

Voltage-to-current (V-I) converter circuit with MOSFET



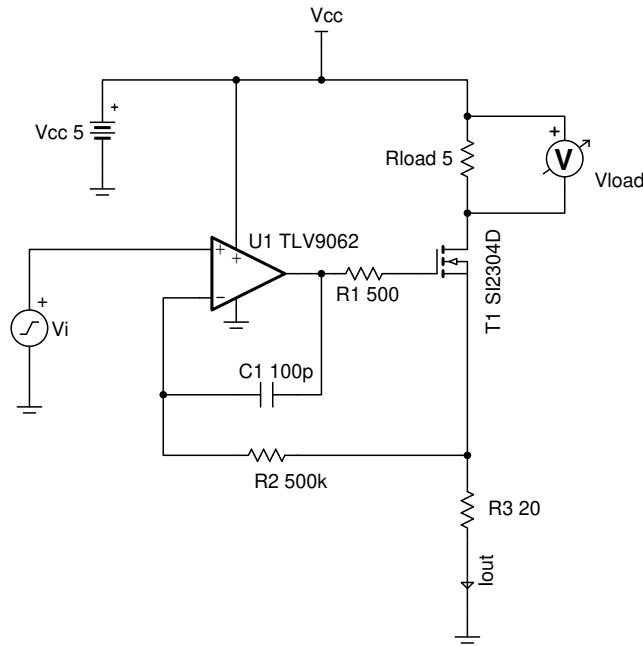
Amplifiers

Design Goals

Input		Output		Supply	
V_{iMin}	V_{iMax}	I_{oMin}	I_{oMax}	V_{cc}	V_{ee}
0V	2V	0mA	100mA	5V	0V

Design Description

This single-supply, low-side, V-I converter delivers a well-regulated current to a load which can be connected to a voltage greater than the op-amp supply voltage. The circuit accepts an input voltage between 0V and 2V and converts it to a current between 0mA and 100mA. The current is accurately regulated by feeding back the voltage drop across a low-side current-sense resistor, R_3 , to the inverting input of the op amp.



Design Notes

1. A device with a rail-to-rail input (RRI) or common-mode voltage that extends to GND is required.
2. R_1 helps isolate the amplifier from the capacitive load of the MOSFET gate.
3. Feedback components R_2 and C_1 provide compensation to ensure stability during input or load transients, which also helps reduce noise. R_2 provides a DC feedback path directly at the current setting resistor (R_3) and C_1 provides a high-frequency feedback path that bypasses the MOSFET.
4. The input bias current will flow through R_2 , which will cause a DC error. Therefore, ensure that this error is minimal compared to the offset voltage of the op amp.
5. Use the op amp in a linear operating region. Linear output swing is usually specified under the A_{OL} test conditions provided in the op amp data sheet.

Design Steps

1. Determine the transfer function.

$$I_o = \frac{V_i}{R_3}$$

2. Calculate the sense resistor, R_3 .

$$R_3 = \frac{V_{iMax} - V_{iMin}}{I_{oMax} - I_{oMin}} = \frac{2V - 0V}{100mA - 0mA} = 20\Omega$$

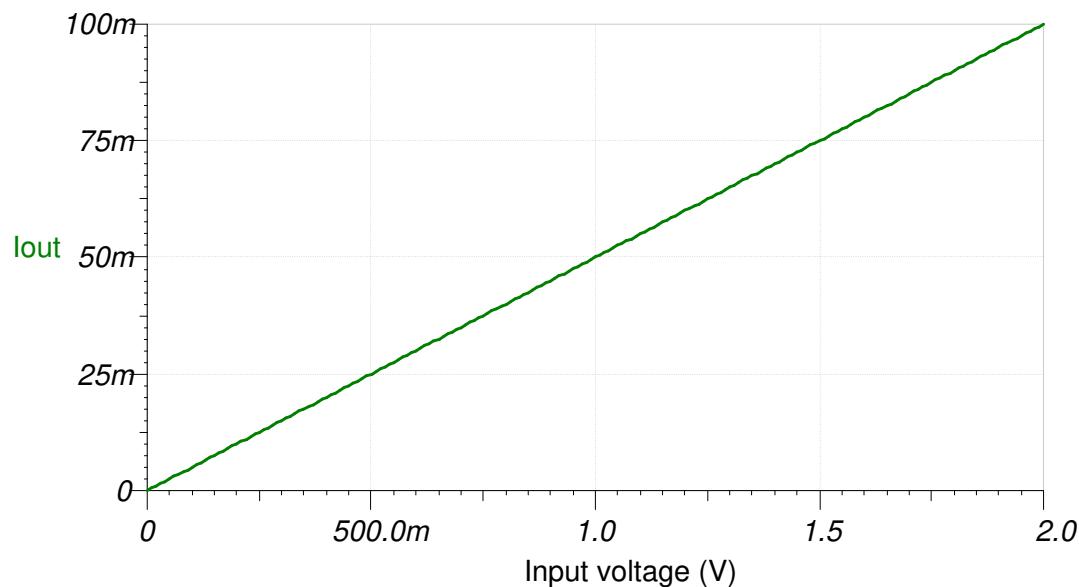
3. Calculate the maximum power dissipated into the sense resistor, R_3 , to ensure the resistor power ratings are not exceeded.

