EE-208 CONTROL ENGINEERING LABORATORY

EXPERIMENT-10

Performance of a stepper motor as servo and drive actuator

Submitted By:

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Introduction:

- A stepper motor is a type of motor that responds to electrical pulses typically by moving in discrete steps or increments.
- Since stepper motors are open-loop devices, they can calculate their position without the need for feedback. Sending a series of pulses to them causes them to move in a certain way.
- Real life applications of stepper motor:
    1. 3D-Printing
    2. CNC Machines
    3. Printers and Plotters
    4. Camera Stabilisation
    5. Biomedical machines
    6. Laboratory Equipment

Objective:

Performance evaluation of a 1.8° stepper motor for servo and drive operations.

Approach:

In this experiment we are provided with a 1.8° stepper motor, complete with controlling IC's in the form of a study kit. Precise specifications are as follows:

- Permanent magnet DC stepper motor with two phase bifilar (two windings on each pole) wound stator.
- Step angle: 1.8° ± 5% non-cumulative.
- Steps per revolutions: 200.

In this experiment we intend to take observations for servo application as well as drive application of the stepper motor. The switching sequence of the stator phases as indicated by the blinking LED's U3-U1-U2-U4 given on the top of the kit is as follows:

STEP	PH-1 (U1)	PH-2 (U2)	A-2 (U3)	B-2 (U4)
1	1	0	1	0
2	0	1	1	0
3	0	1	0	1
4	1	0	0	1

For servo operation:

1. Configure the switch SW3 in Step mode and trun the Mode switch to Automatic followed by pressing the RESET button.
2. Enter the number of steps for servo application by pressing the UP button.
3. Turn the swtich to MANUAL.
4. By pressing CN1 turn the motor ahead repeatedly and number of steps decreases by each rotation.
5. Set the switch to AUTOMATIC and press the RESET button.
6. For rotation in opposite direction enter the negative number of steps by pressing the down button. Follow the same procedure for the rotation in opposite direction.

For Drive operation:

1. Configure the switch SW3 to Free Run.
2. Select the rotation type by turning the switch SW1 to clockwise or anti - clockwise direction and power ON the setup.
3. Turn the mode switch to MANUAL and press the RESET button.
4. The speed control potentiometer can be used to run the motor as a drive by fast changing excitation of stator windings.

5. Initially the potentiometer is set at its lowest position indicating the slowest speed, by using timer on our phone calculate the time taken by the motor to complete say 20 revolutions.
6. Approximate the steps taken for one complete revolution and calculate the angle measured ($\Theta_{MEASURED)}$) and its corresponding error percentage.
7. From the data above we can calculate the angular speed (ω_r) of the stepper motor at different potentiometer voltage levels and compute the error between them.

OBSERVATIONS:

Servo Operation:

NUMBER OF STEPS	$\Theta_{THEORETICAL}$	$\Theta_{MEASURED}$ = (NO. OF STEPS ×1.8°)	ERROR (%)
10	18°	18°	0%
52	90°	93.6°	4%
105	180°	189°	5%
203	360	365.4°	1.5%

The error observed is within the permissible limits set between 0-5% by the manufacturer of the kit. The sources of errors may be because of:

1. **Interference and noise:**

   Electromagnetic interference, electrical noise from neighbouring equipment, and power sources can all interfere with the signals traveling to and from the motor, causing the step size to vary.

2. **Electromagnetic Interference (EMI):** Electromagnetic interference from nearby electronic devices or power sources can disrupt the control signals and cause erratic motor behaviour.

