SERVO MOTORS

HOW THEY WORK?

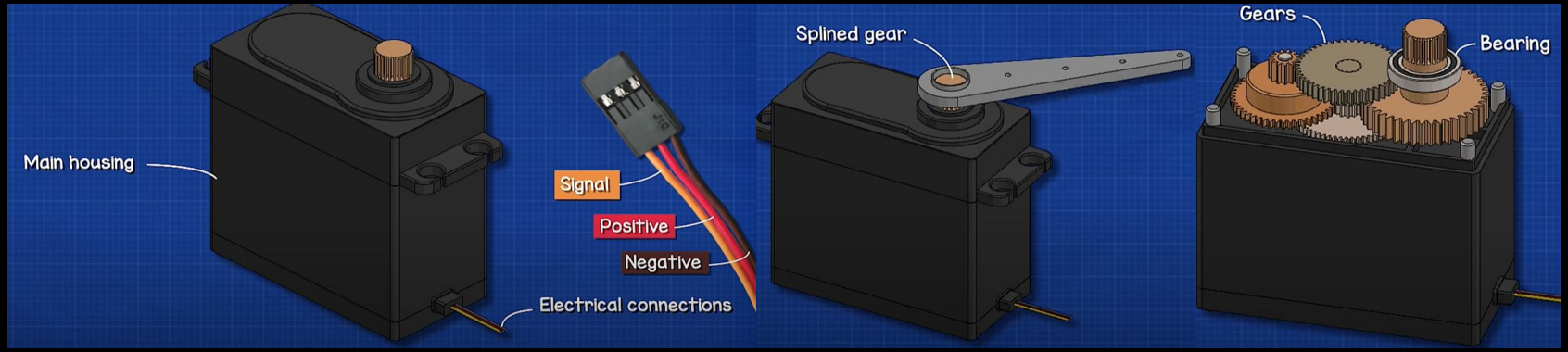
TEJ4M

APPEARANCE

VARIETY

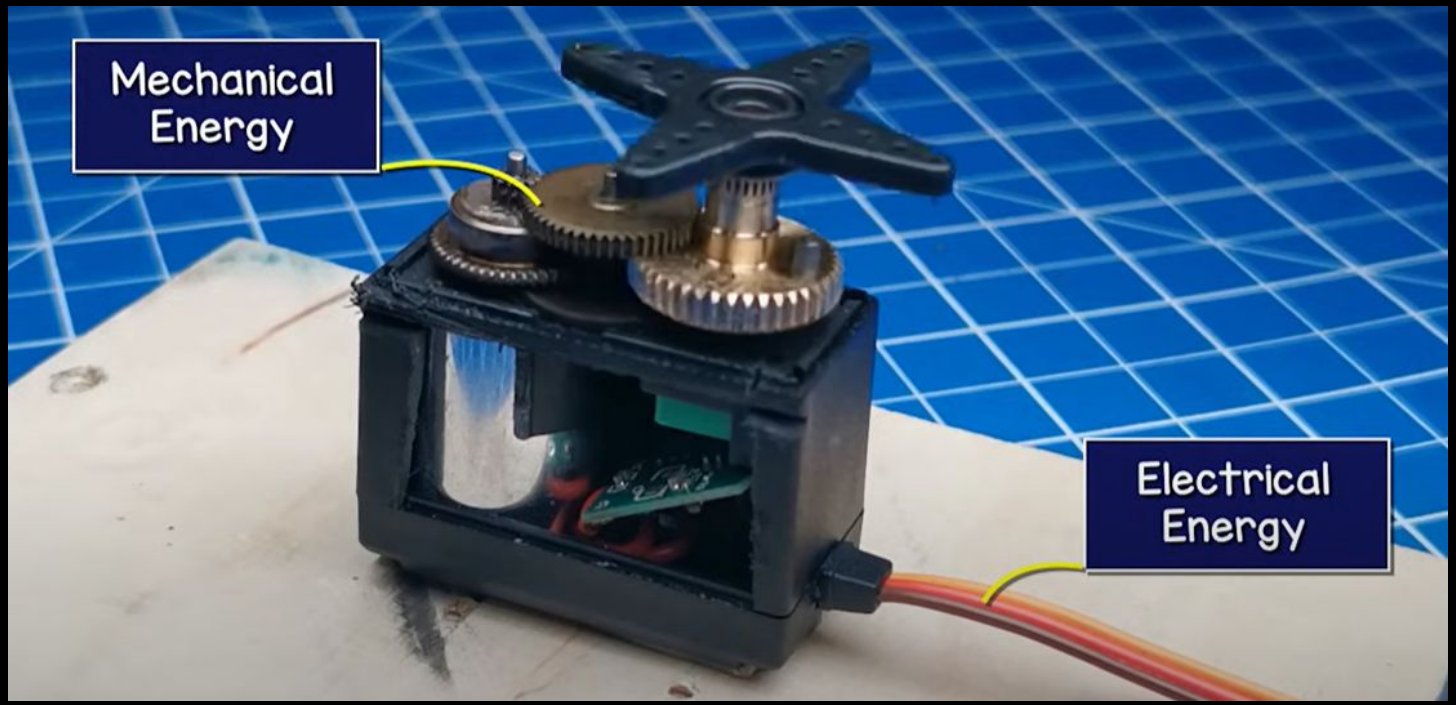
OUTSIDE

COMMON PHYSICAL ATTRIBUTES



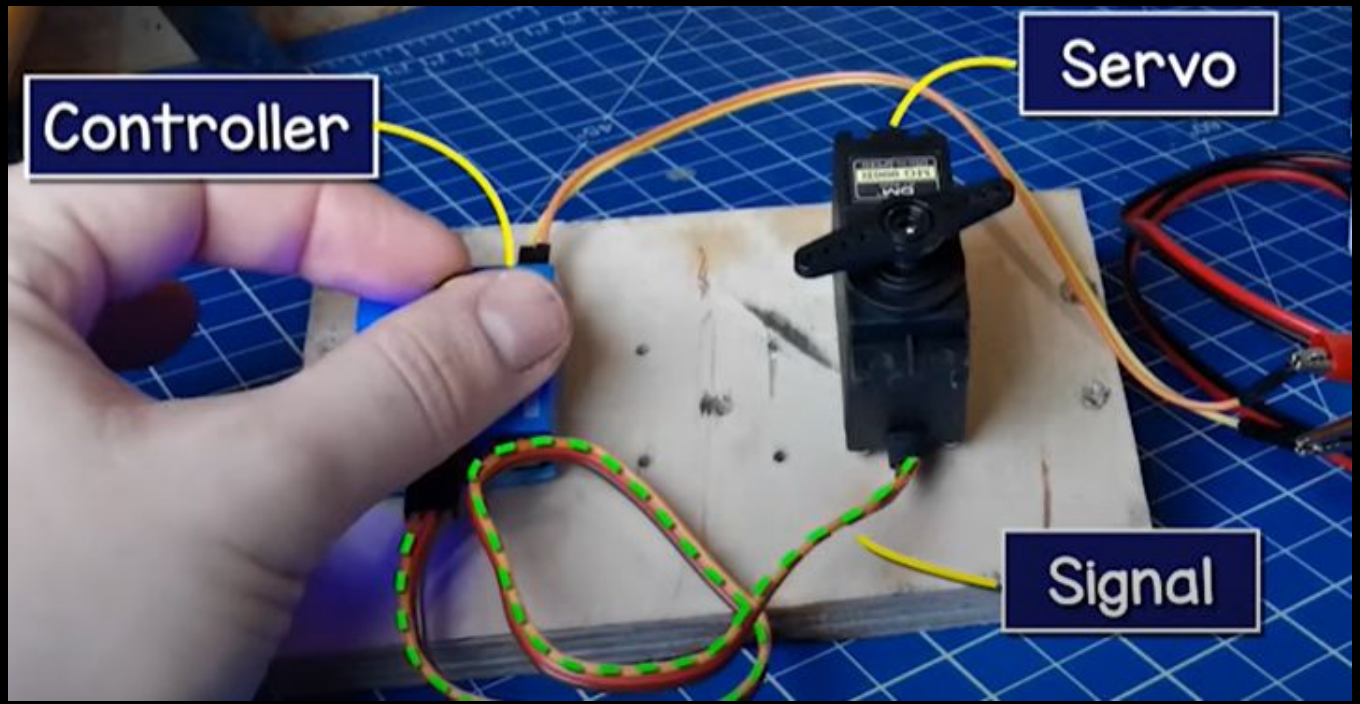
PURPOSE

TO CONVERT ELECTRICAL INTO MECHANICAL ENERGY AND ALLOW YOU TO ROTATE ITS SHAFT TO A PRECISE ANGLE.



