

Analog Engineer's Circuit

Half-Wave Rectifier Circuit

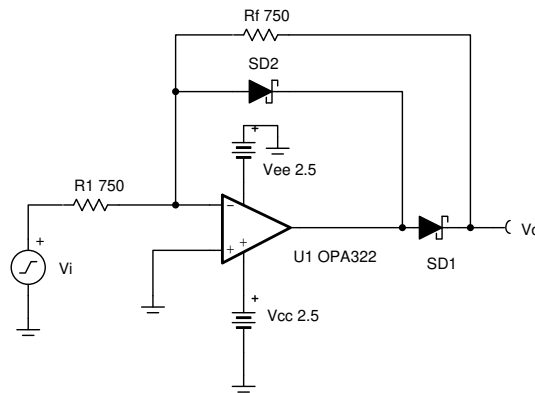


Design Goals

Input		Output		Supply	
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}
$\pm 0.2 \text{ mV}_{pp}$	$\pm 4 \text{ V}_{pp}$	0.1 V_p	2 V_p	2.5 V	-2.5 V

Design Description

The precision half-wave rectifier inverts and transfers only the negative-half input of a time varying input signal (preferably sinusoidal) to its output. By appropriately selecting the feedback resistor values, different gains can be achieved. Precision half-wave rectifiers are commonly used with other op amp circuits such as a peak-detector or bandwidth limited non-inverting amplifier to produce a DC output voltage. This configuration has been designed to work for sinusoidal input signals between 0.2 mV_{pp} and 4 V_{pp} at frequencies up to 50 kHz.



Design Notes

1. Select an op amp with a high slew rate. When the input signal changes polarities, the amplifier output must slew two diode voltage drops.
2. Set output range based on linear output swing (see A_{ol} specification).
3. Use fast switching diodes. High-frequency input signals will be distorted depending on the speed by which the diodes can transition from blocking to forward conducting mode. Schottky diodes might be a preferable choice, since these have faster transitions than pn-junction diodes at the expense of higher reverse leakage.
4. The resistor tolerance sets the circuit gain error.
5. Minimize noise errors by selecting low-value resistors.

Design Steps

1. Set the desired gain of the half-wave rectifier to select the feedback resistors.

$$V_o = \text{Gain} \times V_i$$

$$\text{Gain} = -\frac{R_f}{R_1} = -1$$

$$R_f = R_1 = 2 \times R_{eq}$$

- Where R_{eq} is the parallel combination of R_1 and R_f
2. Select the resistors such that the resistor noise is negligible compared to the voltage broadband noise of the op amp.

$$E_{nr} = \sqrt{4 \times k_b \times T \times R_{eq}}$$

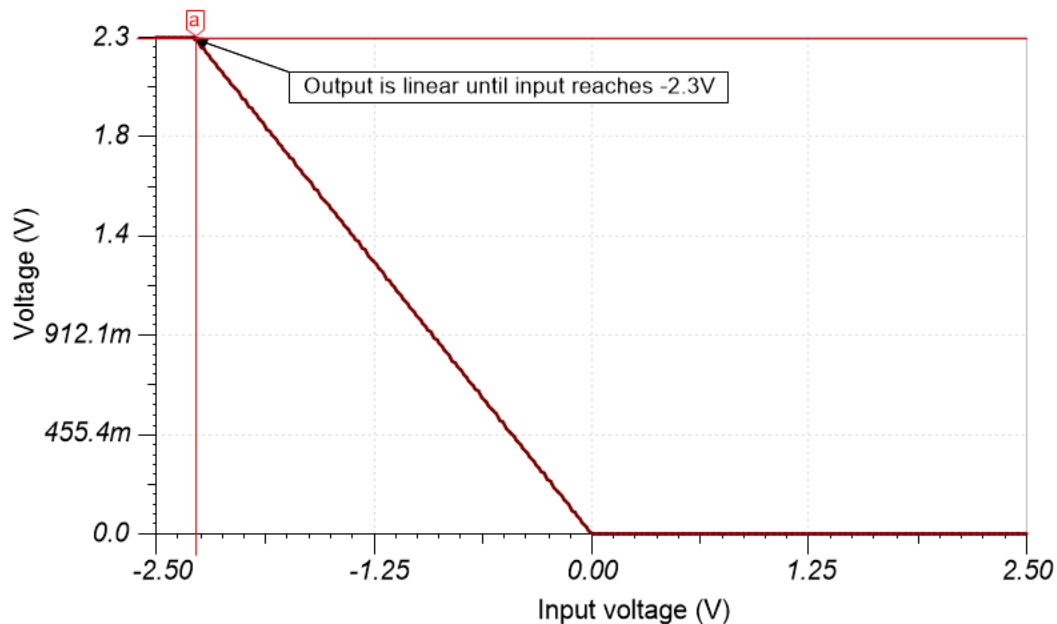
$$R_{eq} \leq \frac{E_{nbb}^2}{4 \times k_b \times T \times 3^2} = (E_{nbb})$$

$$= 7.5 \frac{nV}{\sqrt{Hz}} = \frac{(7.5 \times 10^{-9})^2}{4 \times 1.381 \times 10^{-23} \times 298 \times 3^2} = 380\Omega$$

