butterworth_4_trns.sqproj

a0=1.0   a0=1.0
b0=1.0   b0=1.0
b1=0.7654 b1=1.8478
b2=1.0   b2=1.0

low-pass section

a=1.0
f_hz=50

x

y2_1

a=0.1
f_hz=1k

f0 = 200

y2_2

high-pass section

a0=0   a0=0
a1=0   a1=0
a2=1.0   a2=1.0
b0=1.0   b0=1.0
b1=0.7654 b1=1.8478
b2=1.0   b2=1.0
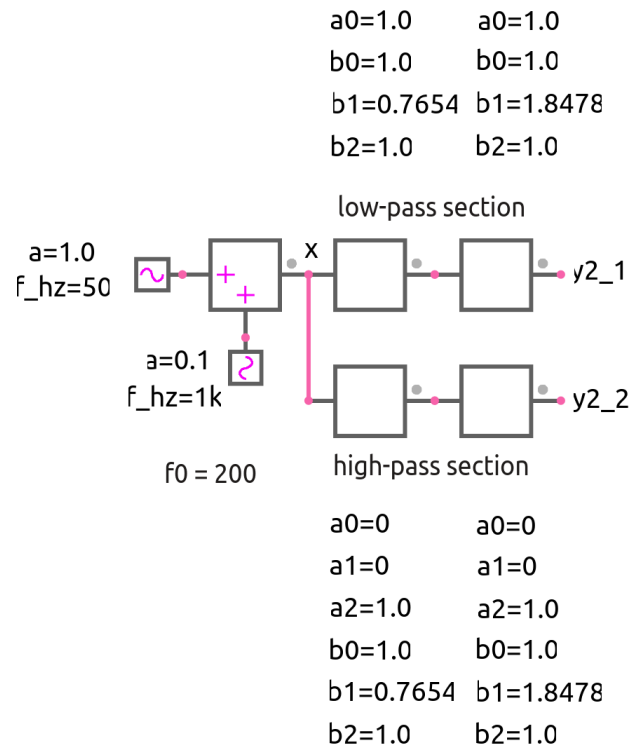
Shown in the figure are 4$^{\text{th}}$-order low-pass and 4$^{\text{th}}$-order high-pass Butterworth filters. Note that the high-pass transfer function is obtained from the low-pass function by substituting $s \leftarrow 1/s$. The filter functions have been implemented with normalised coefficients. The actual coefficients are computed internally using the parameter `f0` of the filter elements. In this exercise, we want to understand the operation of the filters in the time domain.

(The frequency-domain behaviour of the filters is described in `butterworth_4_ac.sqproj`.)

Exercise Set

1. Run the simulation. Plot the input to the filters (`x`), and the outputs of the low-pass and high-pass sections (`y2_1` and `y2_2`, respectively) versus time. Verify the low-pass and high-pass functionality.

2. Interchange the amplitudes of `x1` and `x2`, and repeat (1).

References

1. A. S. Sedra, K. C. Smith, and A. N. Chandorkar, *Microelectronic Circuits: Theory and Applications*, Fifth edition, Oxford University Press, 2009.

2. S. Franco, *Design with Operation Amplifiers and Analog Integrated Circuits,* McGraw-Hill, 1998.