Analog Engineer's Circuit

Single-supply, 2nd-order, multiple feedback band-pass filter circuit

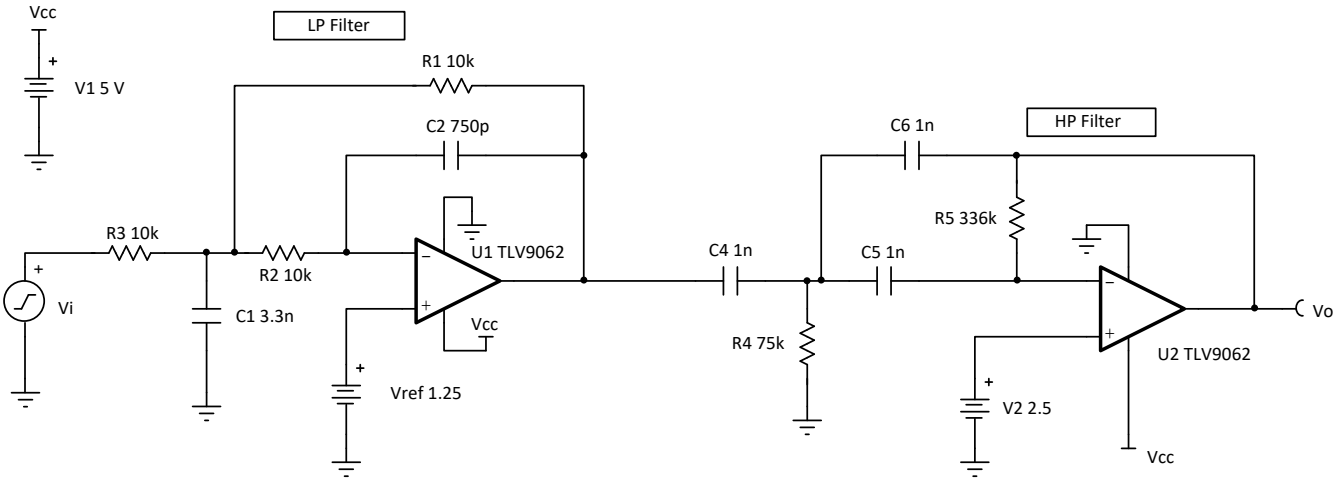
Amplifiers

Input		Output		Supply	
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}
–2.45V	+2.45V	0.05V	4.95V	5V	0V

Gain	Low Cut-off Frequency (f_l)	High Cut-off Frequency (f_h)	V_{ref}
1V/V	1kHz	10kHz	1.25V and 2.5V

Design Description

This circuit is a 2nd-order multiple feedback (MFB) band-pass (BP) filter. This BP filter is created by cascading a low-pass and a high-pass filter. V_{ref} provides a DC offset to accommodate for single-supply applications.



Design Notes

1. Select an op amp with sufficient input common-mode range and output voltage swing.
2. Add V_{ref} to bias the input signal to meet the input common-mode range and output voltage swing.
3. Select the capacitor values first since standard capacitor values are more coarsely subdivided than the resistor values. Use high-precision, low-drift capacitor values to avoid errors in f_l and f_h.
4. To minimize the amount of slew-induced distortion, select an op amp with sufficient slew rate (SR).
5. For HP filters the maximum frequency is set by the gain bandwidth (GBW) of the op amp. Therefore, be sure to select an op amp with sufficient GBW.

Design Steps

This BP filter design involves two cascaded filters, a low-pass (LP) filter and a high-pass (HP) filter. The lower cutoff frequency (f_l) of the BP filter is 1kHz and the higher cutoff frequency (f_h) is 10kHz. The design steps show an LP filter design with f_h of 10kHz and a HP filter design with f_l of 1kHz. See MFB low-pass filter design and MFB high-pass filter design in the circuit cookbook for details on transfer function equations and calculations.

LP Filter Design

1. Use MFB low-pass filter design to determine R_1, R_2, and R_3.

   $R_1 = 10k\Omega$,
   $R_2 = 10k\Omega$,
   $R_3 = 10k\Omega$

2. Use MFB low-pass filter design to determine C_1 and C_2.

   $C_1 = 3.3nF$ (Standard Value), $C_2 = 750pF$ (Standard Value)

