Control System for a Motor Controller

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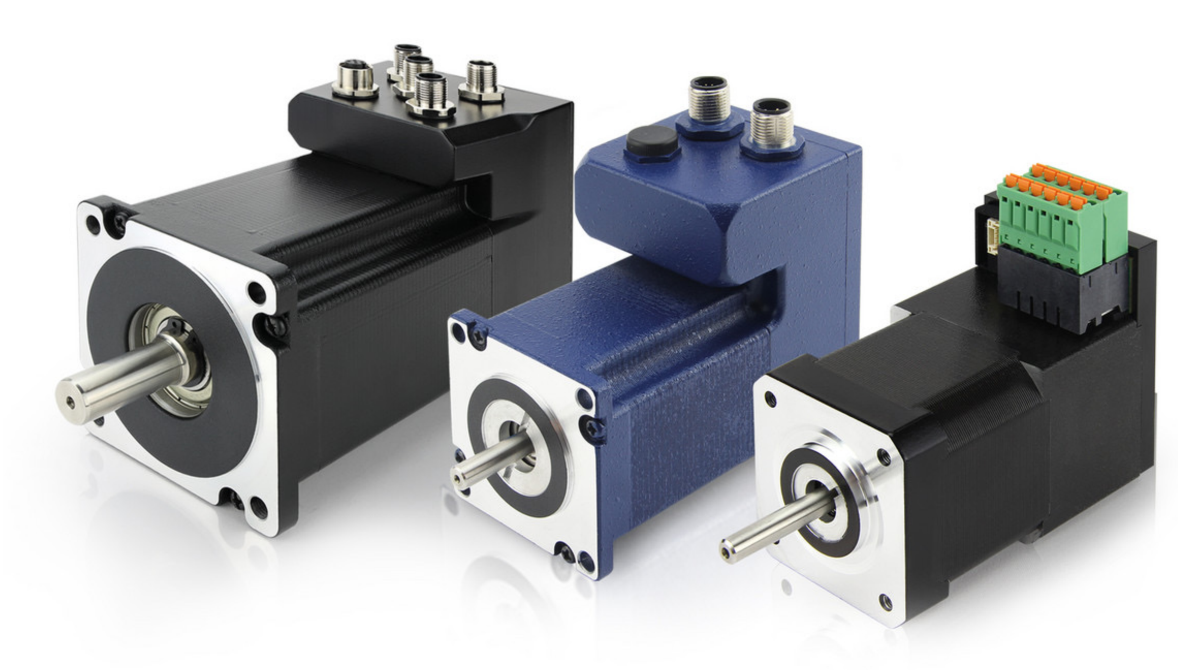
ENGR 480: Modern Control

Many industrial and consumer products rely on precisely controlling the speed of an electric motor. Examples include CD players and printers. Which is why we are modelling and understanding how to control the speed of the motor.

Objectives

Modelling the speed of an electric motor. The motivation behind this system is that modern technologies rely on controlling the precise speed and movement of a motor output.



Phases

Phase 1: Perform Eigen-analysis

Phase 2: Analyze the input response and step response of the state space equation.

Phase 3: Analyze the controllability and observability of the system.

Phase 4: Analyze the stability of the system and control the system based on the stability.

The following equations were made to analyze the control system

Momentum Balance: $J\frac{d\omega}{dt} + D\omega = kI$

Kirchhoff's Law: $E = RI + L\frac{dI}{dt} + V - k\frac{d\omega}{dt}$

$$I = C\frac{dV}{dt}$$

where,

I is the current through the rotor,
V is the Voltage across the capacitor,
ω is the angular velocity of the rotor,
E is the control signal voltage applied to the rotor,
k, D, J, L, C are all constant values.

$$\frac{dx}{dt} = \begin{bmatrix} -\frac{D}{J} & 0 & \frac{k}{J} \\ 0 & 0 & \frac{1}{C} \\ -\frac{kD}{JL} & -\frac{1}{L} & \frac{k^2}{JL} - \frac{R}{L} \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ \frac{1}{L} \end{bmatrix} u$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} x$$

```
A =

   -1.6667         0    0.6667
         0         0    0.0200
   -0.1667   -0.0100    0.0167

>> B = [0; 0; 0.0100]

B =

         0
         0
    0.0100
```

```
>> C = [1 0 0]

C =

     1     0     0

>> D = [0]

D =

     0
```

Phase 1

In lab 1 the following results were achieved: eigen vectors, eigen values and the Jordan form the model:

Eigenvalues

```
   -1.5979         0         0
         0   -0.0478         0
         0         0   -0.0044
```

