International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 7
July 2017

Design of Compensator for Dynamical System

Ms.Saroja S. Chavan
PimpriChinchwad College of Engineering, Pune

Prof. A. B. Patil
PimpriChinchwad College of Engineering, Pune

ABSTRACT
New applications of dynamical system are coming out as technology is growing which require position control and speed control for better and efficient performance. Fin actuation system of missile is one of the such application of dynamical system. Brushless DC motor find a various application in dynamical system such as to position control and speed control due to its advantages over conventional DC motor. But there are different problems in work operation due to fast dynamics and instability. Therefore, in dynamical system, controller plays an important role to achieve stability and to get desired results. To meet this requirement, the response of brushless dc drive system need to be improved. The performance of the typical brushless drive system found to be sluggish. So, it is necessary to improve the performance of such system to expected level. To overcome the shortcomings of conventional method, this paper gives review on various controllers used in dynamical system. Compensator used to improve steady state response and transient response of the system to accommodate required application. So, this paper gives review on selection of compensator and its design techniques to meet system requirement.

Keywords
Dynamical System,BLDCmotor,PIDcontroller,Compensator, Compensator Design methods

1.INTRODUCTION
A dynamical system is a system in which the variables are time-dependent. Fin actuation system of missile is a one of the application of dynamical system. In such system, command signals are translated to physical movement by an electric motor with the help of a precision gear train. The electromechanical actuator assembly mainly consists of the Brushless Direct Current (BLDC) Motor, Gear trains, Feedback sensors, electronics controller, aeronautical or control surfaces. All these are packed together and mounted at the tail end of the missile from the inner side. This forms the missile's Electromechanical Fin Actuator System.Common problems faced in the actuator modeling are that they may be saturated due to their physical constraints such as voltage, current, orslew rate limit. The conventional servo motors do not ensure the required accuracy and dynamic performance. The performance of the typical brushless drive system found to be sluggish. So, it is necessary to improve the performance of such system to expectedlevel.To overcome the shortcomings of conventionalmethod, this system gives methodology of controller design to improve stability andperformance of a guided missilesystem. So,dependingupontherequirementsof the system we have tochoose appropriate controller to improve response of the system.

One basic need of control system design is to obtain desired results, controller and compensator are there to fulfill this need. A controller is tool that forces the output in such direction that it reduces the error e.g., Proportional, Integral, Derivative and PID. The compensator circuit is added to help fix certain system characteristics that outside of a proper operating range.

