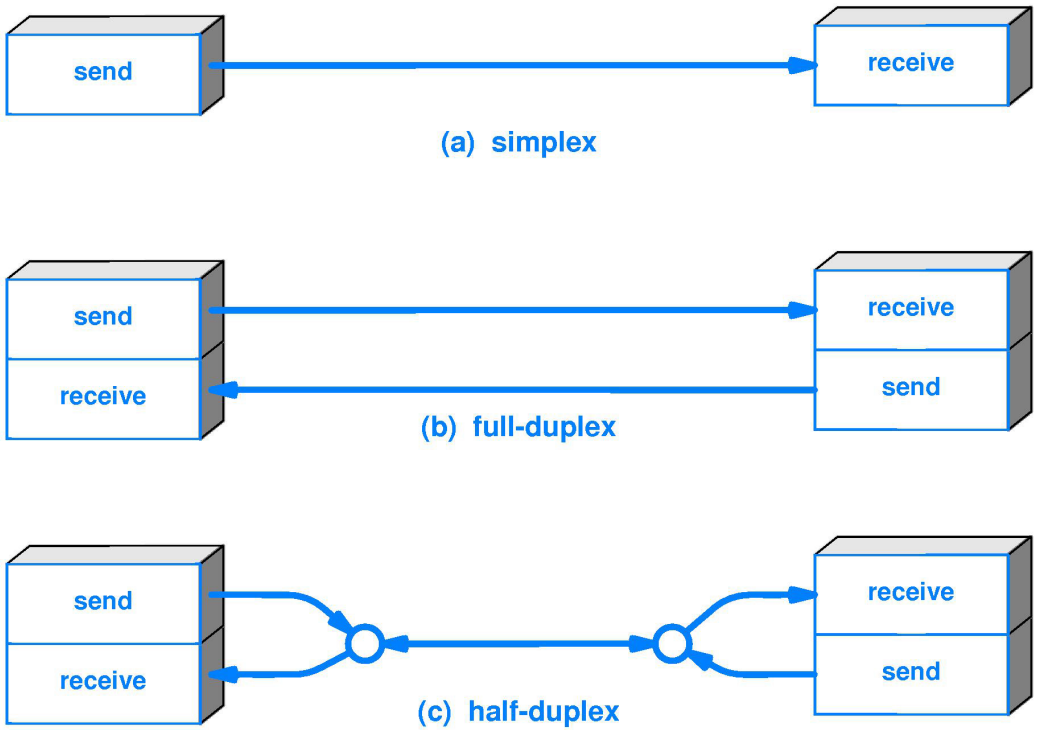

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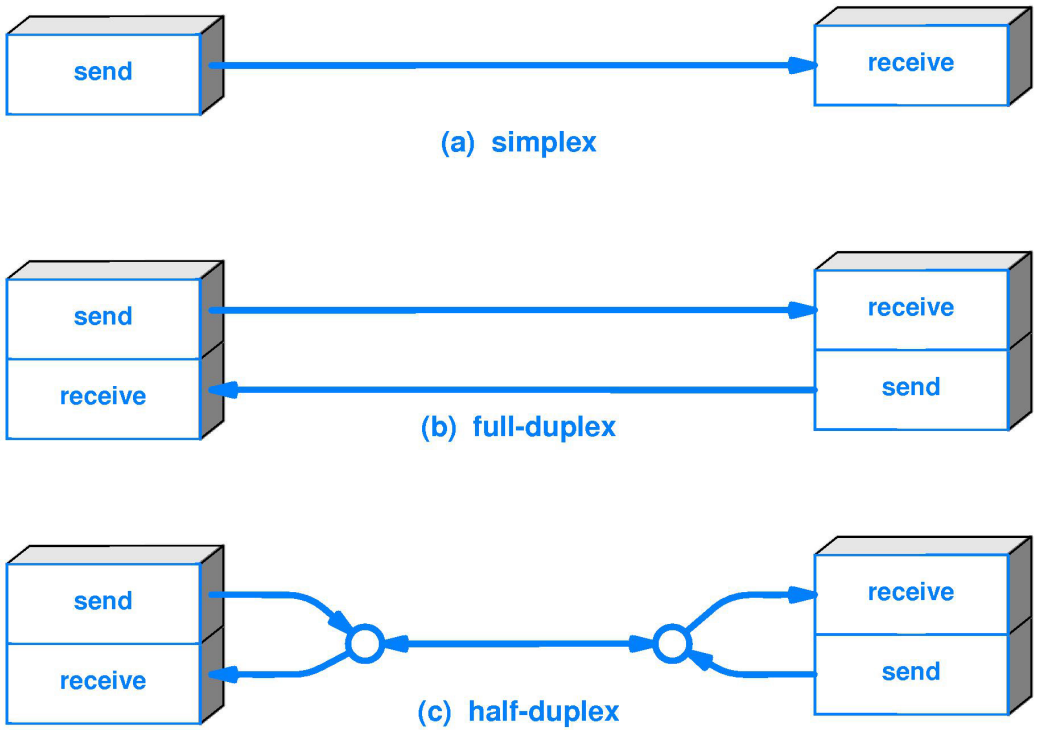

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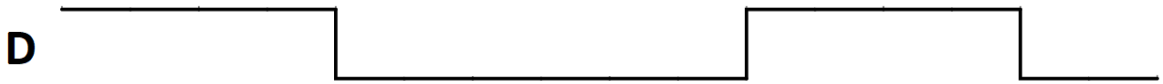

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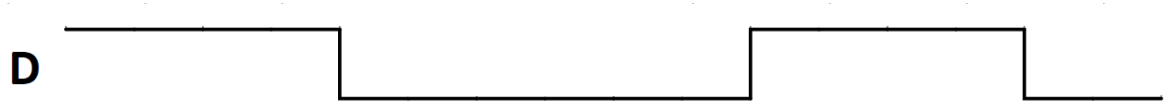

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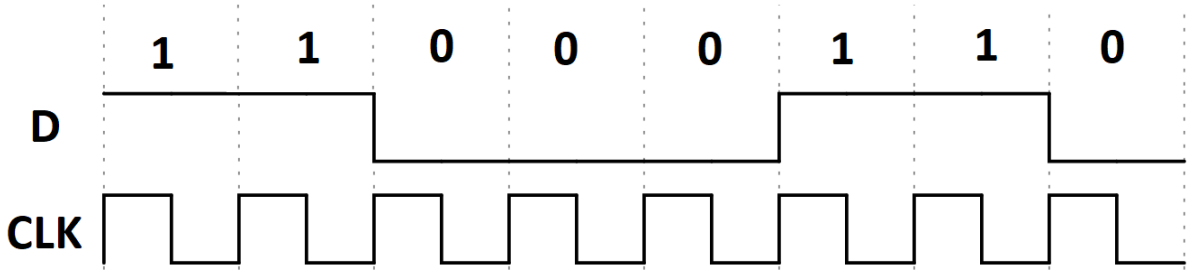

Figure: Data along with Clock

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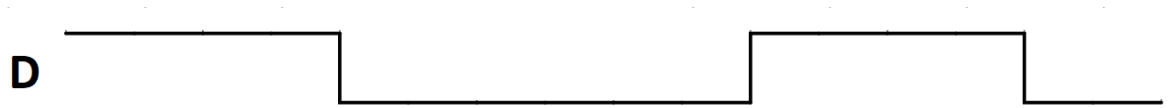

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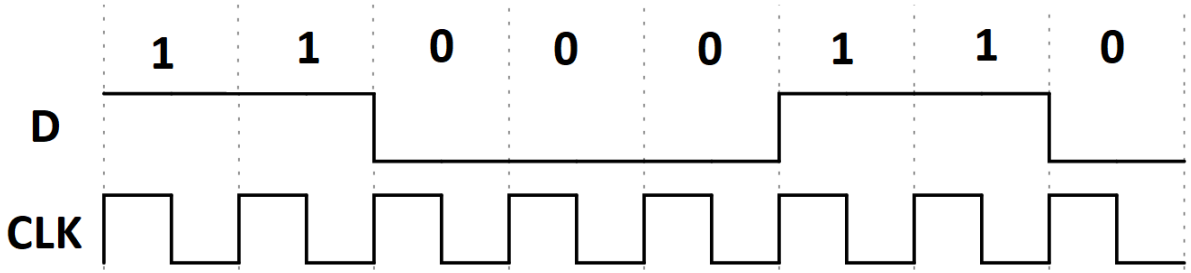

