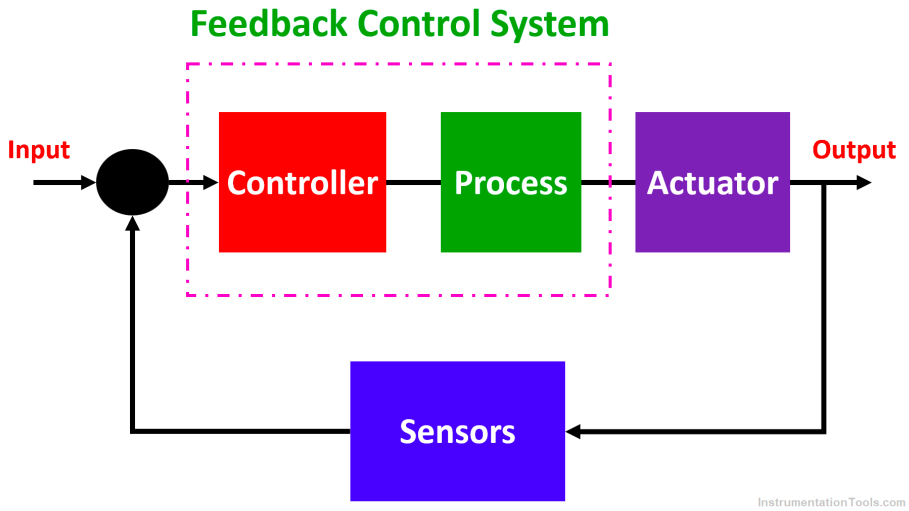
Power Transmission and Signals

Refresher - Control Systems

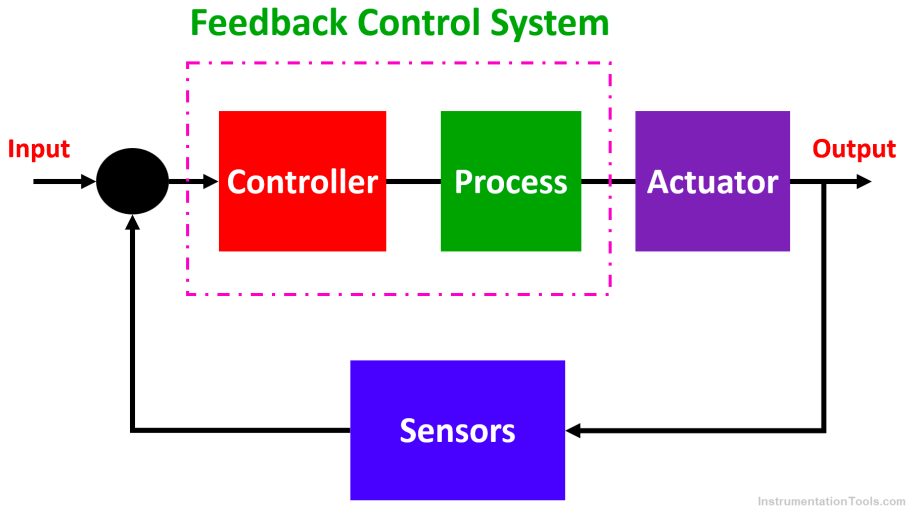
- A control system is a system that manages, commands, or regulates the behaviour of another system to achieve a desired output.

- It does this by:
  - Receiving input signals
  - Processing those signals
  - Producing an output that controls a device or process



Refresher - Control Systems

- A typical control system consists of:
  - **Input** - The desired value or command (e.g. button press, set temperature)
  - **Controller** - Processes the input and decides what action to take(e.g. PLC, microcontroller, relay logic)
  - **Output / Actuator** - Carries out the action(e.g. motor, solenoid valve, hydraulic or pneumatic cylinder)



