Position Control of a Solenoid Based Linearly Movable Armature System using Robust Control Technique

mustefa jibril[1]

[1]Affiliation not available

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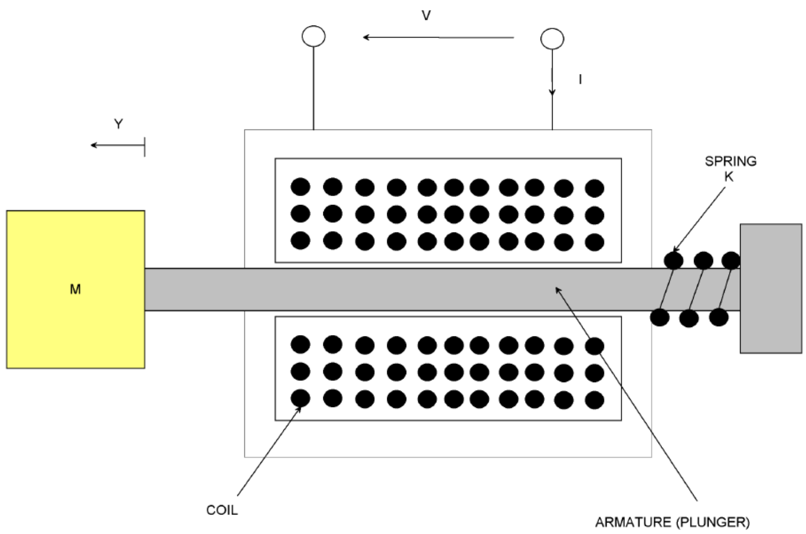

Figure 1 Solenoid based linearly movable armature system

The magnetic flux linkage can be described by

Where

Initial magnetic flux linkage

Differential inductance

Coil inductance

The magnet circuit equation will be

The force exerted by the magnetic circuit to the mass become

The spring-mass system model equation is given by

Upon selecting the voltage *V(t)* as the variable to be manipulated and the linear displacement as the variable to be controlled, substituting Equation (3) in to Equation (4) and in to Equation (2) and taking the Laplace transform results the transfer function

The system parameters are shown in Table 1 below

Table 1 System parameters

No	Parameters	Symbols	Value
1	Mass of the body		3 Kg
2	Resistance of the coil		10 ohm
3	Differential inductance		5 H
4	Coil inductance		10 H
5	Damping friction		3 N-s/m
6	Spring stiffness		6 N/m

The transfer function of the system numerically become

The state space model become

1. **Proposed Controllers Design**
2. **H infinity Mixed-Sensitivity Controller Design**

H infinity mixed-sensitivity evaluates a controller K that minimizes the H infinity norm of the closed-loop transfer function the mixed weighted sensitivity

Where S and T are referred to as the sensitivity and complementary sensitivity, respectively. R measures the manipulate effort. The again controller K is such that S, R, and T fulfill the following loop-shaping inequalities:

Where = GAM. Thus, the inverses of W1 and W3 determine the shapes of sensitivity S and complementary sensitivity T. Typically, you choose a W1 this is large within the desired manipulate bandwidth to acquire accurate disturbance attenuation (i.e., performance). Similarly, you commonly pick a W3 that is large outside the manage bandwidth, which facilitates to make sure precise stability margin. The solenoid based linearly movable armature system with H infinity mixed sensitivity controller block diagram is shown in Figure 2 below.

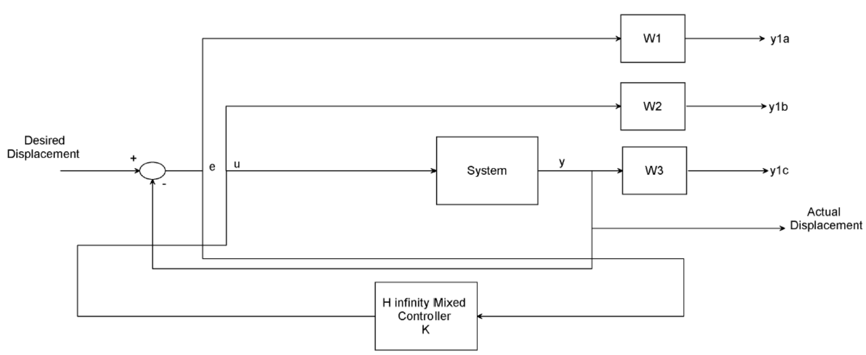

Figure 2 Solenoid based linearly movable armature system with H infinity mixed sensitivity controller block diagram

Here in this system we choose the three weighting functions W1, W2 and W3 as

The Controller transfer function is

Mixed H 2 /H[?] with Regional Pole Placement Controller design

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The mixed H 2 /H[?] control hassle is to reduce the H 2 norm of overall state remarks gains K such that what also satisfies the H[?] norm constraint. Mixed H 2 /H [?] synthesis with regional pole placement is one example of multi-objective layout addressed by means of the LMI. The manipulate problem is sketched in Figure 3. The output channel z is associated with the H [?] overall performance at the same time as the channel z 2 is associated with the H 2 overall performance.

