# Microcontrollers:

- A microcontroller is a device which contains a processor, memory and peripherals allowing it's usage for embedded systems.
- There are various types :-
  ○ 8 bit
  ○ 32 bit
- Each microcontroller requires a timer/counter
- It counts the clock cycles of the system clock
- Timers are usually configurable as 8,24 or 32 bit
- Prescalars are used to determine when the counter needs to be updated.
- **Watchdog Timers**
  ○ Special failsafe mechanism
  ○ Counter starts at a particular value and counts down to 0
  ○ At 0 the system is reset

ADC:

- ADC converts analog voltage on a pin to its equivalent digital value
- The value is calculated using the following formula
  V=(ADC resoulution/(Reference voltage*ADC Value)
- The resolution of ADC depends on the size of the ADC
  ○ For example an 8 bit ADC has 256 discrete levels, a 10 bit has 1024 levels.
  ○ The generalised formula is 2^n
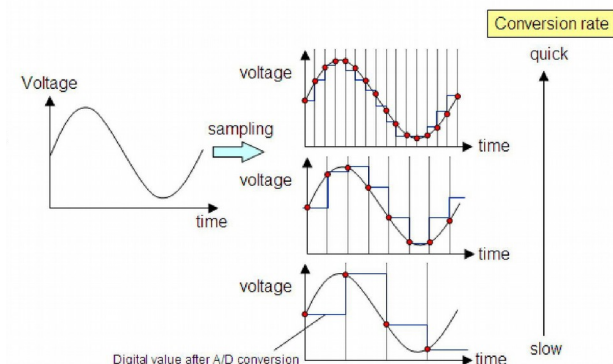
General Purpose I/O pins:

- General pins which can be controlled by the user
- They arranged in ports.
- The total no. of pins assigned to every port depends on the architechture

Serial Communication

- To communicate with other attached devices the MCU uses various techniques
- These techniques need to follow a set of rules or protocols
- Commonly used protocols include
  1. UART
  2. SPI
  3. I2C

- Universal Asynchronous Receiver/Transmitter

  ○ Data tranfer is done without a clock signal
  ○ It requires 2 lines (RX and TX)

- Data is to be framed consisting of: Start bit : Data Bits : Parity Bit : Stop bit
- Both sides need to have a set transfer speed

- Serial Preipheral Interface
  - It is synchronous and requires a clock signal
  - It utilizes 4 lines for communication
  - It is full duplex and supports clock upto 10MHz
  - Can have multiple slaves but each slave requires a seperate Slave Select(SS) line
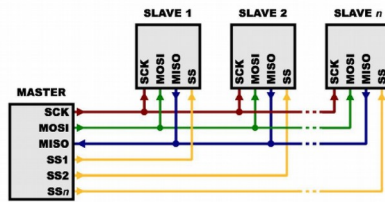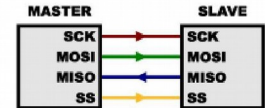
- Inter-integrated circuit
  - Consists of 2 lines i.e. SCL and SDA
 - It is half duplex and can support clock speeds upto 400kHz
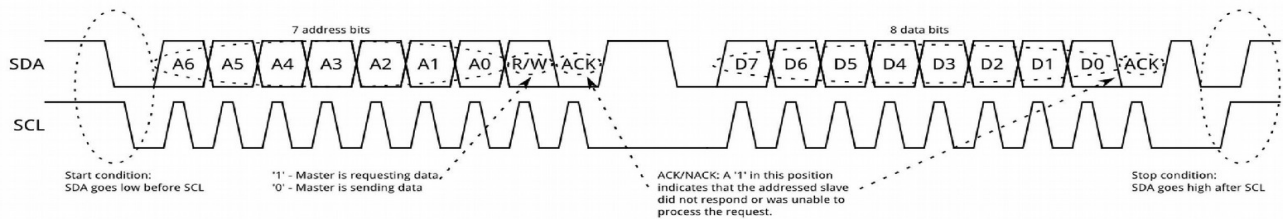
  - The diagram shows transmission of 7 bits using I2C

Polling and Interrupts

- Two ways a MCU reads any peripheral
- Polling is a method used to perform tasks
- The CPU constantly monitors a variable/register to check if it needs to perform a particular task.
- Interrupts are signals which take the CPU away from the main code to perform a particular task/code stored in a branch called Interrupt Service Routine.
- Interrupts are more efficient than polling as they don't require constant monitoring.

Pulse width modulation

- It is used to generate a varying dc signal using a digital source by changing the ON time of the pulse.
- Increasing ON time increases average voltage.
- The T_{ON}/Total Time period is called the Duty Cycle
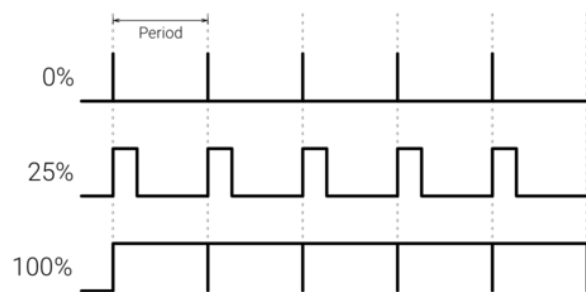
- The diagram shows the pulse at different values of duty cycles.

Embedded C Programming

- C programming on embedded devices
- The data types used are shown in the image below

Data Type	Size (bytes)	Size (bits)	Value Range
unsigned char	1	8	0 to 255
signed char	1	8	-128 to 127
char	1	8	either
unsigned short	2	16	0 to 65,535
short	2	16	-32,768 to 32,767
unsigned int	4	32	0 to 4,294,967,295
int	4	32	-2,147,483,648 to 2,147,483,647
unsigned long	8	64	0 to 18,446,744,073,709,551,616
long	8	64	−9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
unsigned long long	8	64	0 to 18,446,744,073,709,551,616
long long	8	64	−9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
float	4	32	3.4E +/- 38 (7 digits)
double	8	64	1.7E +/- 308 (15 digits)
long double	8	64	1.7E +/- 308 (15 digits)
bool	1	8	false or true

- Endianess
  - Used to define the way in which data is stored
  - Big endian: MSB occupy the lower address
  - Little endian: LSB occupy the lower address

- Hexadecimal notation
  - Generally in a microcontroller the registers are 8,16 or 32 bit.
  - Thus hexadecimal notation is used to write to these registers
  - Other notations include Binary and Octal

Useful Keywords
  - typedef: It is used to explitly associate a data type with an identifier.
  - Eg. typdef signed short int16_t;
  - Here signed short can now be referred to using int16_t.
  - Struct: It is used for declaring a structure which can hold variables of different data types under a single name.
  - The .(dot) and -> operators are used to access member variables.