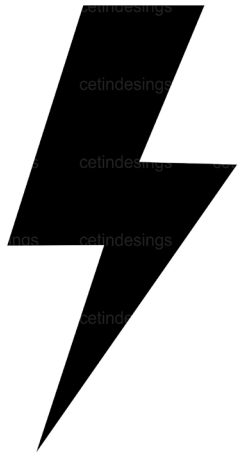
What are signals

- A signal is a measurable quantity used to **communicate information** within a system. (between components)
- Signals do not usually do work themselves — they tell another part of the system what to do.
- Examples of signals:
  - Voltage level from a sensor
  - ON/OFF state of a switch
  - Pressure signal in a pneumatic control line
  - PWM signal controlling motor speed

What is power transmission

- Power transmission is the transfer of energy to perform work.

- **It is responsible for:**
  - Movement
  - Force
  - Heat
  - Mechanical output



- **Examples of power transmission:**
  - Electrical power driving a motor
  - Hydraulic pressure moving a ram
  - Pneumatic air pressure extending a cylinder
  - Mechanical shafts and gears transferring torque

Types of signals

Electrical Signals

- Signals transmitted using voltage or current.
- Analogue – continuous variation (e.g. 0–10 V temperature sensor)
- Digital – discrete states (e.g. 0 V / 24 V switch)
- PWM – digital switching used to control power smoothly
- **Used in:**
  - Sensors
  - PLC inputs and outputs
  - Motor controllers

Mechanical Signals

- Signals transmitted using physical movement or force.
- Examples:
  - Lever movement
  - Gear position
  - Spring displacement
- **Used in:**
  - Mechanical governors
  - Manual control linkages
  - Safety interlocks

Types of signals

Pneumatic Signals

- Signals transmitted using air pressure.
- Often ON/OFF using valves
- Can be analogue using regulated pressure levels
- **Used in:**
  - Air logic circuits
  - Pneumatic control lines
  - Industrial automation systems

Hydraulic Signals

- Signals transmitted using fluid pressure.
- High force, precise control
- Often electrically controlled via valves
- **Used in:**
  - Industrial presses
  - Heavy machinery
  - Position and force control systems

Types of power transmission

Electrical Power

- Energy transferred using electric current.
- **Used to:**
  - Drive motors
  - Heat elements
  - Power electronic systems
- **Examples:**
  - AC motors
  - DC motors
  - Heaters
  - Solenoids

Mechanical Power

- Energy transferred through moving parts.
- **Examples:**
  - Shafts
  - Gears
  - Belts and chains
- **Used where:**
  - Direct motion transfer is needed
  - High efficiency is required

Types of power transmission

Pneumatic Power

- Energy transferred using compressed air.
- **Characteristics:**
  - Fast response
  - Clean and safe
  - Limited force compared to hydraulics due to air being compressible
  - Compression also reduces positional accuracy and stiffness under load.
- **Used in:**
  - Pick-and-place systems
  - Clamping and gripping
  - Packaging machinery

Hydraulic Power

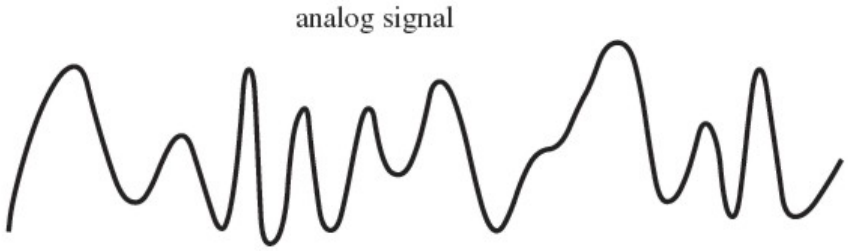
- Energy transferred using pressurised liquid.
- **Characteristics:**
  - Very high force
  - Smooth, controlled movement
  - Compact actuators
- **Used in:**
  - Hydraulic presses
  - Construction equipment
  - Lifting systems

