

# Analog Engineer's Circuit

## Half-Wave Rectifier Circuit



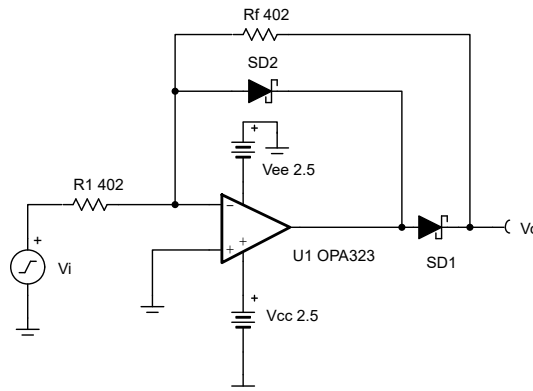
### Amplifiers

### 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 the 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.

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

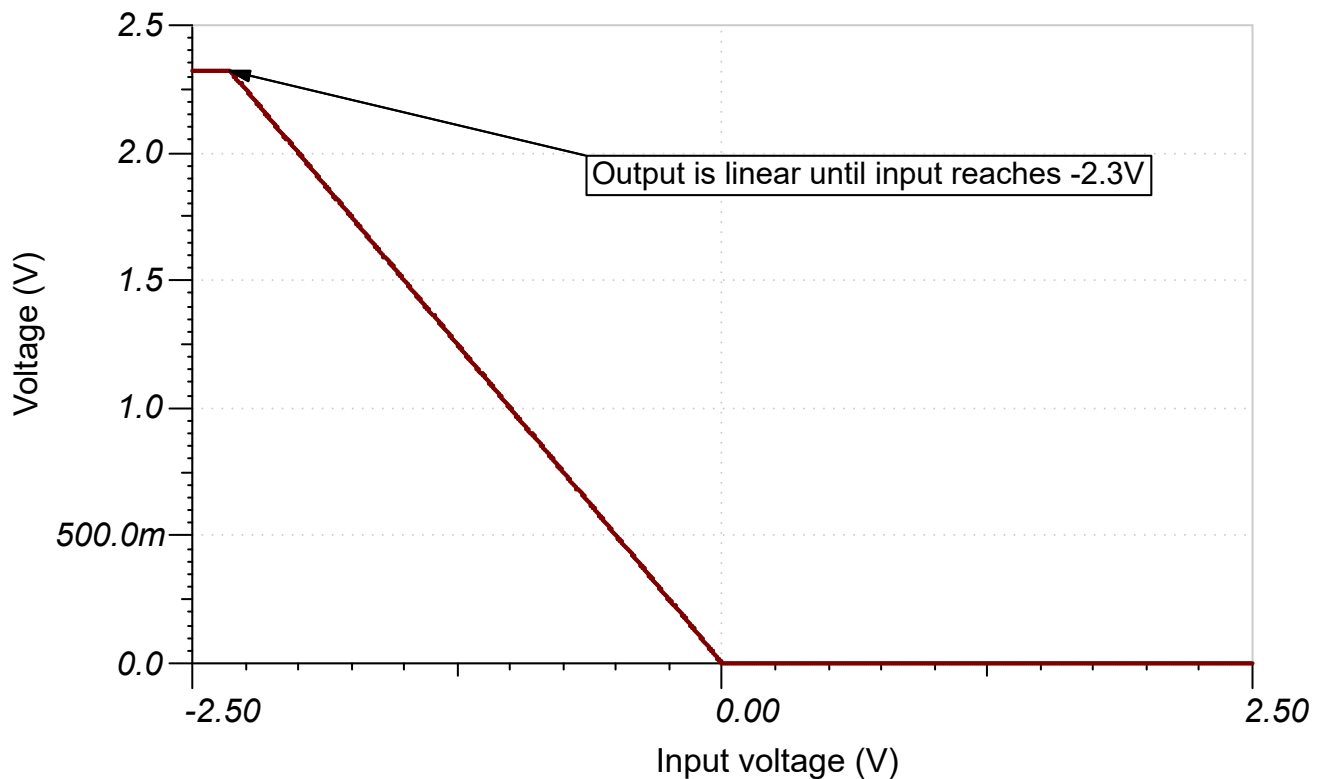
$$R_{eq} \leq \frac{E_{nbb}^2}{4 \times k_b \times T \times 3^2} = (E_{nbb})$$

$$= \frac{(5.5 \times 10^{-9})^2}{4 \times 1.381 \times 10^{-23} \times 298 \times 3^2} = 204\Omega$$

