

# Single-Supply, Low-Side, Unidirectional Current-Sensing Solution With Output Swing to GND Circuit

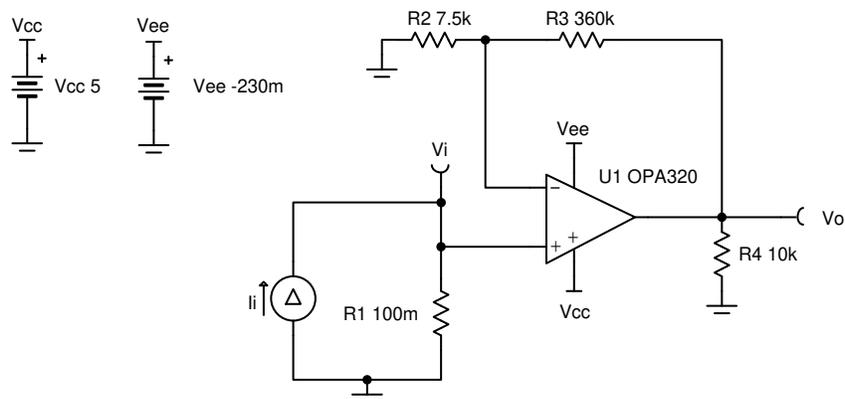


## Design Goals

Input		Output		Supply		
$I_{iMin}$	$I_{iMax}$	$V_{oMin}$	$V_{oMax}$	$V_{cc}$	$V_{ee}$	$V_{ref}$
0 A	1 A	0 V	4.9 V	5 V	0 V	0 V

## Design Description

This single-supply, low-side, current sensing solution accurately detects load current between 0 A to 1 A and converts it to a voltage between 0 V to 4.9 V. The input current range and output voltage range can be scaled as necessary and larger supplies can be used to accommodate larger swings. A negative charge pump (such as the LM7705) is used as the negative supply in this design to maintain linearity for output signals near 0 V.



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## Design Notes

1. Use precision resistors to minimize gain error.
2. For light load accuracy, the negative supply should extend slightly below ground.
3. A capacitor placed in parallel with the feedback resistor will limit bandwidth and help reduce noise.

## Design Steps

1. Determine the transfer function.

$$V_o = I_i \times R_1 \times \left(1 + \frac{R_3}{R_2}\right)$$

2. Define the full-scale shunt voltage and shunt resistance.

$$V_{iMax} = 100\text{mV at } I_{iMax} = 1\text{A}$$

$$R_1 = \frac{V_{iMax}}{I_{iMax}} = \frac{100\text{mV}}{1\text{A}} = 100\text{m}\Omega$$

3. Select gain resistors to set the output range.

$$V_{iMax} = 100\text{mV and } V_{oMax} = 4.9\text{V}$$

$$\text{Gain} = \frac{V_{oMax}}{V_{iMax}} = \frac{4.9\text{V}}{100\text{mV}} = 49\frac{\text{V}}{\text{V}}$$

$$\text{Gain} = 1 + \frac{R_3}{R_2} = 49\frac{\text{V}}{\text{V}}$$

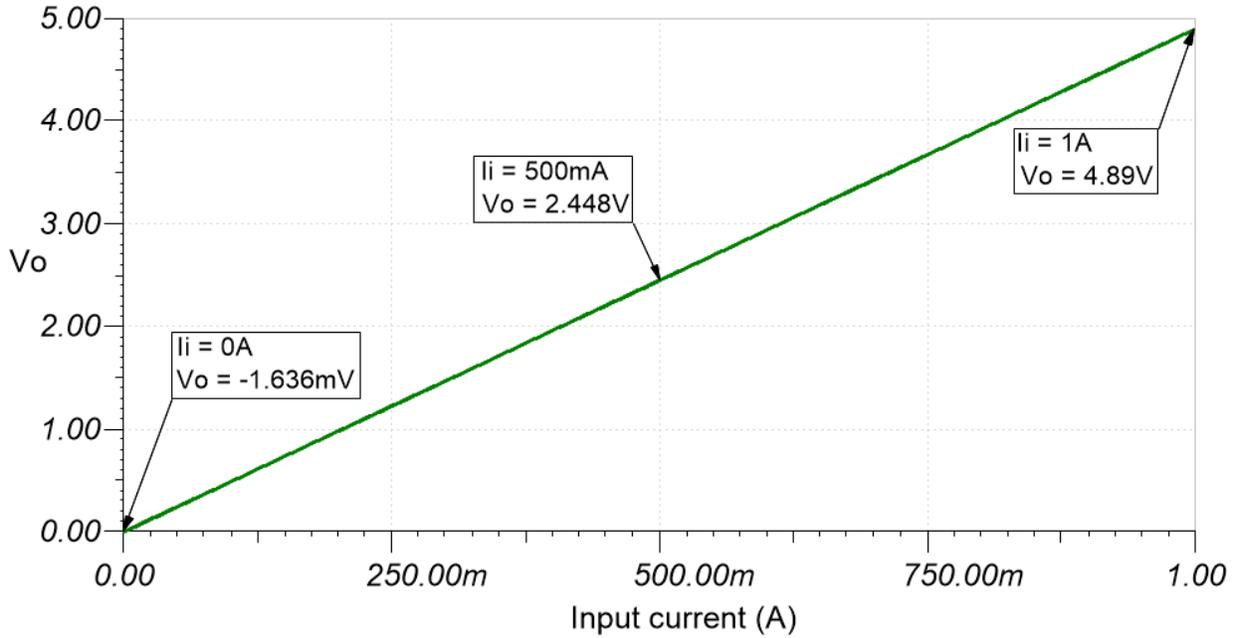
4. Select a standard value for  $R_2$  and  $R_3$ .