Feature	Pneumatic	Hydraulic	Electrical
Medium Used	Compressed air	Pressurised liquid (oil)	Electric current
Typical Operating Pressure	Low to medium	Very high	Varies with system voltage
Force Capability	Low to medium	Very high	Medium to high (motor-dependent)
Speed of Operation	Fast	Moderate	Fast and highly controllable
Precision	Moderate	High	Very high
Cleanliness	Clean and safe	Risk of oil leaks	Very clean
System Complexity	Simple	More complex	Highly configurable
Control Method	Valves and regulators	Valves and pumps	PLCs, drives, controllers
Energy Efficiency	Lower (air losses)	High for heavy loads	High, especially with drives
Maintenance	Low	Higher (fluid care)	Low to moderate
Safety	Safe in explosive areas	High force risk	Electrical hazard risk
Typical Applications	Packaging, pick-and-place	Presses, lifting systems	Automation, conveyors, robots

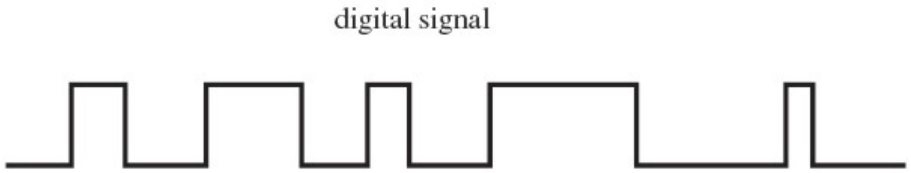
Analogue vs Digital signals

Signals (particularly electrical) can be categorised into two categories:

- Analogue signals are continuous and change smoothly over time (for instance 2.5v to 3.4v)

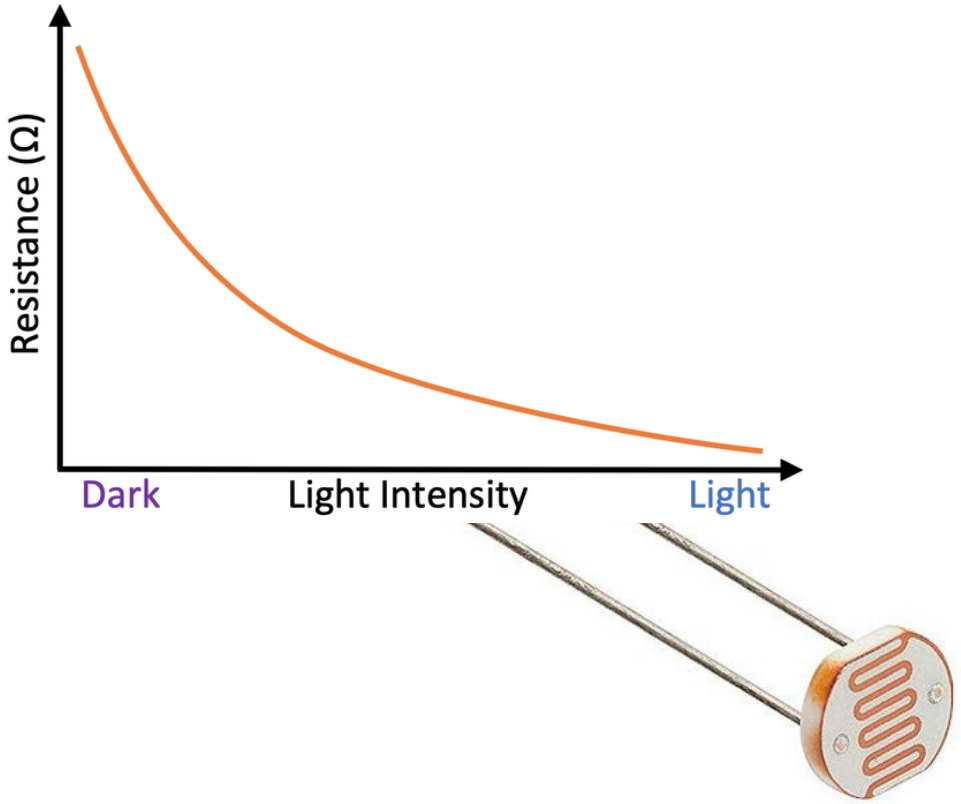


- Digital signals are discrete and therefore have set values which they change between (for instance on or off)



