Back to search page

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AWR Microwave Office Element Catalog > General > Bessel Lowpass Filter: LPFD

Prev Next

Bessel Lowpass Filter: LPFD

Symbol

Summary

LPFD models represent lumped-element Bessel-Thomson lowpass filters. They offer simplicity and maximally flat group delay, but suffer from poor selectivity.

Parameters

Name	Description	Unit Type	Default
ID	Element ID	Text	LPFD1
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 < 34
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

The 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 is that of a Bessel-Thomson filter:

$$|S_{21}(s)|^2 = \frac{b_0^2}{|g(s)|^2} = \frac{b_0^2}{1 + |h(s)|^2}$$

where

$$g(s) = \sum_{i=0}^{N} b_i s^i$$

$$b_i = \frac{(2N-i)!}{2^{N-i}(i)!(N-i)!} \text{ for } i = 0, \ldots, N$$

Where b_0 = (2N-1)!!,i.e, the product of all odd integers less than 2N.

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

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

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:

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

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

$$y_{12} = y_{21} = \left(\frac{1}{\sqrt{RS \times RL}}\right)\frac{(-2)b_0}{g(s) - g(-s) + h(s) - h(-s)}$$

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

Note that 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] Rolf Schaumann, Mohammed S. Ghausi, and Kenneth R. Laker, Design of Analog Filters: Passive, Active RC, and Switched Capacitor, (Prentice-Hall, 1990), pp. 51-56.

[2] Louis Weinberg, Network Analysis and Synthesis, (Robert E. Krieger Publishing, 1975), pp. 499-506.

[3] Herman J. Blinchikoff and Anatol I. Zverev, Filtering in the Time and Frequency Domains, (Robert E. Krieger Publishing Co., 1987), pp. 124-127.

Prev Up Next
Home