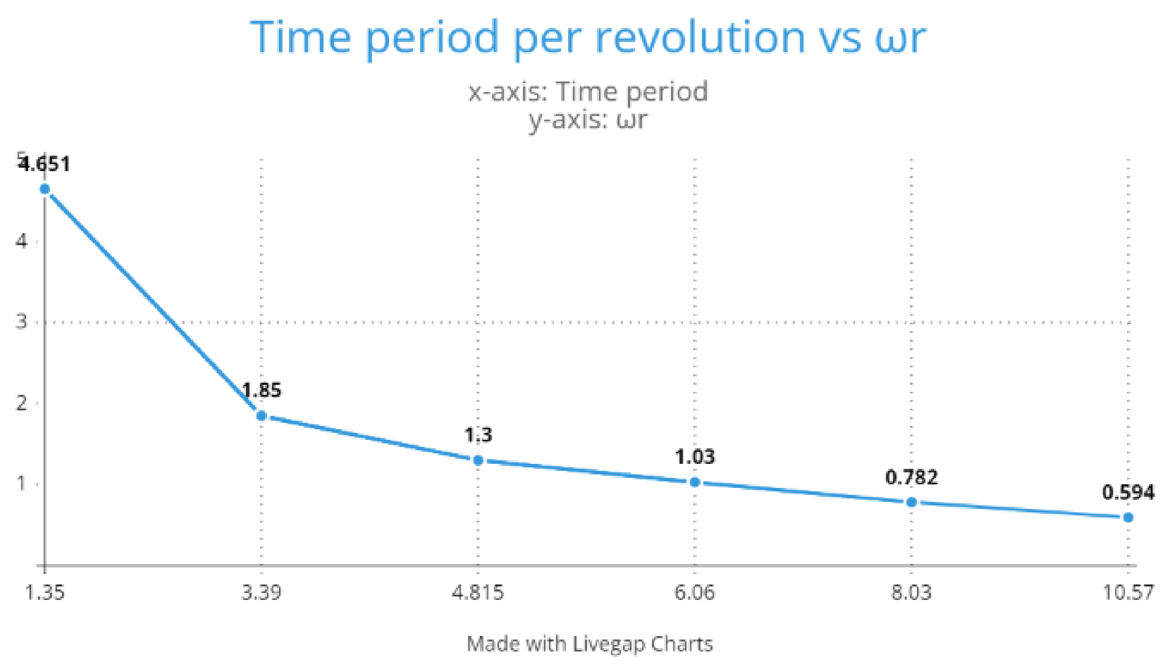
Drive Operation:

- Readings for the drive operation were taken by increasing the potentiometer voltage in every successive observation.
- Stop watch was used to calculate the time period of revolutions of the stepper motor and for one cycle time period, the total time period was divided by number of revolutions.
- For calculating the ω_r we performed: , where 'T' is the time period for one revolution.

S No.	Number of Revolutions	Number of STEPS	STEPS per revolution (360°)	$\Theta_{THEORETICAL}$	$\Theta_{MEASURED}$ = (No. of steps ×1.8°)	Time taken (sec)	Time taken per rev.	ω_r (rad/sec)	Error (%)
1.	20	4180	209	360°	376.2°	211.4	10.57	0.594	4.5%
2.	20	4122	206	360°	370.8°	160.6	8.03	0.782	2.9%
3.	20	4100	205	360°	369°	121.2	6.06	1.03	2.5%
4.	20	4082	204	360°	367.2°	96.3	4.815	1.30	2%
5.	20	4060	203	360°	365.4°	67.8	3.39	1.85	1.5%
6.	28	5665	202	360°	363.6°	38.07	1.35	4.651	1.16

Sources of error may be because interference and noise, microcontroller programming delay, environmental factors such as heat, driver configuration delay etc.

GRAPH:



CONCLUSION:

- As per the observed readings of servo operation, we observed the maximum error to be 5% and minimum error to be 0% which were both in the permissible limits as per the apparatus designed by the manufacturer.
- Hence based upon our readings for drive operation, we observed the longest time taken to be 10.57 seconds and shortest time taken to be 1.35 seconds for completing one 0-360° complete cycle. The maximum error percentage observed was 4.5% and minimum error percentage was found to be 1.16% which were both in the permissible limits as per the apparatus designed by the manufacturer.

Key take-aways from the experiment:

1. Understood the servo and drive operation of the stepper motor.
2. Understood the sources of error of both the operations.
3. Understood that stepper motors and basically open loop systems, i.e they don’t provide feedback on their position.
4. Learned how to generate correct pulse sequence for desired motor movement.
5. Acquired practical experience in setting up, configuring, and controlling stepper motors.