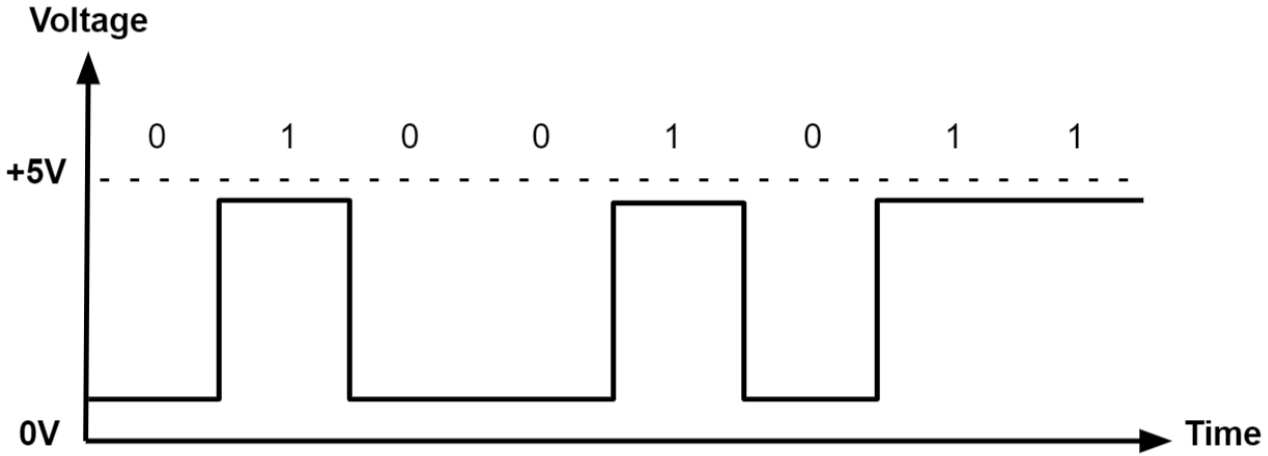
Example of an analogue signal

- **Light Sensor (e.g., LDR)**
- Produces a voltage that varies continuously based on light intensity.
- It does this by varying resistance based on the light hitting the LDR which relates directly to voltage
- This voltage then can be read by a microcontroller



Example of a digital signal

- **Push Button or Switch**
- Outputs either HIGH (1) or LOW (0) depending on whether the switch is pressed.
- It does this by completing the circuit when the button is pressed
- A microcontroller can detect when a voltage is input and when it isn't



