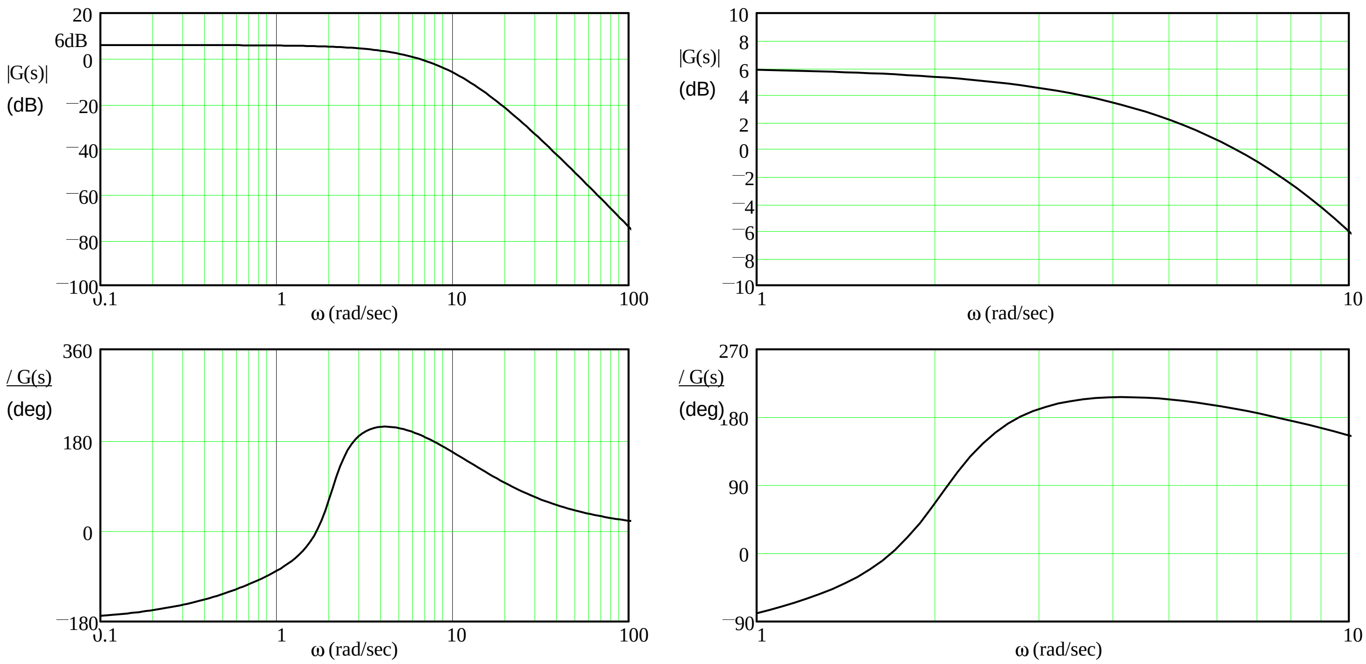
Name: ____________________ Homework # BP3 b

1. Problem 5.13 b & new c & d in the text.

b) Bode plots of the open-loop transfer function of a feedback system are shown below, with the detail from 1 to 10 rad/sec shown on the left. For this system:

- How much can the open-loop gain be changed (increased and/or decreased) before the closed-loop system becomes unstable ?
- What is a rough estimate of the phase margin of the feedback system? Show on the graph how the results are obtained. The numerical results do not have to be precise.
- How much time delay can there be in feedback system before the phase margin disappears.

