Selecting the right amplifier for a filter

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Question:

How to select the right amplifier for a filter?

Answer:

Part selection plays a vital role in any circuit design. Before the final production go-ahead, it is very important to verify – through simulation and prototyping – that the right parts have been selected. The ability to fine-tune parts selection can be a confidence builder before the simulation phase. One such tool is the Analog Filter Wizard, which not only helps design of low-pass, high-pass or band-pass filters, as in Figure 1, it also analyses their theoretical and practical performance.

Tool operation

The process includes defining specifications through to filter response characterisation, as shown in Figure 2. An option allows selection of the type of filter response required, say Butterworth, Bessel, Chebyshev, etc., and helps select between fewer stage variants or fast settling variants.

With a variety of available views, such as 'Magnitude', 'Phase', 'Step response', 'Power' and 'Noise', the tool checks for incremental performance as the parameters change. As shown in Figures 2 and 3, the magnitude and phase views help understand these effects on the signal.

The 'Stages' view shows the op-amp filter stages and their characteristics; see Figure 4. This view makes it easier to understand the filter stage by stage.

Overshoot and ringing define the waveform distortion, and can be analysed with the 'Step response' view; see Figure 5.

After settling on the theoretical characteristics, the next step would be circuit design; see Figure 6. Here, the tool gives recommendations based on the type of specified optimisation, such as power, noise, or voltage range, for example. There's an option of using the recommended part or choosing a different one.

Whilst the tool selects components with values best suited to the specification, it may be difficult or impractical to find and use the exact recommended parts, hence the 'Component tolerances' function which gives the flexibility to choose resistor and capacitor tolerances; see Figure 7. Simultaneously, the effects of accommodating those

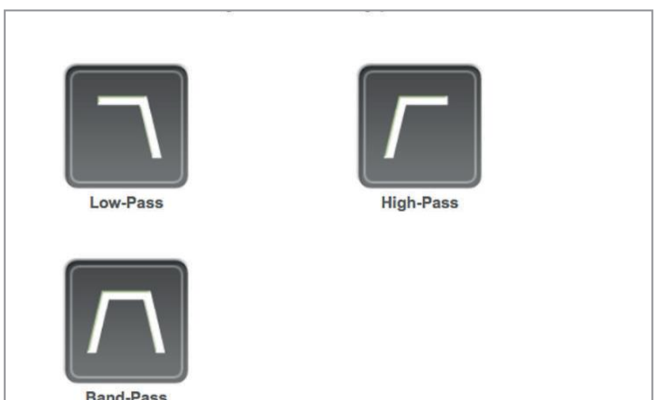


Figure 1: Filter types

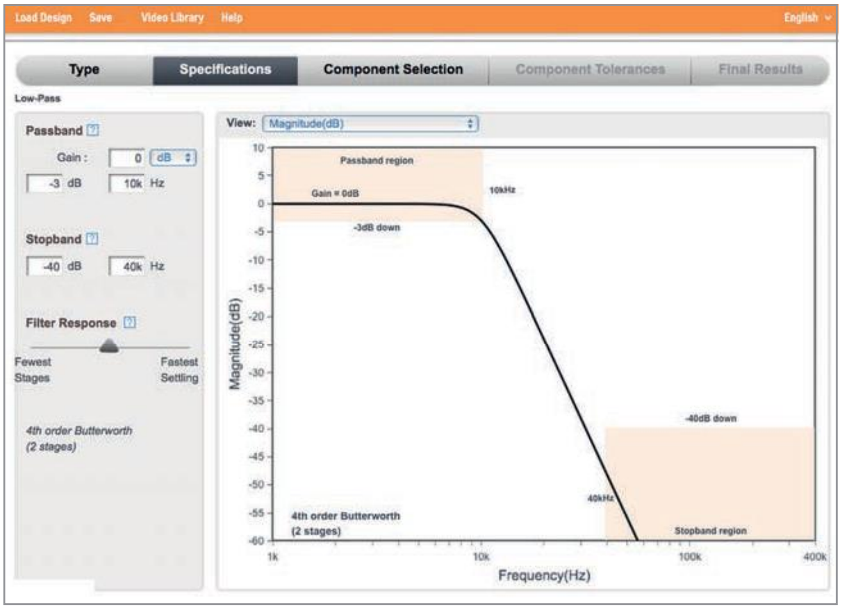


Figure 2: Defining the specifications in the 'Magnitude' view

tolerances on filter performance can also be analysed.

Figure 8 shows the final circuit design incorporating the correct amplifier before circuit simulation and prototyping.

