ECE311
Design Project: Part 3

Aim: To design a more effective compensator for the Buck converter system we have been using. The performance of the closed loop design is compared with open loop performance and the performance of a prior integral compensated design through simulation. The response to a step input will be examined in PECS (a circuit level simulator).

Terminology: T&K refers to the instructor's book: "*Applied Classical and Modern Control System Design***",** by R. Tymerski and F. Rytkonen, available in draft form on the course web site.

Introduction:
So far in this project we have performed the following tasks:

1) **Part 1:** Examined the open-loop performance of our system. Confirmed the modelling approach through transfer function and circuit level simulation.
2) **Part 2a:** Designed an integral controller using Routh-Hurwitz.
3) **Part 2b:** Designed an integral controller using the asymptotic Bode plot method to satisfy specified gain/phase margins.

In this final part we again employ the asymptotic Bode plot method in design to satisfy specified gain/phase margins while maximizing bandwidth, but a more effective compensator will be used to improve performance.

Tasks:
Design a 'dominant pole plus lead' compensator for the system. In T&K this is discussed for the Buck regulator in Section 6.7 starting on page 107. There are two design variations discussed; one being better than the other.

The Bode plot design method discussed in class is to be used. This methodology involves using asymptotic Bode plot construction of the desired loop gain from which simplified equations may be derived for use in the design process. This methodology does not inherently rely on trial and error iteration and so you are requested not to use such an approach.

An integral part of the design methodology is to carefully ***sketch and fully annotate the magnitude and phase asymptotes of the compensated loop gain*** as demonstrated in many places in T&K. (Note: an appreciable portion of the grade for this report is allocated to this task.).

Determine the compensator parameters from simplified equations derived from you asymptotic plots (a reminder again: do not use a trial and error approach for this). Use Matlab to verify your design using the *'margin'* command. Also, obtain a step response of your closed loop system using Matlab/Simulink.

As a final step in the design, implement the compensator as a circuit. The table of compensators on pages 124 and 125 in the instructor's book may be helpful in this regard. Simulate your closed loop system using a circuit based simulator, such as PECS.

Report:

In your report do not copy any figures from T&R. Your own computer generated or neatly hand drawn asymptotic gain and phase plots are required.

Write up a clearly written report presenting your results. Be sure to include all your Matlab code. This normally should go into the appendix. (There needs to be complete transparency as to how your results have been produced). Your report needs to focus on your results so your introduction should be very short. Also present a cogent summary in your conclusion. Clearly state why your design gives the best performance compared to two benchmarks discussed below.

The following is a non-exhaustive list of items you need to provide in your report:

1) The transfer function of the 'dominant pole plus lead' compensator, with the particular pole and zero values determined. The compensator should achieve a phase margin $\geq 45°$ and gain margin ≥ 10 dB, while maximizing loop gain bandwidth. Use overshoot considerations to fine tune these specs. Presentation of the transfer function should be similar to that in Table 6.2 on page 122 of T&K.
2) Sketch of the magnitude and phase asymptotic Bode plots of the compensated loop gain fully annotated. (appreciable effort should be devoted to this task).
3) A Matlab Bode plot of the loop gain, using the *'margin'* command, verifying (2).
4) Step response of your closed loop design using Matlab/Simulink.
5) Step responses of your closed loop system obtained using circuit simulator PECS.
6) A comparison table similar to Table 6.2 on page 122 of T&K, to show a comparison of performance of three systems:
   i) Open loop system (do not close the loop). (From Part 1)
   ii) Closed loop system using integral control. (From Part 2b)
   iii) Your closed loop design using the 'dominant pole plus lead' compensator.

   Feel free to use whatever other performance metrics you like for the comparison.
7) Include all Matlab code and Simulink and circuit simulator (PECS) schematics.
8) Provide a concise explanation of why this compensator results in a much better performance than seen before.

Presentation:

A separate document needs to be produced which is a copy of your presentation slides.

Submission:

Please submit your report and presentation slides to the appropriate dropboxes on D2L by the deadlines stated there.