Analog Engineer's Circuit

Single-supply, high-input voltage, full-wave rectifier circuit

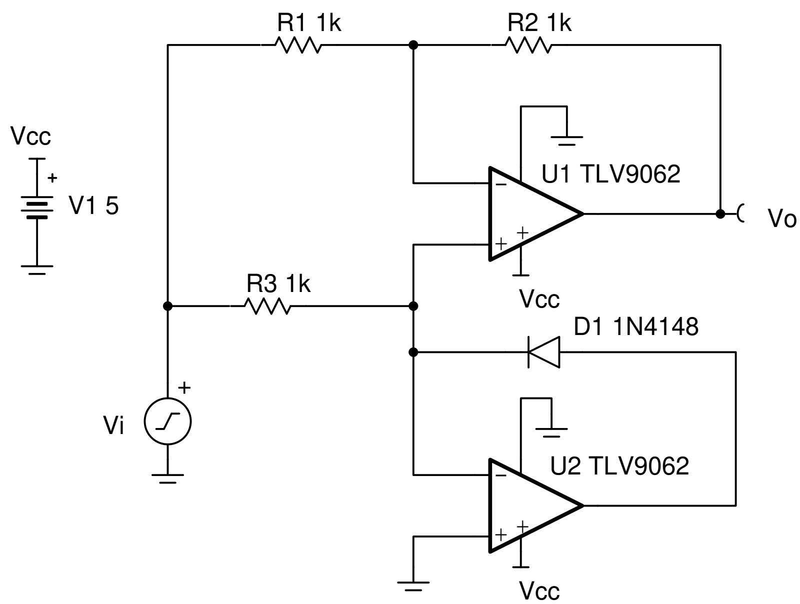
Amplifiers

Design Goals

Input	Output	Frequency	Supply	
V_{iMax}	V_{oMax}	f_{Max}	V_{cc}	V_{ee}
9Vpp	4.5Vpp	50kHz	5V	0V

Design Description

This single-supply precision full-wave rectifier is optimized for high-input voltages. When V_i > 0V, D_1 is reverse biased and the top part of the circuit, U1, is activated resulting in a circuit with a gain of 1V/V. When Vi < 0V, D_1 is forward biased and the bottom part of the circuit, U2, is activated resulting in an inverting amplifier circuit with a gain of –1V/V.

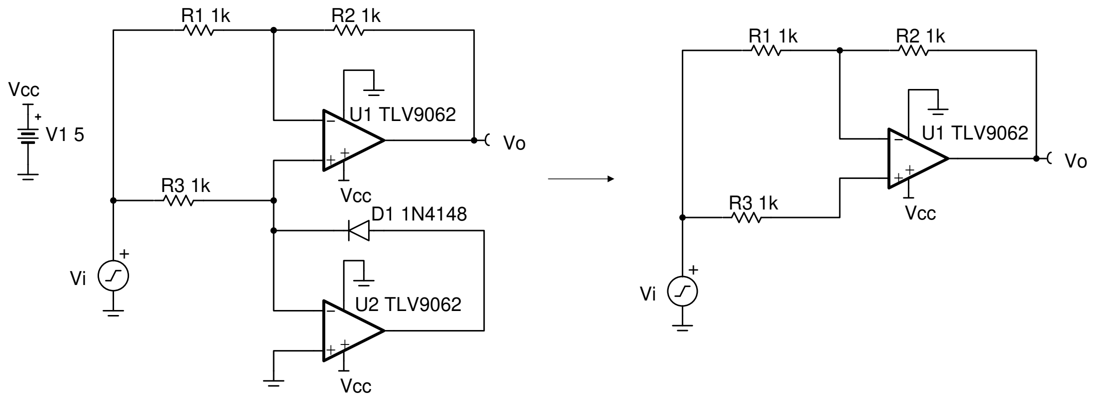


Design Notes

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 for positive input cycles while ensuring the op amp can drive the load.
3. Use a fast switching diode for D_1.
4. Resistor tolerance determines the gain error of the circuit.
5. Use a negative charge pump (such as the LM7705) for output swing requirements to GND to maintain linearity for output signals near 0V. For additional information. see *Single-supply, low-input voltage, full-wave rectifier circuit*.
6. For more information on op amp linear operating region, stability, capacitive load drive, driving ADCs, and bandwidth please see the *Design References* section.

