

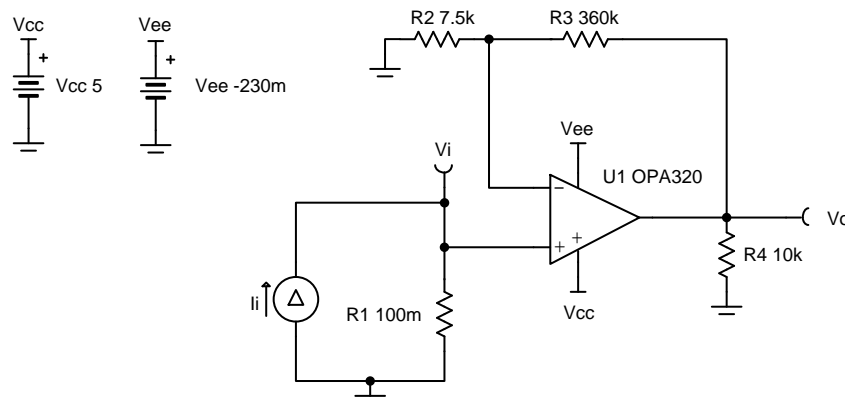
Single-supply, low-side, unidirectional current-sensing solution with output swing to GND circuit

Design Goals

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

Design Description

This single-supply, low-side, current sensing solution accurately detects load current between 0A to 1A and converts it to a voltage between 0V to 4.9V. 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 0V.



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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.

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

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

3. Select gain resistors to set the output range.

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

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

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

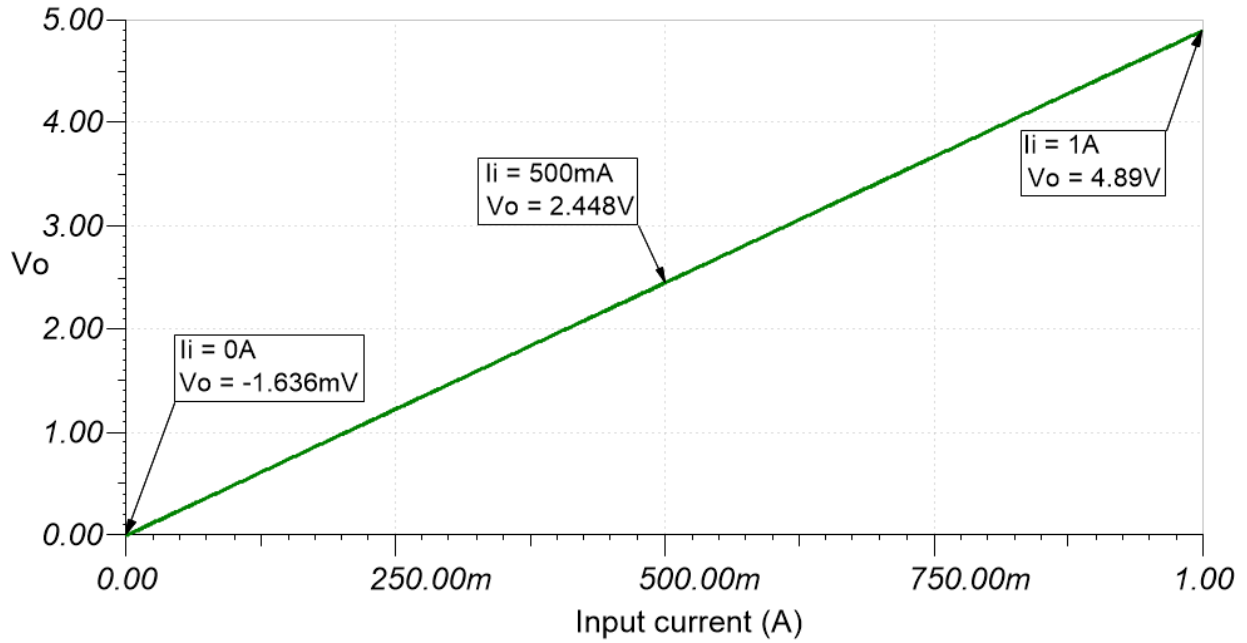
4. Select a standard value for R_2 and R_3 .

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

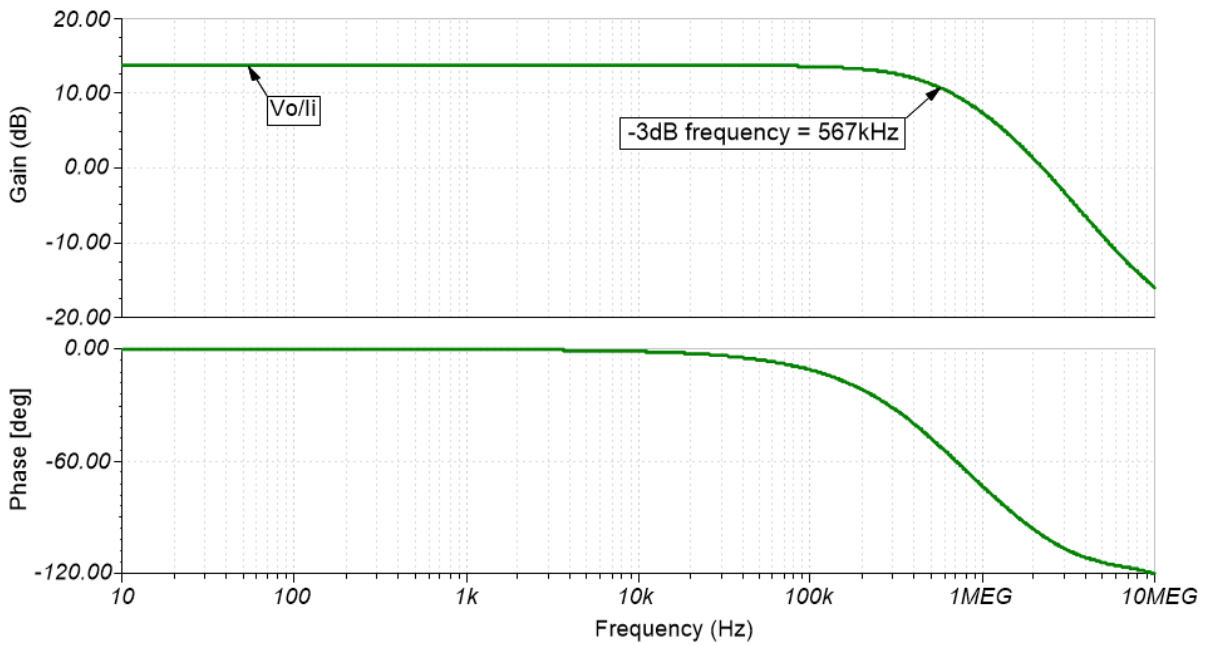
$$R_3 = 48 \times R_2 = 360\text{k}\Omega \text{ (0.05\% Standard Value)}$$

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, www.ti.com/tool/tipd129.

Design Featured Op Amp

OPA320	
V_{cc}	1.8V to 5.5V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	40 μ V
I_q	1.5mA/Ch
I_b	0.2pA
UGBW	10MHz
SR	10V/ μ s
#Channels	1, 2
www.ti.com/product/opa320	

Design Alternate Op Amp

TLV9002	
V_{cc}	1.8V to 5.5V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	400 μ V
I_q	60 μ A
I_b	5pA
UGBW	1MHz
SR	2V/ μ s
#Channels	1, 2, 4
www.ti.com/product/tlv9002	

Revision History

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

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