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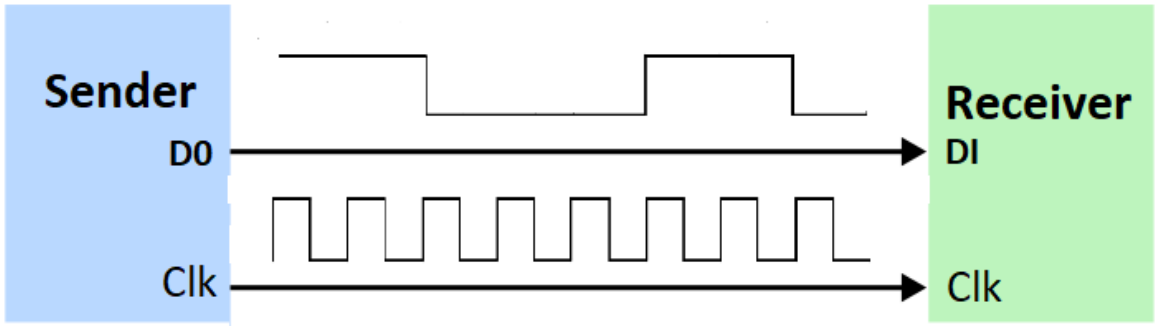

Figure: Communication between Two Devices

Synchronous v/s Asynchronous

Synchronous v/s Asynchronous

Parameters	**Synchronous**	**Asynchronous**
Clock signal	Required	Not required
Overhead bits	Not required	Required
Data transmission speed	Fast	Slow
Data Tx/Rx	Blocks or frames	Bytes or character

Different types of communication available in Embedded System

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- SPI (Serial Peripheral Interface)

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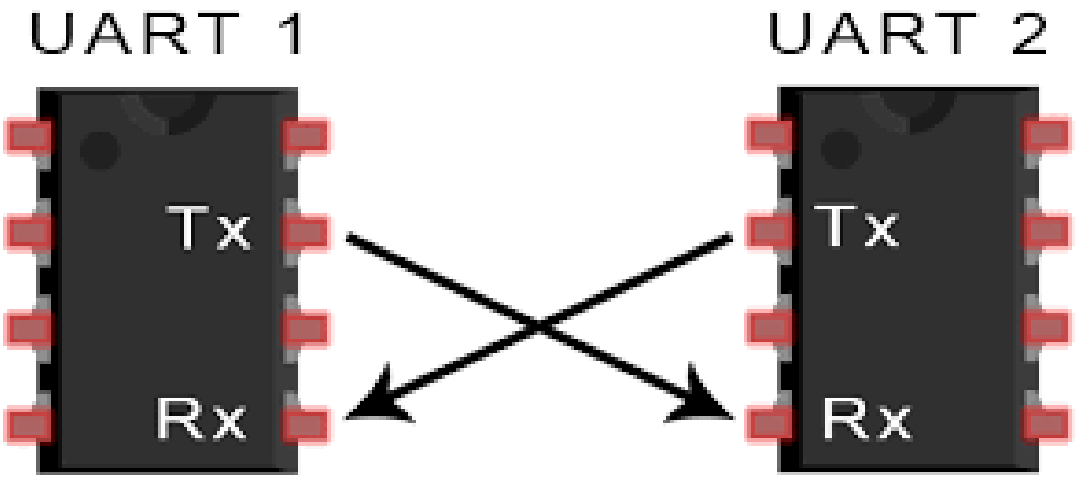
UART (Universal Asynchronous Receiver Transmitter)



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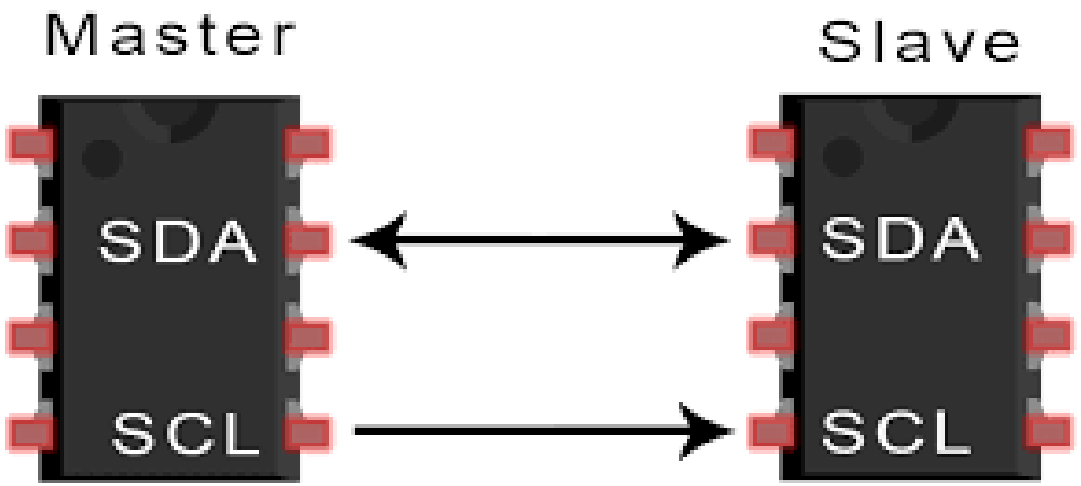

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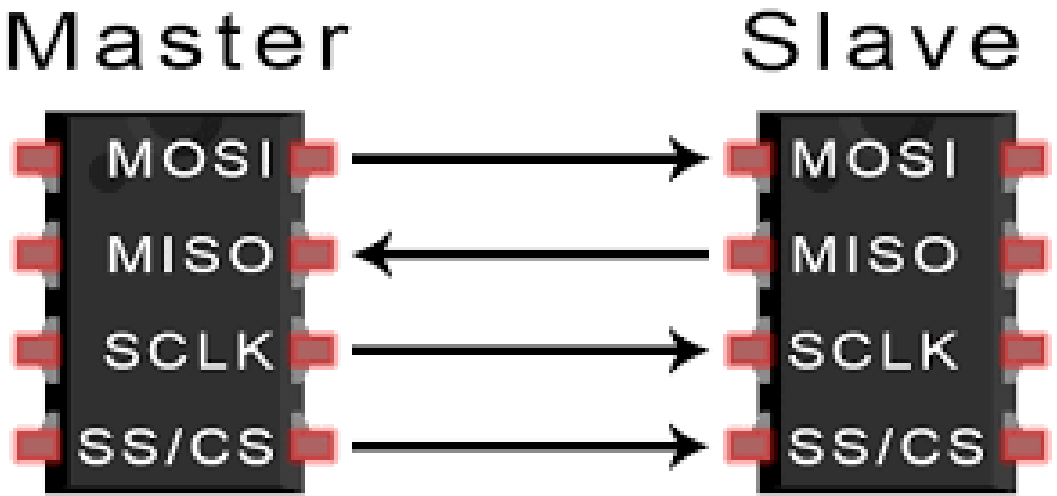

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- UART requires two lines for communication
  1. Transmit - TX
  2. Receive - RX

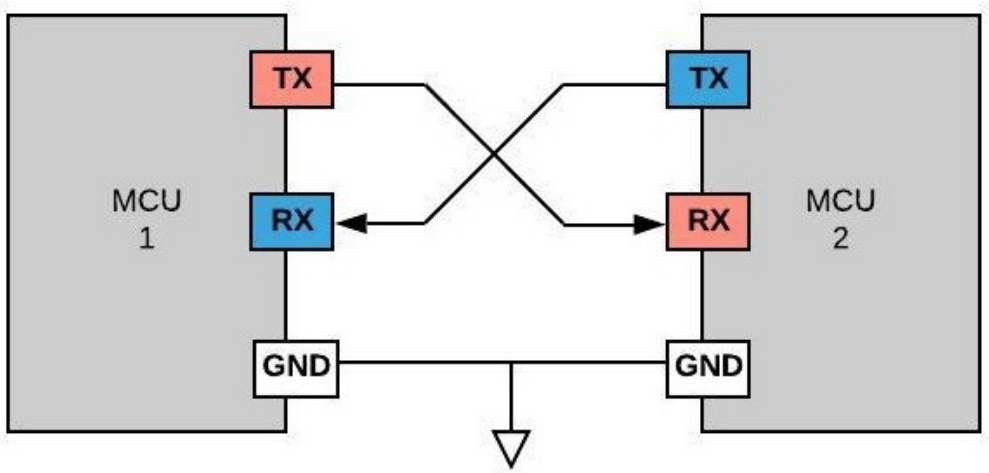

Figure: UART connection between two MCUs

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  1. Data Packet
     - Synchronization Bits
     - Data Bits
     - Parity Bits
  2. Baud Rate