HP Filter Design

1. Use MFB high-pass filter design to determine C_4, C_5, and C_6.

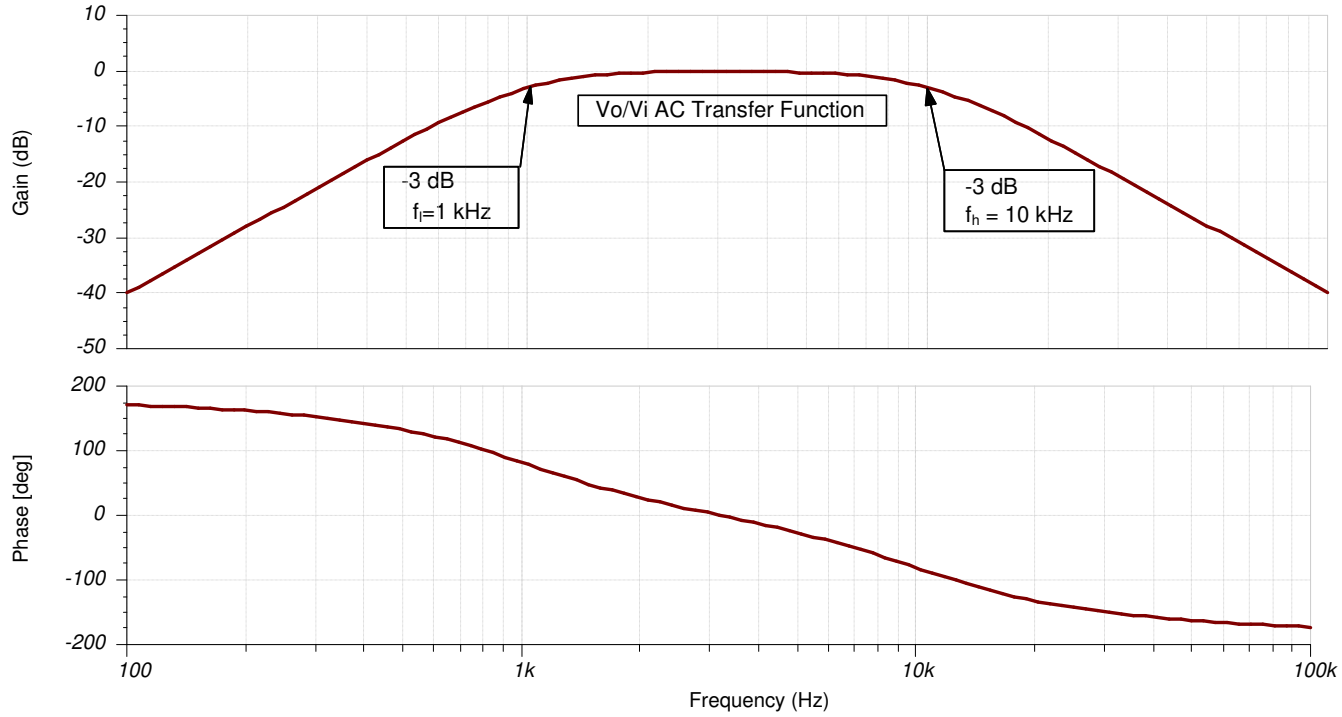
   $C_4 = 1nF$,
   $C_5 = 1nF$,
   $C_6 = 1nF$