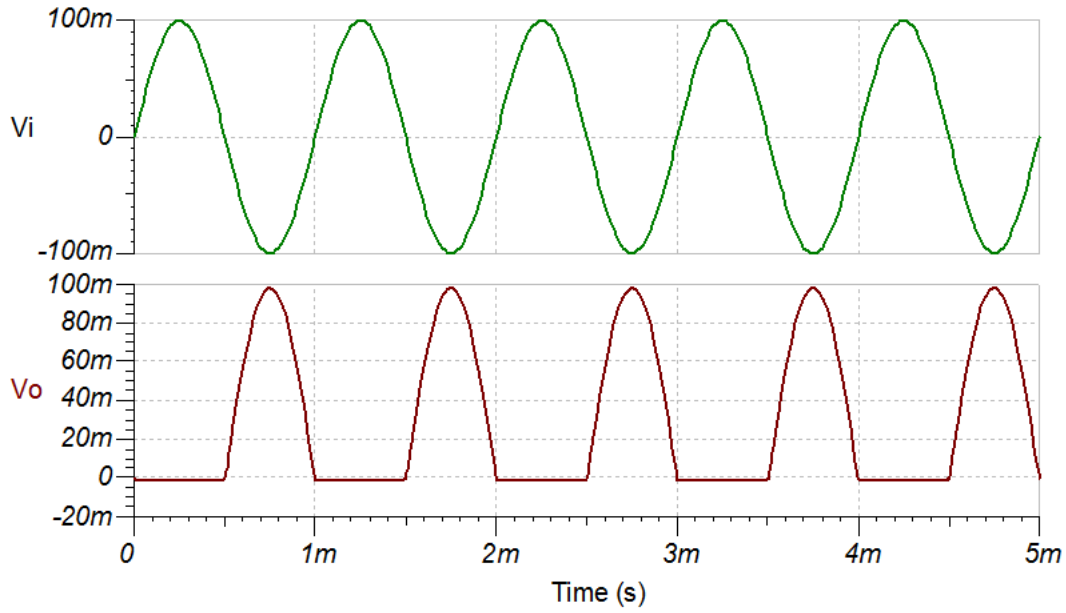
$$R_f = R_1 \leq 760\Omega \rightarrow 750\Omega \text{ (Standard Value)}$$

Design Simulations

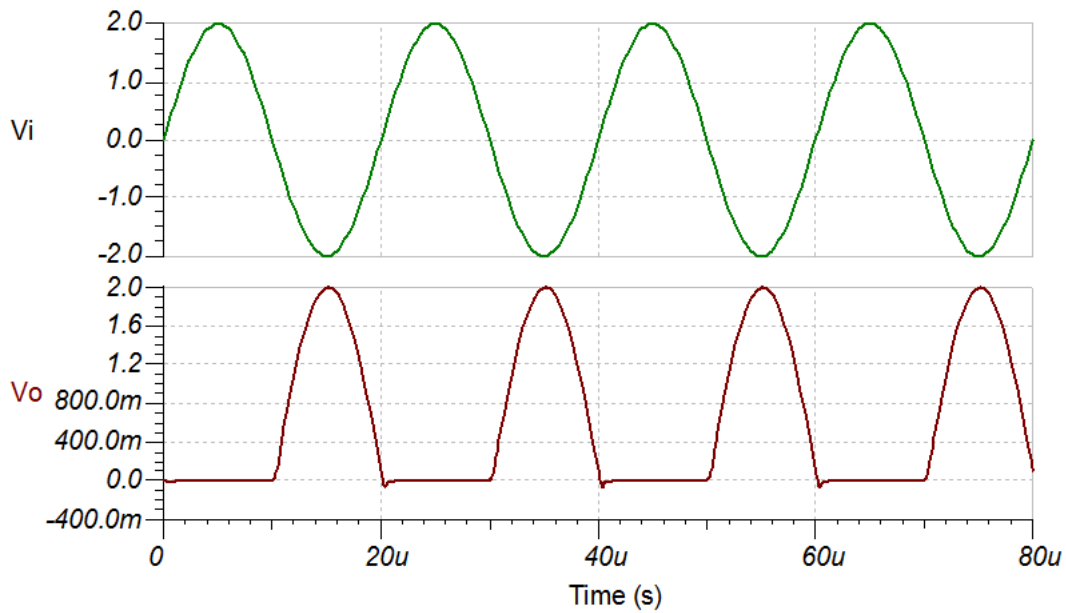
DC Simulation Results



Transient Simulation Results



200 mV_{pp} at 1 kHz



2 V_{pp} at 50 kHz

Design References

See [Analog Engineer's Circuit Cookbooks](#) for TI's comprehensive circuit library.

See circuit SPICE simulation file [SBOC509](#).

Design Featured Op Amp

OPA322	
V_{SS}	1.8 V to 5.5 V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	500 μ V
I_q	1.6 mA/Ch
I_b	0.2 pA
UGBW	20 MHz
SR	10 V/ μ s
#Channels	1, 2, and 4
OPA3222	

Design Alternate Op Amp

OPA2325	
V_{SS}	2.2 V to 5.5 V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	40 μ V
I_q	0.65 mA/Ch
I_b	0.2 pA
UGBW	10 MHz
SR	5 V/ μ s
#Channels	2
OPA2325	

Revision History

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

Changes from August 2, 2017 to February 1, 2019

Page

- | | |
|--|----------|
| <ul style="list-style-type: none"> • Downscale the title and changed title role to 'Amplifiers'. Added link to circuit cookbook landing page and link to Spice simulation file..... | 1 |
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