Structured Electronic Design

Phantom Zero Compensation of 2nd-order Systems

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Phantom compensation 2nd order system

$$L(s) = L_{DC}\frac{1-s/z}{(1-s/p_1)(1-s/p_2)}$$

$$S(s) = \frac{-L_{DC}}{1-L_{DC}}\frac{1-s/z}{\frac{(1-s/p_1)(1-s/p_2)}{1-L_{DC}} - \frac{L_{DC}}{1-L_{DC}}(1-s/z)}$$

$$A_f = A_i(s)\frac{-L_{DC}}{1-L_{DC}}\frac{1}{1+s\left(\frac{L_{DC}}{z(1-L_{DC})} - \frac{p_1+p_2}{p_1 p_2(1-L_{DC})}\right) + \frac{s^2}{p_1 p_2(1-L_{DC})}}$$

← Phantom zero canceled by pole in the ideal gain (= asymptotic gain)

$$A_f \approx A_i(s)\frac{-L_{DC}}{1-L_{DC}}\frac{1}{1+s\left(-\frac{1}{z} - \frac{p_1+p_2}{p_1 p_2(1-L_{DC})}\right) + \frac{s^2}{p_1 p_2(1-L_{DC})}}$$

← Low-pass cut-off frequency designed with LP product

↑

A negative real zero increases the coefficient of s
Absolute value of the sum of the poles can only be increased!

↓

Second-order MFM if: $S'(s) = \frac{1}{1+s\frac{\sqrt{2}}{\omega_h} + \frac{s^2}{\omega_h^2}}$ → $\left\{\begin{array}{l} z = -\frac{\omega_h^2}{\sqrt{2}\omega_h + p_1 + p_2} \\ |p_1 + p_2| < \frac{\omega_h}{\sqrt{2}} \end{array}\right.$

Phantom compensation 2nd order system

Example 12.2

Phase margin:
67 degrees
at 1.5kHz