Academic Science

International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 7
July 2017

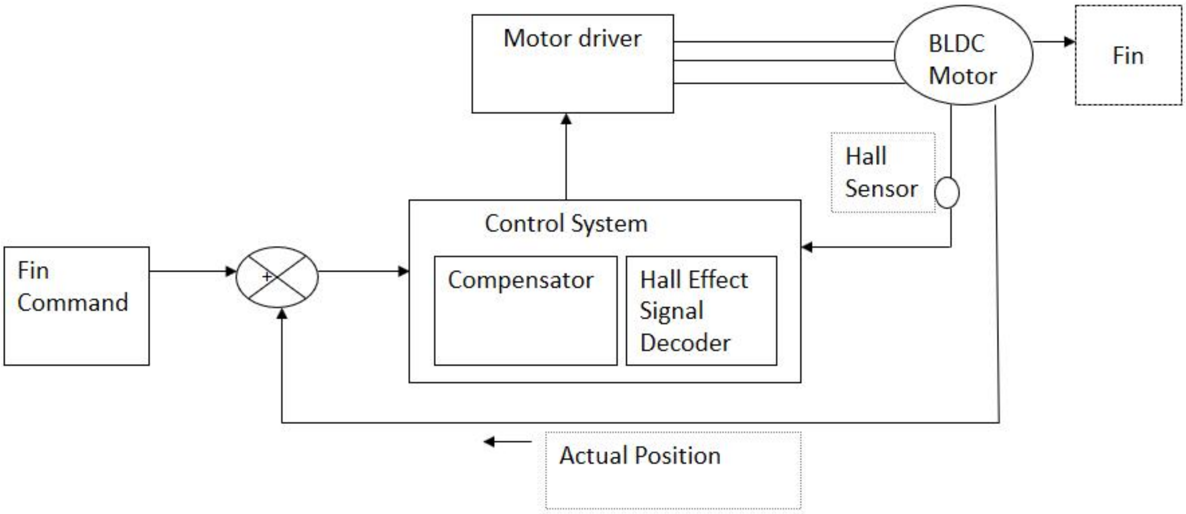

Fig 1: Block Diagram of Dynamical System

The BLDC motor setup consist of motor block, position estimation block provided with hall sensors, control system block provided with compensator, gate pulse generator block with commutation logic and finally inverter block to supply the voltage to the motor. The block diagram of position control of BLDC motor in Fig.1. represents a closed loop position control of BLDC motor system. The position command is sensed by position sensor and it is compared with the reference position command signal. The error signal is applied to control system block consist of compensator. The output obtained after comparison is used to generate PWM signal. The six gating signals which generates phase voltages are provided to inverter to run the BLDC motor. Each dynamic state of motor is modelled using MATLAB/SIMULINK. Control system block containing compensator can be designed to improve response of the compared output. [1].

2.ROLE OF COMPENSATOR IN DYNAMICAL SYSTEM

Compensator used to improve response of the control system to accommodate required application. It is used to improve transient as well as steady state response by improving rise time, settling time, overshoot, steady state error, phase margin, gain margin etc. Due to additional poles and zeros, control system consist of compensator or controller will modify loci shape [7]. It is used to alter phase characteristics of given system. Also help in improving time and frequency response of the system.There are three types of compensator are as follows:

2.1 Lag Compensator

In this, output voltage phase lags the input voltage phase. It helpsto improves steady state response. To improve phase margin, lag compensator is used to reduce gain in high frequency range. Lag compensator reduces the gain in high frequency range to improve phase margin. Transfer function for Lag compensator is given by,

$$C(s)=K\frac{(s+a)}{(s+b)}, \text{ Where } a>b$$

Where ‘a’ is zero, ‘b’ is pole and ‘K’ is compensator gain

2.2 Lead Compensator

In this, output voltage phase leads the phase of input voltage phase. It improves transient response. Lag compensator is used to improve phase margin. But this increase in gain at high frequency due to which

performance of system get sluggish. It helps to improve phase margin, speed response, bandwidth. Transfer function for Lead compensator is given by,

$$C(s)=K\frac{(s+a)}{(s+b)},\ \text{Where } b>a$$

2.3 Lag -Lead Compensator

In this, both phase lag and phase lead occur in the output but in different frequency region. It helps to improve speed response of the system. It helps to reduced percentage overshoot Transfer function for Lag-lead compensator is given by,

$$c = K\frac{(s+a1)(s+a2)}{(s+b1)(s+b2)}, \text{where a1>b1 and b2>a2}$$

3.SELECTION OF COMPENSATOR

The compensation scheme is designed as per requirements and plant dynamics. Lag compensator increases phase margin by reducing the gain crossover frequency. Lead compensator increases Phase margin by adding more phase to the system. Therefore, response of the system with lead compensator will be faster than lag compensator. In servo application, the required gain must be constant.so that lag compensator not suitable for this application. So that the required phase margin without affected gain must use lead compensator. IzI<IpI this properly must be satisfyingin order to work properly. As Phase margin of the system is less, in order to increase it, lead compensator is introduced in the feed forward path. But while inserting a lead compensator it is seen that Phase margin of system is increasing but there is necessarily increase in the gain of the system at high frequency [8]. Due to increase in gain will decrease the stability margin, that will tend to lower the overshoot. but system will be unacceptably sluggish.