Eigenvectors

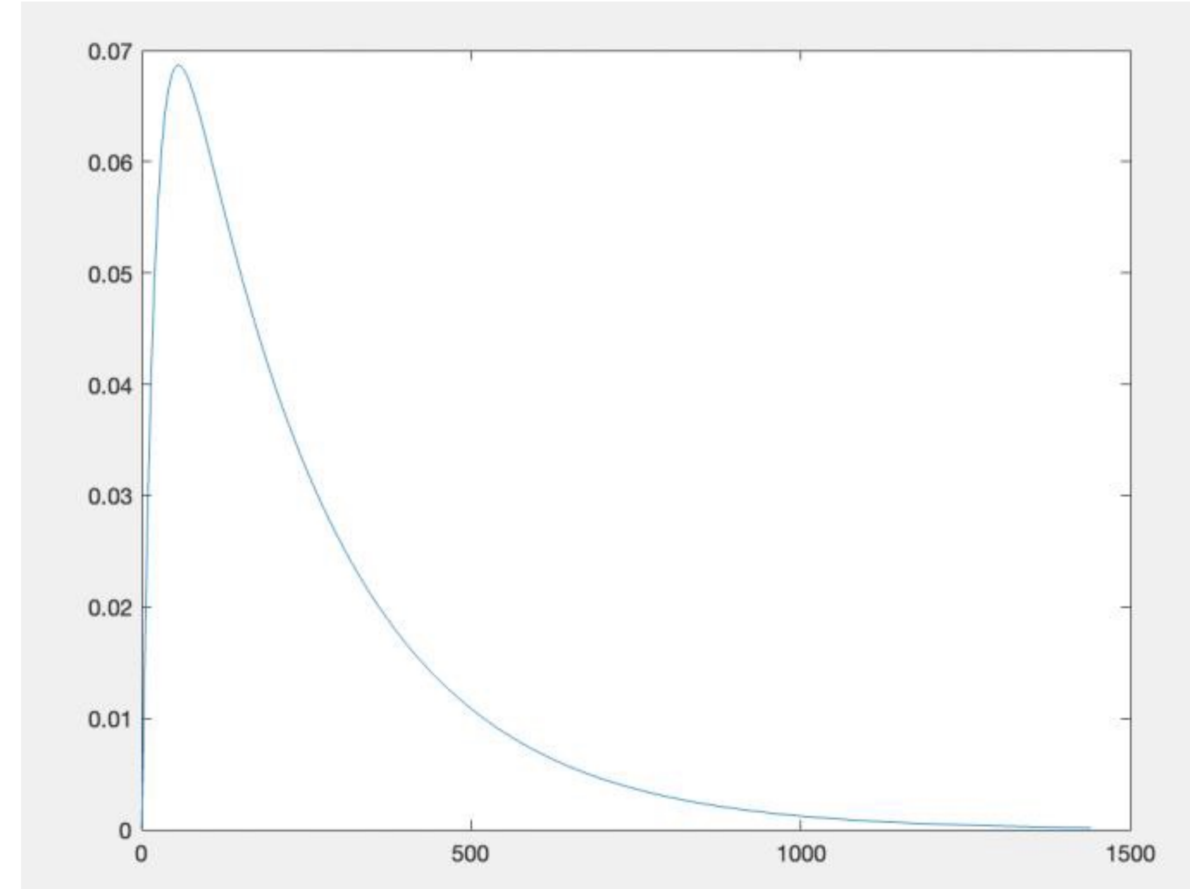
```
   -1.5979         0         0
         0   -0.0478         0
         0         0   -0.0044
```