This tool is very useful, as it shows the incremental performance of the filter at every step, from defining the filter specifications to choosing the tolerances, helping fine-tune the design throughout the process. EW

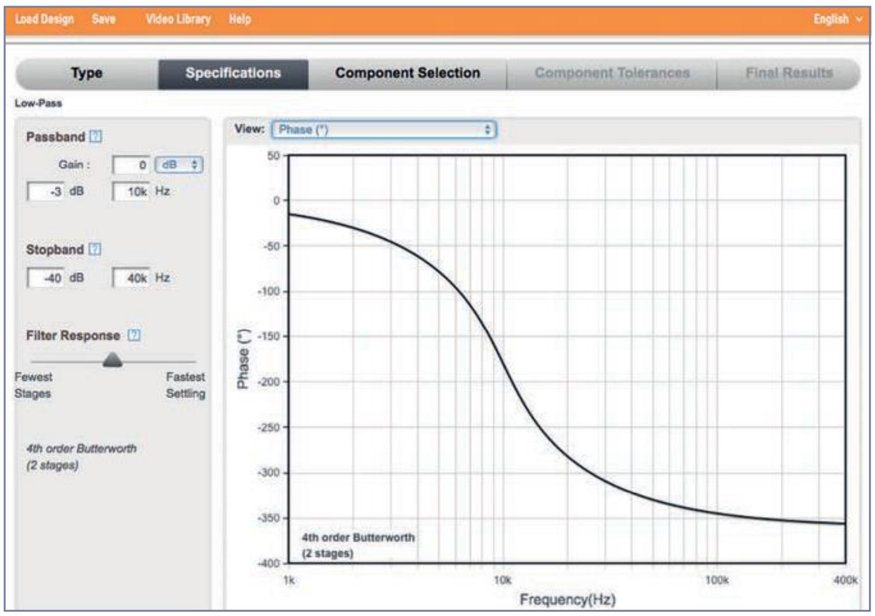
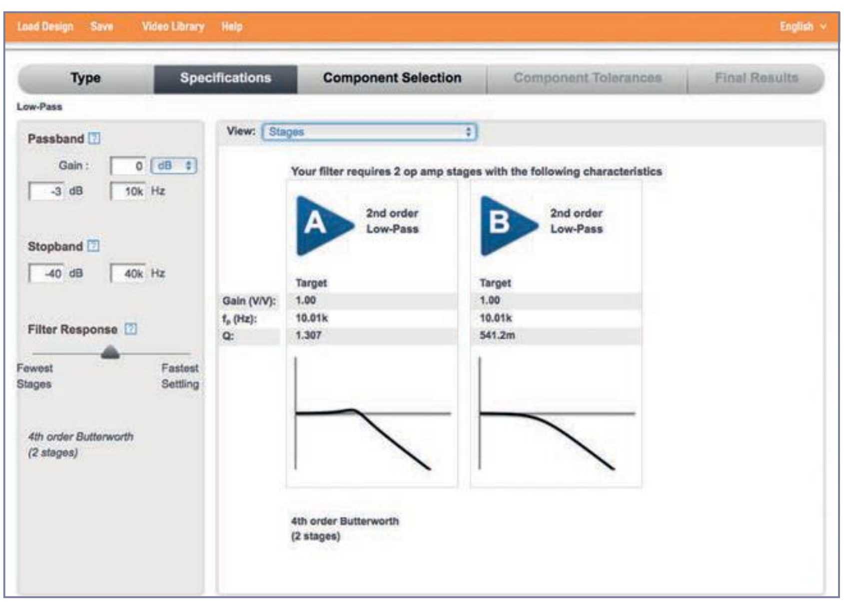


Figure 3: 'Phase' view



With a variety of available views, such as 'Magnitude', 'Phase', 'Step response', 'Power' and 'Noise', the tool checks for incremental performance as the parameters change

Figure 4: Filter stages

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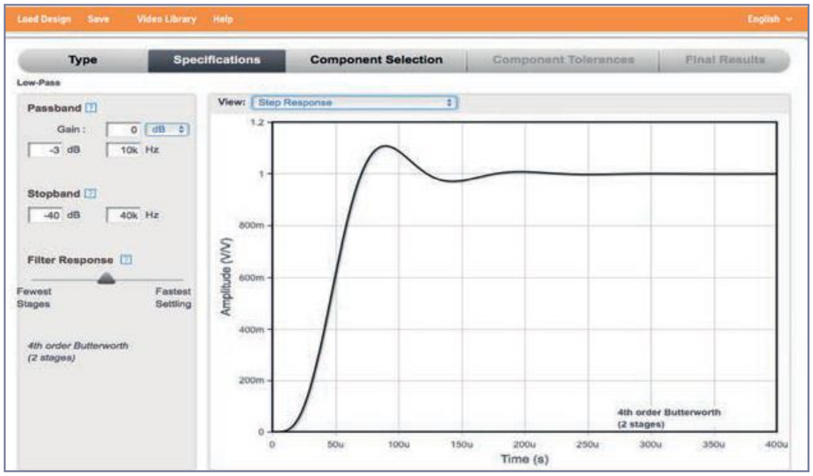