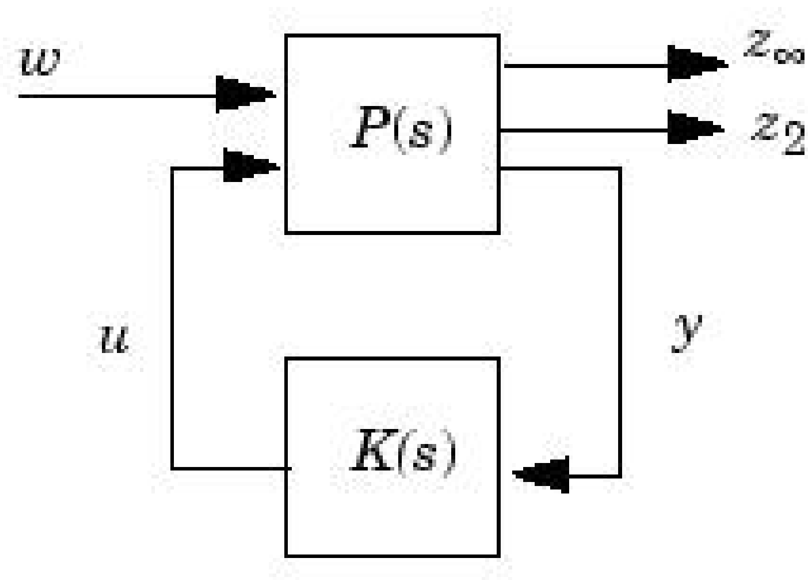

Figure 3 Mixed H 2 /H[?] configuration

The LMI region for the pole placement is determined the use of the command lmireg and we select the 1/2 plane region and the output region is

And we use this region for the mixed H 2 /H[?] controller synthesis.

The transfer function of the controller is

Result and Discussion

In this section, the Simulink model design and simulation of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and Mixed H 2 /H[?] with regional pole placement controllers by comparing the two proposed controllers for tracking the step and sine wave references displacement signals.

Comparison of the proposed controllers for tracking the step reference displacement

The Simulink model of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and mixed H 2 /H[?] with regional pole placement controllers for tracking the step references displacement signal is shown in Figure 4 below.

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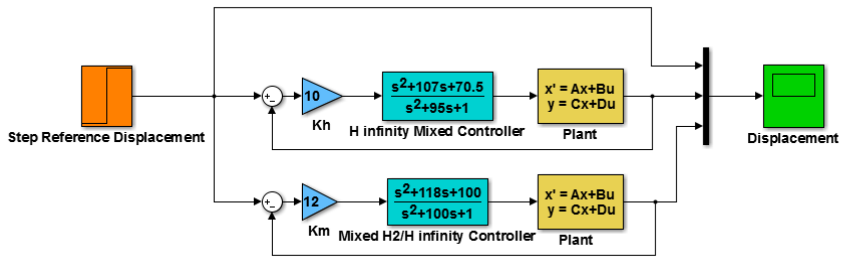

Figure 4 Simulink model of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and mixed H 2 /H[?] with regional pole placement controllers for tracking the step references displacement signal

The solenoid based linearly movable armature system performance for the proposed controllers using a step reference (step change from 0 to 6 m) of the displacement output simulation is shown in Figure 5 below.

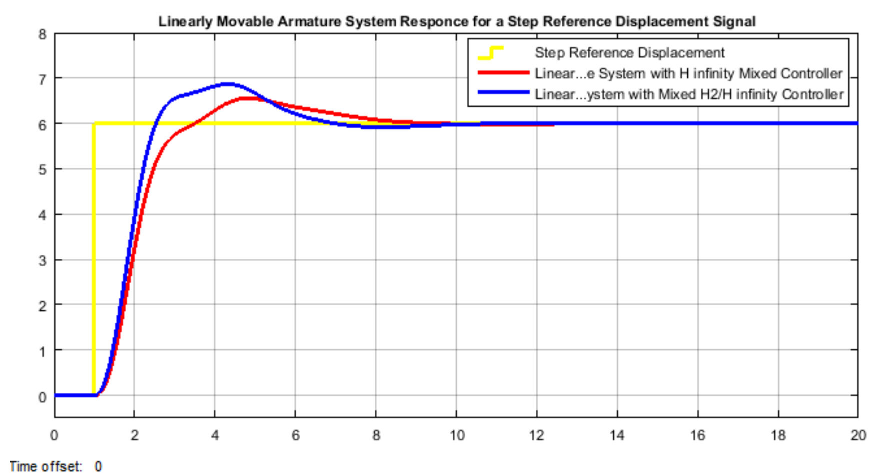

Figure 5 Simulation result for a step reference input

The data of the rise time, percentage overshoot, settling time and peak value is shown in Table 1.