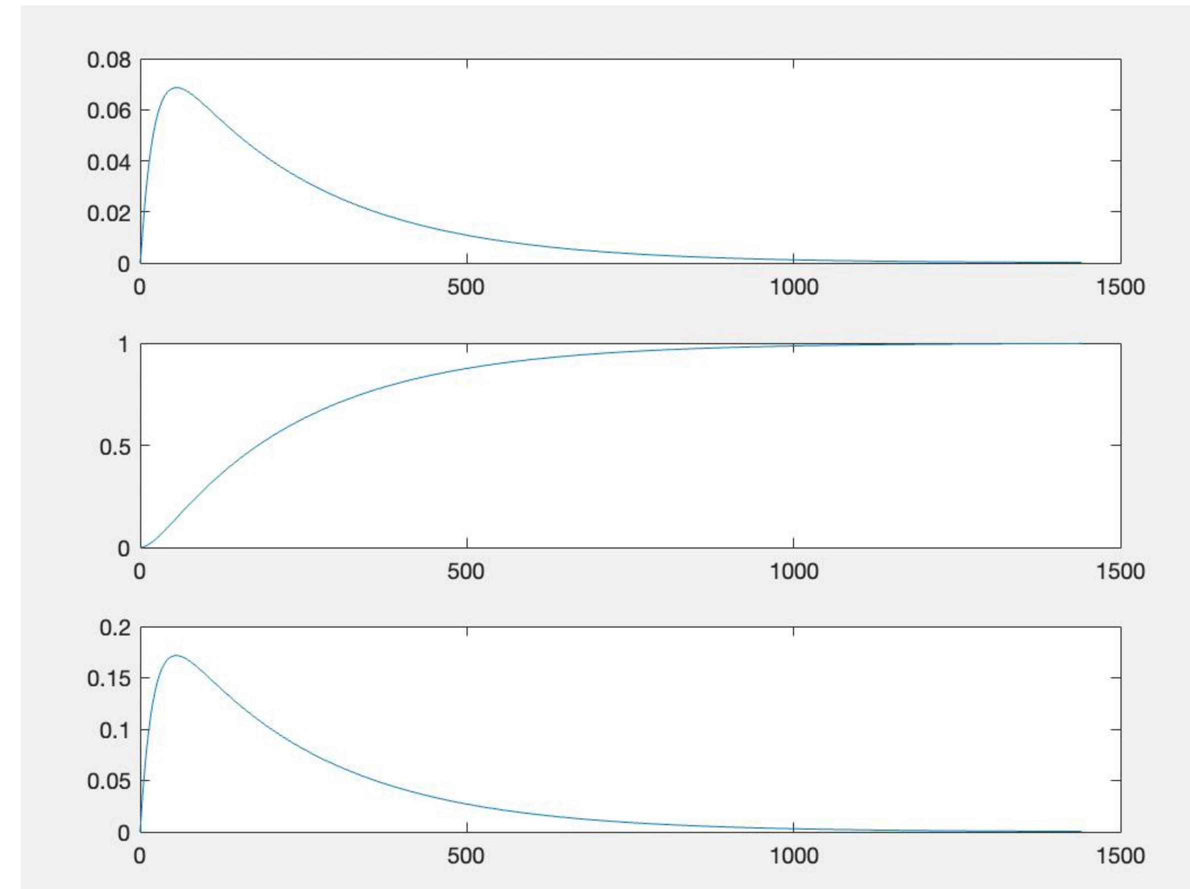
Jordan and Q Matrix

```
Q =

   0.4011 + 0.0000i   9.6879 - 0.0000i   0.4118 - 0.0000i
  -4.5809 + 0.0000i  -0.0125 + 0.0000i  -0.4186 + 0.0000i
   1.0000 + 0.0000i   1.0000 + 0.0000i   1.0000 + 0.0000i


J =

  -0.0044 - 0.0000i   0.0000 + 0.0000i   0.0000 + 0.0000i
   0.0000 + 0.0000i  -1.5979 + 0.0000i   0.0000 + 0.0000i
   0.0000 + 0.0000i   0.0000 + 0.0000i  -0.0478 + 0.0000i
```

Phase 2

In lab 2 the step response, state response. It was found that the system is stable:





Phase 3

In lab 3 controllability and observability of the control system was found. The system is controllable and observable

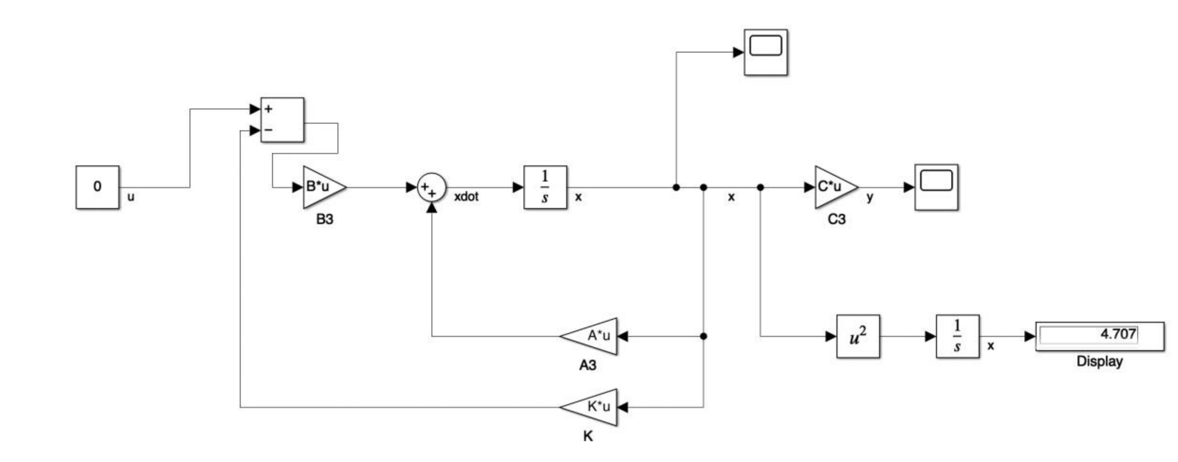
```
CMatrix =

         0    0.0067   -0.0110
         0    0.0002    0.0000
    0.0100    0.0002   -0.0011


C_Rank =

     3
```

```
OMatrix =

    1.0000         0         0
   -1.6667         0    0.6667
    2.6668   -0.0067   -1.1001


O_rank =

     3
```

Phase 4

The system was found to be BIBO and asymptotically stable. Obtained an ISE of 297.9 when poles were [-1 -1 -1].