$$R_2 = 7.5\text{k}\Omega \text{ (0.05\% Standard Value)}$$

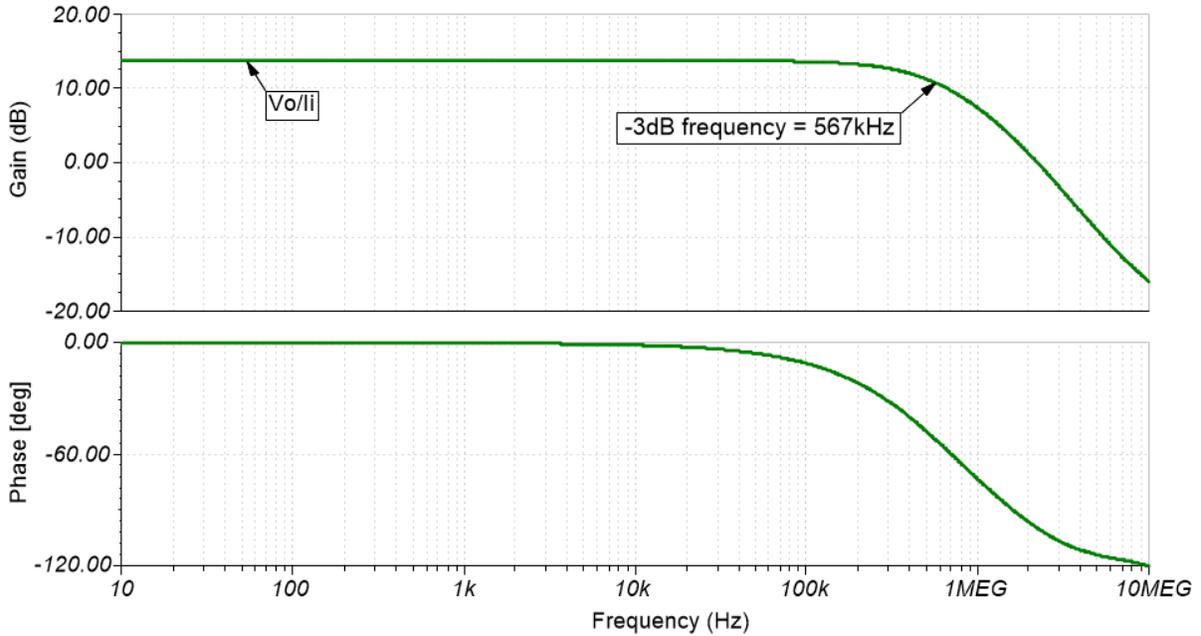
$$R_3 = 48 \times R_2 = 360\text{k}\Omega \text{ (0.05\% Standard Value)}$$

**Design Simulations**

**DC Simulation Results**



**AC Simulation Results**



## Design References

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

See circuit SPICE simulation file [SBOC499](#).

See [TIPD129](#).

## Design Featured Op Amp

OPA320	
$V_{CC}$	1.8 V to 5.5 V
$V_{inCM}$	Rail-to-rail
$V_{out}$	Rail-to-rail
$V_{os}$	40 $\mu$ V
$I_q$	1.5 mA/Ch
$I_b$	0.2 pA
UGBW	10 MHz
SR	10 V/ $\mu$ s
#Channels	1 and 2
<a href="#">OPA320</a>	

## Design Alternate Op Amp

TLV9002	
$V_{CC}$	1.8 V to 5.5 V
$V_{inCM}$	Rail-to-rail
$V_{out}$	Rail-to-rail
$V_{os}$	400 $\mu$ V
$I_q$	60 $\mu$ A
$I_b$	5 pA
UGBW	1 MHz
SR	2 V/ $\mu$ s
#Channels	1, 2, and 4
<a href="#">TLV9002</a>	

## Revision History

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

Changes from February 1, 2018 to February 1, 2019	Page
• Downscale the title and changed title role to <i>Amplifiers</i> . Added link to circuit cookbook landing page.....	1

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