Bainter Notch Filters

by Hank Zumbahlen,
Analog Devices, Inc.

IN THIS MINI TUTORIAL

A simple notch filter is the Bainter operational amplifier (op amp) notch filter, one of multiple discrete circuits described in a series of mini tutorials.

INTRODUCTION TO BAINTER NOTCH FILTERS

A simple notch filter is the Bainter circuit (see the Reference section). It is composed of simple circuit blocks with two feedback loops as shown in Figure 1. Low-pass, high-pass, and standard notch responses can be realized.

The circuit in Figure 1 has several interesting properties. The Q of the notch is not based on component matching as it is in every other implementation, but is instead only dependent on the gain of the amplifiers. Therefore, the notch depth does not drift with temperature, aging, and other environmental factors. The notch frequency may shift, but not the depth. In addition, the component sensitivity is very low.

FILTER DIAGRAM

Amplifier open-loop gain of 10^4 yields a Q_z of > 200. It is capable of orthogonal tuning with minimal interaction. R6 tunes Q and R1 tunes ω_z. Varying R3 sets the ratio of ω_0/ω_z, producing low-pass notch (R4 > R3), notch (R4 = R3) or high-pass notch (R4 < R3) responses. The values of K1 and K2 set the gain above and below the notch frequency. In general, a value of 1 is a starting point.

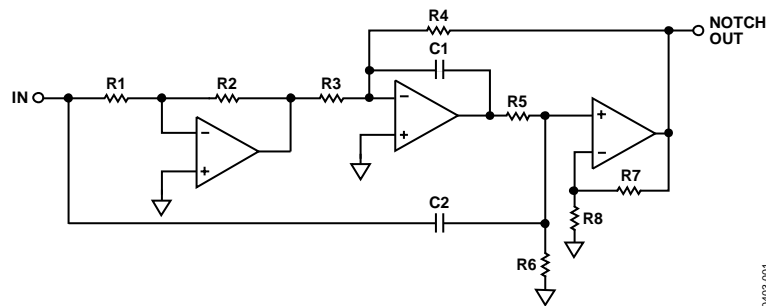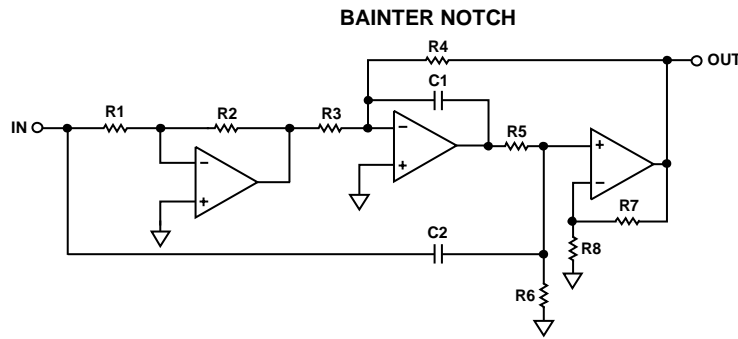The design equations of the Bainter circuit are given in Figure 2.

Figure 1. Bainter Notch Filter

DESIGN EQUATIONS

BAINTER NOTCH

$$\frac{H\,(S^2 + \omega_Z 2)}{S^2 + \dfrac{\omega_0}{Q}\,S + \omega_0{}^2}$$

$$\frac{V_{OUT}}{V_{IN}} = \frac{K2 \times \left[S^2 + \dfrac{K1}{R3\,R5\,C1\,C2}\right]}{S^2 + \dfrac{(R5 + R6)}{R5\,R6\,C2}\,S + \dfrac{K2}{R4\,R5\,C1\,C2}}$$

CHOOSE C1, R1, R7, K1, K2

$$C2 = C1 = C$$
$$k = 2\,\pi\,F_O\,C$$
$$R2 = K1 \times R1$$
$$Z = \left(\frac{\omega_Z}{\omega_0}\right)^2$$
$$R3 = \frac{K1}{2\,Z\,Q\,k}$$

$$R4 = \frac{K2}{2\,Q\,k}$$
$$R5 = R6 = \frac{2\,Q}{k}$$
$$R8 = (K2 - 1)\,R7$$

10401-002

Figure 2. Bainter Notch Filter Design Equations

REFERENCES

Bainter, J. R. "Active Filter Has Stable Notch and Response Can Be Regulated," *Electronics*, Oct. 2, 1975, pages 115 to 117.

Zumbahlen, Hank. *Linear Circuit Design Handbook*. Elsevier. 2008. ISBN: 978-7506-8703-4.

REVISION HISTORY
4/12—Revision 0: Initial Version

ANALOG DEVICES

w w w . a n a l o g . c o m

www.BDTIC.com/ADI