Table 1 Step response data

No	Performance Data	H infinity mixed-sensitivity	Mixed H 2 /H[?]
1	Rise time	2 sec	1.9 sec
2	Per. overshoot	8.33 %	15 %
3	Settling time	10 sec	13 sec
4	Peak value	m	m

Comparison of the proposed controllers for tracking the Sine Wave speed reference

The Simulink model of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and mixed H 2 /H[?] with regional pole placement controllers for tracking the sine wave references displace-

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ment signal is shown in Figure 6 below.

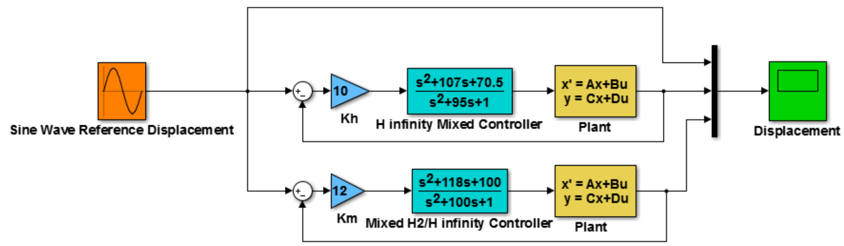

Figure 6 Simulink model of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and mixed H 2 /H[?] with regional pole placement controllers for tracking the sine wave references displacement signal

The solenoid based linearly movable armature system performance for the proposed controllers using a sine wave reference (displacement moving in the forward and reverse with 6 m) of the displacement output simulation is shown in Figure 7 below.

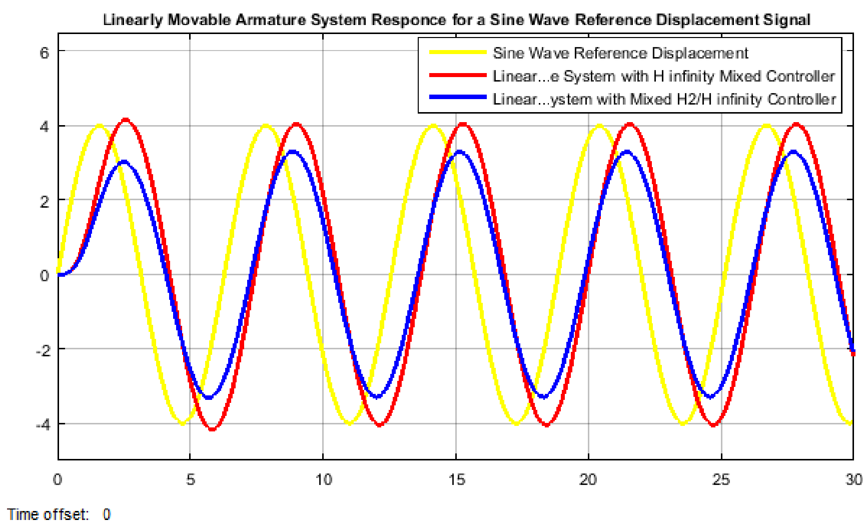

Figure 7 Simulation result for a sine wave reference input

The simulation result shows that the solenoid based linearly movable armature system with H infinity mixed-sensitivity controller track the reference speed better than the solenoid based linearly movable armature system with mixed H 2 /H[?] with regional pole placement controller.

Conclusion

In this paper, modelling, design and control of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and mixed H 2 /H[?] with regional pole placement controllers have been successfully done with the aid of Matlab/Simulink Toolbox. The proposed controllers improved the performance of the position controlling mechanism and comparison of the system with the two controllers for tracking a reference displacement signals (step and sine wave) is done. The solenoid based linearly movable armature system using H infinity mixed-sensitivity controller has better percentage overshoot and settling time in the step

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reference displacement signal and better tracking the input signal in the sine wave reference displacement signal than the solenoid based linearly movable armature system with mixed H 2 /H[?] with regional pole placement controller.

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