Analog Engineer's Circuit

Half-Wave Rectifier Circuit

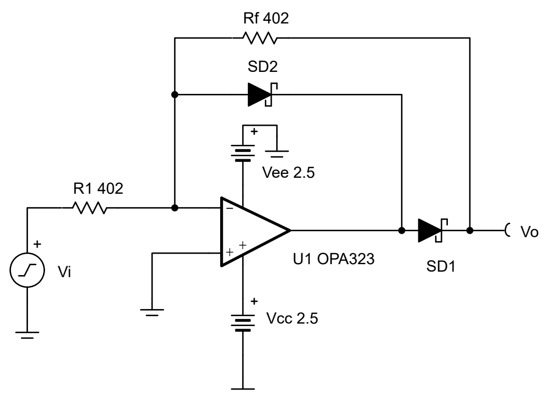
Amplifiers

Design Goals

Input		Output		Supply	
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}
±0.2mV_{pp}	±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.

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

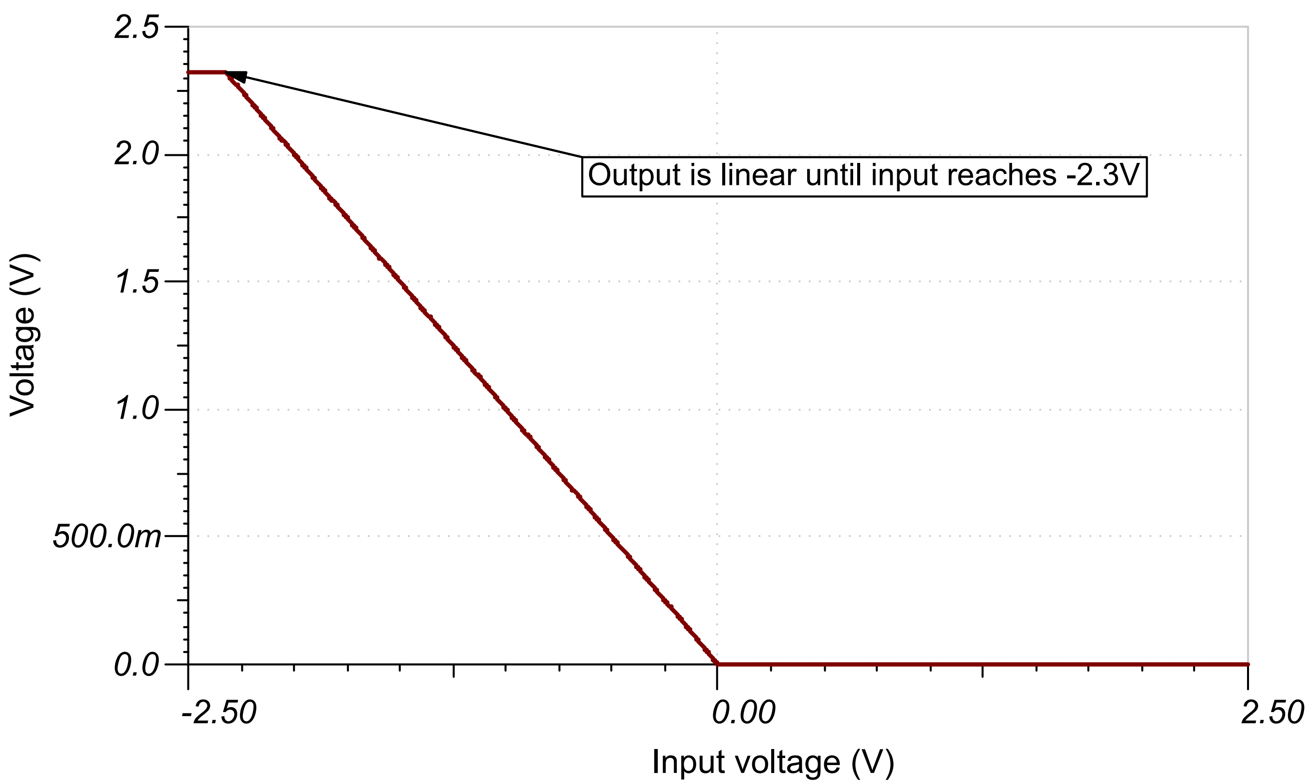
$$R_{eq} \le \frac{{E_{nbb}}^2}{4 \times k_b \times T \times 3^2} = (\text{Enbb})$$

