

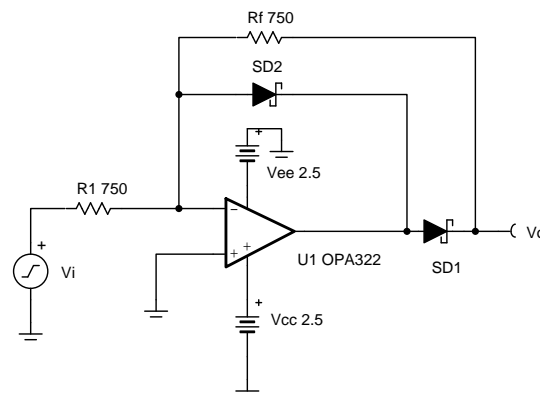
## Half-wave rectifier circuit

### Design Goals

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

### 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  $0.2mV_{pp}$  and  $4V_{pp}$  at frequencies up to 50kHz.



### 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.

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

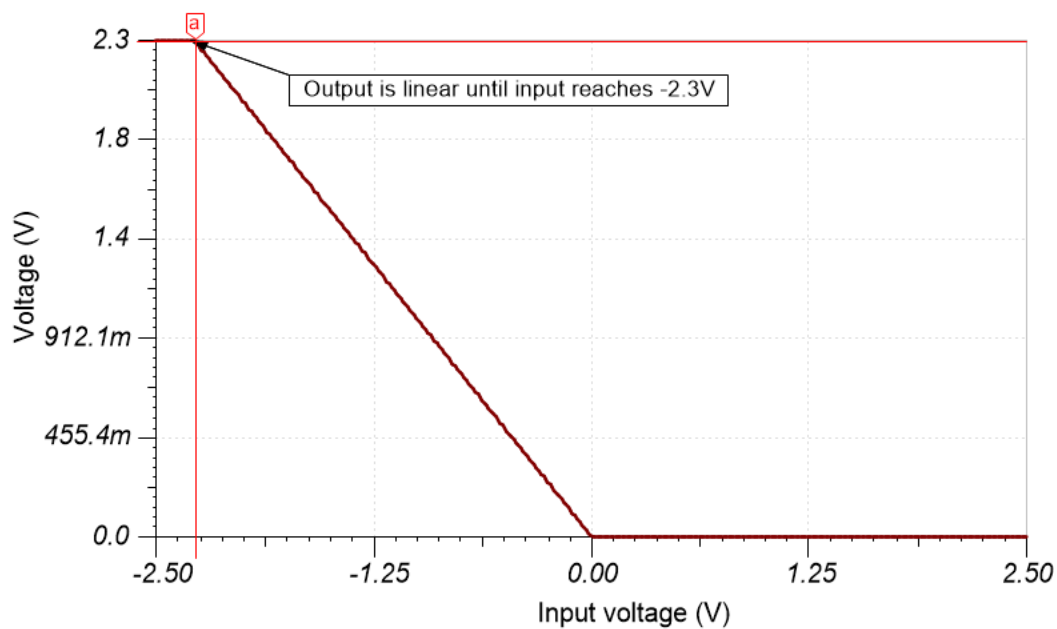
$$R_{eq} \leq \frac{E_{nbb}^2}{4 \times K_b \times T \times 3^2} = (E_{nbb})$$

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

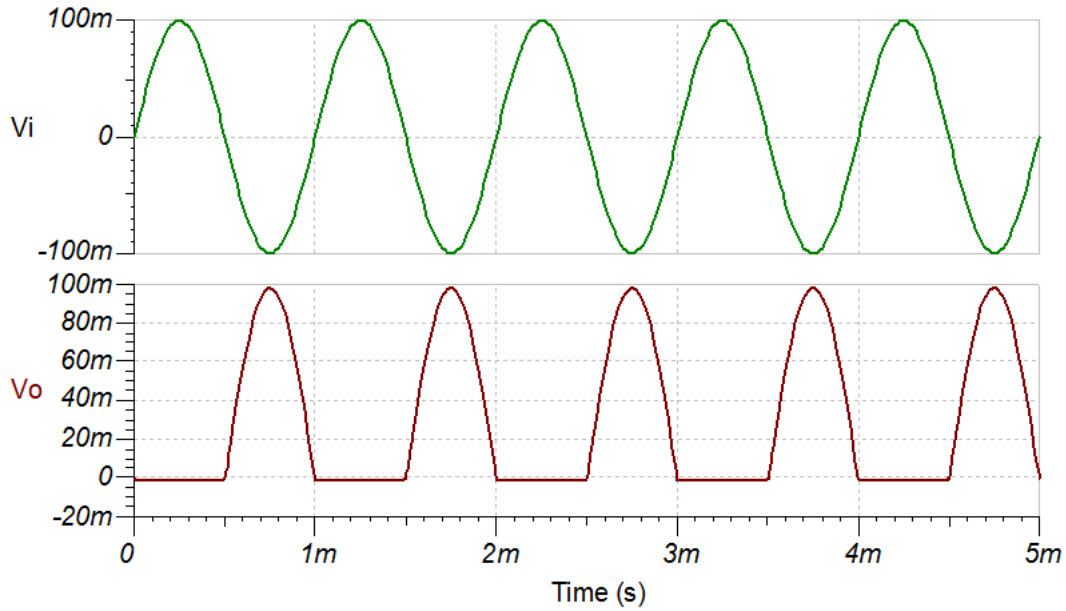
$$R_f = R_1 \leq 760\Omega \rightarrow 750\Omega \text{ (Standard Value)}$$

