**Feedback Control Systems**

**Lab Report 8**

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**19l-1316**

**Section-6B2**

**QNET DC Motor Speed Control**

**INTRODUCTION:**

The proportional integral control system is used to regulate the DC motor's speed. Set point weight is also included in the PI control. The exchange capability addressing the DC-engine speed voltage connection is utilized to plan the PI regulator. The numerical model of a DC engine has created and its actual boundaries are distinguished in past examination. When the model is confirmed it is utilized to plan a corresponding fundamental, or PI, regulator that should meet specific given particulars The exchange capability addressing the DC engine speed-voltage connection in Condition 1 is utilized to plan the PI regulator. For a PI controller with setpoint weighting, the time-domain input-output relation is. Where is the integral gain, is the proportional gain, and is the set point weight, respectively. The standard second-order transfer function has the form Where is the natural undamped frequency and is the damping ratio. The closed loop transfer function from the speed reference, r, to the angular motor speed output, Wm, is We can determine the expressions for control gains and by comparing the characteristic equations of 2 and 3.

**OBJECTIVES:**

• Design a PI controller to regulate the speed of the DC motor

**Procedure:**

1. Open the QNET\_DCMCT\_Speed\_Control.vi.

2. Ensure the correct Device is chosen.

3. Run the QNET\_DCMCT\_Speed\_Control vi. The motor should begin rotating.

4. In the Signal Generator section set: Signal type = ‘square wave’ Amplitude = 25.0 rad/s Frequency = 0.40 Hz Offset = 100.0 rad/s

5. In the Control Parameters section set: kp = 0.050 V.s/rad ki = 1.00 V/rad bsp = 0.00

6. Examine the behavior of the measured speed, shown in red, with respect to the reference speed, shown in blue, in the Speed (rad/s) scope. Explain what is happening.

7. Increment and decrement kp by steps of 0.005 V.s/rad.

8. Look at the changes in the measured signal with respect to the reference signal. Explain the performance difference of changing kp.

9. Set to kp to 0 V.s/rad The motor should stop spinning.

10. Increment the integral gain, ki , by steps of 0.05 V/rad. Vary the integral gain between 0.05 V/rad and 1.00 V/rad.

11. Examine the response of the measured speed in the Speed (rad/s) scope and compare the result with is set low to when it is set high. Explain what is happening?

12. Stop the VI by clicking on the Stop button.

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| --- | --- |
| Graph when Kp is 0.05 | Graph when Kp is increased  Chart  Description automatically generated |

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| Graph when Ki is 0.05 | Graph when Ki is 1  Chart  Description automatically generated |

1. Using the equations 8.9 and 8.10 , Record the expected peak time, , and percentage overshoot, PO in table 8.1, given the following Speed Lab Designs (SLD) specifications:

ζ= 0.75 Wn= 16.0 rad/s

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| --- | --- | --- | --- | --- |
| Description | | Symbol | Value | Unit |
|  | Natural frequency | Wn | 16 | rad/s |
| Damping ratio | ζ | 0.75 |  |
| Peak time | | tp | 0.2968 | S |
| Percentage overshoot | | PO | 9.68 | % |

1. Calculate the proportional, kp, and the integral, ki, control gains according to the model parameters (found in modeling section, Exp # 7) and SLD specifications and write the calculated values in table 8.2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | | Symbol | Value | Unit |
| SLD specifications | Natural frequency | Wn | 16.0 | rad/s |
| Damping ratio | ζ | 0.75 |  |
| Steady-state model gain | | K | 29 | rad/(V.s) |
| Model time constant | | t | 0.06 | S |
| Proportional gain | | kp | 0.01517 | V.s/rad |
| Integral gain | | ki | 0.529 | V/rad |

3. Run the QNET\_DCMCT\_Speed\_Control.vi. The motor should begin spinning.

4. In the Signal Generator set Signal type = ‘square wave’ Amplitude = 25.0 rad/s Frequency = 0.40 Hz Offset = 100.0 rad/s

5. In the Control Parameters section, enter the SLD PI control gains found in table 8.2 and make sure bsp = 0.00.

6. Stop the VI when you obtain two sample cycles by clicking on the Stop button.

7. Capture the measured SLD speed response. Make sure you include both the Speed (rad/s) and the control signal Voltage (V) scopes.