2. Use MFB high-pass filter design to determine R_4 and R_5.

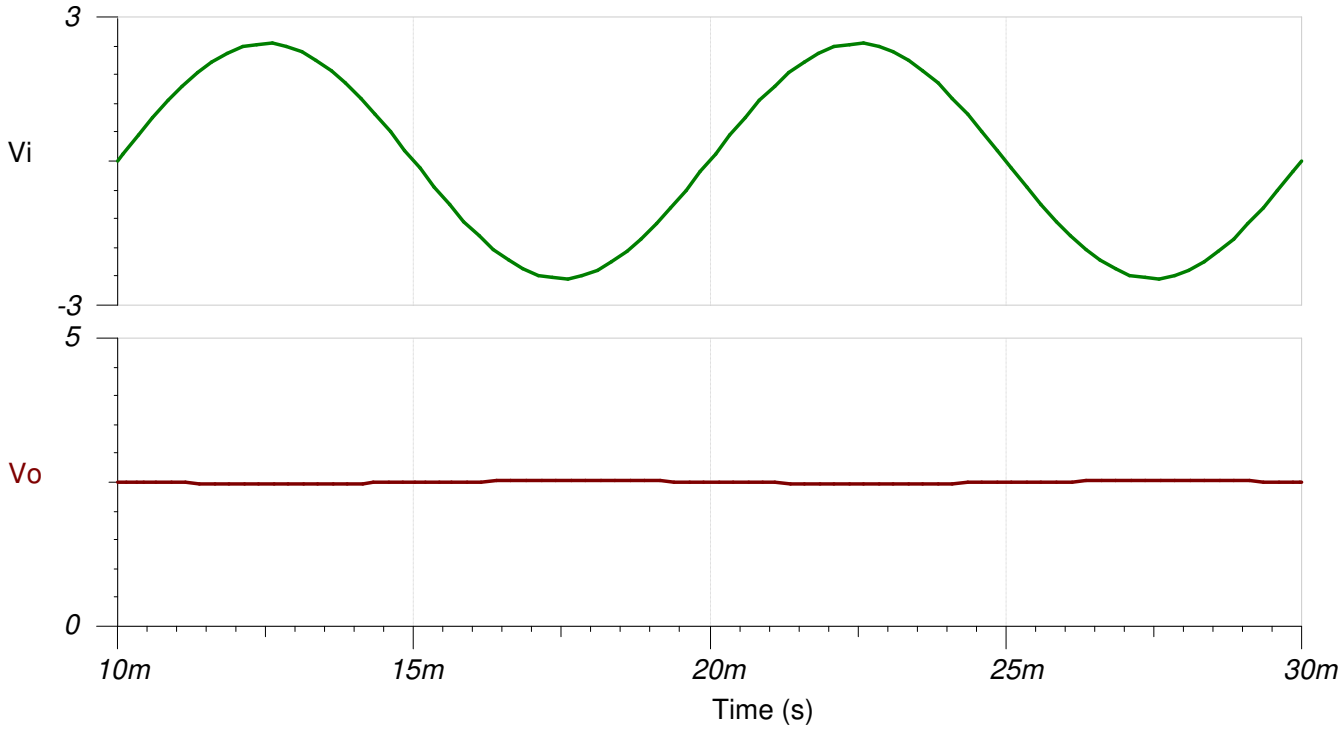
   $R_4 = 75k\Omega$,
   $R_5 = 336k\Omega$