Design Steps

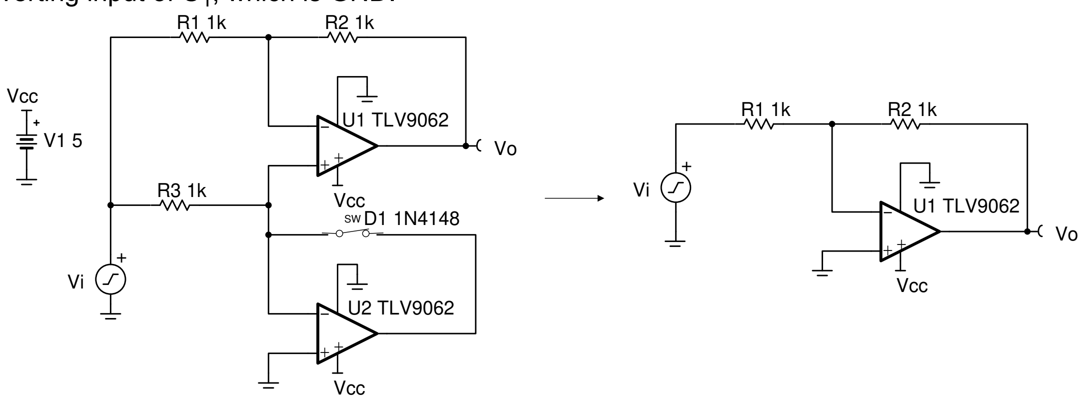
1. Circuit analysis for positive input signals. D_1 is reverse-biased disconnecting the output of U_2 from the non-inverting input of U_1.



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

$$V_o = V_i$$

2. Circuit analysis for negative input signals. D_1 is forward biased, which connects the output of U_2 to the non-inverting input of U_1, which is GND.



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

$$V_o = -V_i$$

3. Select R_1, R_2, and R_3.

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

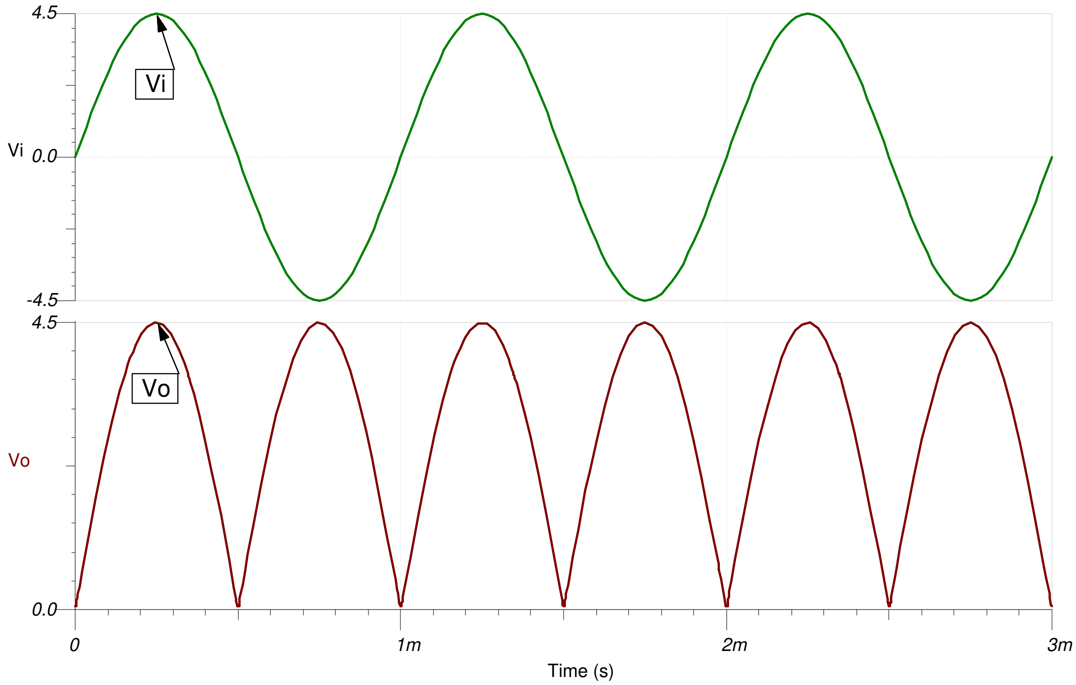
$$\text{If } R_2 = R_1 \quad \text{then } V_o = -V_i$$

