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Excerpt of Sedra/Smith Chapter 10: Feedback

Content

General Feedback Structure (book 10.1)

Effect on Poles and Stability (book 10.8, 10.9)

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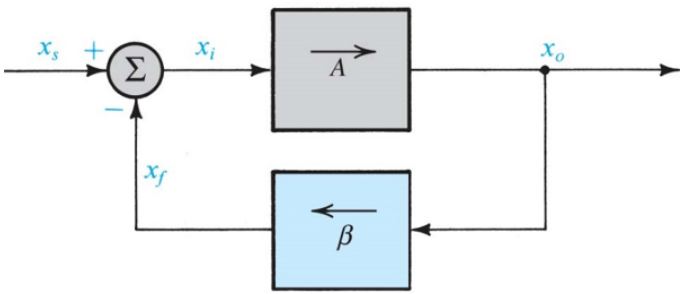
General Feedback Structure (book 10.1)

Effect on Poles and Stability (book 10.8, 10.9)

General Concept

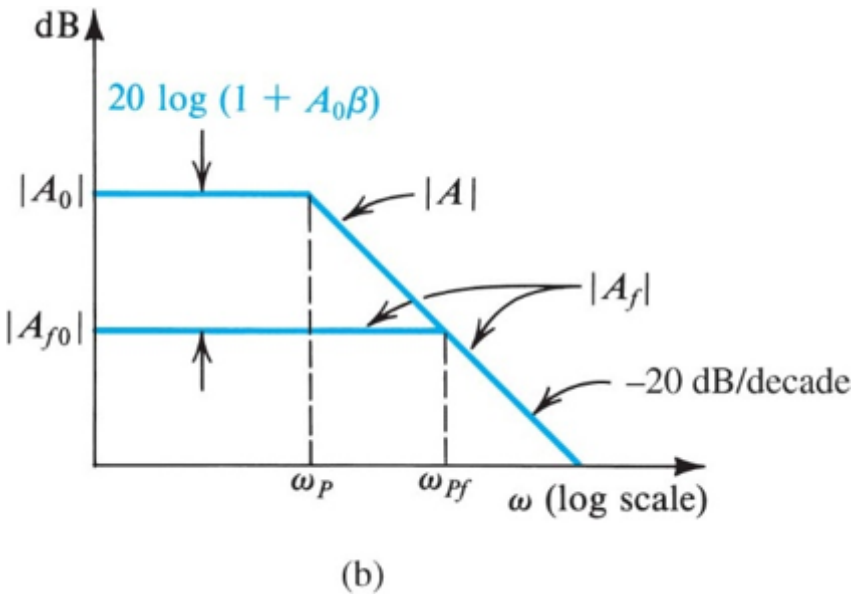


$$A_f = \frac{A}{1 + A\beta}$$
$$\approx \frac{1}{\beta} \text{ for } A\beta >> 1$$

A_f: closed loop gain
$A\beta$: loop gain
β normally considered to be free of any frequency dependency!)

Content

A Has a Single Pole



(b)

$$A_f = \frac{\frac{A_0}{1+A_0\beta}}{1+\frac{s}{\omega_p}(1+A_0\beta)}$$

$$\omega_{pf} = \omega_p(1+A_0\beta)$$

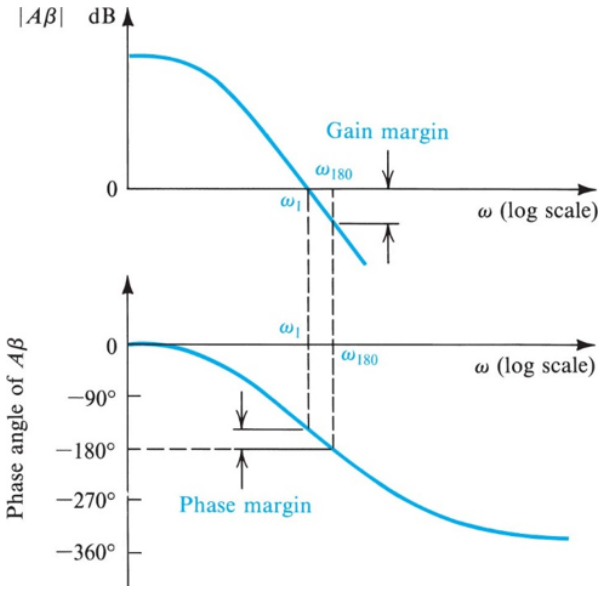
A Has Two Real Poles

Solving for poles: $1 + A(s)\beta = 0 \Rightarrow$

$$\begin{aligned} s &= -\frac{1}{2}(\omega_{p1} + \omega_{p1}) \pm \frac{1}{2}\sqrt{(\omega_{p1} + \omega_{p1})^2 - 4(1 + A_0\beta)\omega_{p1}\omega_{p1}} \\ Q &= \frac{\sqrt{(1 + A_0\beta)\omega_{p1}\omega_{p1}}}{\omega_{p1} + \omega_{p1}} \end{aligned}$$

Generally more separation between ω_{p1} and ω_{p1} (i.e. a dominant pole) helps to keep A_f stable at higher loop gains.

Why the Resonance?



Negative feedback should not lead to amplification. The crux: a phase shift $\phi = -180^o$ turns negative feedback into positive feedback. If the loop gain $A\beta > 1$ at such a point, the circuit has infinite gain, i.e. is unstable.

In a low pass circuit the difference of the phase from -180^o, i.e. $\phi + 180^o$ where the loop gain becomes unity ($A\beta = 1$ or $A = \frac{1}{\beta}$) is the *phase margin* (PM). A high PM indicates no or little resonance. A negative phase margin indicates an unstable circuit.