Single Diode Increases Bandpass Filter's Q

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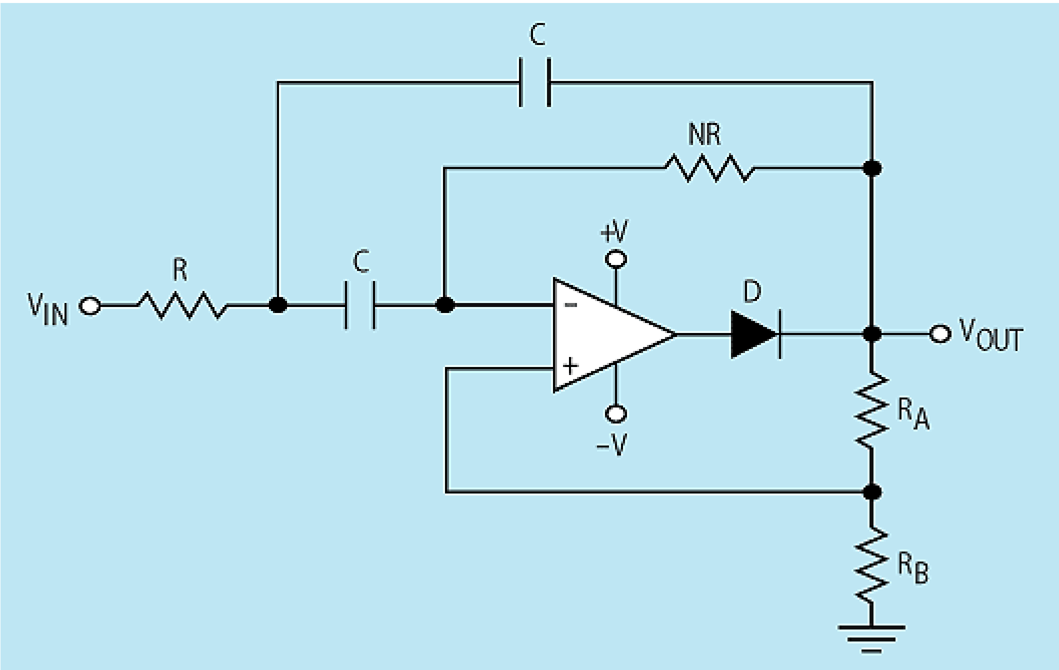
When implementing filters, the design goal is often to achieve maximum Q while using a minimum number of components. In certain applications, the Q of the filter is more important than the need for high signal fidelity in the pass-band. Such designs include displays for graphic equalizers or other user interface feedback devices (i.e., where the human ear isn't the end "customer" of the analyzed signal).

This design uses the classical single op-amp "Delyannis" bandpass-filter topology with one extra component (Fig. 1). The addition of a signal diode at the output of the operational amplifier increases the Q of this bandpass section by at least 100%. The center frequency is affected only slightly.



1. The single op-amp Delyannis bandpass-filter circuit is modified with the addition of a single diode at the amplifier's output. The diode increases the filter's Q by at least 100%.

This filter's transfer function is modeled as:

$$T(s) = \frac{s\left[\frac{1}{RC(a-1)}\right]}{s^2 + s\left[\frac{Na + 2(a-1)}{(a-1)RCN}\right] + \frac{1}{C^2R^2N}}$$

where a represents the feedback divider formed by R_A and R_B as defined by:

$$a = \frac{R_B}{(R_B + R_A)}$$

Q is then determined by:

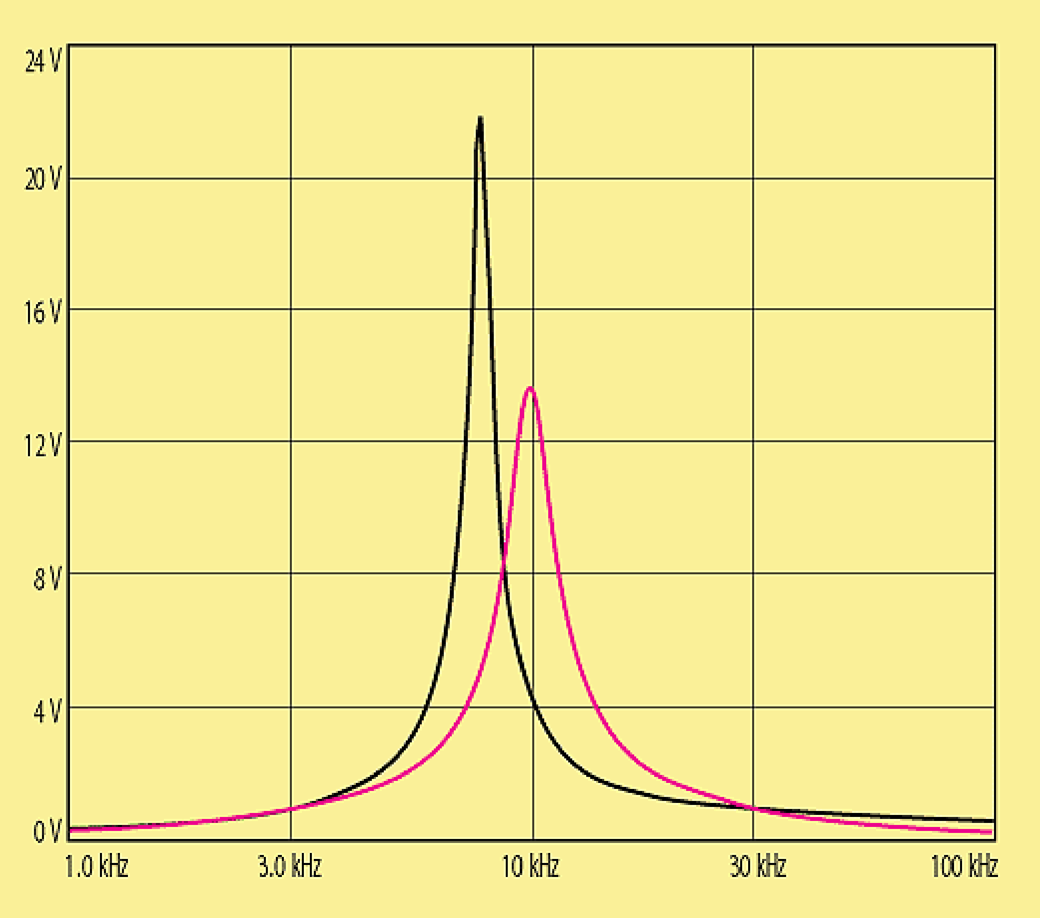
$$Q = \frac{\frac{R_A}{R_B}\sqrt{N}}{2\frac{R_A}{R_B} - N}$$

It follows that the center frequency is given by:

$$f_o = \frac{1}{2\pi CR\sqrt{N}}$$

Illustrated in the graph is the frequency response of the standard filter block with values calculated at f_O = 10 kHz (Fig. 2). Superimposed on the graph is the frequency response of the same filter with an additional diode at the output of the op amp. Note that the center frequency has been shifted by approximately 25%. The frequency shift can be mitigated by component selection. Or, the Delyannis center-frequency design parameter can be adjusted in the initial design to account for this shift.

Distortion of the signal is audible with the added diode. But for LED display purposes, board space and cost can be saved versus using traditional methods to achieve comparable passband Q. Components used were 1% metal film resistors (R = 4.99k, RA = 100k, RB = 180k), monolithic capacitors (C = 330 pF), a 1N4148 diode, and an OP-27 operational amplifier.



2. The bandpass filter response shows a 100% increase in Q. The 25% shift in the calculated center frequency can be compensated for in the design calculations.