Data Packet

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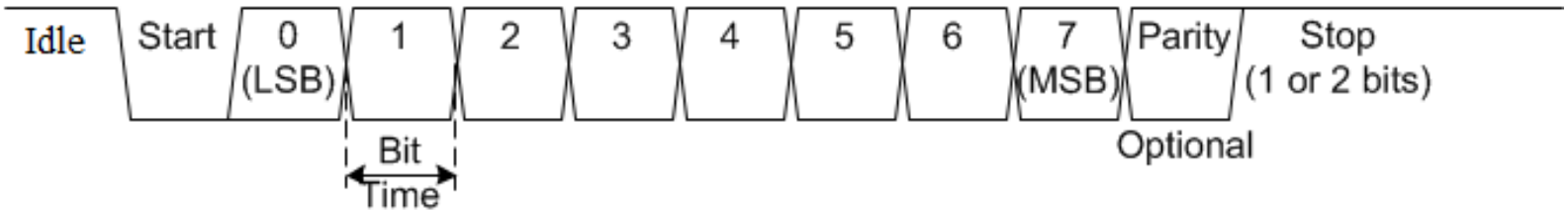
- It is a packet of Synchronization and Parity bits appended to Data bits.



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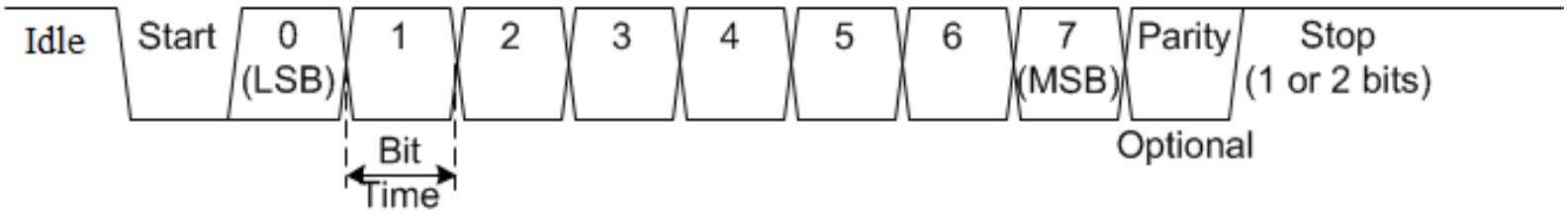

Figure: UART Data Packet

1. **Synchronization Bits**

   Overhead bits are added for each data packet:
   - Start (1 bit) - transition on idle data line from 1 to 0.
   - Stop (1-2 bit/s) - transition back to idle state, holding the line at 1.

Data Packet

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2 Data Bits

- Number of Data bits can vary from 5 to 9, the standard data size is 8-bits.
- Data can be sent as Big Endian (MSB first) or as Little Endian (LSB first) and both communicating devices need to agree on the same endianness.
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3 Parity Bits

- Low-level and simple form of error checking.
- It can be odd or even.
- For example, consider Data byte = **0b10101011**
  If Parity mode = **Even**, then Parity bit = **1**.
  Similarly, if Parity mode = **Odd**, then Parity bit = **0**.

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- These baud rates are achieved in microcontroller by dividing the clock frequency.

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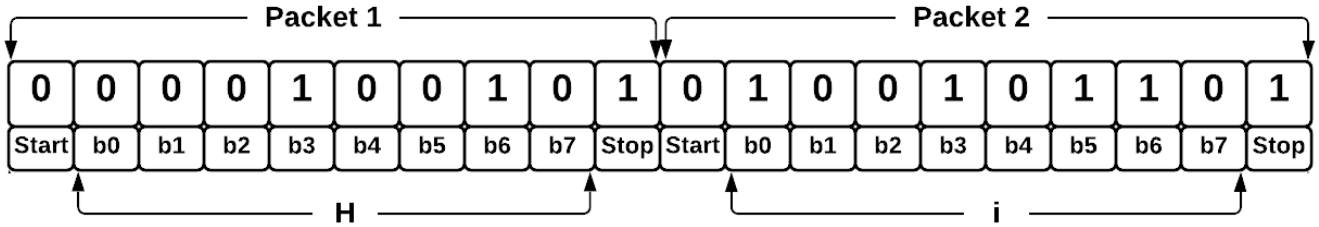

Figure: Data Frame format with two packets

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- Can be multi-master.
- Ensures transmission by acknowledgment.

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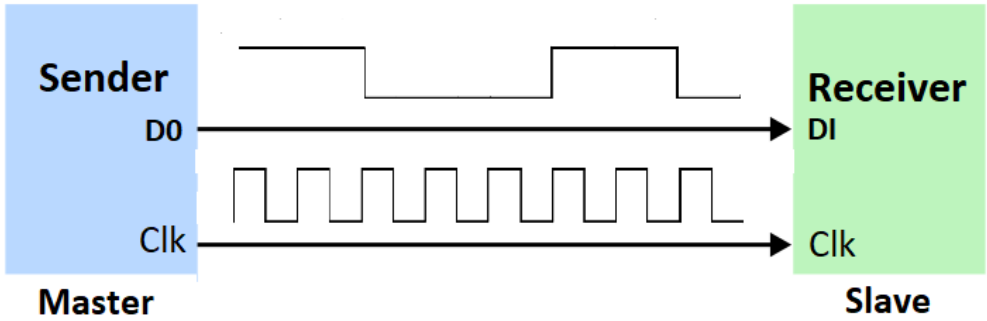

Figure: Master Transmitter Slave Receiver

Master-Slave configuration:

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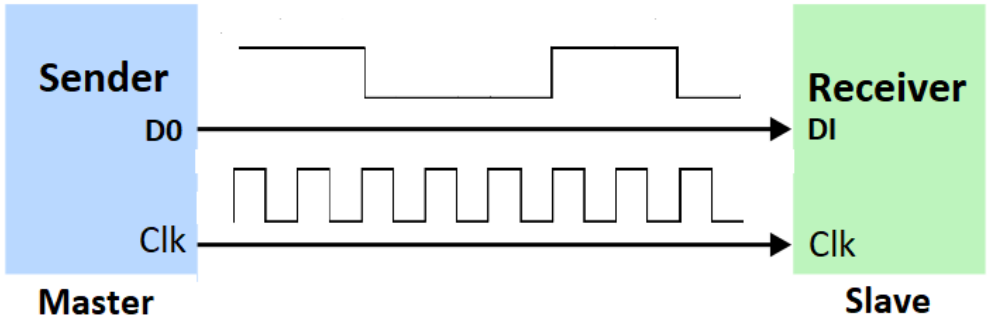

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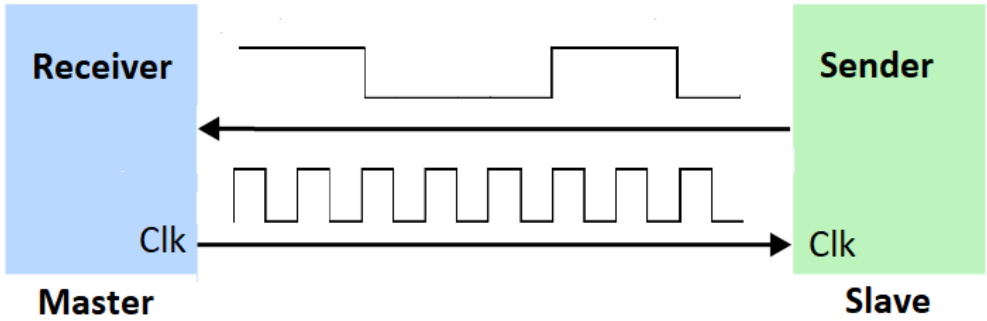

