Analog Engineer's Circuit

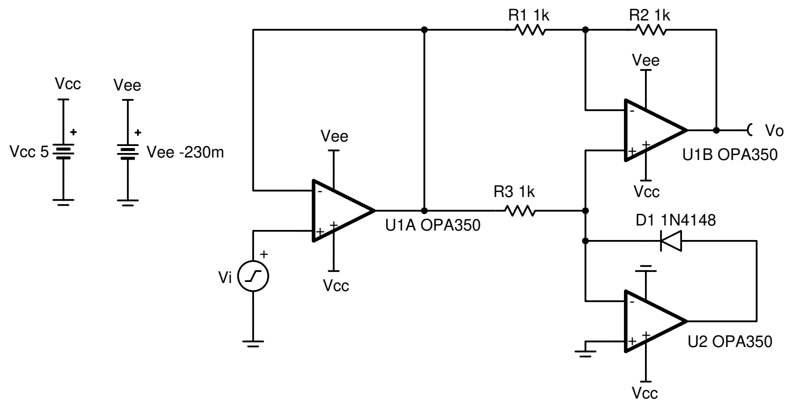
Single-Supply, Low-Input Voltage, Full-Wave Rectifier Circuit

Design Goals

Input		Output		Supply		
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}	V_{ref}
5 mVpp	400 mVpp	2.5 mVpp	200 mVpp	5 V	–0.23 V	0 V

Design Description

This single-supply precision absolute value circuit is optimized for low-input voltages. It is designed to function up to 50 kHz and has excellent linearity at signal levels as low as 5 mVpp. The design uses a negative charge pump (such as LM7705) on the negative op amp supply rails to maintain linearity with signal levels near 0 V.

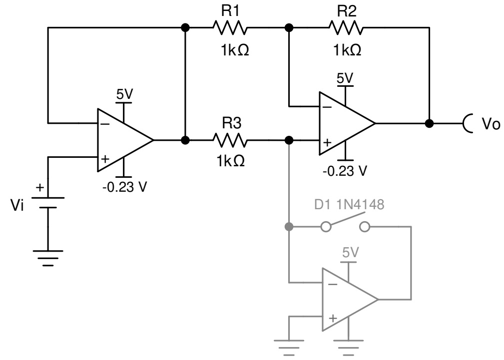


Design Notes

1. Observe common-mode and output swing limitations of op amps.
2. R_3 should be sized small enough that the leakage current from D_1 does not cause errors in positive input cycles while ensuring the op amp can drive the load.
3. Use a fast switching diode for D_1.
4. Removing the input buffer will allow for input signals with peak-to-peak values twice as large as the supply voltage at the expense of lower input impedance and slight gain error.
5. Use precision resistors to minimize gain error.

Design Steps

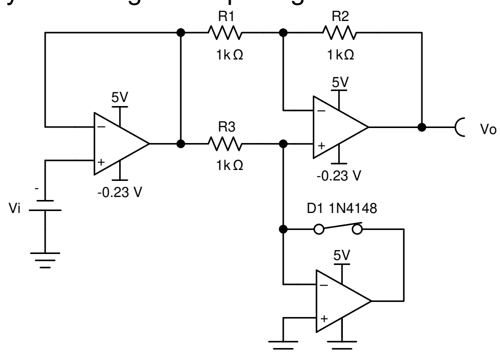
1. Circuit analysis for positive input signals.

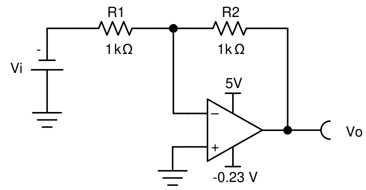


$$\frac{V_o}{V_i} = \left(-\frac{R_2}{R_1}\right) + \left(1 + \frac{R_2}{R_1}\right) = 1$$

