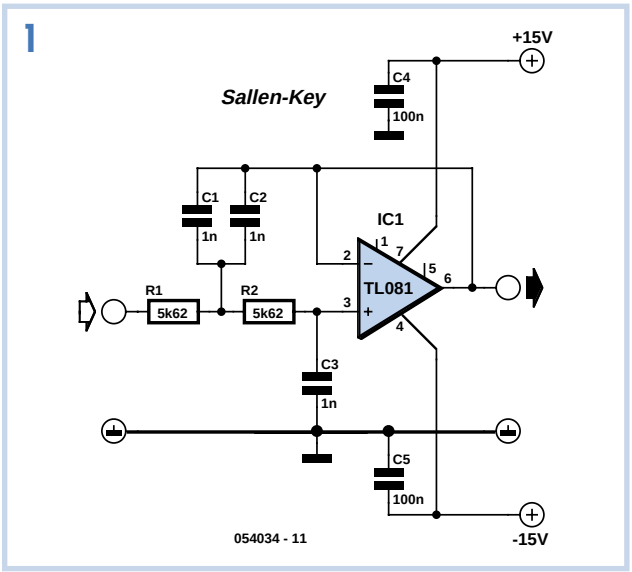
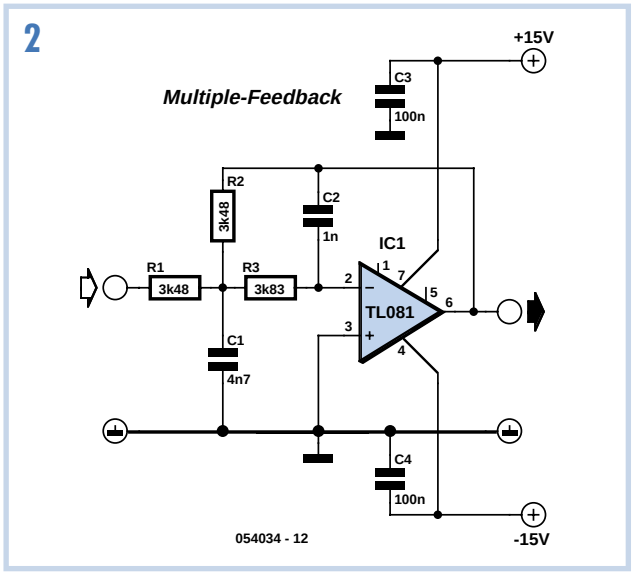
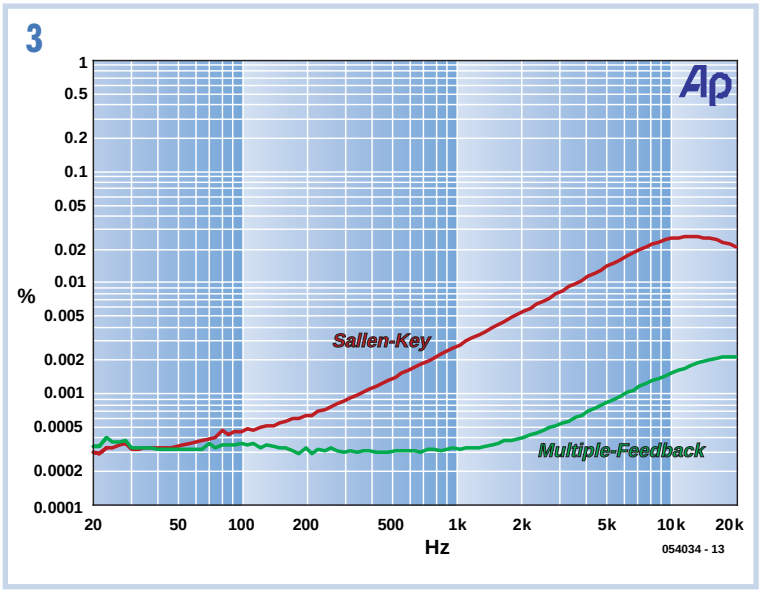
THD: Sallen–Key versus MFB







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There are various types of active filters, and the Sallen–Key version is probably the most commonly used type. A voltage follower is usually used for such filters, although gain can also be realised using two additional resistors. A disadvantage of this type of filter is its relatively high sensitivity to component tolerances. Measurements made on such filters have shown that component variations affect not only the filter characteristic but also the amount of distortion. However, an advantage is that filters more complex than third-order types can also be realised using a single amplifier stage, although severe requirements are placed on the component values in such cases.

One of the alternatives to the Sallen–Key filter is the 'multiple feedback' (MFB) filter. It owes its name to the fact that the feedback occurs via two paths. The inverting architecture can perhaps be regarded as a slight disadvantage, but that is offset by the fact that non-unity gain can be obtained without using extra components. In addition, the filter is less sensitive to component tolerances. Another drawback is that the implementation is restricted to third-order filters, so additional stages (and thus opamps) are necessary for higher-order filters.

That's all very nice, you might think, but how can multiple-feedback filters be calculated? That's practically impossible to do by hand. Fortunately, various software programs have been developed to do this for you, such as the quite usable FilterPro program from Texas Instruments, which can even calculate component values that exactly match the various E series.
For both types of filter, we designed a 20-kHz low-pass Butterworth bandpass filter using a standard TL081 IC (**Figures 1 and 2**) and then measured the distortion in the output signal for an input signal of 5 V_{rms}. Standard polyester (MKT) capacitors were used in the circuits. To make the ultimate result more distinct, we intentionally used a simple opamp (TL081) and avoided using expensive polypropylene, polystyrene or silver-mica capacitors.

The results of the measurements can be characterised as astonishing. The multiple-feedback filter proved to generate considerably less distortion than the Sallen–Key architecture. **Figure 3** shows the measurements for the two filters, which speak for themselves. The amplitude curves were the same within a few tenths of a dB. The Sallen–Key filter clearly generates up to more than ten times as much distortion at certain frequencies. With the Sallen–Key architecture, better results can be obtained by using better capacitors and opamps (such as an OPA627). From the results, it is clear the multiple-feedback architecture is less sensitive to the components used in the filter.

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FilterPro:
http://focus.ti.com/docs/toolsw/folders/print/filterpro.html