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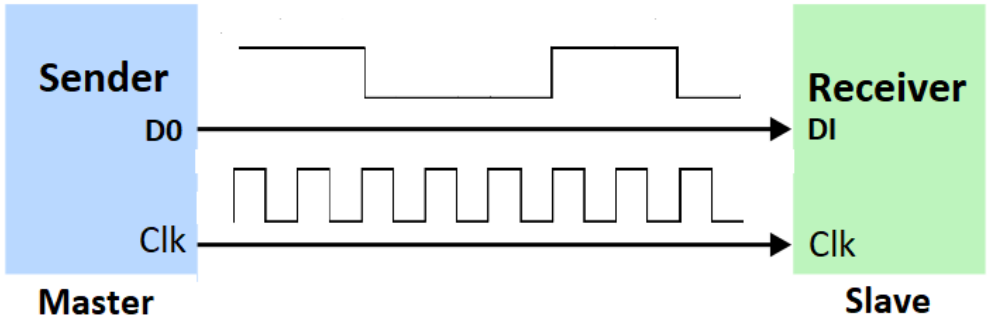

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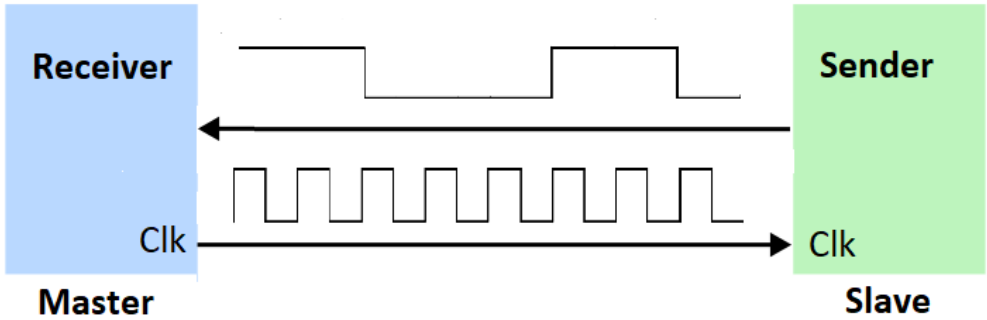

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I2C is a Half-Duplex communication.

Multi-master and multi-slave

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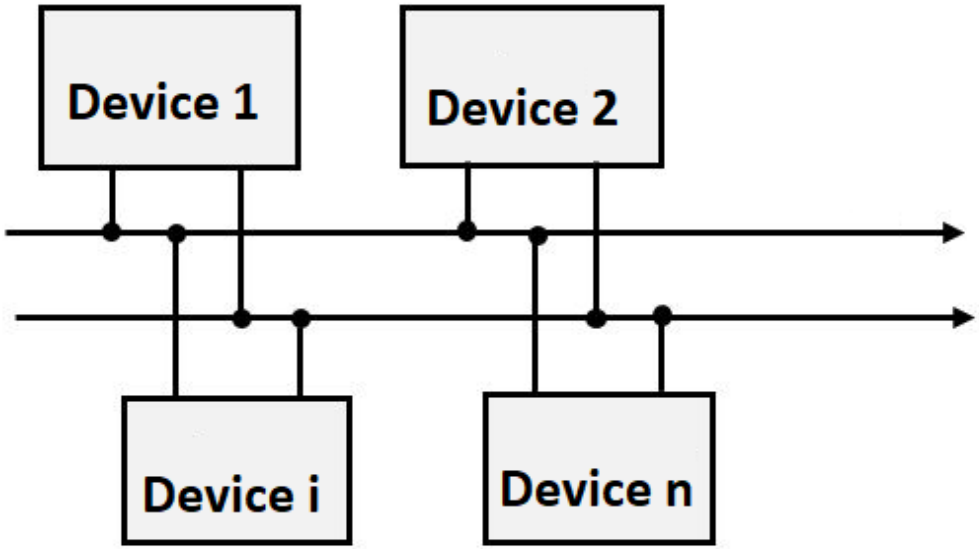

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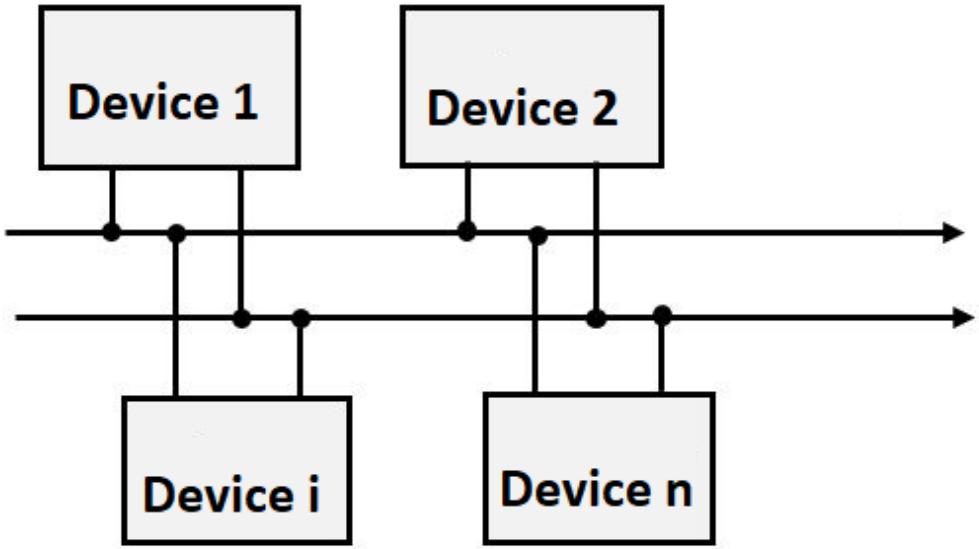

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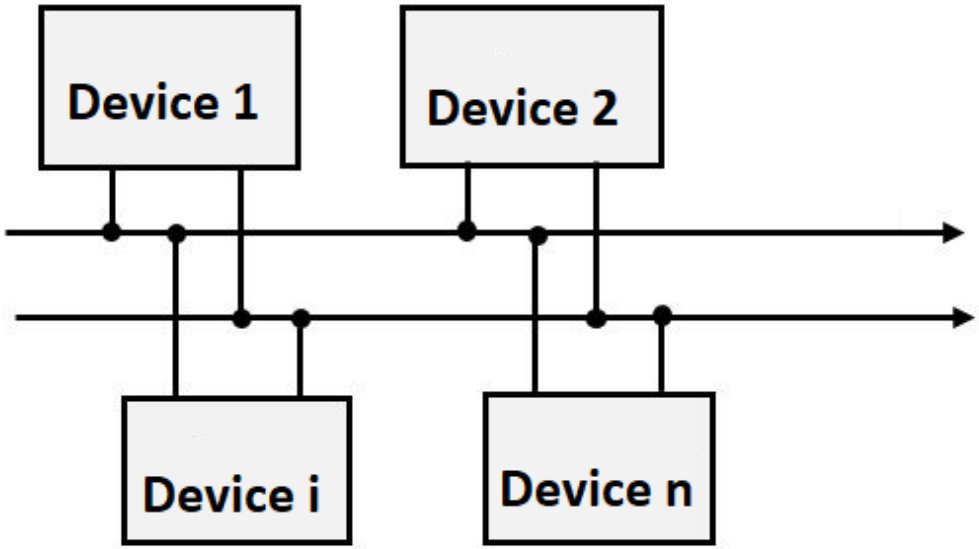

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Hence n can be maximum 128
At a time only one device will act as a master

Multi-master and multi-slave

We can connect upto 128 devices on I2C bus.