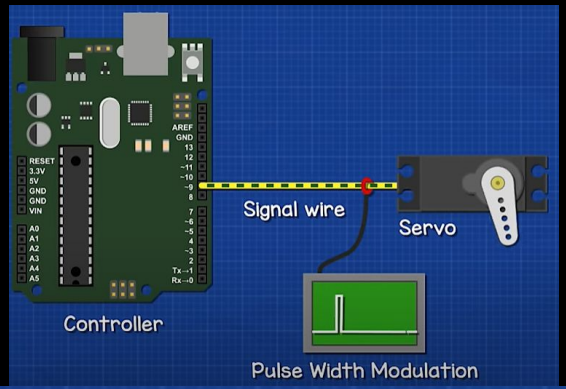
CONTROL

ITS POSITION IS CONTROLLED BY A CONTROLLER THAT SENDS A PWM(PULSE WIDTH MODULATION) SIGNAL



MCU CONTROL

A MICROCONTROLLER IS MOST COMMONLY USED TO SEND THE PWM SIGNAL TO THE SERVO. IT CAN ONLY DO THIS THROUGH ITS PINS THAT SUPPORT PWM.



PWM

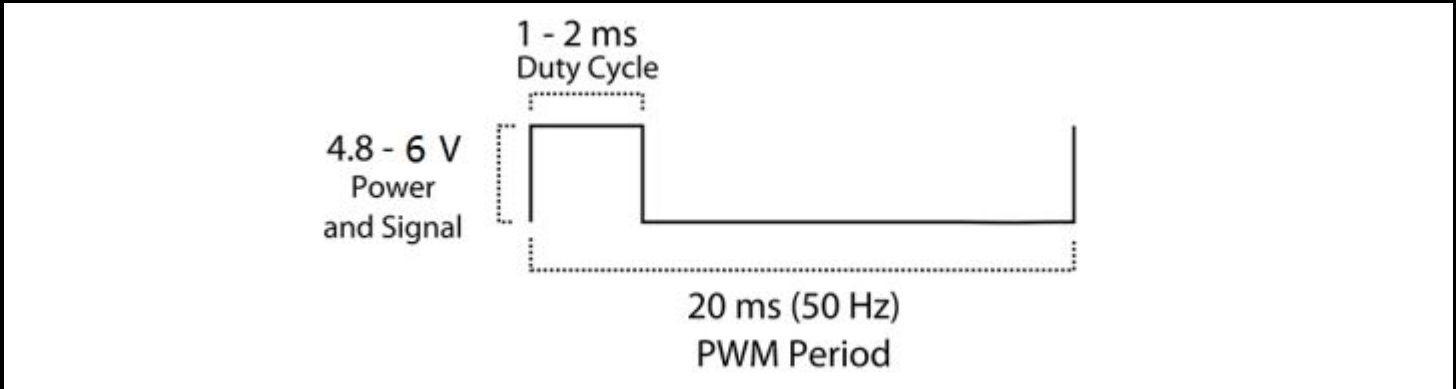
PULSES ARE NORMALLY SENT EVERY 20mS. 20mS IS THE PERIOD OF THE PULSE. THERE ARE 1000ms IN 1s. 1000ms/20ms = 50 PULSES PER SECOND. THE FREQUENCY THEREFORE OF THE SIGNAL IS 50Hz. OSCILLOSCOPES ARE USED TO MEASURE AND SEE THESE PULSES.