### Design Simulations

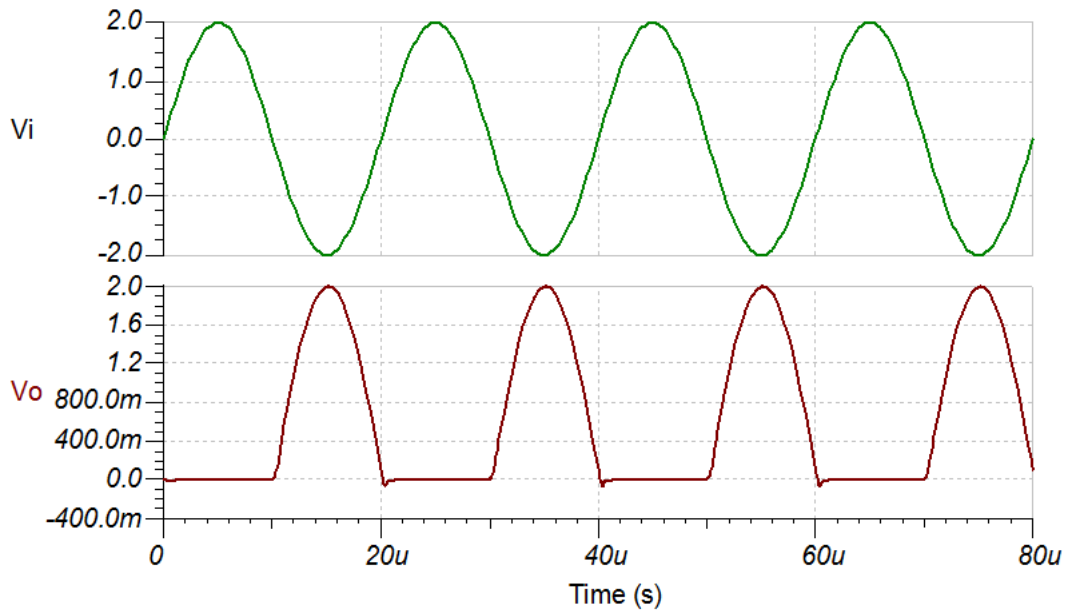
#### DC Simulation Results



Transient Simulation Results



200mV<sub>pp</sub> at 1kHz



2V<sub>pp</sub> at 50kHz

## 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	
$V_{SS}$	1.8V to 5.5V
$V_{inCM}$	Rail-to-rail
$V_{out}$	Rail-to-rail
$V_{OS}$	500 $\mu$ V
$I_q$	1.6mA/Ch
$I_b$	0.2pA
<b>UGBW</b>	20MHz
<b>SR</b>	10V/ $\mu$ s
<b>#Channels</b>	1, 2, 4
<a href="http://www.ti.com/product/opa322">www.ti.com/product/opa322</a>	

## Design Alternate Op Amp

OPA2325	
$V_{SS}$	2.2V to 5.5V
$V_{inCM}$	Rail-to-rail
$V_{out}$	Rail-to-rail
$V_{OS}$	40 $\mu$ V
$I_q$	0.65mA/Ch
$I_b$	0.2pA
<b>UGBW</b>	10MHz
<b>SR</b>	5V/ $\mu$ s
<b>#Channels</b>	2 $\mu$
<a href="http://www.ti.com/product/opa2325">www.ti.com/product/opa2325</a>	

## Revision History

Revision	Date	Change
A	January 2019	Downscale the title and changed title role to 'Amplifiers'. Added link to circuit cookbook landing page and link to Spice simulation file.

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