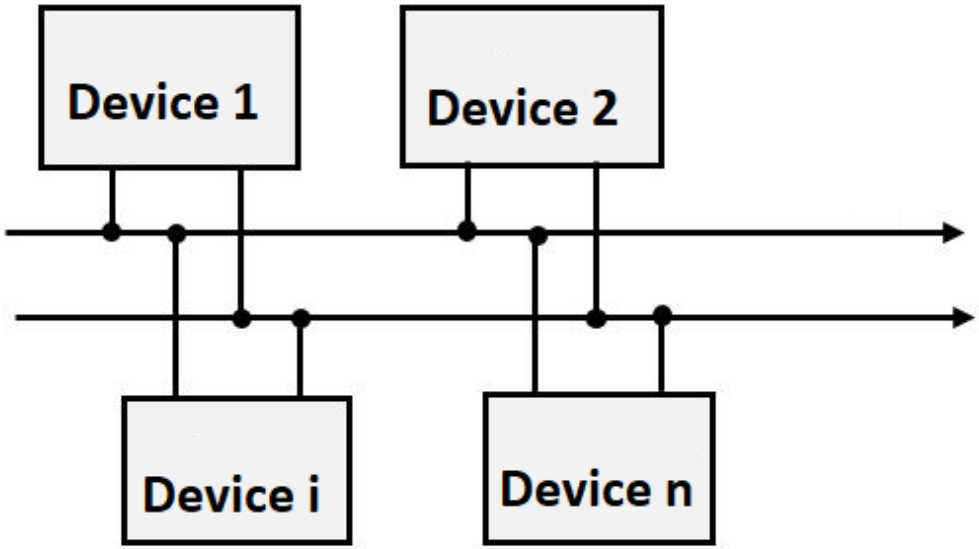

Figure: I2C Communication

Hence n can be maximum 128
At a time only one device will act as a master
Each device in I2C is addressed by its unique address

Connection Diagram:

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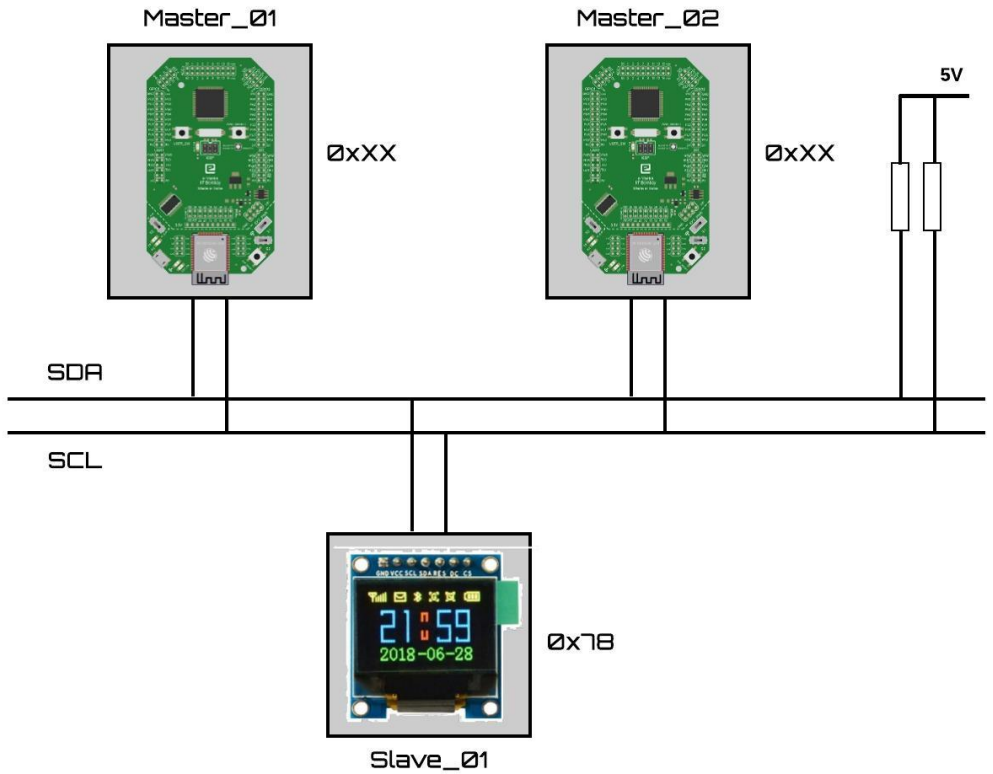
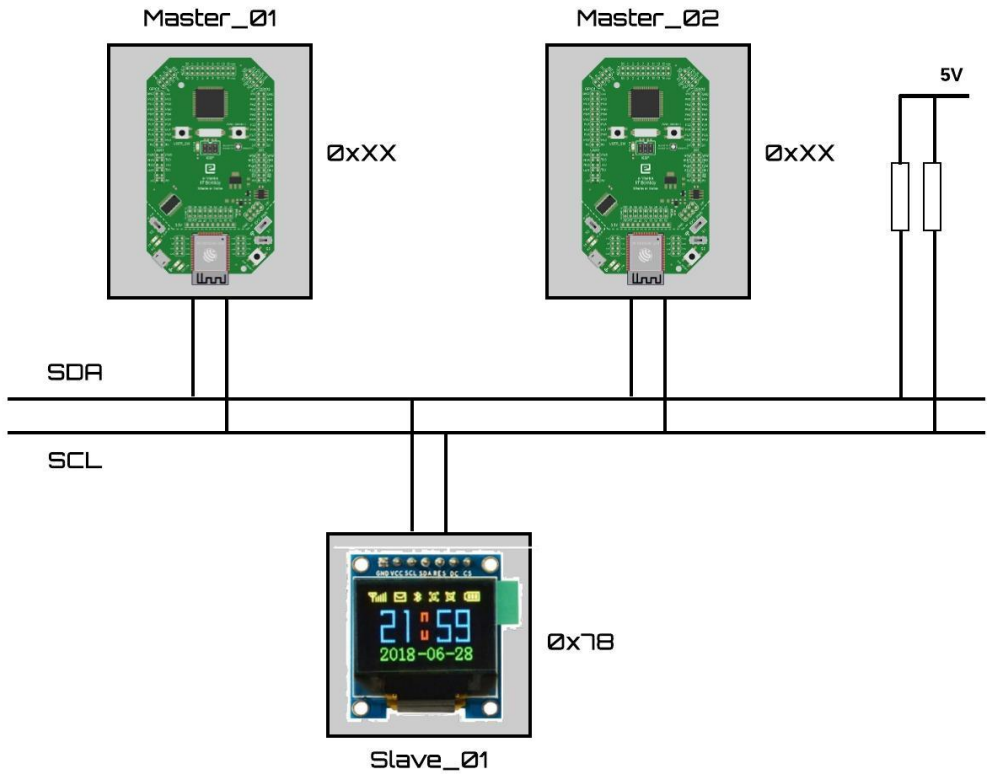


Connection Diagram:



- Pins required for I2C:
  1. SDA: Serial Data Line - To send and receive information.
  2. SCL: Serial Clock Line - To synchronize the communication.

I2C Communication Steps:

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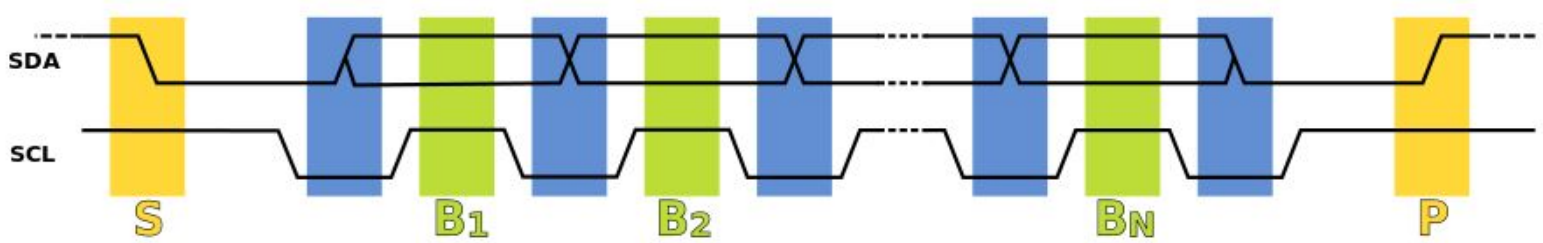

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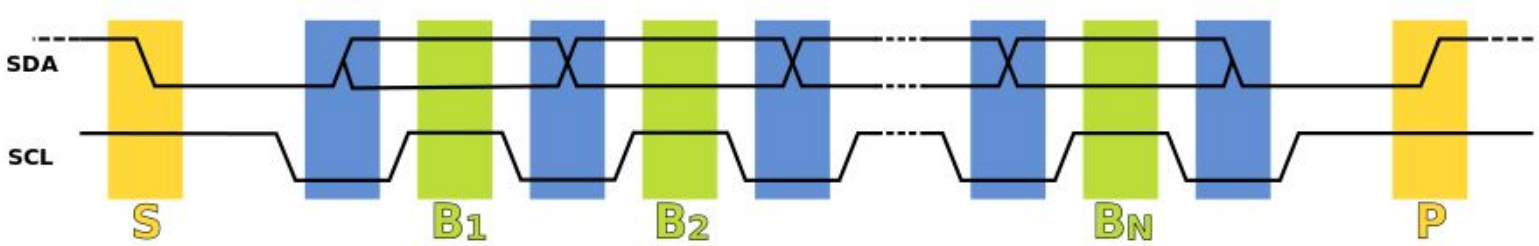

