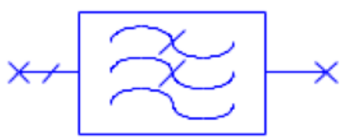
Raised-Cosine Lowpass Filter (Closed Form): LPFRC

Symbol



Summary

LPFRC models represent Raised-Cosine lowpass filters. Raised-Cosine filters are applied in digital transmission system theory to represent ideal (intersymbol interference free) Nyquist filtering of impulse and pulse data transmissions. Hardware designers attempt to design channel filters which approximate these characteristics and have the smallest possible bandwidth.

Parameters

Name	Description	Unit Type	Default
ID	Filter ID	Text	LPFRC1
FP	Passband corner frequency	Frequency	1 GHz
A	Roll-off factor (between 0 and 1)		0.5
TYP	Transmission type	Vector Text(pull-down)	Impulse
E	Exponent of the raised-cosine response		1.
*RS	Expected source resistance	Resistance	50 ohm
*RL	Expected load resistance	Resistance	50 ohm

** indicates a secondary parameter*

Parameter Restrictions and Recommendations

1. 0 < FP

2. 0 ≤A≤1.

   A minimum bandwidth (A=0) filter would require an infinite number of filter sections. Approximations of a 30% excess Nyquist bandwidth (A=0.3) raised-cosine filter are considered feasible with present-day technology.

3. TYP is either {0,1} .

   TYP = 0 (Impulse) specifies the ideal raised-cosine response, the theoretical filter model for infinitesimally narrow impulses. TYP = 1 (Pulse) specifies a sinc-normalized raised-cosine response, the filter model for rectangular pulse transmission.

4. 0<E≤1 .

   The ideal raised-cosine response is raised to the exponent, E. For cascaded identical transmit and receive filters, you would typically specify E=0.5 for each filter. The composite channel response of the cascaded filters would be represented by specifying E=1.

5. 0 < RS.

   By definition, the model matches RS at its input port.

6. 0 < RL.

   By definition, the model matches RL at its output port.

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 amplitude functions S21 and S12 implement the raised-cosine response for impulse or pulse data transmission, while S11 and S22 are, by definition, constant and matched to the filter port termination resistances (i.e., equal to 1). For impulses,

$$S_{21}(j\omega) = 1 \text{ for } [0 \le \omega \le (1 - A)]$$

$$S_{21}(j\omega) = \left(\cos^2\left(\left(\frac{\pi}{4}\right)\left(\frac{\omega + A - 1}{A}\right)\right)\right)^E \text{ for } [(1 - A) \le \omega \le (1 + A)]$$

$$S_{21}(j\omega) = 0 \text{ for } [(1 + A) \le \omega]$$

For pulses,

$$S_{21}(j\omega) = 1 \text{ for } [0 \le \omega \le (1 - A)]$$

$$S_{21}(j\omega) = \frac{\left(\cos^2\left(\left(\frac{\pi}{4}\right)\left(\frac{\omega + A - 1}{A}\right)\right)\right)^E}{\mathrm{sinc}\left(\frac{\pi}{2}\omega\right)} \text{ for } [(1 - A) \le \omega \le (1 + A)]$$

$$S_{21}(j\omega) = 0 \text{ for } [(1 + A) \le \omega]$$

where

$$\mathrm{sinc}(x) = \frac{\sin(x)}{x}$$

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

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

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

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

$$y_{11} = \left(\frac{1}{RS}\right)\left(\frac{-S_{21}^2(j\omega)}{S_{21}^2(j\omega)-4}\right)$$

$$y_{22} = \left(\frac{1}{RL}\right)\left(\frac{-S_{21}^2(j\omega)}{S_{21}^2(j\omega)-4}\right)$$

$$y_{22} = \left(\frac{1}{\sqrt{RS \times RL}}\right)\left(\frac{2S_{21}(j\omega)}{S_{21}^2(j\omega)-4}\right)$$

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 expects that the source impedance equals RS and that the load impedance equals RL, but RS need not equal RL for ideal transmission.

References

[1] Kamilo Feher, Digital Communications: Microwave Applications, (Prentice-Hall, 1981), pp. 46-51.

[2] John G. Proakis, Digital Communications, 2nd Ed., (McGraw-Hill, 1989), pp. 532-536.

[3] John Bellamy, Digital Telephony, 2nd Ed., (John Wiley & Sons, 1991), pp. 523-528.

[4] E. A. Lee and D. G. Messerschmitt, Digital Communications, 2nd Ed., (Kluwer Academic Publishers, 1994), pp. 188-191, 226-228.

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