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Gaussian Lowpass Filter (Closed Form): LPFG

Symbol

Summary

LPFG models represent lumped-element Gaussian lowpass filters. They approximate the ideal Gaussian magnitude response and offer simplicity, relatively flat group delay, and good time domain performance, but suffer from poor frequency selectivity. Although similar to Bessel-Thomson filters, Gaussian filters offer faster rise times and lower transient overshoots, but have slightly less stopband attenuation and less group delay flatness.

Parameters

Name	Description	Unit Type	Default
ID	Element ID	Text	LPFG1
N	Number of reactive elements in the filter		3
FP	Passband corner frequency (when Qu is infinite).	Frequency	1 GHz
AP	Passband corner attenuation (when Qu is infinite).	DB	3.0103 dB
*RS	Expected source resistance.	Resistance	50 ohm
*RL	Expected Load resistance	Resistance	50 ohm
*QU	Average unloaded Q of reactive elements in the filter.		1e12

** indicates a secondary parameter*

Parameter Restrictions and Recommendations

1. 0 < N < 51
2. 0 < FP
3. 0 < AP Recommend AP greater than or equal to 0.001 dB.
4. 0 < RS
5. 0 < RL
6. 0 < QU. Recommend QU less than or equal to 1e12.

Implementation Details

This model is implemented as a short-circuit admittance matrix,

$$\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}$$

, whose equivalent transfer function squared magnitude approximates that of an ideal Gaussian filter. The ideal Gaussian squared magnitude characteristic is:

$$|S_{21}|^2 = \frac{1}{\exp(-s^2)}$$

In the model, the denominator of this ideal Gaussian characteristic is approximated by a truncated Maclaurin series:

$$\exp(-s^2) \approx \sum_{i=0}^{N} \frac{(-1)^i s^{2i}}{i!} = |g(s)|^2 = 1 + |h(s)|^2$$

where

$$s = \frac{1}{\mathrm{QU}} + j\omega$$

$$j = \sqrt{-1}$$

and a lowpass-to-lowpass frequency transformation has been applied:

$$\omega = \frac{\mathrm{\_FREQ}}{\mathrm{FP}}$$

_FREQ is the variable containing the project frequency, and the admittances are:

$$y_{11} = \left(\frac{1}{\mathrm{RS}}\right)\frac{g(s) + g(-s) - h(s) - h(-s)}{g(s) - g(-s) + h(s) - h(-s)}$$

$$y_{22} = \left(\frac{1}{\mathrm{RL}}\right)\frac{g(s) + g(-s) + h(s) + h(-s)}{g(s) - g(-s) + h(s) - h(-s)}$$

$$y_{12} = y_{21} = \left(\frac{1}{\sqrt{\mathrm{RS} \times \mathrm{RL}}}\right)\frac{(-2)}{g(s) - g(-s) + h(s) - h(-s)}$$

Layout

This element does not have an assigned layout cell. You can assign artwork cells to any element. See “Assigning Artwork Cells to Layout of Schematic Elements” for details.

Recommendations for Use

This model behaves as if it has ideal impedance transformers at its ports, so there is no attenuation due to mismatched source and load impedances. The model expects that the source impedance equals RS and that the load impedance equals RL, but RS need not equal RL for ideal transmission (as would normally be the case).

References

[1] Milton Dishal, "Gaussian-Response Filter Design," Electrical Communication, vol. 36, March 1959, pp. 3-26.

[2] Anatol I. Zverev, Handbook of Filter Synthesis, (John Wiley & Sons, 1967), pp. 67, 70, 71, 73, 74, 90, 91.

[3] DeVerl. S. Humpherys, The Analysis, Design, and Synthesis of Electrical Filters, (Prentice-Hall, 1970), pp. 413-417.

[4] Herman J. Blinchikoff and Anatol I. Zverev, Filtering in the Time and Frequency Domains, (Robert E. Krieger Publishing Co., 1987), pp. 130-132.

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