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

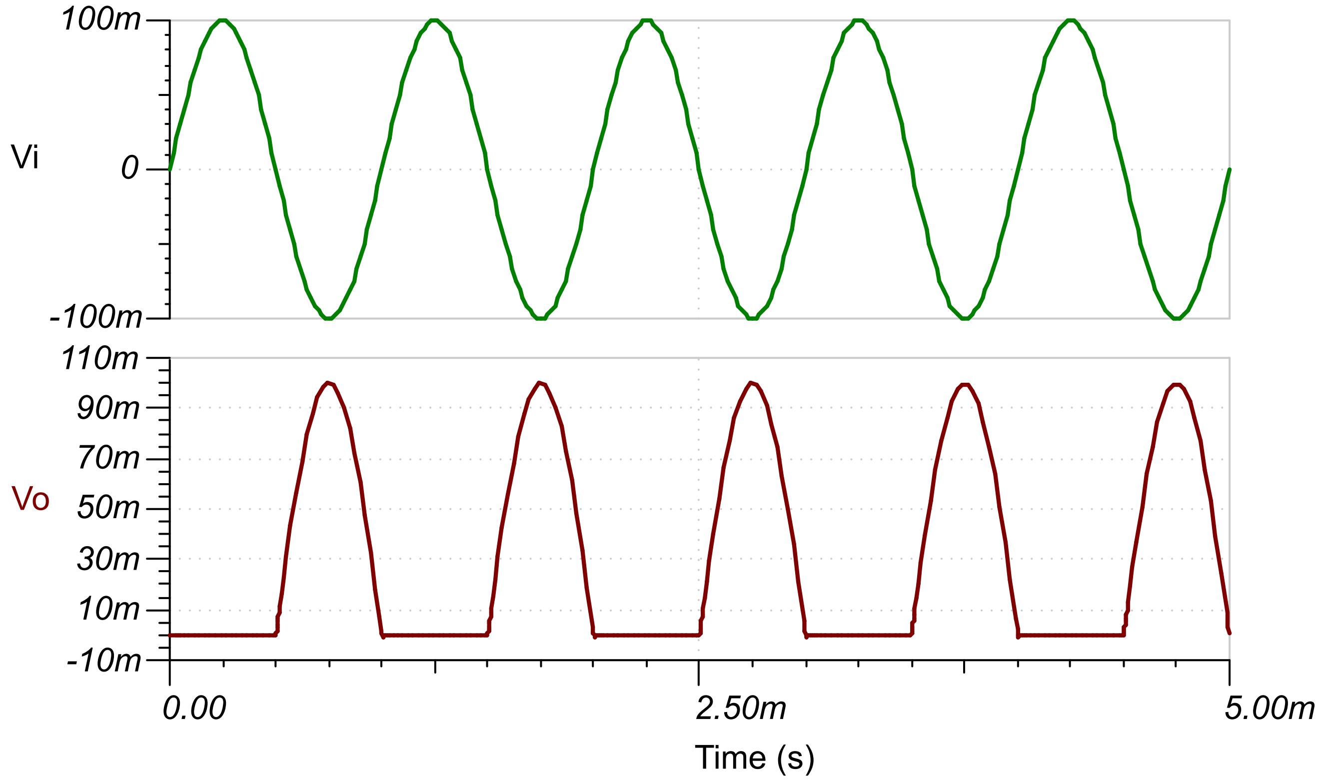
$$R_f = R_1 = 2 \times 204 \le 408\Omega \to 402\Omega \text{ (Standard Value)}$$