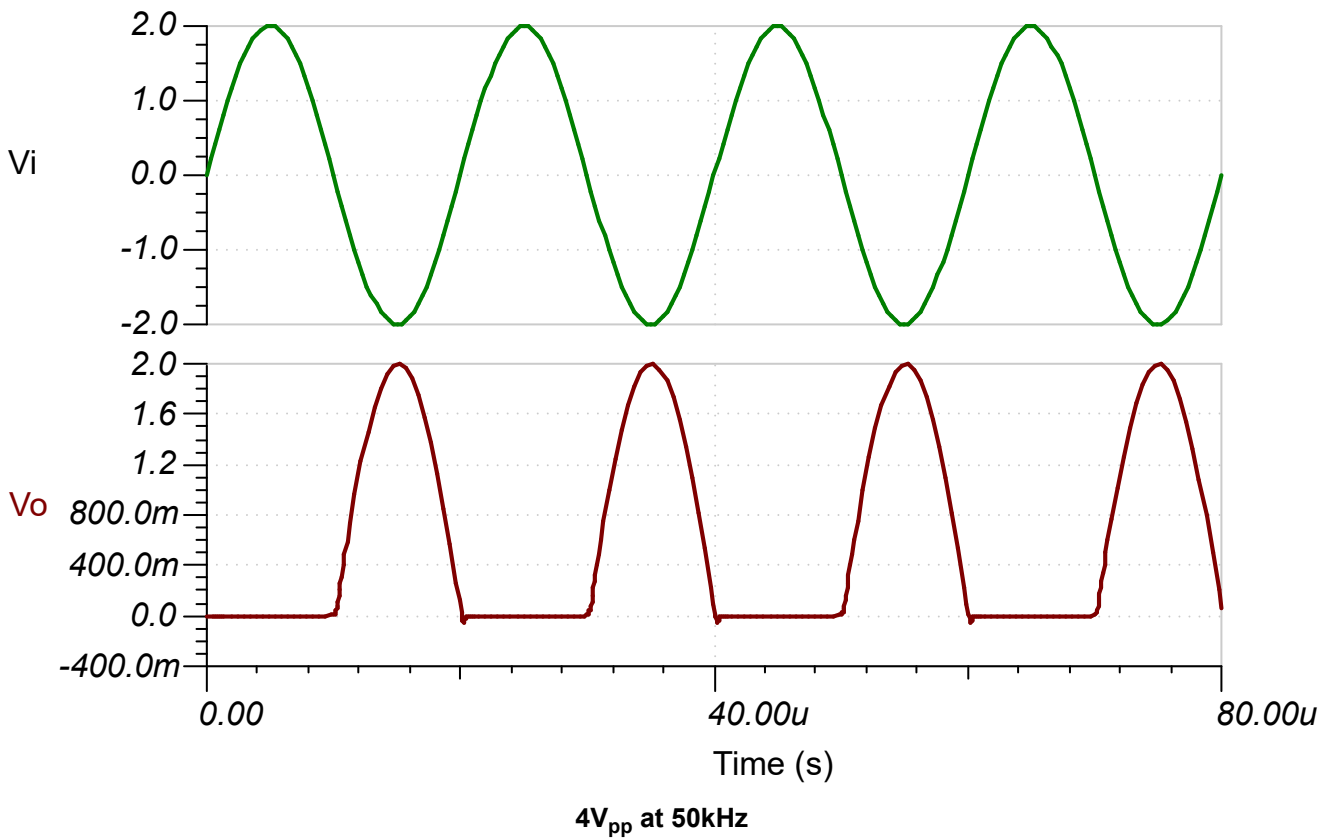
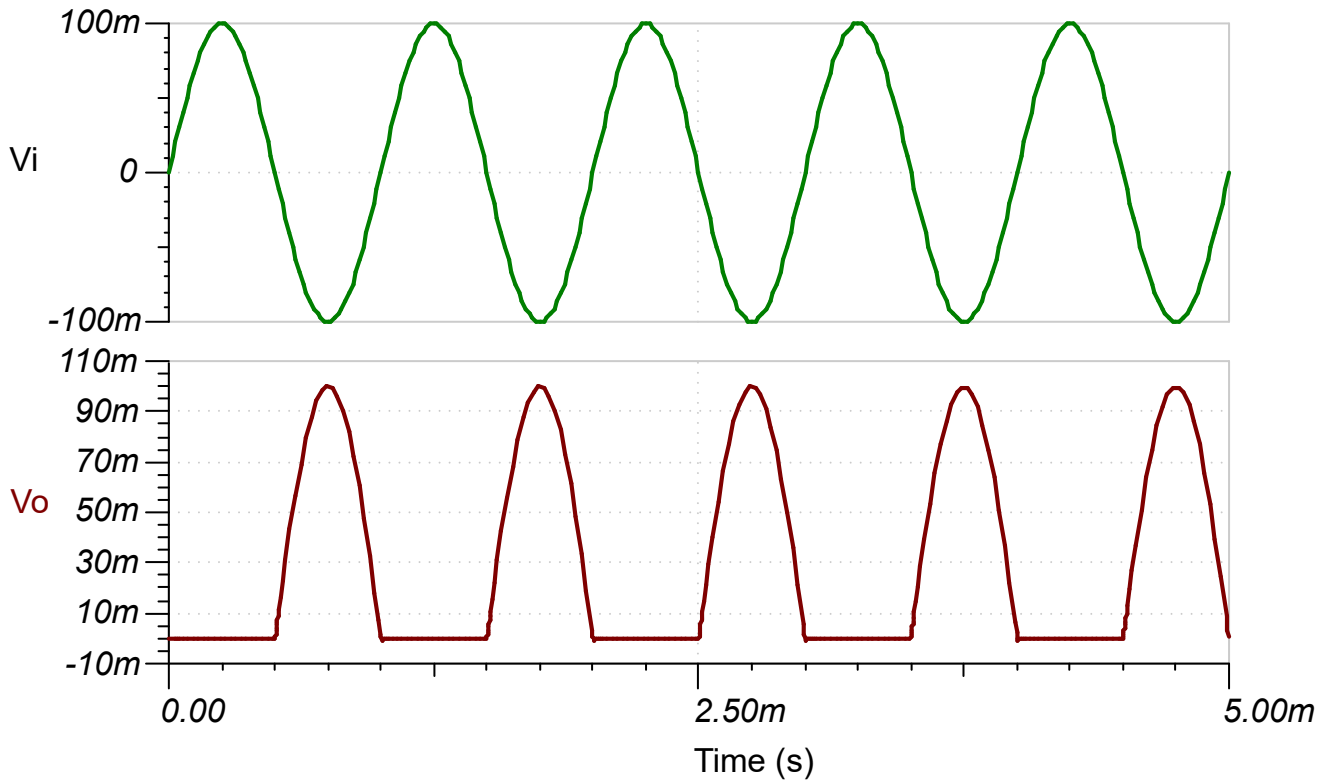
$$R_f = R_1 = 2 \times 204 \leq 408\Omega \rightarrow 402\Omega \text{ (Standard Value)}$$

## Design Simulations

### DC Simulation Results



### Transient Simulation Results



## Design References

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

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

## Design Featured Op Amp

OPA323	
$V_{SS}$	1.7V to 5.5V
$V_{inCM}$	Rail-to-rail
$V_{out}$	Rail-to-rail
UGBW	20MHz
SR	33V/ $\mu$ s
Link	<a href="#">OPA323</a>

## Design Alternate Op Amp

Device Specifications	
$V_{SS(Max)}$	$\geq 5V$
$V_{inCM}$	Rail-to-rail
$V_{out}$	Rail-to-rail
UGBW	$\geq 10MHz$
SR	$\geq 5V/\mu s$
Link	<a href="#">Devices</a>

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