Figure 5: Step response of the filter

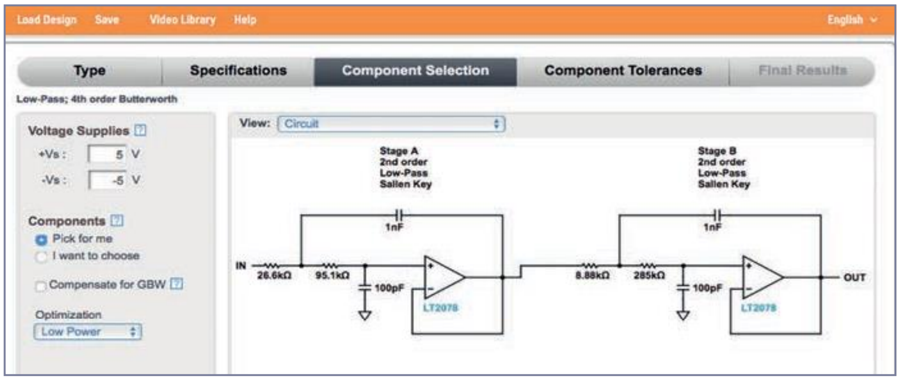

Figure 6: Component selection

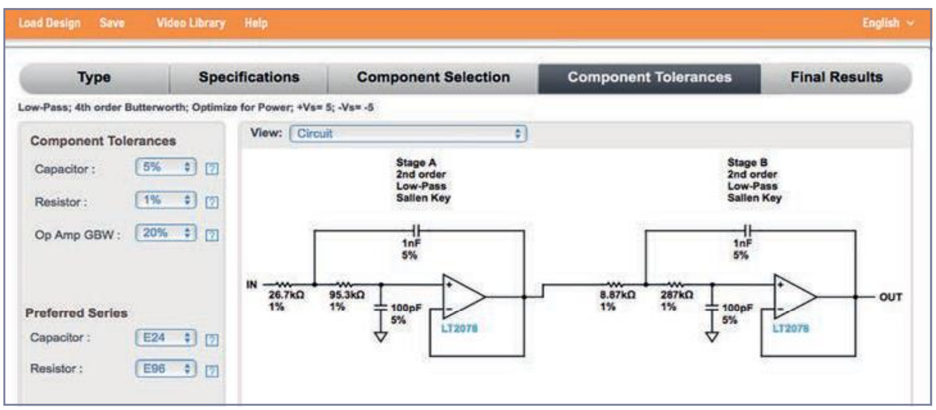

Figure 7: Defining the component tolerances

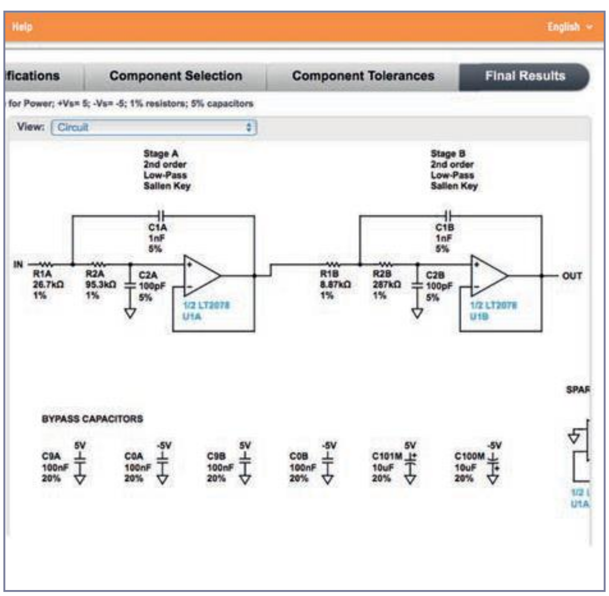

Figure 8: Final circuit

QUIZ

Question 1:

Design a two-stage, low-pass Butterworth filter with a cutoff frequency of 1MHz, stop band of 3MHz and gain of 0dB, for a ±5V supply. Optimise the design for low noise. Use the default component tolerance and the amplifiers recommended by the tool. **What is the total quiescent power of the filter?**

Question 2:

Design a two-stage, low-pass, 4th-order Chebyshev filter with a pass-band ripple of 0.08dB, and 4th-order Butterworth filter with the same specifications for comparison. **Which filter has the narrow transition band?**