TFE 4200 Analog Integrated Circuits
Problem sheet #5

#1. Consider a feedback amplifier for which the open-loop transfer function A(s) is given by

$$A(s) = \left(\frac{10}{1 + s/10^4} \right)^3$$

Let the feedback factor β be a constant and independent of frequency. Find the frequency W_{180} at which the phase of the loop transfer function (**A(s)β**) is -180. Then, show that the feedback amplifier will be stable if the feedback factor β is less than a critical value β_{cr} and unstable if β is greater than or equal to β_{cr} , and find the value of β_{cr}.

#2. An op amp having a single-pole rolloff at 100 Hz and a low-frequency gain of 10^5 is operated in a feed-back loop with β=0.01. What is the factor by which feedback shifts the pole? To what frequency? If β is changed to a value that results in a closed-loop gain of +1, to what frequency does the pole shift?

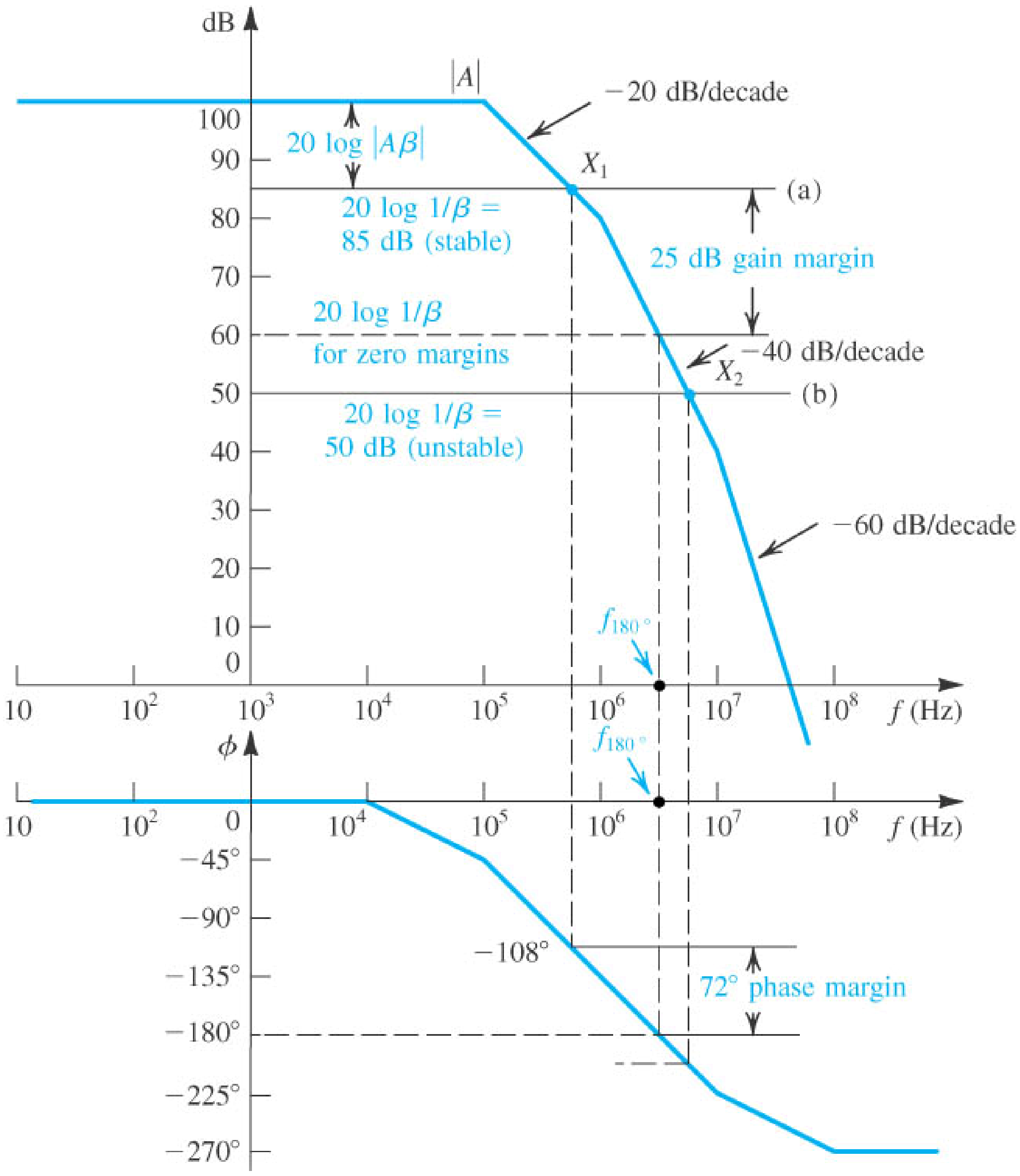
#3. An amplifier with a low-frequency gain of 100 and poles at 10^4 rad/s and 10^6 rad/s is incorporated in a negative-feedback loop with feedback factor β. For what values of β do the poles of the closed-loop amplifier coincide? What is the corresponding Q of the resulting second-order system? For what value of β is a maximally flat response achieved? What is the low-frequency closed-loop gain in the maximally flat case?

#4. Consider an op amp having a single-pole open-loop response with $A_0 = 10^5$ and $f_P = 10$ Hz. Let the op amp be ideal (infinite input impedance, zero output impedance). If this amplifier is connected in the noninverting configuration with a nominal low-frequency closed-loop gain of 100, find the frequency at which |Aβ| = 1. Also, find the phase margin.

#5. Find the closed-loop gain at w1 (the frequency at which magnitude of loop gain is unity) relative to the low-frequency gain (1/β) when the phase margin is 30^o, 60^o and 90^o.

#6. Consider an op amp whose open-loop gain is identical to that of the one shown in Fig.1. Assume that the op amp is ideal and it is connected as a differentiator. Show that for stable performance the differentiator time constant should be greater than 159 ms.

HINT: For stable performance "at the intersection of 20log(1/|β[jw]|) and 20log|(A[jw])| the difference of slopes should not exceed 20 dB/decade"



dB
|A|
−20 dB/decade
100
90
80
70
60
50
40
30
20
10
0
20 log |Aβ|
X1
(a)
20 log 1/β =
85 dB (stable)
25 dB gain margin
20 log 1/β
for zero margins
−40 dB/decade
X2
(b)
20 log 1/β =
50 dB (unstable)
−60 dB/decade
f180°
10
10^2
10^3
10^4
10^5
10^6
10^7
10^8
f (Hz)
ϕ
f180°
0
−45°
−90°
−108°
−135°
72° phase margin
−180°
−225°
−270°

Fig. 1.