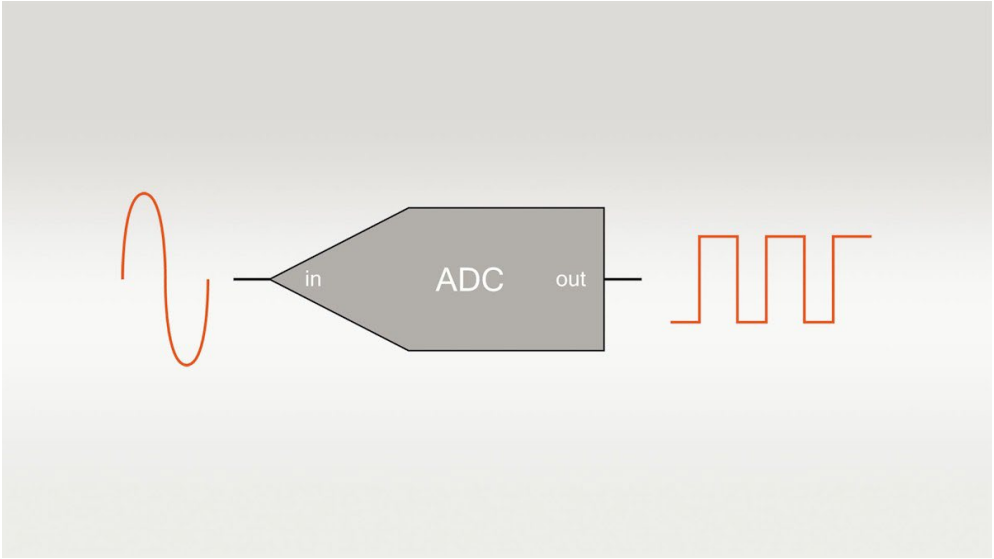
Your turn

Determine whether these components are digital or analogue and whether they are input or output:

Switch	Motor speed control
Relay	Micro-switch
Thermocouple	Solenoid
Pressure sensor	A moving coil meter
Variable flow valve	Proximity Switch
Motor ON/OFF	Optical Sensor
Current Loop	LED

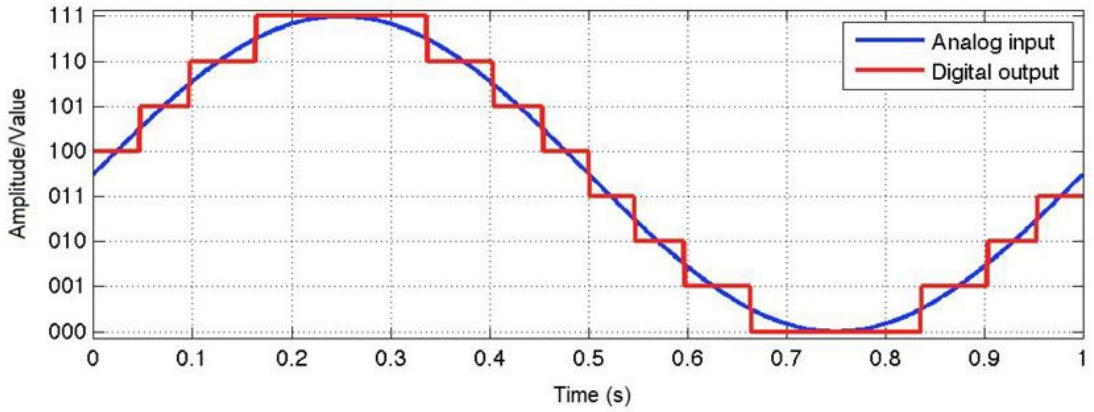
Microcontrollers and Analogue Signals

- Most controllers only understand digital logic as they use binary logic
- So, when putting an analogue signal into a controller you must change it into a digital signal
- This is done using an ADC or Analogue to Digital Converter



Analogue to Digital Converter

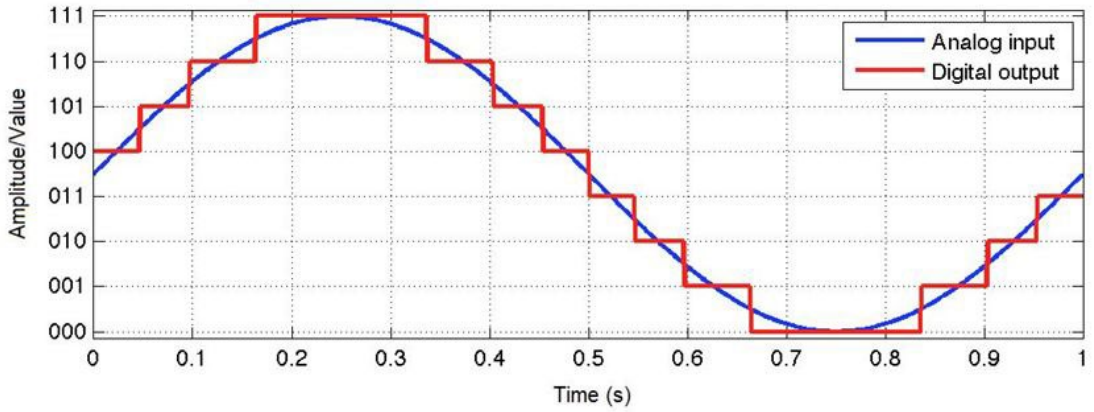
- An ADC converts and analogue signal to digital by having “steps”
- Each of these steps are equal to a certain range of values in an analogue signal
- The wave is then sampled where points are taken from it and rounded to these steps