Design Simulations

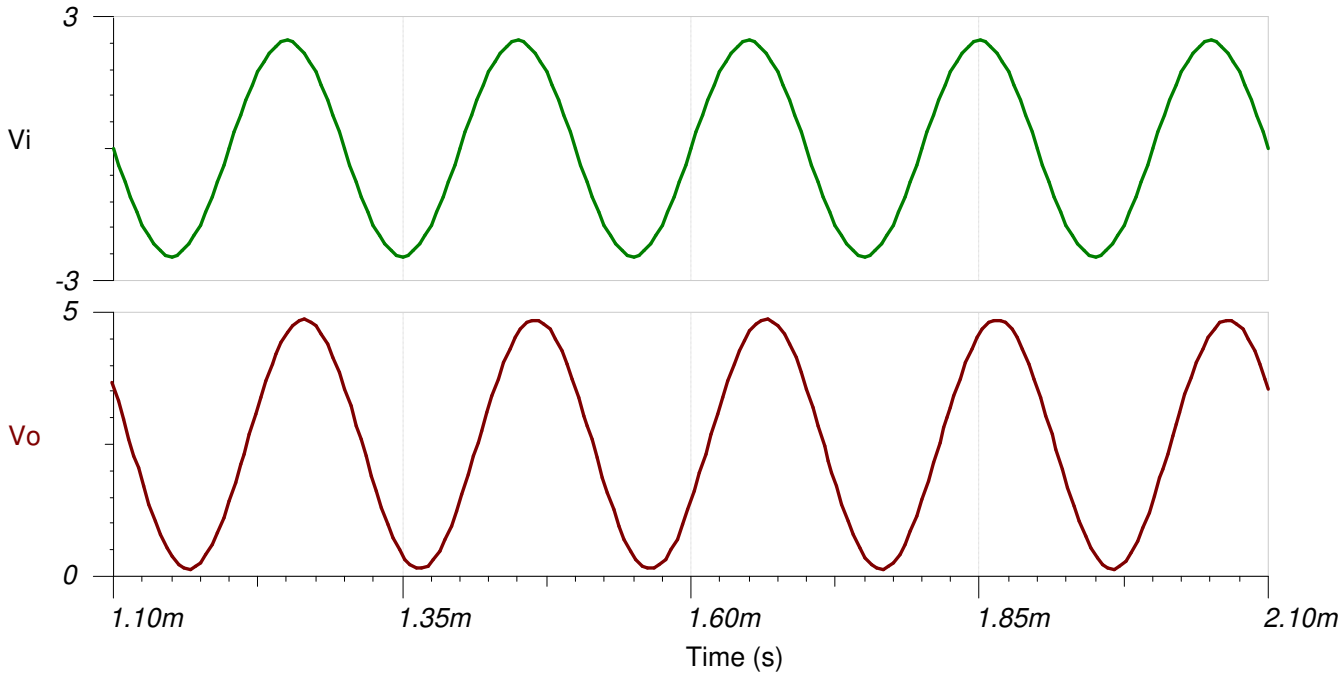
AC Simulation Results



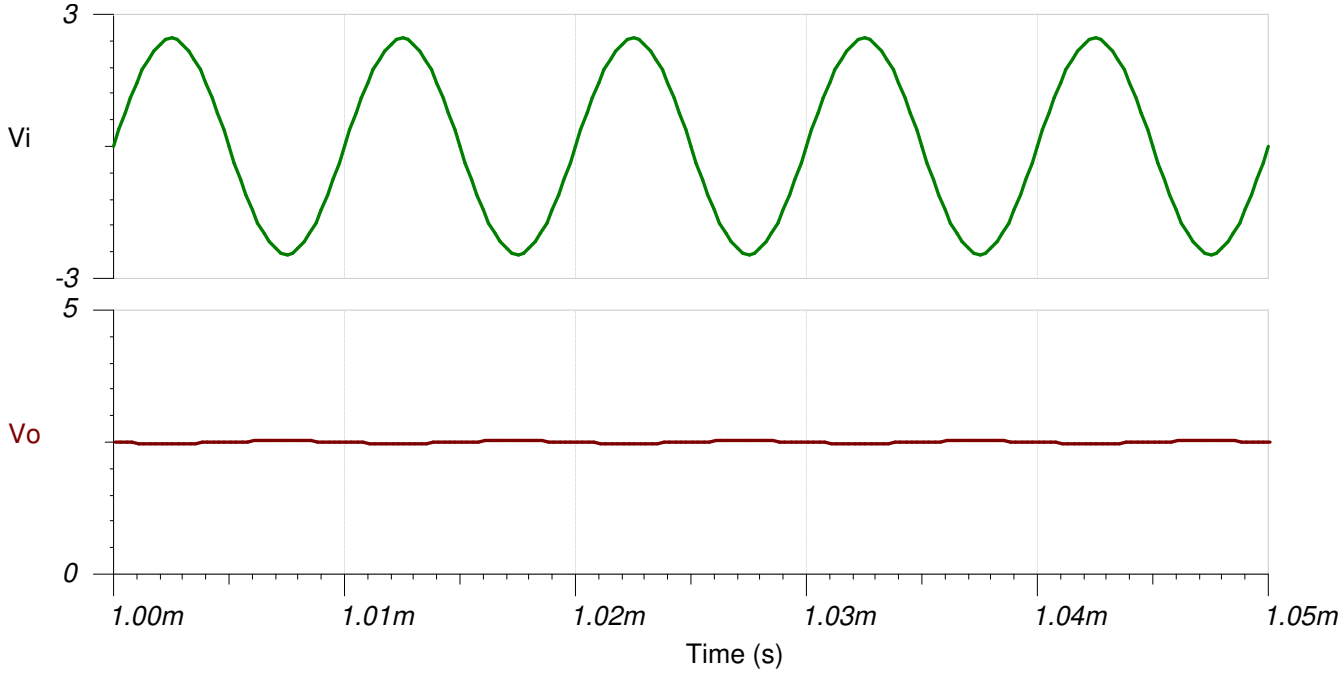
Transient Simulation Results



Filter Ouput in Response to a 5-Vpp, 100-Hz Input Signal (Gain = 0.01V/V)



Filter Ouput in Response to a 5-Vpp, 5-kHz Input Signal (Gain = 1V/V)



Filter Ouput in Response to a 5-Vpp, 100-kHz Input Signal (Gain = 0.01V/V)

Design References

1. See Analog Engineer's Circuit Cookbooks for TI's comprehensive circuit library.
2. SPICE Simulation File: SBOC596.
3. TI Precision Labs.

Design Featured Op Amp

TLV9062	
Vss	1.8V to 5.5V
VinCM	Rail-to-Rail
Vout	Rail-to-Rail
Vos	0.3mV
Iq	538µA
Ib	0.5pA
UGBW	10MHz
SR	6.5V/µs
#Channels	1, 2, 4
www.ti.com/product/TLV9062	

Design Alternate Op Amp

	TLV316	OPA325
Vss	1.8V to 5.5V	2.2V to 5.5V
VinCM	Rail-to-Rail	Rail-to-Rail
Vout	Rail-to-Rail	Rail-to-Rail
Vos	0.75mV	0.150mV
Iq	400µA	650µA
Ib	10pA	0.2pA
UGBW	10MHz	10MHz
SR	6V/µs	5V/µs
#Channels	1, 2, 4	1, 2, 4
	www.ti.com/product/TLV316	www.ti.com/product/OPA325

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