PULSE WIDTH

THE WIDTH OF THE PULSE DETERMINES ITS POSITION.

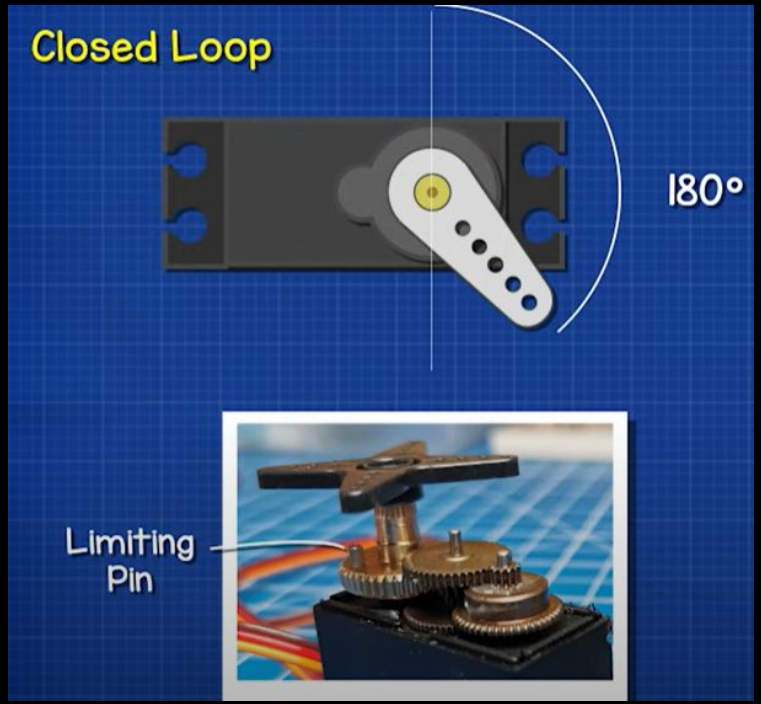
DUTY CYCLE

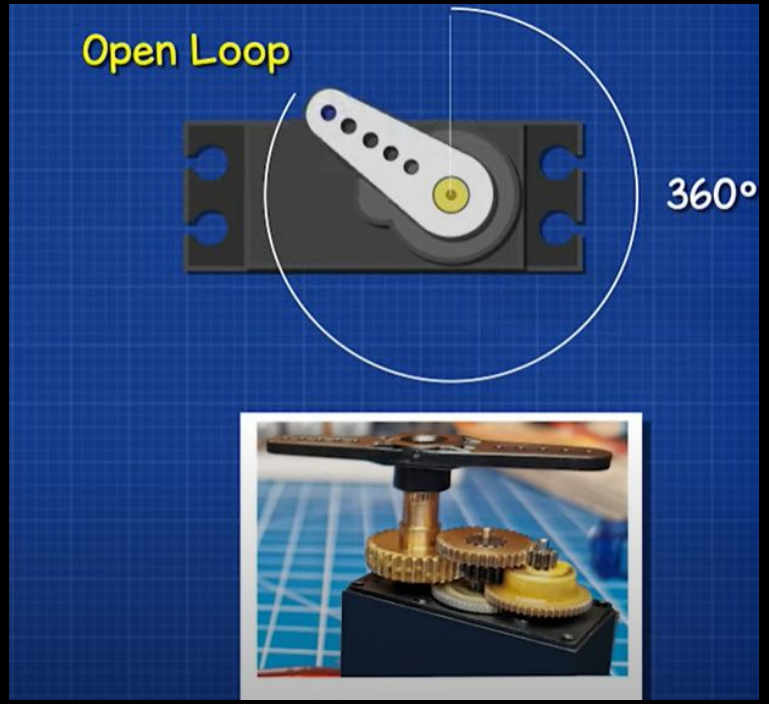
THE DUTY CYCLE REFERS TO THE WIDTH OF THE PULSE THE SERVO CAN READ AND RESPOND TO. IN THE EXAMPLE BELOW THE DUTY CYCLE IS 1-2ms WHICH MEANS THAT IT WILL ROTATE TO AN ANGLE ONLY IF WE SEND A PULSE WIDTH OF BETWEEN 1 AND 2 ms. IN THE DATASHEET FOR THIS SERVO A 1ms PULSE ROTATES THE SERVO TO 0 DEGREES, 1.5ms TO 90 DEGREES AND 2ms TO 180 DEGREES. CHANGING THE VOLTAGE CHANGES THE STRENGTH OR HEIGHT OF THE PULSE AND THEREFORE SPEED AND TORQUE BUT NOT WIDTH SO THE ANGLE IS NOT AFFTECTED.