Analogue to Digital Converter

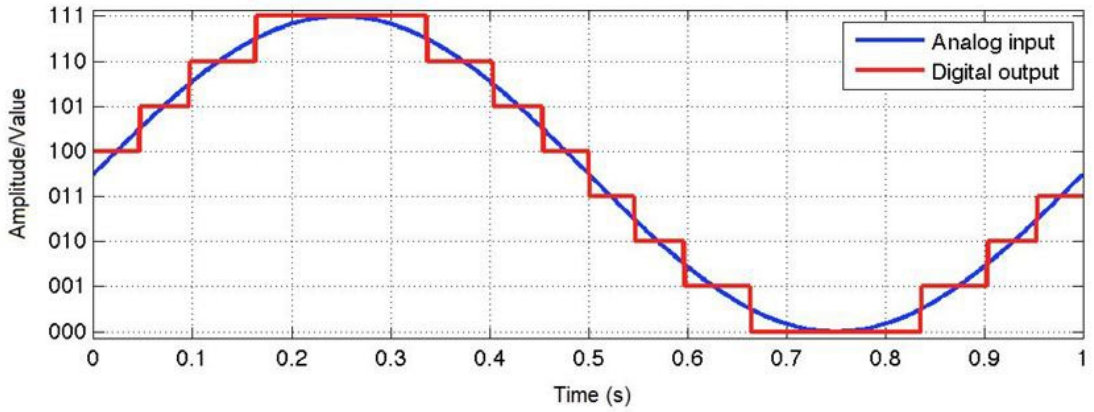
- So an ADC follows this process:

- **Sampling**: The ADC measures the analogue signal at regular intervals.
- **Quantization**: The sampled values are rounded to the nearest digital level.
- **Encoding**: The values are stored as binary numbers (e.g., 8-bit, 10-bit, etc.).



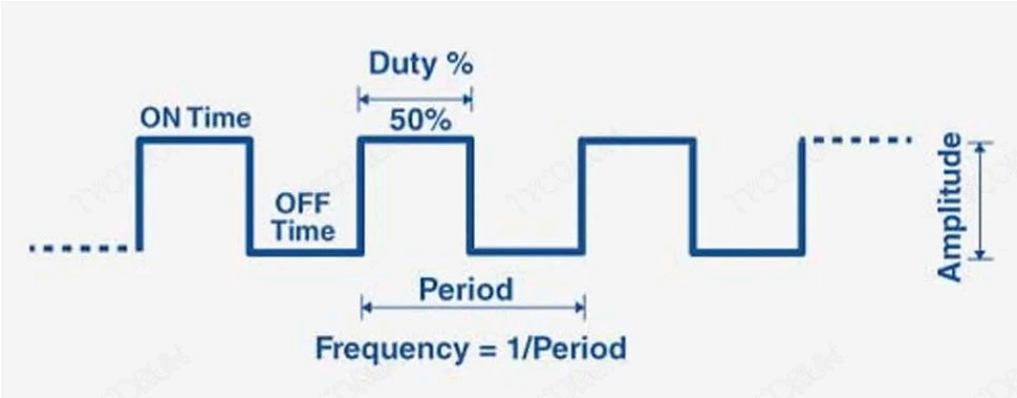
ADC Resolution

- The resolution of ADC is the number of steps a wave will be converted to
- For an 8-bit ADC a wave is split into 256 separate values (2^8)
- For a 10-bit ADC a wave is split into 1024 separate values (2^{10})
- Higher resolution means the ADC is more accurate, but the controller needs more processing power



