EE302-S2, Control Systems, Quiz-2 (1st Apr 2024)

Notes & instructions:

- Attempt all the questions: each question carries 10 marks. Unnecessarily long, convolved, redundant or irrelevant text could attract marks-reduction.
- Unless otherwise explicitly specified, k is real and positive.
- If a graph-paper based question is asked, then use graph-paper judiciously after a rough sketch on your own answer-sheet (within 'rough-work', which will **not be evaluated**). Using judiciously will avoid carefully resketching (and save your own time) and also graph-paper.
- Some questions might not have the sought answer. In such a case, give reasons why the sought answer is not possible.
- If you feel a question has ambiguity and/or needs clarification, then assume yourself appropriately, state and justify your assumption and then proceed to solve the problem with that assumption.
  Do not call any TA or instructor for your query.

Ques 1: Consider the standard negative unity feedback configuration with $G(s) = \dfrac{1}{(s+5)(s+6)(s+7)}$.

(a) On a graph-paper, sketch the root-locus for $k > 0$ and **estimate**, using your graph-paper's sketch,

(i) the value of $k > 0$ that makes the closed loop unstable, and

(ii) the frequency ω_c at this value of k.

(Use root-locus asymptotes to estimate: this is adequate accuracy.)

(b) Use Routh-table to obtain exact range of $k > 0$ that results in closed loop instability.

(c) Sketch Nyquist plot and use Nyquist criteria for obtaining exact range of $k > 0$ that results in closed loop instability. (This sketch is on your plain answer sheet, and not on graph paper.)

(d) On (preferably same) graph-paper, sketch Bode gain/phase plots (asymptotic sketch only) to obtain **approximate** range of $k > 0$ that results in closed loop instability.

Ques 2: Consider the polynomial $p(s) = s^8 - 2s^7 - s^6 + s^5 + s^4 + s^3 + 3s + 2$.

(a) Without any calculations, comment

(i) if all roots of $p(s)$ are in the closed left half plane: yes/no,

(ii) if all roots of $p(s)$ are in the open left half plane: yes/no.

Give reasons for each of the comments for (i) and (ii).

(b) Obtain the Routh-Table.

(c) Use the Routh-Table to find the number of roots in the open left half plane, imaginary axis and open right half complex plane, with reasons.

Ques 3: (a) Suggest two different transfer functions $G_1(s)$ and $G_2(s)$ such that they are band-pass filters with asymptotic gain plot as follows:

(b) Give reasons for each of the two transfer functions as to why the specifications (in the plot above) are satisfied.

Ques 4: Draw Bode gain and phase plots for following two transfer functions: both asymptotic & actual.

(a) $\dfrac{5}{s^2 + 0.1s + 10}$, (b) $\dfrac{s-4}{s+8}$.

For each of the transfer function's plots, mark cut-off frequencies and gain/phase values at these cut-off-frequencies.

Ques 5: (a) Explain briefly what is 'lead' and 'lag' about lead and lag compensators respectively.

(b) For each one of these: comment on whether the compensator would be high-pass, all-pass, low-pass or any other.

(c) Give an example of an all-pass filter (i.e. provide numerator and denominator of such a $G(s)$: denominator has to have degree at least one). For the specific example you provide, plot its Bode plot: both gain and phase plots.