ROTATION ANGLE

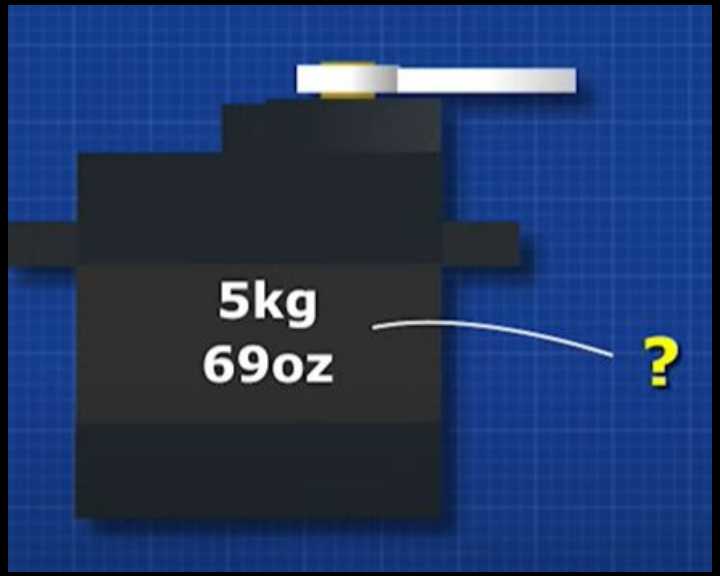
USUALLY UP TO 180 DEGREES BUT CAN BE CONTINUOUS





TORQUE SPECS

OFTEN YOU WILL SEE A TORQUE VALUE ON THE SIDE OF THE SERVO. IT DETERMINES THE MAX TORQUE IT CAN APPLY VIA ITS SHAFT. THE SMALLER THE SERVO TYPICALLY MEANS THE LOWER ITS TORQUE CAPABILITY.