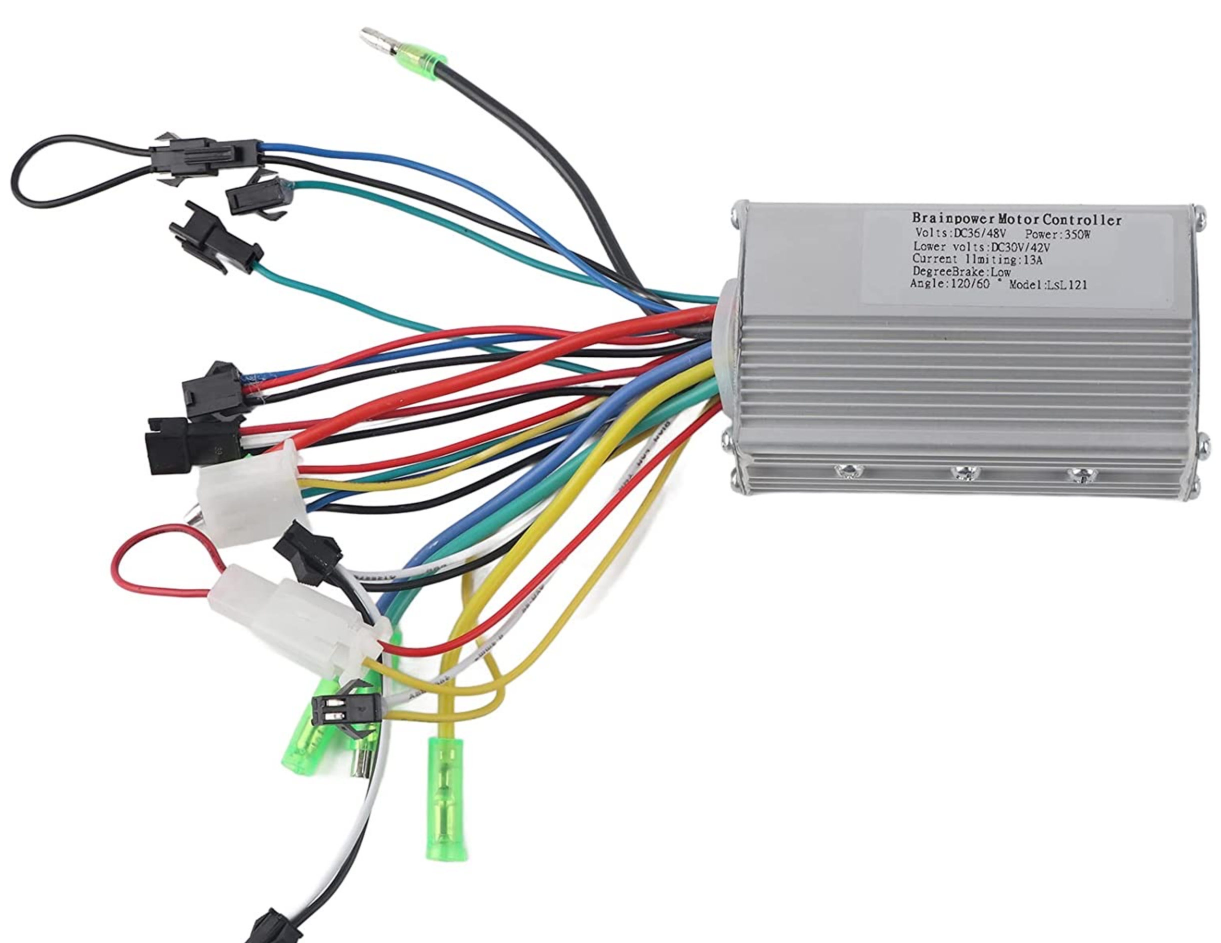
Later, the poles were changed to at [-1 -0.041 -0.1] to obtain controller values that generate a much more stable system at K = [136.0520 11.5997 -50.8000]. the better ISE is 4.707



Conclusion

Main purpose of this lab was to make the model the speed of the motor and introduce a controller to make it more stable. It is made more stable using the Ackerman controller whose values are presented above.

In future it is intended that a much more stable version of the motor find applications in multiple avenues, such as building rovers for space exploration, making many industrial machineries, vehicles, power generation and etc.



References

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