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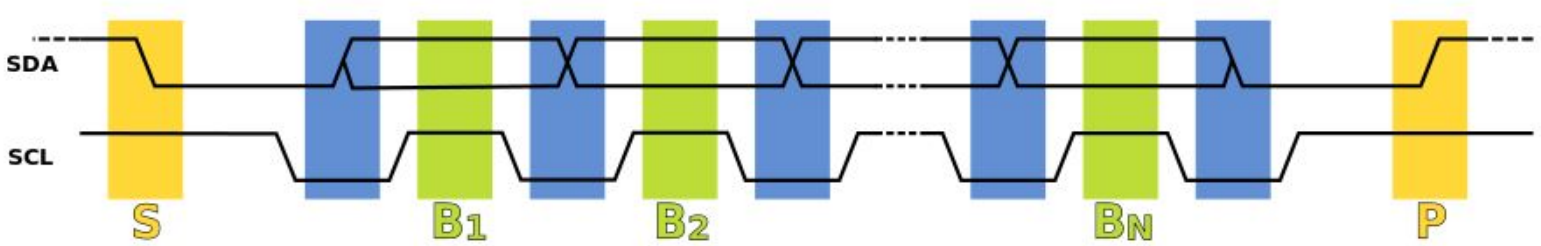
I2C Communication Steps:



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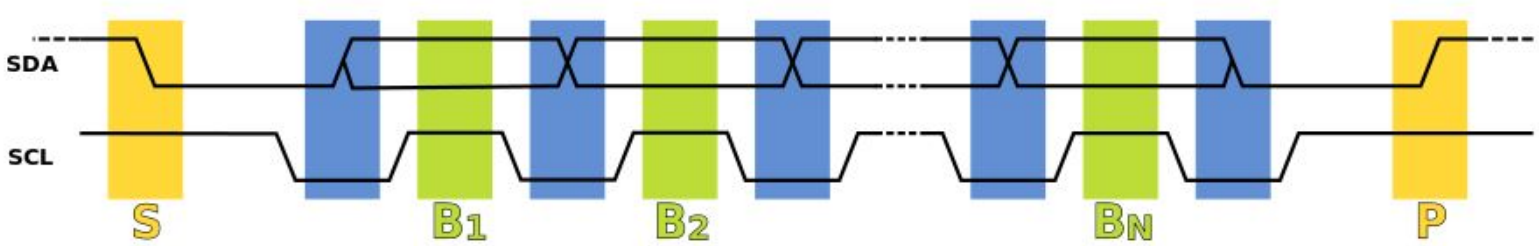

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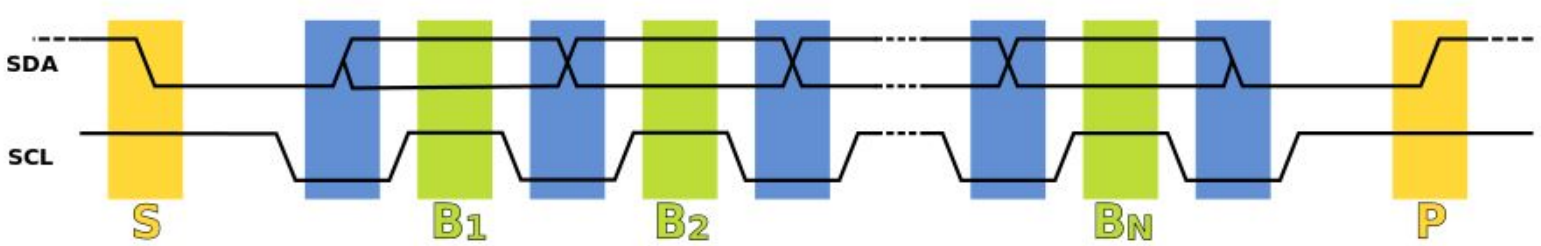

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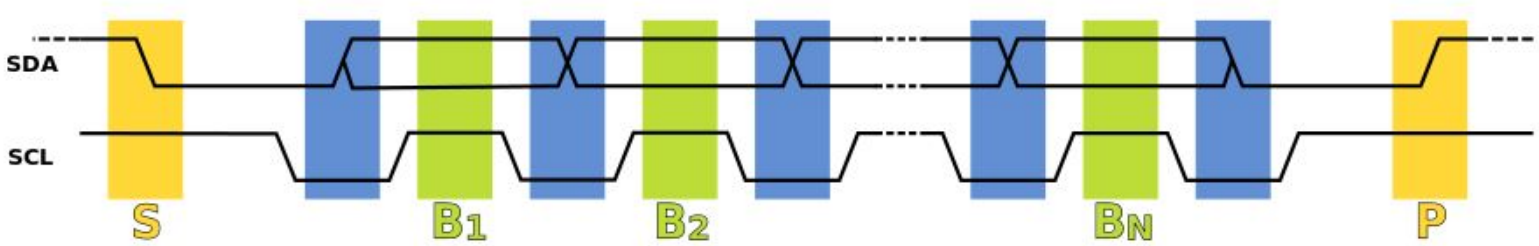

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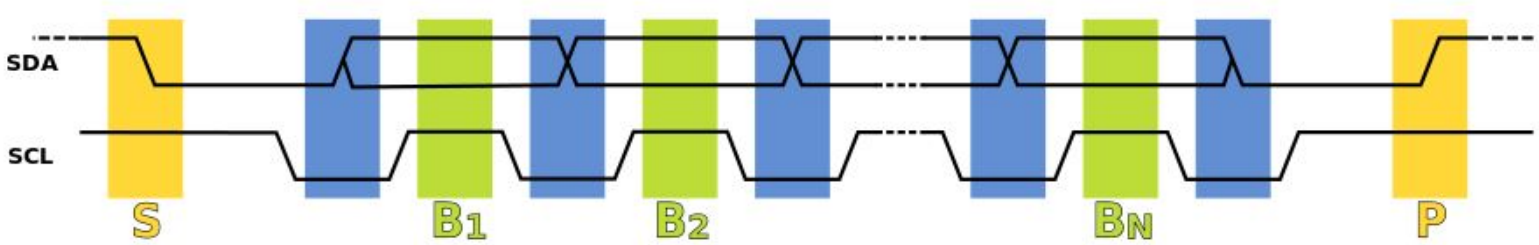

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6. A stop bit (P) is signaled when SCL rises, followed by SDA rising.

I2C Protocol

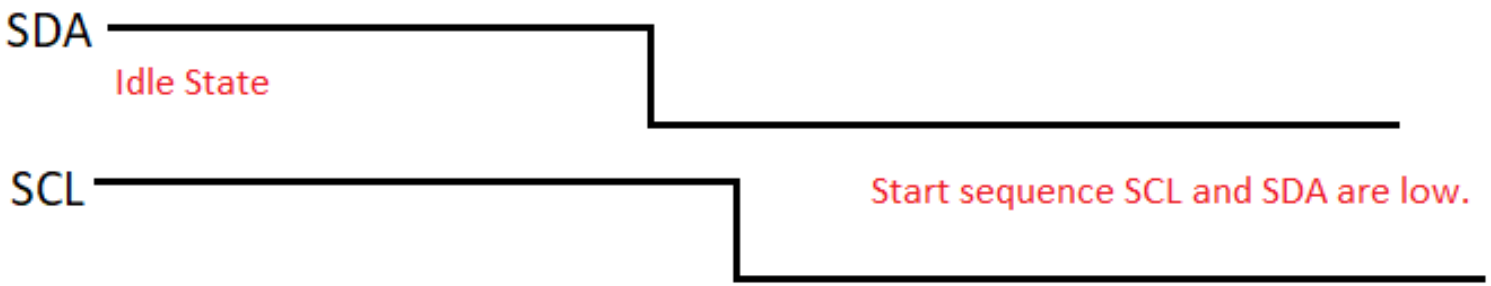
I2C Protocol

Start + Slave Addressing + Ack + Data transfer + Ack + Stop

I2C Protocol

Start + Slave Addressing + Ack + Data transfer + Ack + Stop

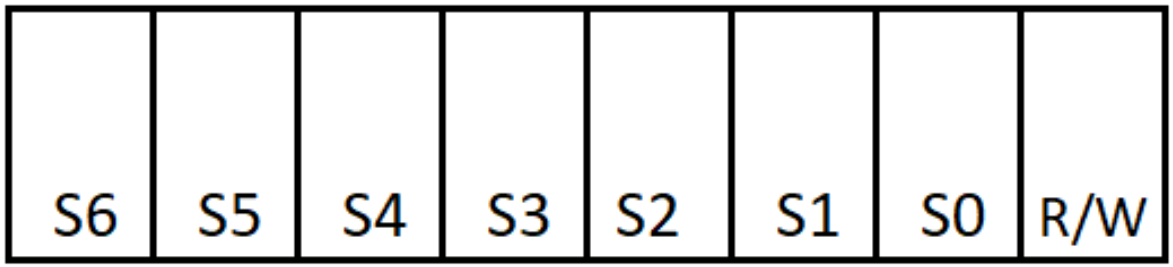
- Start condition marks the start of the protocol.
- SCL line is pulled down by lowering the voltage.