8. Measure the peak time and percentage overshoot of the measured SLD response. Are the specifications satisfied?

9. Write down the effect of increasing the specification have on the measured speed response in Table 8.3? How about on the control gains?

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| --- | --- | --- | --- |
| Description | Symbol | Behaviour | Unit |
| Peak time | tp | 0.23 | S |
| Percent overshoot | PO | 12 | % |
| Proportional gain | kp | 0.0152 | V.s/rad |
| Integral gain | ki | 0.529 | V/rad |

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| Chart, line chart  Description automatically generated | Chart, line chart  Description automatically generated |

10. Write down the effect of increasing specification have on the measured speed response and the generated control gains in Table 8.4.

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| --- | --- | --- | --- |
| Description | Symbol | Behaviour | Behaviour |
| Peak time | tp | 0.28 | s |
| Percent overshoot | PO | 2 | % |
| Proportional gain | kp | 0.031 | V.s/rad |
| Integral gain | ki | 0.529 | V/rad |

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1. Run the QNET\_DCMCT\_Speed\_Control vi. The motor should begin rotating.

2. In the Signal Generator section set: Signal type = ‘square wave’ Amplitude = 25.0 rad/s Frequency = 0.40 Hz Offset = 100.0 rad/s

3. In the Control Parameters section set: kp= 0.050 V.s /rad, ki= 1.00 V/rad, bsp= 0.00

4. Increment the set-point weight parameter in steps of 0.05. Vary the parameterbetween 0 and 1.

5. Examine the effect that raising bsp has on the shape of the measured speed signal in the Speed (rad/s) scope. Explain what the set-point weight parameter is doing.

6. Stop the VI by clicking on the Stop button

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1. Run the QNET\_DCMCT\_Speed\_Control vi. The motor should begin rotating.

2. In the Signal Generator section set: Signal type = ‘triangular wave’ Amplitude = 50.0 rad/s

Frequency = 0.40 Hz Offset = 100.0 rad/s

3. In the Control Parameters section set: kp= 0.020, ki= 0.00, bsp= 1.00

4. Compare the measured speed and the reference speed. Explain why there is a tracking error

5. Increase to 0.1 V/rad and examine the response. Vary between 0.1 V/rad and 1.0 V/rad.

6. What effect does increasing have on the tracking ability of the measured signal? Explain using the observed behavior in the scope.

7. Stop the VI by clicking on the Stop button.

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| --- | --- | --- |
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**Application:**

Understanding the characteristics of motor speed control and step response can benefit greatly from the concepts used in this lab.

**Issues:**

No issue found while performing the lab.

**Conclusion:**

In this lab We are now able to comprehend the characteristics of the motor's step response because all the tasks were carried out correctly.

**Post lab:**

1. **What do you understand by inertia, friction and dampening?**

**Ans:** **Inertia**: Rotational inertia is a property of any object which can be rotated. It is a scalar value which tells us how difficult it is to change the rotational velocity of the object around a given rotational axis.

**Friction:** Friction is the resistance to motion of one object moving relative to another. It is not a fundamental force, like gravity or electromagnetism. Instead, scientists believe it is the result of the electromagnetic attraction between charged particles in two touching surfaces.

**Damping:** Damping is any effect, either deliberately engendered or inherent to a system that tends to reduce the amplitude of oscillations. In applied mathematics, damping is mathematically modelled as a force with magnitude proportional to that of the velocity of the object but opposite in direction to it.

1. **What kind of controller is used to control the speed of the motor? Give reasons to support your answer.**

**Ans:** The Proportional-Integral-Derivative (PID) controller. The PID controller is widely employed because it is very understandable and because it is quite effective. One attraction of the PID controller is that all engineers understand conceptually differentiation and integration, so they can implement the control system even without a deep understanding of control theory. Further, even though the compensator is simple, it is quite sophisticated in that it captures the history of the system (through integration) and anticipates the future behaviour of the system (through differentiation).

1. **Explain the purpose of proportional, integral and derivative gains and how do they affect the speed of the motor.**

**Ans:** These are control parameters and use to control overshoot and settling time etc.speed increases as kp increases and also increases due to increase in kd.