Design Simulations

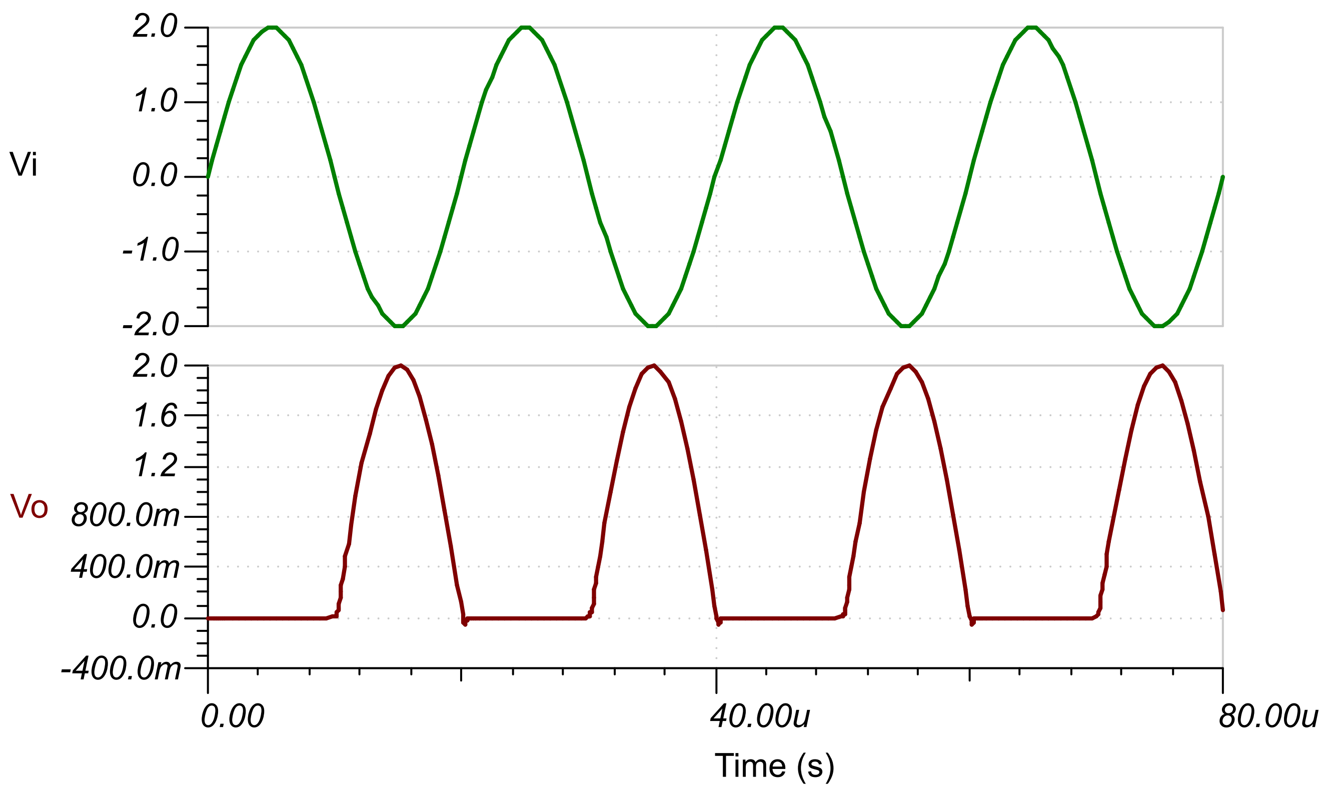
DC Simulation Results



Transient Simulation Results



200mV$_{pp}$ at 1kHz



4V$_{pp}$ 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

OPA323	
V_{ss}	1.7V to 5.5V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
UGBW	20MHz
SR	33V/µs
Link	OPA323

Design Alternate Op Amp

Device Specifications	
$V_{ss(Max)}$	≥ 5V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
UGBW	≥ 10MHz
SR	≥ 5V/µs
Link	Devices