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Design of an Appropriate Lead Compensator for a Servomotor

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Abstract: ***The present paper aims to designing the best controller of the servo motor. Servo motors feature a motion profile, which is a set of instructions programmed into the controller that defines the servo motor operation in terms of time, position, and velocity based on compensator modern control system. The control method is used to determine the gains of the controllers to apply the lead compensator The transfer equation of control system with required controller gains is established. The transfer functions for the servo motor system is obtained based on automatic control principles. The lead compensator for open loop is drawn and then gain margin values is .Finally the step responses of the closed loop system with servo motor system controller were drawn. The simulation results have proven the effectiveness of adding a lead compensator to a servomotor system on the overall gain margin value which is settable for the system under control.***

Keywords: servo motor, compensator, lead compensator.

1. Introduction

The term automation system identifies the technology that uses control system to manage machine and process reducing the need for human intervention. The automation is introduced to perform repetitive, complex or heavy operations where the environment is unsafe or unsuitable for human operators .moreover, automation employed to obtain a high quality band fast production [1] The main objective of this design is to obtain the ideal control system of servo motor by improving the speed and the torque using compensator to eliminate the overshoot, decrease the rise time, and eliminate steady-state error. The steps taken in the proposed design of the servo motor system is to ensure that it's response should be acceptable, which means that it's response characteristic, rise time, over shoot, and the steady state are in particular should be in the desired range . Its transfer function which depends on the system parameters must be adjusted to meet the required response.

The servo motors which are utilized as DC servo motor generally have separate DC source for field winding and armature winding. The control can be archived either by controlling the field current or armature current. Field control has some specific advantages over armature control and on the other hand armature control has also some specific advantages over field control. Which type of control should be applied to the DC servo motor, is being decided depending upon its specific applications [4].

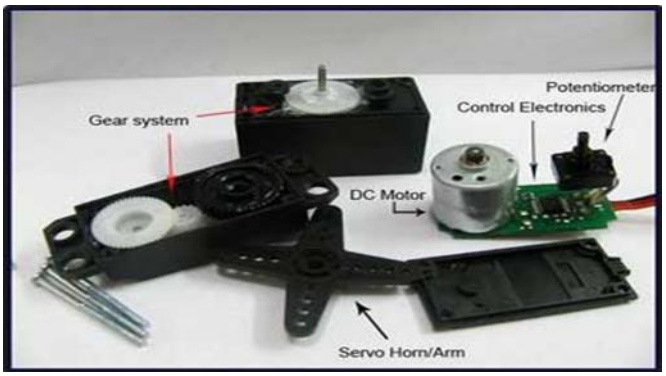

Figure 1: Dc Servo motor [4]

2. System Compensator

System Compensation is known as setting the gains the first step in adjusting the system for satisfactory performance. In many practical cases, however, the adjustment of the gain alone may not provide sufficient alteration of the system behaviour to meet the given specifications. As is frequently the case, increasing the gain value will improve the steady-state behaviourbut will result in poor stability or even instability. It is then necessary to redesign the system (by modifying the structure or by incorporating additional devices or components) to alter the overall behavior so that the system will behave as desired such a redesign or addition of a suitable device is called compensation. A device inserted into the system for the purpose of satisfying the specifications is called a compensator. The compensator compensates for deficit performance of the original system [2].

A compensator, or controller, placed forward path of control system will modify the shape of the loci if it contains additional poles and zeros [2] Compensator use to improve response of control system to accommodate the required application. By increasing the phase margin without effect in required magnitude of gain and there are two type of compensator lead compensator and lag compensator. Lag compensator increases the phase margin by reducing the

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gain crossover frequency and the lead compensator increases the phase margin by adding more phases to the system. Therefore the response of the system with the lead compensator will generally be faster than that of the same system with a lag compensator. The choice of controller will depend on the application requirement and constraints. In servomotor applications the required gain must be constant so that the lag compensator control not as suitable for this application. So that to alter the required phase margin without effected in required gain must use the lead compensator control [3]. Lead Compensators: There are many ways to realize continuous-time (or analog) lead compensators, such as electronic networks using operational amplifiers, electrical RC networks, and mechanical spring-dashpot systems [3].

$$\text{Tlead (S)} = \frac{s-z}{s-p} \quad (2\text{-}1)$$

To make the compensator work correctly, the following property must be satisfied:

$$|z| < |p|$$

That the lag compensator control not as suitable for this application. So that to alter the required phase margin without effected in required gain must use the lead compensator control [3].

3. Methodology

The methodology followed to achieve the desired system in this paper is could be stated as, first of all it was the modelling of the system this includes, transfer function of the motor system, then comes the setting the requirement and testing the controller with different gains and analysing the result to obtain the final desired controller which alter the required gain margin of the system under control.

1. Transfer Function of the Servo motor System

When servo motor used in applications, the equation which describe the servo motor system must be obtained to improve the system stability of the desired application so we assume that the servo motor equation is:

$$TF = \frac{1}{s^2 + s} \quad (3-1)$$

2. Gain Margin and Phase Margin − measures of stability

Gain and phase margins are measures of stability for a feedback system, though often times only phase margin is used rather than both. Based the Magnitude response of the loop gain.