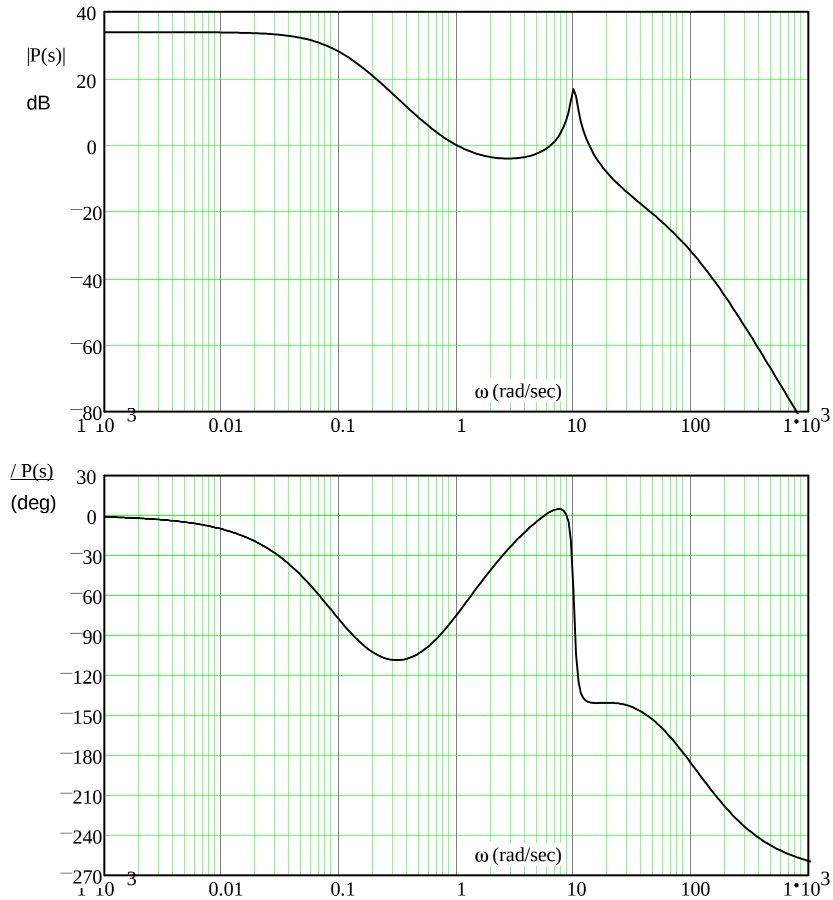


c) For the system of part (a), give the steady-state response of the open-loop system an input $x(t) = 4\cos(10t)$. express the answer in the time-domain.

d) Give the steady-state response of the closed-loop system for the same input. Hint: closed loop output is: $\text{input}\cdot\dfrac{G(10\cdot j)}{1 + G(10\cdot j)}$

2. Like problem 5.9a in the Bodson text.

   a) Give the gain margin, the phase margin and the delay margin of the system whose Bode plots are shown at right (the plots are for the open-loop transfer function and the closed-loop transfer function is assumed to be stable).



3. A system has a delay of $D := 0.01 \cdot \text{sec}$ How many degrees of phase does this represent at:

   a) $f := 1 \cdot \text{Hz}$

   $f := 10 \cdot \text{Hz}$

   $f := 100 \cdot \text{Hz}$

   $f := 1 \cdot \text{kHz}$

   b) $\omega := 1 \cdot \frac{\text{rad}}{\text{sec}}$

   $\omega := 10 \cdot \frac{\text{rad}}{\text{sec}}$

   $\omega := 100 \cdot \frac{\text{rad}}{\text{sec}}$

   $\omega := 1000 \cdot \frac{\text{rad}}{\text{sec}}$

4. a) If the phase response of a pure time delay were plotted on linear phase vs. linear frequency plot, what would be the shape of the curve?

   b) If the phase response of a pure time delay were plotted on linear phase vs. logarithmic frequency plot, what would be the shape of the curve?

Find your textbook from your electronics class (ECE 2280 here at the U). Find the chapter or section which covers feedback in amplifiers. Read the sections covering bandwidth or frequency response, noise reduction, distortion reduction and gain reduction.