Lag compensator gives higher gain at low frequencies as it is low pass filter and reduces gain in high frequency range to improve the phase margin. Lead- lag compensator combines the effects of lead compensator and lag compensator. It takes advantages of both lead compensator and lag compensator. To implement a lead-lagcompensator, first design the lead compensator and then design a lag compensator.

4. ALGORITHM FOR COMPENSATOR DESIGN

1: Identify the system requirements

2: Evaluation of Response Parameters like Percentage overshoot, Settling Time

3: Input Desired Parameters like Dampingfactor, Natural frequency

4: Calculation of pole and zero

5: Calculation of gain (K)

6.Substitution of pole, zero and gain in transfer function of suitable compensator for given system

7.Evaluation of Compensated response

5. COMPENSATOR DESIGN METHODS

5.1 Using Root-Locus

The root-locus method is a graphical method, which is used to analyze the position of the poles and zeros. By using this tool, we can predict for stability.

5.2 Using Bode Plot

Bode plot tool is popular tool used in control system design. Phase margin and gain margin of the controller can be analyzed using bode plot tool.

International Journal of Electronics, Electrical and Computational System
IJEECS
ISSN 2348-117X
Volume 6, Issue 7
July 2017

5.3 Using MATLAB/Simulink

In Matlab Simulink we can design and analyze our system using model. Simply drag tools available in Simulink library according to our system design requirement. For above figure1., we can create model for control system, control Plant like BLDC motor. For this calculation of transfer function of BLDC motor and controller is required. Each component in the design can be modeled using Matlab Simulink.

5.4 Using SISO Tool

Single input single output (SISO) tool is a graphical user interface allow to design single input single output compensator by using root locus plot, bode plot of closed loop or open loop system. Let us consider one example of Lead compensator $G(s) = \frac{1}{s(s+1)}$and design requirements are: , $M_p \leq 20\%$ $t_r \leq 0.3\ s$ .Following are some results obtained using SISO tool:

5.4.1 Simulation resultofUncompensated system

Step response of system gives information about Rise time, Overshoot, Settling time. Following figure.2 shows step response before adding zero.

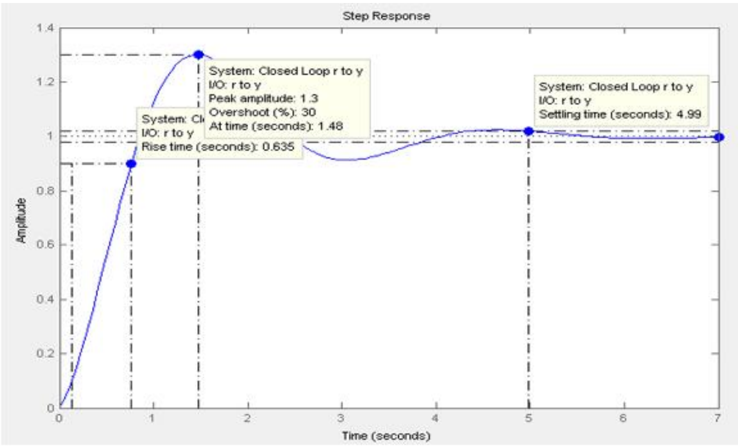

Fig 2:Output response of Uncompensated system

From fig.2 shows that Rise time=0.635, Settling time =4.99 for uncompensated system.

5.4.2 Simulation result of Compensated system

After adding zero (z=8.05) step respose is shown in following Fig.3. from this result one can analyze effect of adding zero on rise time,settling time and peak overshoot.