I2C Protocol

Start + Slave Addressing + Ack + Data transfer + Ack + Stop

- Slaves are selected by sending 7 or 10 bit along data line.



- R/W bit decides the read or write operation.

I2C Protocol

Start + Slave Addressing + Ack + Data transfer + Ack + Stop

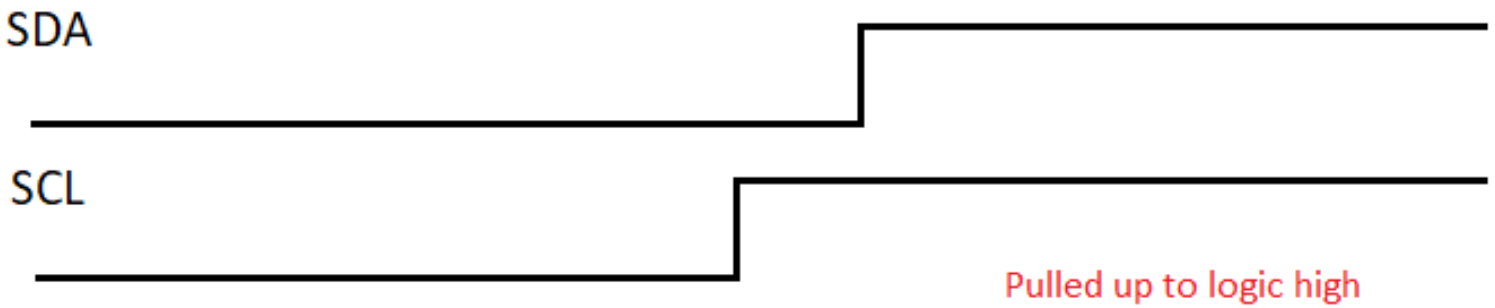
- Data is transferred (Read or Write) b/w master and selected.

- The direction of data transfer is determined by R/W bit.

I2C Protocol

Start + Slave Addressing + Ack + Data transfer + Ack + Stop

- Stop condition marks the End of the protocol.



- SCL and SDA lines are released.

I2C Protocol

I2C Protocol

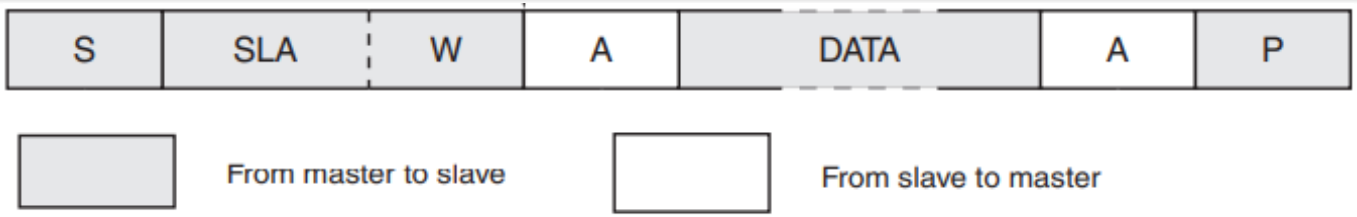
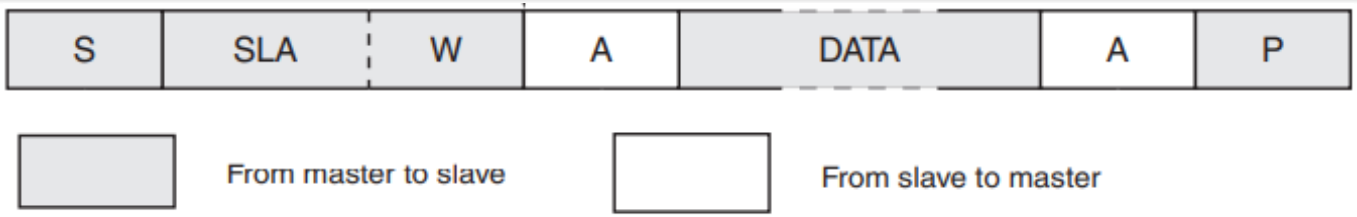


Figure: Master Transmitter

I2C Protocol



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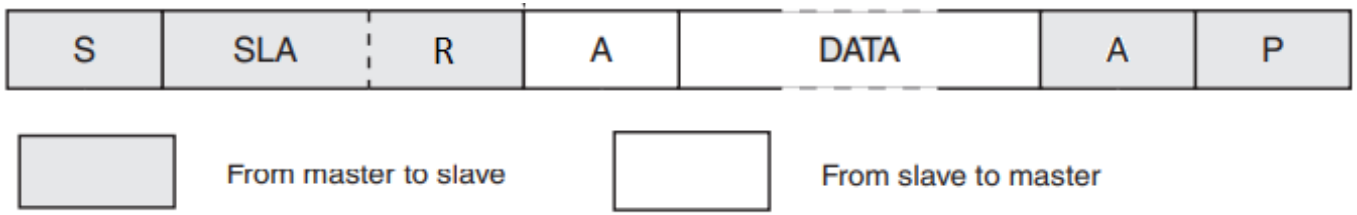
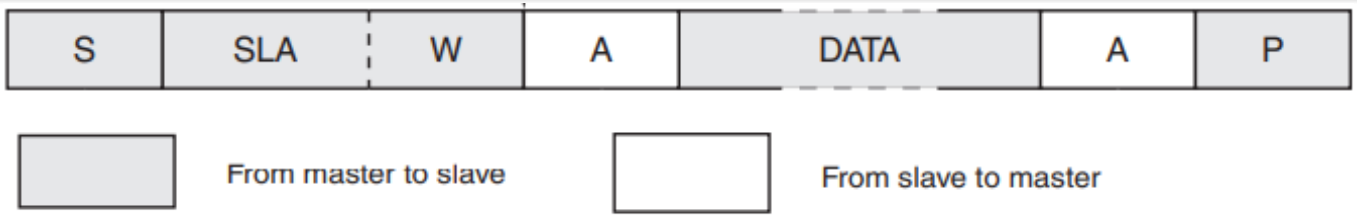


Figure: Master Receiver

I2C Protocol



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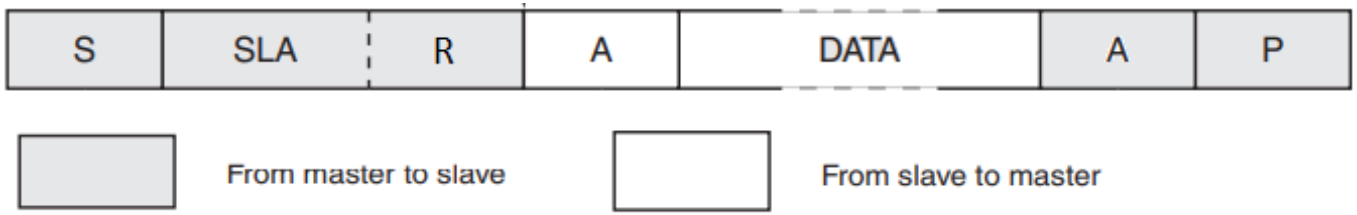