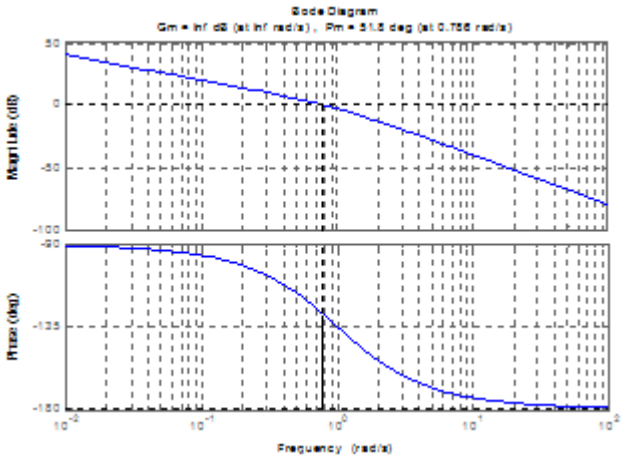

Figure 2: The response of the servo motor equation (1)

4. Software Verification

The system is design and implementing by software knows MATLAB. Nowadays over walling majority of engineers and scientists use MATLAB to analyse and design. A lot of systems and products transforming our world. Actually MATLAB is an automobile active. Safety systems, interplanetary spacecraft, health monitoring devices, smart power grids, in addition to that LTE cellular networks. Indeed it is used for machine learning, signal processing, and image. Processing, computer vision, communications, computational finance, control design, Robotics, and much more applications. [6]

5. Verification Results

When we addgain. The plant deviation from desired response can processed by many ways, the controller can solve this problem.

In this Paper used special type of controller named lead compensator which used in frequency response domain. When added gain (100) and required phase margin 45.but as shown in figure below the required phase margin is very small.

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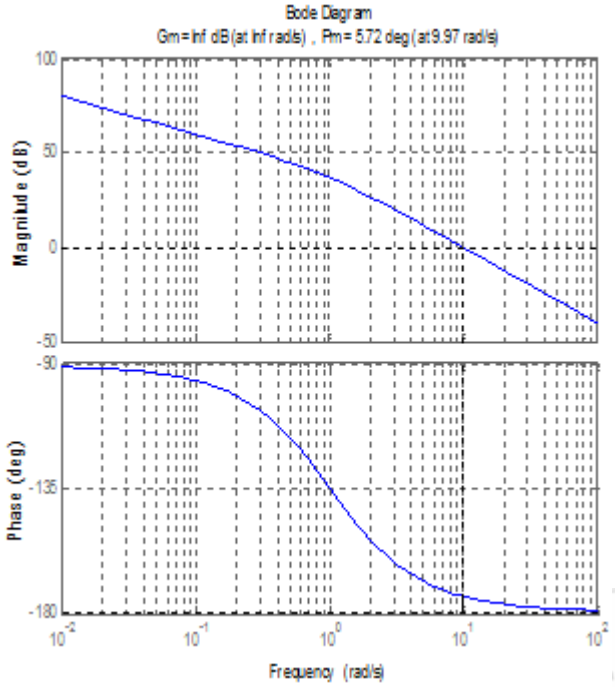

Figure 3: The plant of servomotor without compensator

As shown in figures below obtainedthe desired phase margin after added lead compensator, to the system.

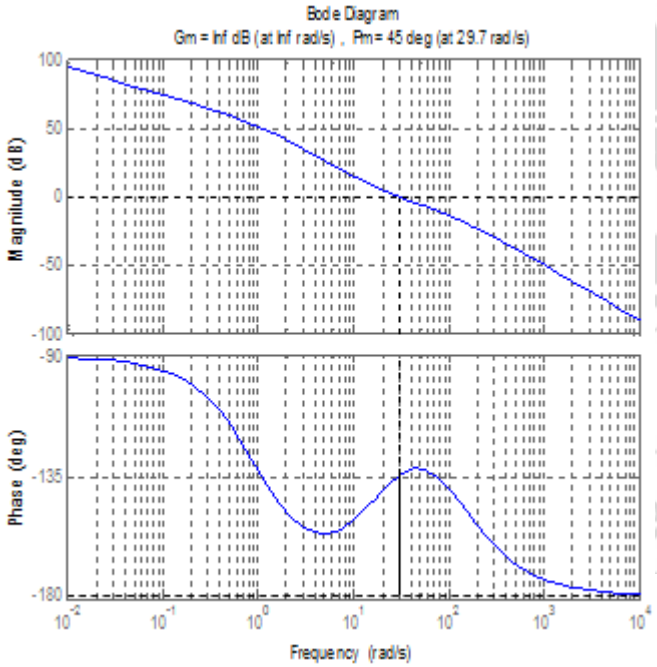

Figure 4: The plant of servomotor with compensator when the gain is 100 and required phase margin is 45.

Note from the figure above the gain required has been obtained when using lead compensator non-impact on the phase margin.

6. Conclusion

Working in frequency response of the system almost faces many problems regarding stability issues .this because methods used in design lead compensator sometime are not preside.

The step response of the servo motor before adding the designed lead compensator has encounter many an acceptable values such as overshoot ,settling time ,rise time ,and steady state .

The lead compensator designed in this paper has proved great effect on the servo motor margin response after adding gain to the servo motor transfer function as summaries in the table blew.

Table 1: Phase margin values

system	*Phase margin value*
Servo motor	51.5
Servo motor after adding gain=100	5.72
Servomotor after adding lead compensator	45

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