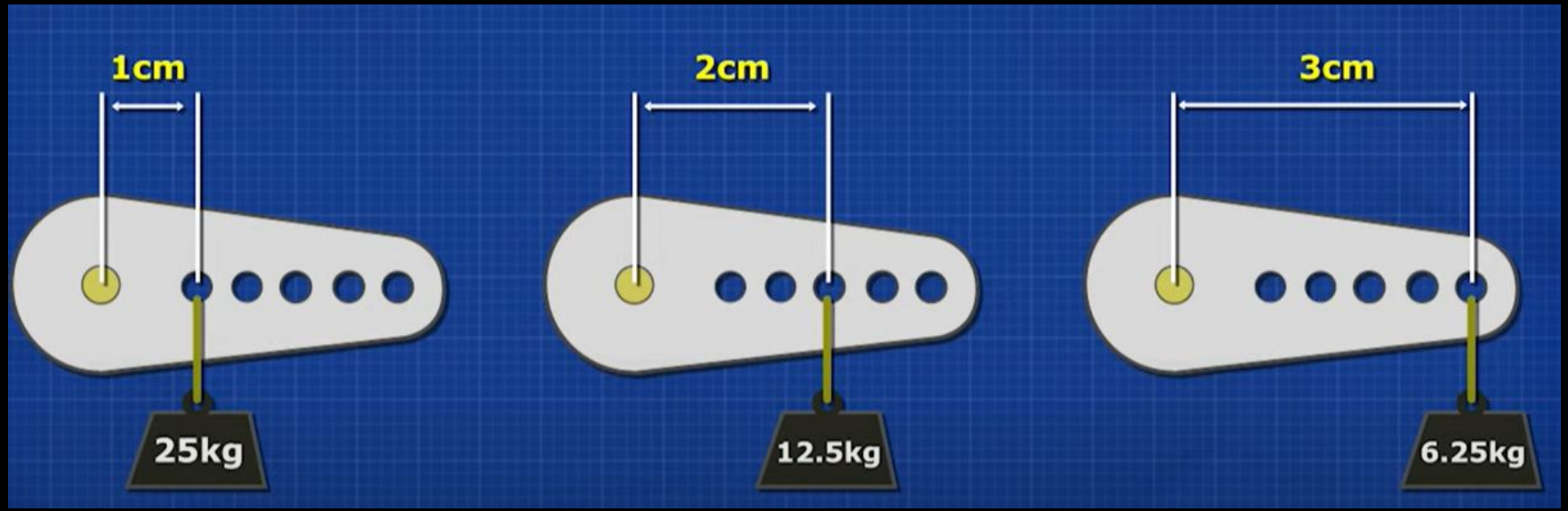


25 kg

9g (0.009 kg)

TORQUE SPECS

A 25KG SERVO MEANS IT CAN SUPPORT 25KG 1CM AWAY FROM THE CENTRE OF ITS SHAFT, 12.5KG 2CM AWAY, 6.25KG 3CM AWAY AND SO ON.



DATASHEET

TORQUE SPECS ARE ON THE DATASHEET.

DATA SHEET

Example

Operating Voltage:	4.8V - 7.2V
Stall torque:	9kg-cm (4.8V) 11kg-cm (6V)
Stall Current:	2.5A (6V)
Operating Current:	500 mA - 900 mA
Operating Speed:	0.17 s/60º (4.8 V) 0.14 s/60º (6 V)

QUESTION #1

HOW ARE SERVO MOTORS DIFFERENT FROM REGULAR DC MOTORS?

Servo motors rotate to a specific angle based on PWM signals, whereas regular DC motors rotate continuously as long as power is applied. Servos include feedback and control circuitry, allowing precise positioning

QUESTION #2

ACCORDING TO THE DATA SHEET ON SLIDE 8, WHAT INCREASES WHEN YOU APPLY INCREASING VOLTAGE TO A SERVO?

Torque and speed increase with higher voltage. The angle of rotation remains the same because it is controlled by pulse width, not voltage

QUESTION #3

HOW MANY DEGREES OF ROTATION DOES A TYPICAL SERVO HAVE?

A typical servo has 180 degrees of rotation, although some models can rotate more or continuously

QUESTION #4

HOW MANY WIRES DOES A TYPICAL SERVO HAVE? EXPLAIN THE ROLE OF EACH ONE AND HOW YOU CAN IDENTIFY THEM

A typical servo has three wires:

Red – Power (usually 5V)

Black or Brown – Ground

Yellow, Orange, or White – PWM Signal input

These control power, grounding, and angle positioning via a PWM signal.

QUESTION #5

WE HAVE THE MG995 AND HS-311 SERVOS IN CLASS. FIND THEIR DATASHEETS AND DESCRIBE THEIR DIFFERENCES.

MG995: Higher torque (~9.4 kg·cm), metal gears, more durable, slightly slower.

HS-311: Lower torque (~3.7 kg·cm), plastic gears, lighter, more suitable for light-duty tasks.

QUESTION #6

DESCRIBE THE TYPE OF SIGNAL THAT IS SENT TO A SERVO TO CONTROL ITS ANGLE OF ROTATION.