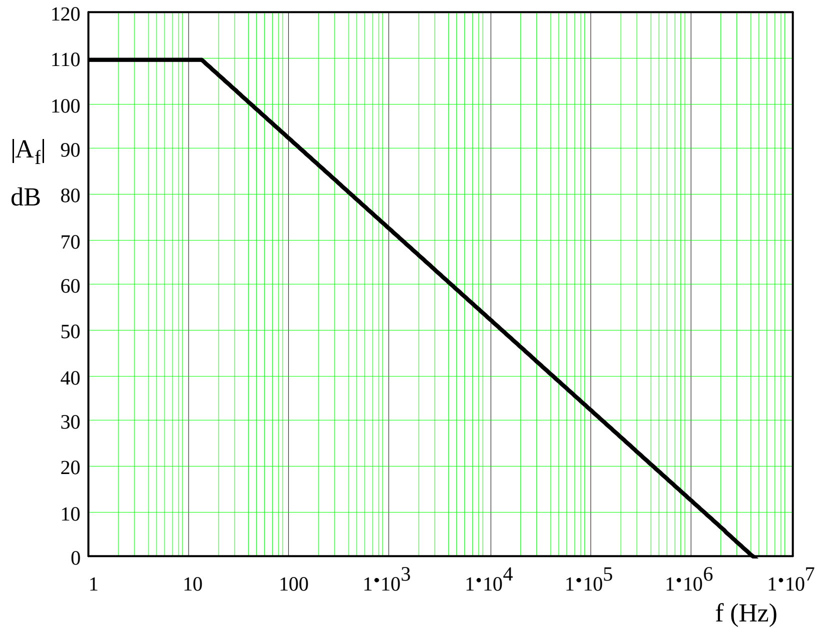
Amplifier Compensation

5. The plot at right shows the frequency response of an LF353 op amp.

   a) Find the gain-bandwidth product (GBW).

   b) Find A_o in both dB and as a factor.

   c) Find the open-loop roll-off point and the compensation pole location.



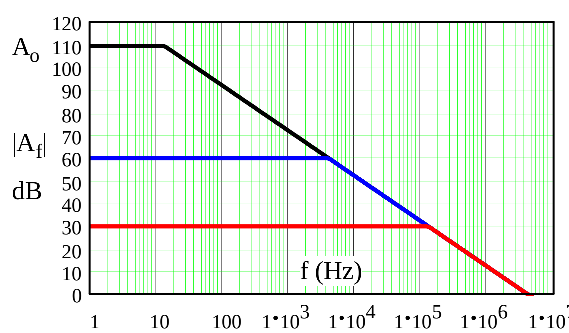
   d) A voltage (series-shunt) feedback network is used to feed back 0.1% of the output back to the input in a negative manner. Find the closed-loop gain (as a factor and in dB) and the closed-loop roll-off point. Draw the closed-loop frequency response on the drawing above.

   e) Now use two equal amplifier stages (two op amps) to achieve the same gain as part in d), Find the closed-loop roll-off point of a single stage. Draw the closed-loop frequency response of a single stage on the drawing above.

   Would this also be the 3dB roll-off point of the entire two-stage amplifier? If not, why not?

Answers

1. b) Gain may be increased by ~ 2dB and reduced by ~ 4.4dB. PM ~ 13·deg DM ~ 36·ms
   c) $2\cdot\cos(10\cdot t + 158\cdot deg)$ d) $3.5\cdot\cos(10\cdot t + 140\cdot deg)$
2. a) GM ~ 30·dB PM ~ 40·deg DM ~ 50·ms
3. a) 3.6·deg 36·deg 360·deg 3600·deg b) 0.573·deg 5.73·deg 57.3·deg 573·deg
4. a) A straight line of negative slope, ωD, where D is the time delay.
   b) A negative sloping line with a slope of ωD. Since the frequency increases by a factor of 10 each decade, so would the downward slope of the line.
5. a) 4·MHz b) 110·dB $3.162\cdot 10^5$ c) 12.65·Hz pole: $\frac{1}{s + 79.5}$
   d) 1000 60·dB 4·kHz e) 126.5·kHz



The 3dB roll-off point of the entire two-stage amplifier is a bit less than 126.5kHz because that would actually be a 6dB roll-off point.