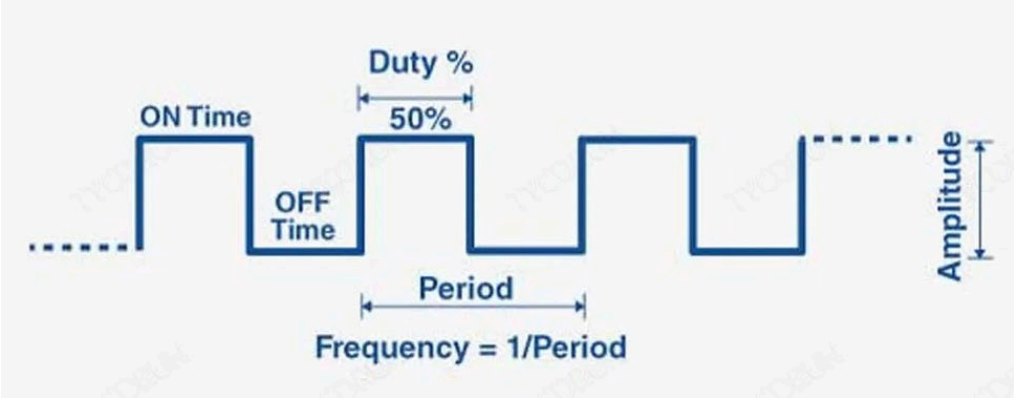
What is PWM

- A technique to control power by rapidly switching a signal between ON and OFF states.
- Simulates an analogue output using a digital signal
- Used for controlling motors, LEDs, and power regulation



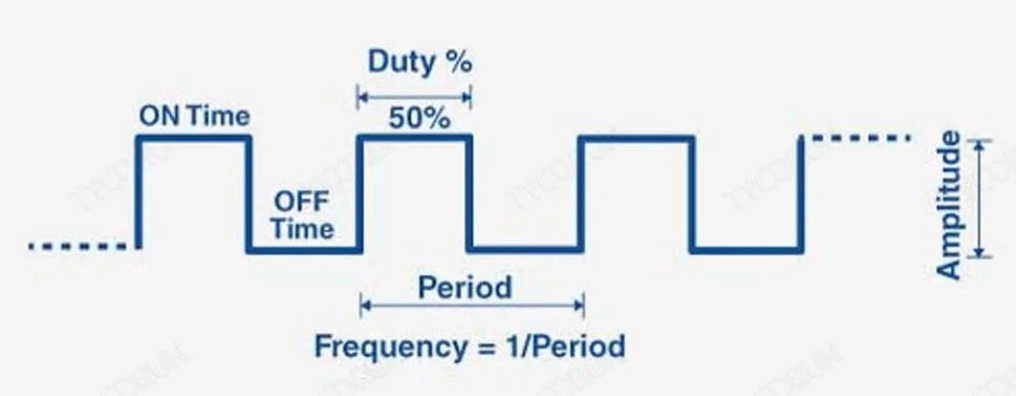
Parts of a PWM

- The duty cycle determines what percentage of the wave is “on”
- This can be worked out by:
- Duty Cycle (%) = (Time HIGH / Total Period) × 100
- 100% Duty Cycle → Always ON (Full Power)
- 50% Duty Cycle → ON half the time (Half Power)
- 0% Duty Cycle → Always OFF (No Power)



PWM Frequency

- How fast the signal switches ON and OFF (measured in Hz).
- Higher frequency = smoother control (important in motors & audio signals).
- Lower frequency = flickering or choppy motion in certain applications.



PWM Applications

LED Dimming – Adjust brightness without changing voltage.

Motor Speed Control – DC motors respond to different duty cycles.

Servo Motors – PWM signals determine precise angular positions.

Audio Signals & Power Supplies – Used in digital sound processing and voltage regulation.

Communication Systems – Used in encoding signals for wireless communication.