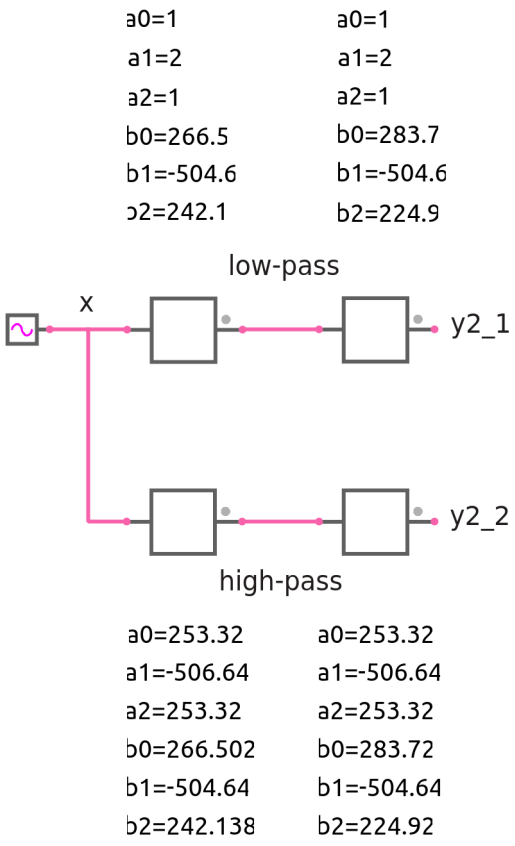
butterworth_4_digital_ac.sqproj



Shown in the figure are 4^{th}-order low-pass and 4^{th}-order high-pass digital Butterworth filters. Starting with the analog normalised filter function, the z-domain digital filter function can be obtained as follows.

(a) Substitute $s \leftarrow s/\omega_c$ where ω_c is the desired cut-off frequency in rad/sec.

(b) Use the bilinear transformation,

$$s \leftarrow \frac{2}{T_d}\left(\frac{1-z^{-1}}{1+z^{-1}}\right), \tag{1}$$

where T_d is the sampling interval.

(c) Rewrite $H(z)$ in standard form.

The filters shown in the figure are designed for a cut-off frequency of 200 Hz.

Exercise Set

1. Work out the filter coefficients, and check the values against those shown in the figure.

2. Run the simulation. Plot the outputs `y2_1`, `y2_2` versus frequency (log-log plot), and verify the low-pass and high-pass functionality.

3. From the plots, verify that they are 4^{th}-order filters, and that the cut-off frequency is 200 Hz.

References

1. A.V. Oppenheim, R.W. Schafer, and J.R. Buck, *Discrete-time Signal Processing*, Pearson/Prentice-Hall, 1999.