ISBN 978-93-5156-328-0
International Conference of Advance Research and Innovation (ICARI-2015)

Designing of Lag compensator using Matlab

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Article Info

Article history:
Received 4 January 2015
Received in revised form
10 January 2015
Accepted 20 January 2015
Available online 31 January 2015

General Terms

Compensator,
Stability Analysis

Keywords

Lag compensator,
Bode plot, and Stability regions,
Settling Time and Matlab,
Overshoot,
Frequency Response

Abstract

The gain crossover frequency and closed-loop bandwidth for the lag-compensated system will be lower than for the uncompensated plant (after the steady-state error specification has been satisfied), so the compensated system will respond more slowly in the time domain. The slower response may be regarded as a disadvantage, but one benefit of a smaller bandwidth is that less noise and other high frequency signals (often unwanted) will be passed by the system. The smaller bandwidth will also provide more stability robustness when the system has unmodeled high frequency dynamics, such as the bending modes in aircraft and spacecraft. Thus, there is a trade-off between having the ability to track rapidly varying reference signals and being able to reject high-frequency disturbances. The design procedure presented here is basically programming based. All of the measurements needed can be obtained from accurate Bode plots of the uncompensated system. If data arrays representing the magnitudes and phases of the system at various frequencies are available, then the procedure can be done numerically, and in many cases automated. The examples and plots presented here are all done in MATLAB.
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1. Introduction

Sometimes it is necessary to compensate an unstable system to make it stable or it may be necessary to improve the existing system to satisfy or to meet the required specifications the system performance is given by time response and frequency response. Main requirement of the control system is accuracy and stability. For greater accuracy of the system steady state error should be small but to reduce the steady state error the gain of the amplifier must be increased, overshoot will also increase and stability will decrease but we are interested in both that is accuracy and stability this can be done by connecting a circuit between error detector and plant known as compensation. The purpose of phase lag compensator design in the frequency domain generally is to satisfy specifications on steady-state accuracy and phase margin.

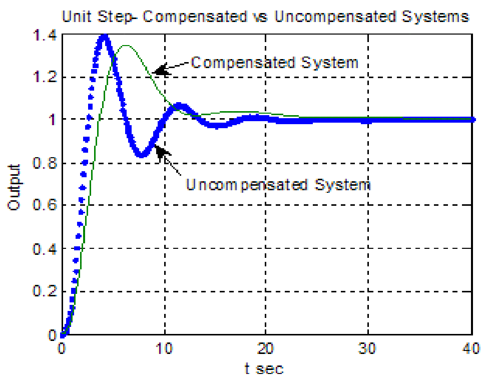

Fig: 1.

There may also be a specification on gain crossover frequency or closed-loop bandwidth. A phase margin specification can represent a requirement on relative stability due to pure time delay in the system, or it can represent desired transient response characteristics that have been translated from the time domain into the frequency domain. The overall philosophy in the design procedure presented here is for the compensator to adjust the system's Bode magnitude curve to establish a gain-crossover frequency, without disturbing the system's phase curve at that frequency and without reducing the zero-frequency magnitude value.

For tuning the phase lead/lag compensators, specific knowledge about the frequency response of the plant is required. Such points are specified by their frequency, gain and phase and cannot be easily found out without the help of an accurate model of the plant.

2. Design Procedure

The basic phase lag compensator consists of a gain, one pole, and one zero. Based on the usual electronic implementation of the compensator, the specific structure of the compensator is:

$Gc\_lag = Kc\,(1(s+zc))/\,(\alpha(s+pc))$ …….. (1)

$Gc\_lag = Kc\,((s/zc+1))/\,((s/pc+1))$ …….. (2)

$Gc\_lag = Kc\,((Ts+1))/\,((\alpha sT+1))$ …….. (3)

With

$zc > 0,\ pc > 0,\ \alpha = zc/pc > 1 \quad T = 1/zc = 1/\alpha pc$

The following steps outline the procedure that will be used to design the phase lag compensator to satisfy steady-state error and phase margin specifications. Each step will be described in detail in the subsequent sections.

1) Determine if the System Type N needs to be increased in order to satisfy the steady-state error specification, and if necessary, augment the plant with the required number of poles at s = 0. Calculate Kc to satisfy the steady-state error.
2) Make the Bode plots of $G(s) = KcGp(s)/s^{(Nreq-Nsys)}$.

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3) Design the lag portion of the compensator:
   a) Determine the frequency where G(jω) would satisfy the phase margin specification if that frequency were the gain crossover frequency;
   b) Determine the amount of attenuation that is required to drop the magnitude of G(jω) down to 0 db at that same frequency, and compute the corresponding α;
   c) Using the value of α and the chosen gain crossover frequency, compute the lag compensator's zero zc and pole pc.
4) If necessary, choose appropriate resistor and capacitor values to implement the compensator design.

Design example:

The plant to be controlled is described by the transfer function

250
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s^3 + 117 s^2 + 2916 s

This is a Type 1 system, so the closed-loop system will have zero steady-state error for a step input, and a non-zero, finite steady-state error for a ramp input (assuming that the closed-loop system is stable).

Also, the error constant.

Steady error, ess : 5

Maximum overshoot, Mp: 45

These specifications do not impose any explicit requirements on the gain crossover frequency or on the type of compensator that should be used. It may be possible to use either lag or lead compensation for this problem, or a combination of the two, but we have used the phase lag compensator design procedure described above.

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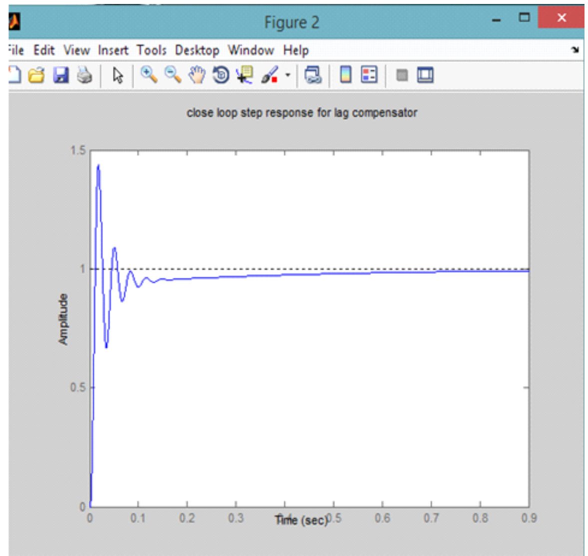
3. Response



4. Conclusion

From above we have concluded that by considering the steady state error ess and peak overshoot Mp we have seen that the response of the system due to decrease in bandwidth, the rise time and the settling time becomes more. As we have shown that the gain will increase by reducing the steady state error, and overshoot also increases as a result of which stability of the system reduces.

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