ACS221 – Control System Design Assignment

Assignment weighting

20% of final Module Mark Assignment Breakdown:

- 70% of Assignment for Technical Solution to Questions
- 30% of Assignment for the General Writing, Presentation and Formatting

Assignment Release Date: 11 April 2015

Assignment Due: Tuesday 25 April 2015 at 5PM. You must submit the completed assignment through Turn-it in on the ACS221 MOLE page as a single .pdf or Word document. You must include your registration number at the top of every page.

Penalties for Late Submission: Late submissions will incur the usual penalties of a 5% reduction in the mark for every working day (or part thereof) that the assignment is late and a mark of zero for submission more than 5 working days late. For more information see http://www.shef.ac.uk/ssid/exams/policies.

Feedback: Feedback will be provided in Week 12. This will include the overall mark, individual component marks and comments on performance on the assignment (in MOLE). Note that marks will be adjusted if plagiarism is detected.

Unfair Means: The assignment should be completed individually. You should not discuss the assignment with other students and should not work together in completing the assignment. The assignment must be wholly your own work. References must be provided to any other work that is used as part of this assignment. Any suspicions of the use of unfair means will be investigated and may lead to penalties. See http://www.shef.ac.uk/ssid/exams/plagiarism for more information.

Special Circumstances: If you have medical or personal circumstances which cause you to be unable to submit this assignment on time or that may have affected your performance, please complete and submit an appropriate circumstances form along with any documentary evidence of the circumstances. Please see: http://www.sheffield.ac.uk/ssid/forms/circs, for guidance as to which form is appropriate for your circumstances, and what, if any, supporting documentation is required.

Learning Outcomes: On completion of the assignment, students should demonstrate:

- Understanding of the design methodologies for lead and lag compensators based on root locus and Bode diagram.
- Ability to design and test a controller starting from performance specifications.
- Ability to use MATLAB in the design process.

Help: This assignment briefing and the lecture notes provide all the information that is required to complete this assignment. It is not expected that you should need to ask further questions. Remember that you need to decide on what the most appropriate approach to

solve the assignment is and also how to present your results. This is part of what you are being assessed on and will assess your knowledge and understanding of the lecture notes.

Notes:

- Remember that in an assignment, there is often no standard "staff answer". You have the freedom to investigate any aspect of the problem that you think is relevant.
- If you cannot meet the specification of the problem exactly with your solution, submit that part you have succeeded with rather than nothing at all. Credit will be given to those students who have carried out additional design iterations and have succeeded to meet the performance requirements.
- You are reminded that this assignment must be carried out independently and the written submission must be the student's own work. Your assignments will be submitted through Turn-it in and checked for potential plagiarism – any unfair means identified will be investigated, and penalties may be applied.

Assignment Briefing:

- Your assignment should be written as a worded document, not just a series of mathematical steps.
- Within your answer to each question, you should provide an introduction to the solution, provide the solution as the 'body' of your answer, and conclude your answer, with respect to the performance specification provided. Each answer should be self-contained, and not refer to a previous or subsequent question.
- Make sure that you explain clearly all the steps in your calculations, write down the equations used, explain the notation, and the choices you made during the design process.
- The report should be word processed. Use Arial 11 point font throughout.
- Page margins should be set to 'normal' (top-bottom-left-right margins all set at 2.54cm).
- Line spacing must be set to "1".
- Figures should be incorporated at the appropriate positions in the text and not as appendices.
- You must include your registration number at the top of every page.
- Appendices are not allowed and will not be marked.

Marking Criteria: This assignment will be marked in two elements:

Technical Content: The technical aspects of this assignment make-up 70% of the final mark for this assignment. The marks awarded for each section of each question are provided in the assignment brief above, and will be used in assessing technical aspects of this assignment.

General Writing, Presentation & Formatting: This will make up 30% of the final mark. The marking criteria, listed below, will be used to assess the technical report writing quality.

General Writing, Presentation & Formatting Criteria

1. Clarity and structure of the report [10 marks]
2. Presentation of mathematical solutions, and formatting [10 marks]
3. Explanations and conclusions [10 marks]

Questions

1. [35 Marks] A unity feedback servo system has a plant with the transfer function given by:

$$G(s) = \frac{5000}{s(s+.3)(s+22)(s+100)}$$

   a. Using the frequency domain approach, determine the gain K required to give an overshoot, in response to a step input, of approximately 20%. Explain how you achieved your result.
   b. Using frequency domain approach, design a lead compensator to achieve a velocity error constant that is at least 35 and a step response overshoot that is no greater than 20%. Describe each stage of your design. If performance specifications are not met first time, perform additional design iterations (i.e. refine the lead compensator or design additional compensators/prefilter).
   Write down the final compensated open- and closed-loop transfer functions and use MATLAB to evaluate the performance of your final design in the time and frequency domain.
   Use MATLAB to plot the response of the control system to a unit ramp, showing both system output and ramp input, and evaluate the percentage steady state error to the ramp input signal.
   Summarize the performance indices of your final design in a table – see Table 1 - and provide a written conclusion for your design.

Quantity	**Value**
Steady state error to a unit ramp	
Rise Time	
Settling Time	
Percentage Overshoot	
Phase Margin	
Gain Margin	
Bandwidth	
Peak Magnitude	
Resonant frequency	

Table 1

2. [35 marks] Consider again the unity feedback servo system with a plant transfer function given by:

$$G(s) = \frac{5000}{s(s+.3)(s+22)(s+100)}$$

   a. Using the root locus approach, design a phase lead compensator to meet the following performance specifications:
      - The settling time resulting from a step input to be less than 4s
      - The overshoot is less than 15%

      Describe clearly each stage of your design. If performance specifications are not met first time try to refine the lead compensator.

   a. Design a phase lag compensator in series with the lead compensator designed in a. such that the steady state error resulting from a ramp input should be no greater than 3.5% of the ramp magnitude. Describe each stage of your design. If performance specifications are not met first time, perform additional design iterations (i.e. refine the lag compensator or design additional compensators/prefilter).

      Write down the final compensated open- and closed-loop transfer functions and use MATLAB to evaluate the performance of your final design in the time and frequency domain.

      Use MATLAB to plot the response of the control system to a unit ramp, showing both system output and ramp input, and evaluate the percentage steady state error to the ramp input signal.

      Summarize the performance indices of your final design in a table – see Table 1 - and provide a written conclusion for your design.

End of Assignment Questions