Structured Electronic Design

Frequency Compensation:
the Phantom zero

Anton J.M. Montagne

Phantom zeros

Phantom zeros

Design of the characteristic polynomial of the servo function

Phantom zeros

Design of the characteristic polynomial of the servo function

$$S(s) = \frac{-L(s)}{1-L(s)} = \frac{-L_{\mathrm{DC}}N(s)}{D(s)-L_{\mathrm{DC}}N(s)}$$

Phantom zeros

Design of the characteristic polynomial of the servo function

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$$D(s) - L_{\mathrm{DC}}N(s) = 0$$

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Loop gain with n poles:

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2. n-1 zeros can be inserted in the loop to adjust the other coefficients to those of desired filter characteristic

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Loop gain with n poles:

1. Loop gain-poles product defines the coefficient of the highest order of s
2. n-1 zeros can be inserted in the loop to adjust the other coefficients to those of desired filter characteristic
3. Those zeros are also zeros in the servo function

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4. An all-pole source-to-load transfer can still be established if these zeros appear as poles in the asymptotic gain

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$$A_f(s) = A_{f\infty}(s) \frac{-L(s)}{1-L(s)}$$

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$$A_f(s) = A_{f\infty}(s)\ \frac{-L(s)(1-s/z_1)}{1-L(s)(1-s/z_1)}$$

← Zero in loop gain appears in servo function

↑ Zero changes characteristic equation and thus the poles of the servo function

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$$A_f(s) = \frac{A_{f\infty}(s)}{(1-s/z_1)} \frac{-L(s)(1-s/z_1)}{1-L(s)(1-s/z_1)}$$ ⟵ Zero in loop gain appears in servo function

Pole in asymptotic gain at the frequency of the zero (arrow to $(1-s/z_1)$ in the denominator of the first factor)

Zero changes characteristic equation and thus the poles of the servo function (arrow to $(1-s/z_1)$ in the denominator of the second factor)

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↑ Pole in asymptotic gain at the frequency of the zero

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