Figure: Master Receiver

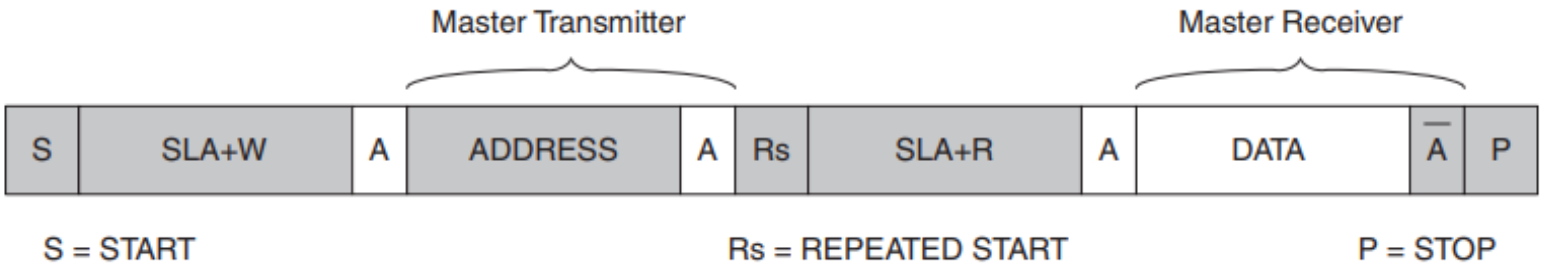
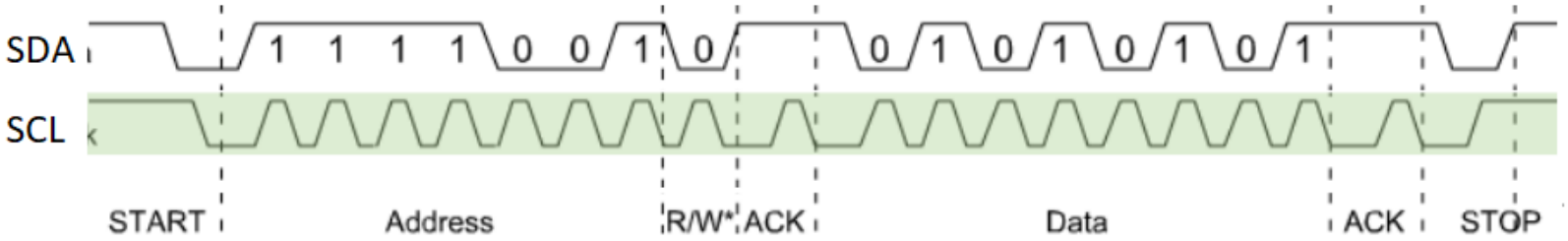


Figure: Master Transmitter and Receiver

I2C Protocol

I2C Protocol



Features of I2C:

- Bus Arbitration: When multiple devices initiates a communication
- Clock Stretching: When slave wants to take control of the clock

What is SPI?

What is SPI?

Serial Peripheral Interface

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Serial Peripheral Interface

- Serial and synchronous communication Protocol.

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What is SPI?

Serial Peripheral Interface

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- Master-Slave, full duplex protocol.
- Only Single master.

Multiple Slaves

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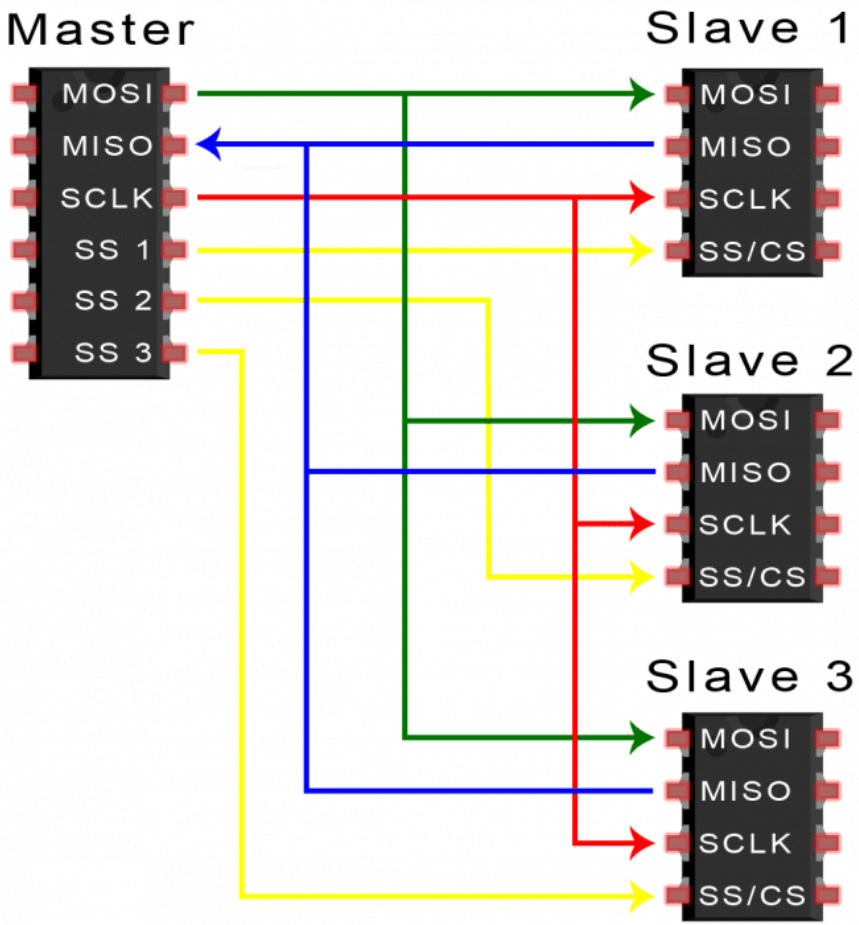

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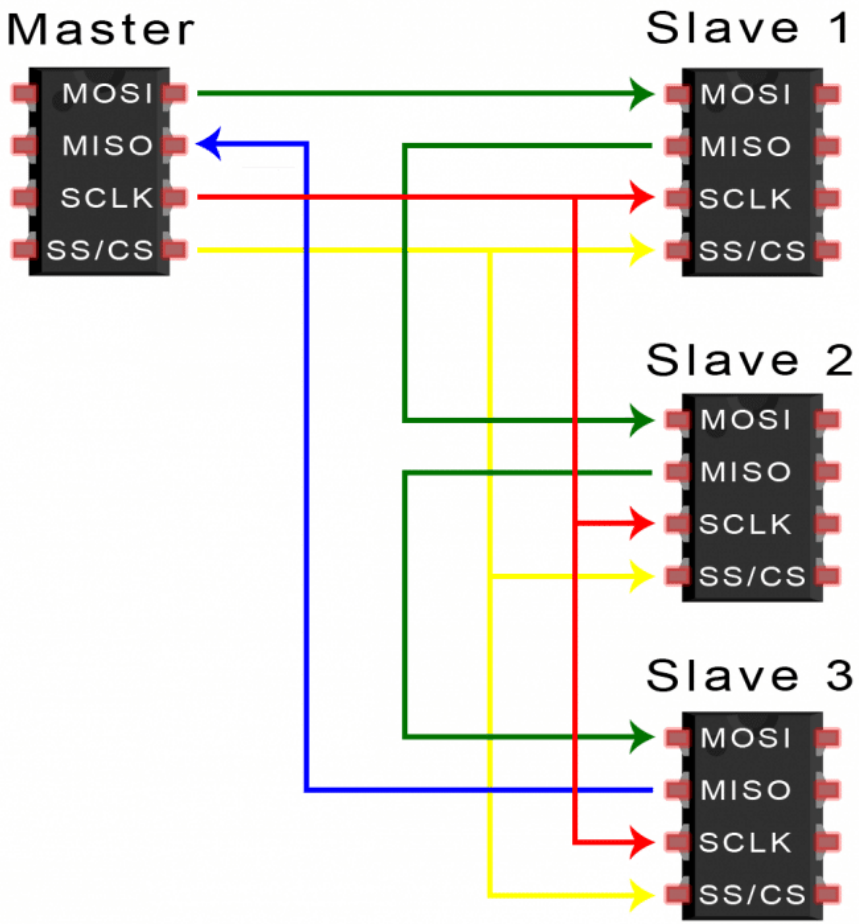

Thank You!

Post your queries on: helpdesk@e-yantra.org