Digital-to-analog converter controls active filter

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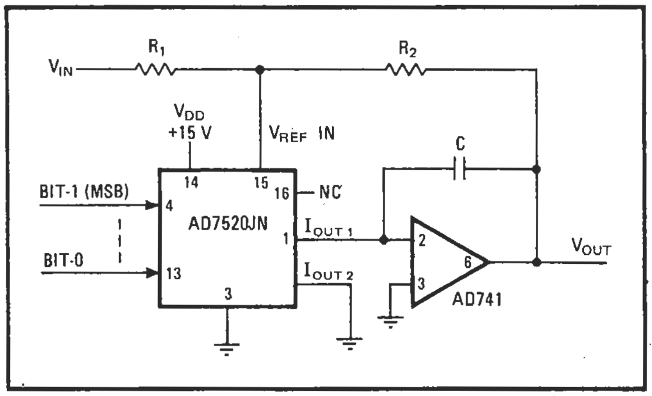
A monolithic digital-to-analog converter can be the control element of an active filter. Shown in Fig. 1 is a circuit that generates a low-pass, single pole that can be moved over a dynamic frequency range of $2^n{:}1$, where n is the resolution in bits of the d-a converter. If, for example, a converter with 10-bit resolution is used in this circuit, dynamic range is 1,024:1.

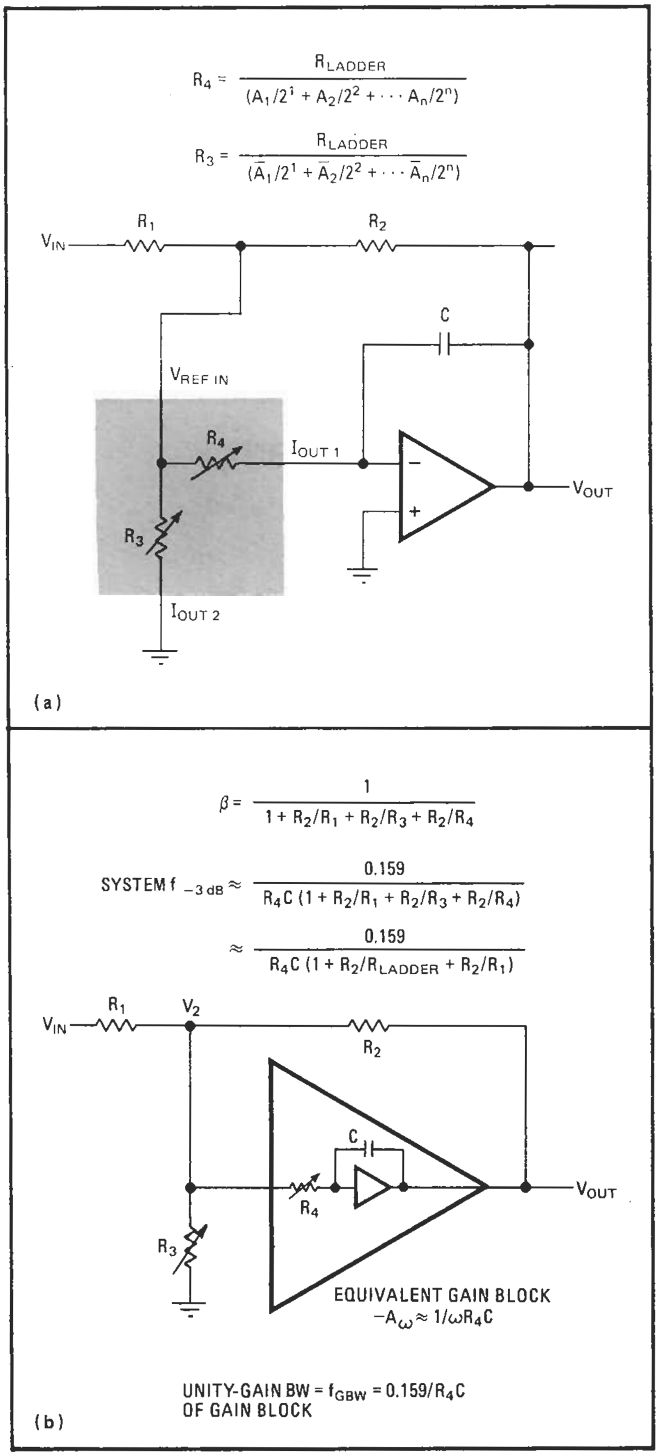
An equivalent simplified version of Fig. 1 is shown in Fig. 2(a), where R_4 and R_3 take on the values shown. R_{ladder} is the characteristic resistance of the R-2R ladder of the d-a converter and the coefficients A assume a value of 1 for an on bit, and zero for an off bit. Note that R_4 in parallel with R_3 equals R_{ladder}.

The circuit, consisting of R_4, C, and the amplifier, can be treated as a gain block as shown in Fig. 2(b). At frequencies above the open-loop corner, the response of the gain block is $A(\omega) = V_{out}/V_2$ or about $1/\omega R_4C$. Its unity gain bandwidth is $F_{GBW} = 0.159/R_4C$.

Frequency response of a closed-loop amplifier is $F_{3dB} = Bf_{GBW}$ where B is the amplifier feedback attenuation ratio. Using the unity gain bandwidth of the gain block and the system B results in the filter closed loop frequency response equations shown in Fig. 2(b). □



1. 1,024:1. An active low-pass filter such as this, built around an operational amplifier, passive components, and a 10-bit digital-to-analog converter, has a dynamic-frequency range of 1,024:1.



2. Equivalent circuits. The d-a of (1) can be replaced by the circuit within the dashed lines (a). A further simplification (b) lumps R4, C and the op amp into a gain block.