$$V_o = V_i$$

2. Circuit analysis for negative input signals.





$$\frac{V_o}{V_i} = \left(-\frac{R_2}{R_1}\right) = -1$$

$$V_o = -V_i$$

3. Select R_1, R_2, and R_3.

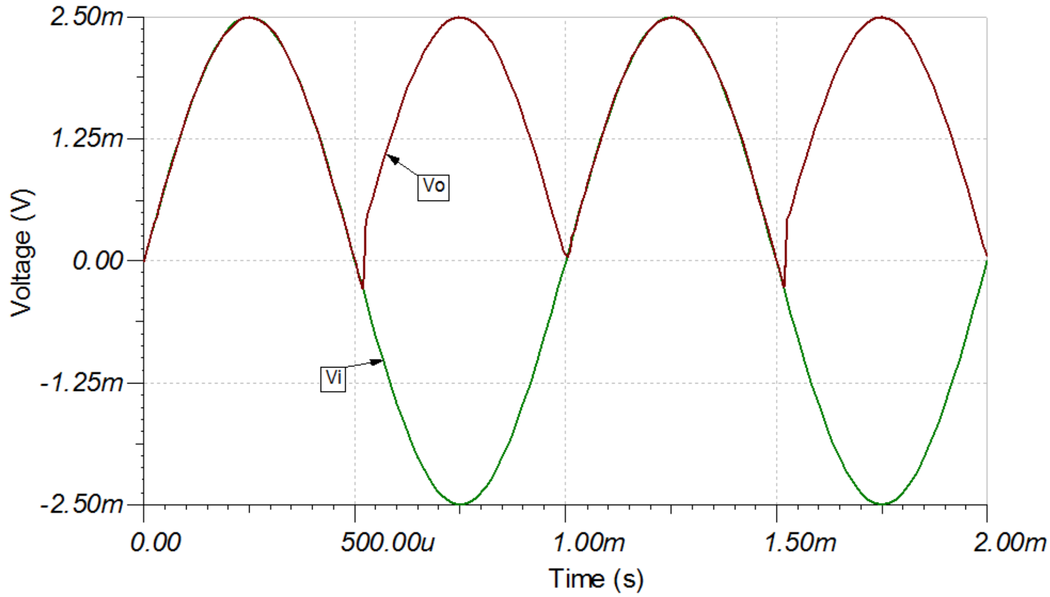
$$\frac{V_o}{V_i} = -\frac{R_2}{R_1}$$

$$\text{If } R_2 = R_1 \quad \text{then } V_o = -V_i$$

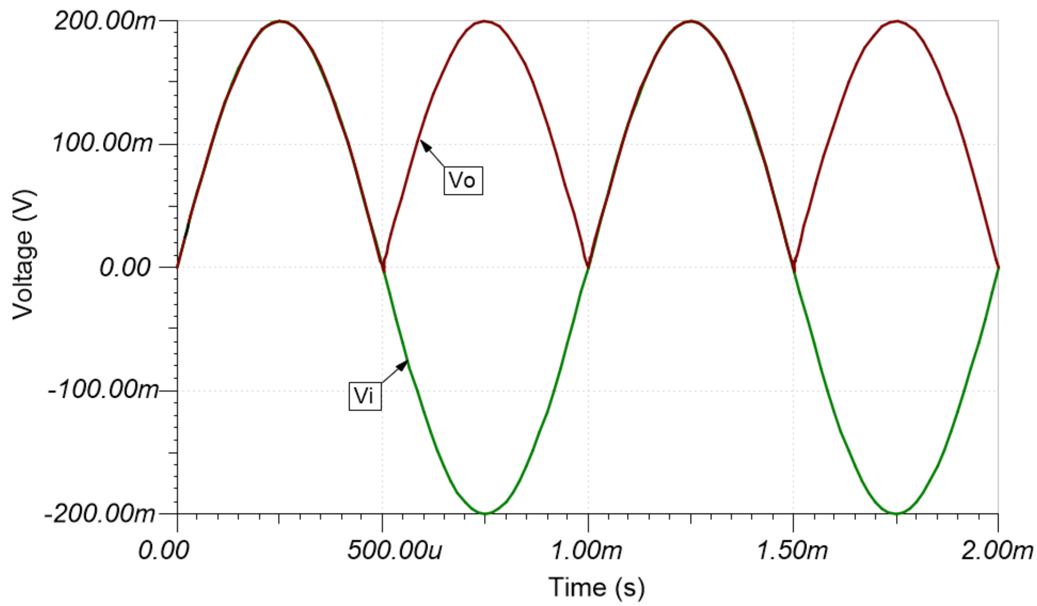
$$\text{Set } R_1 = R_2 = R_3 = 1 \quad k\Omega$$

Design Simulations

Transient Simulation Results



5 mVpp at 1 kHz Input



400 mVpp at 1 kHz Input

Design References

See *Analog Engineer's Circuit Cookbooks* for TI's comprehensive circuit library.

See circuit SPICE simulation file SBOC506.

See TIPD124, Single-Supply Low-Input Voltage Optimized Precision Full-Wave Rectifier Reference Design.

Design Featured Op Amp

OPA350	
V_{ss}	2.7 V to 5.5 V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	150 µV
I_q	5.2 mA/Ch
I_b	0.5 pA
UGBW	38 MHz
SR	22 V/µs
#Channels	1, 2, and 4
OPA350	

Design Alternate Op Amp

OPA353	
V_{ss}	2.7 V to 5.5 V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	3 mV
I_q	5.2 mA
I_b	0.5 pA
UGBW	44 MHz
SR	22 V/µs
#Channels	1, 2, and 4
OPA353	

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from February 1, 2018 to February 4, 2019 **Page**

- Downscale the title and changed title role to 'Amplifiers'. Added links to circuit cookbook landing page and SPICE simulation file.......... 1

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