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

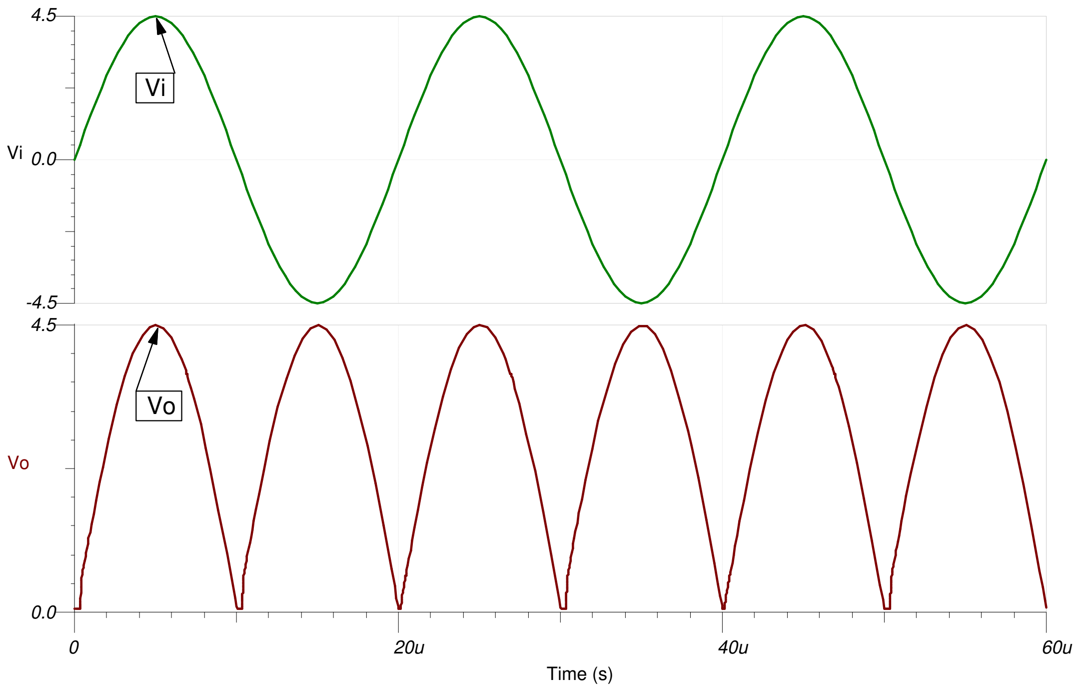
Design Simulations

Transient Simulation Results

A 1-kHz, 9-V_{pp} sine wave yields a 4.5-V_{pp} output sine wave.



A 50-kHz, 9-V_{pp} sine wave yields a 4.5-V_{pp} output sine wave.



Design References

1. See *Analog Engineer's Circuit Cookbooks* for the comprehensive TI circuit library.
2. SPICE Simulation File SBOC529.
3. TI Precision Labs
4. See the *Single-Supply Low-Input Voltage Optimized Precision Full-Wave Rectifier Reference Design*.

Design Featured Op Amp

TLV9062	
V_{ss}	1.8V to 5.5V
V_{inCM}	Rail–to–rail
V_{out}	Rail–to–rail
V_{os}	0.30mV
I_q	538µA
I_b	0.5pA
UGBW	10MHz
SR	6.5V/µs
#Channels	1, 2, 4
www.ti.com/product/TLV9062	

Design Alternate Op Amps

	OPA322	OPA350
V_{ss}	1.8V to 5.5V	2.7V to 5.5V
V_{inCM}	Rail–to–rail	Rail–to–rail
V_{out}	Rail–to–rail	Rail–to–rail
V_{os}	2mV	0.15mV
I_q	1.9mA	5.2mA
I_b	10pA	0.5pA
UGBW	20MHz	38MHz
SR	10V/µs	22V/µs
#Channels	1, 2, 4	1, 2, 4
	www.ti.com/product/OPA322	www.ti.com/product/OPA350