A PWM signal is sent with a period of 20 ms (50 Hz). The pulse width (typically 1 ms to 2 ms) determines the rotation angle.

QUESTION #7

DESCRIBE THE DIFFERENCES BETWEEN SERVO, DC AND STEPPER MOTORS.

Servo Motor: Precise angle control, PWM-driven, feedback loop.

DC Motor: Continuous rotation, speed depends on voltage, no position control.

Stepper Motor: Moves in precise steps, open-loop control, good for positioning but no feedback.

QUESTION #8

SOMEONE WANT TO ROTATE AN OBJECT THAT WEIGHS 2 KGS, 3CM FROM THE CENTRE OF AN SG90 MICRO SERVO. IS THIS ADVISABLE?

No.

Torque required = 2 kg × 3 cm = 6 kg·cm

SG90 provides only ~1.8 kg·cm — not enough torque, risking damage.

QUESTION #9

HOW LONG WOULD IT TAKE FOR THE SHAFT OF AN MG90S SERVO TO ROTATE 180 DEGREES?

The MG90S typically rotates **60 degrees in 0.1 seconds**, so:

$180^\circ \div 60^\circ = 3 \quad \Rightarrow \quad 3 \times 0.1 = 0.3$ seconds

Answer: 0.3 seconds

QUESTION #10

WHY ARE METAL GEARED SERVOS MORE VALUABLE THAN THOSE BUILT WITH PLASTIC?

Metal gears are stronger, more durable, and resistant to wear, making them suitable for high-torque and demanding applications.

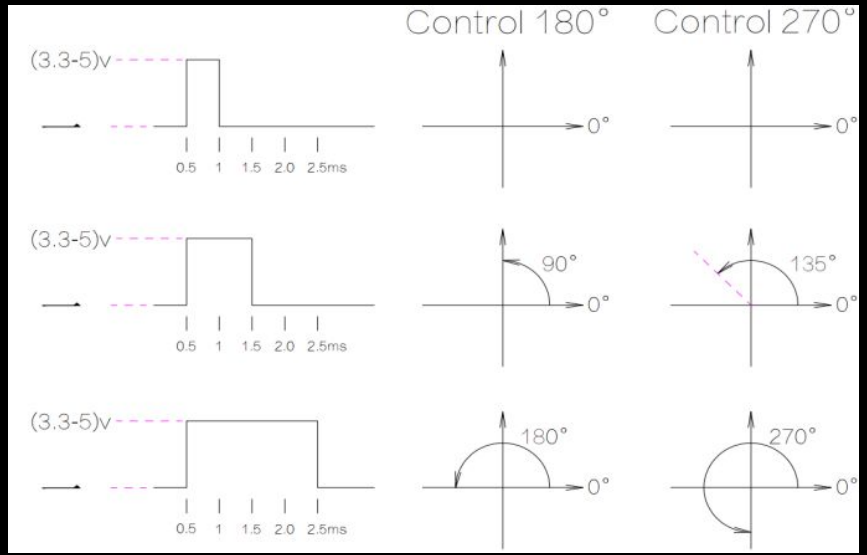
QUESTION #11

WHAT IS THE DEAD BAND WIDTH VALUE COMMONLY LISTED IN THE DATASHEET OF A SERVO?

It’s the minimum change in input signal required before the servo moves. A typical value is 5–10 µs, preventing jitter from minor signal noise.

QUESTION #12

THE FOLLOWING IS TAKEN FROM A SERVO SPEC SHEET. WHAT IS ITS DUTY CYCLE? EXPLAIN THE DATA.



A **duty cycle** refers to the **percentage of time the PWM signal is HIGH** within its 20 ms cycle.

For example, a **1.5 ms pulse width in a 20 ms period = 7.5% duty cycle** (1.5/20 × 100).

This duty cycle corresponds to the servo angle — e.g., 1 ms = 0°, 1.5 ms = 90°, 2 ms = 180°.