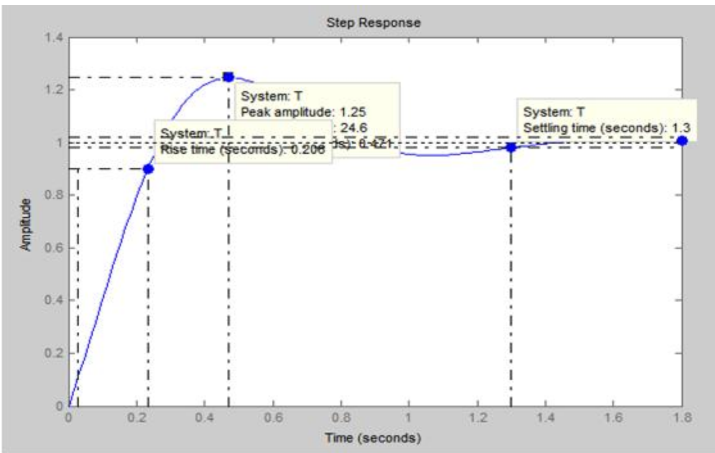

Fig 3:Output response of Compensated system

From fig.3 shows that Rise time=0.206, Settling time =1.3 for uncompensated system. Also from fig. 2 And fig.3 it analyzed that rise time, settling time is smaller in case of compensated system than that of uncompensated system.

5.4.3 Root locus and Bode plot

Following Fig.4. shows root locus plot and bode plot for compensated system and gives phase margin of 51.6 degrees.

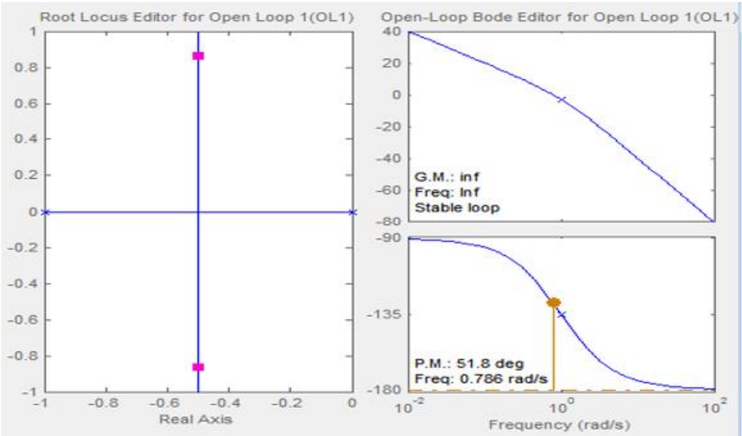

Fig 4:Root locus and Bode plot

CONCLUSION

By developing algorithm for compensator design in dynamical system, steady state response and transient response of the system can be improved. Among the different types of compensator like Lag, Lead, Lag-Lead appropriate compensator can be selected depending upon the system requirement. The model of BLDC motor can be obtained by modeling each block of the setup with its corresponding equations using MATLAB/SIMULINK. Also, Compensator can be designed and modelled. Also analyzed the rise time, settling time in case of both compensated system and uncompensated system.

REFERENCES

[1] E. Anithaet.all "Design of Dynamic States and Digital Speed Control of BLDC Motor" 2016 International Conference on Circuit, Power and Computing Technologies [ICCPCT],2016
[2] R. G. Rajeshet.all " Speed Control of BLDC Motor Using PID Controller" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. 3, Issue 4, April 2014
[3] HemchandImmaneniet.all, "Mathematical modelling and Position control of Brushless DC motor", International Journal of Engineering research and application,2013
[4] MinnuJayan C et.all" Modelling of Quadruplex BLDC motor actuator based position servo system", International journal ISSN,vol3,issue 12,Dec 2012
[5] J V Pavan Chand et.all, "Position Control of DC motor by Compensating strategies", International Journal of Engineering research and technology,2012
[6] JinghuaZhong"PID Controller Tuning: A Short Tutorial Mechanical Engineering, Purdue University Spring, 2006
[7] MohgaAbdAlrhmanet.all " Design of an Appropriate Lead Compensator for a Servomotor", International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391
[8] GeethuBiju Kumar et.all " Servo Design of Electromechanical Actuator Based System for Launch Vehicle Applications", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 2, Issue 5, May 2013