$$P_{R_3} = \frac{V_{iMax}^2}{R_3} = \frac{2V^2}{20\Omega} = 0.2W$$

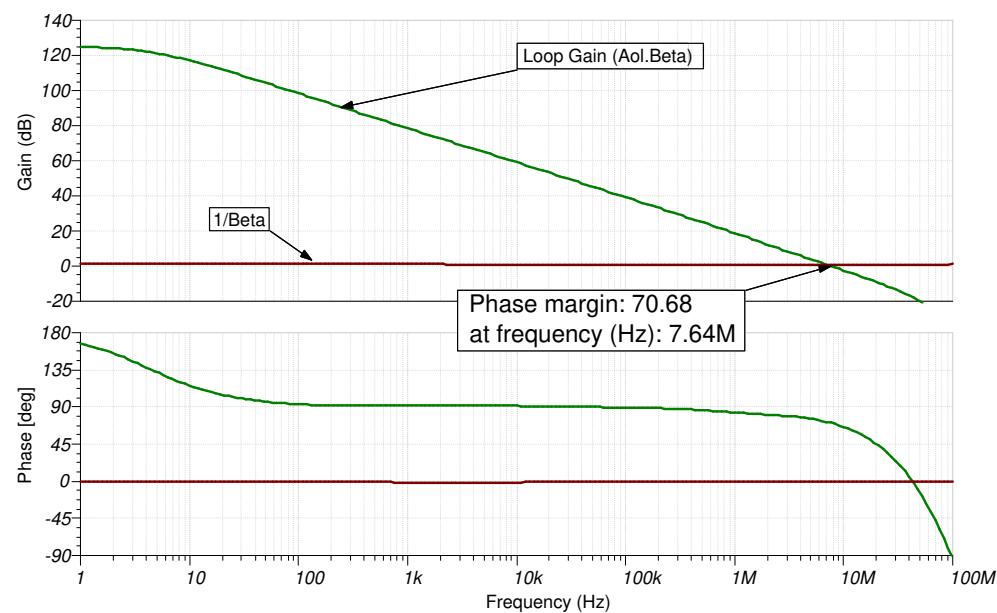
4. See the [Design References](#) section, [2] for the design procedure on how to properly size the compensation components, R_1 , R_2 , and C_1 .

Design Simulations

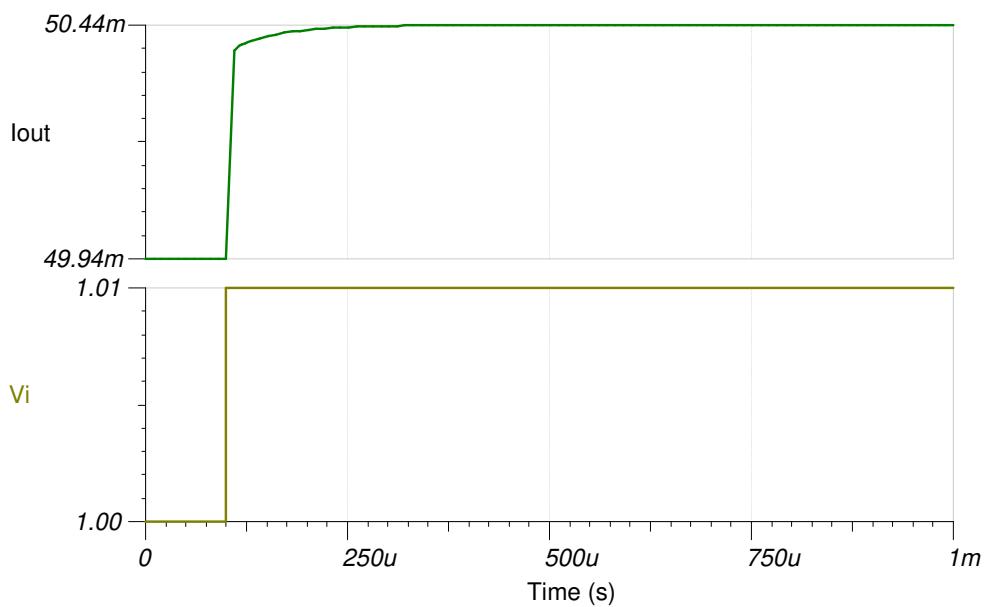
DC Simulation Results



Loop Stability Simulation Results

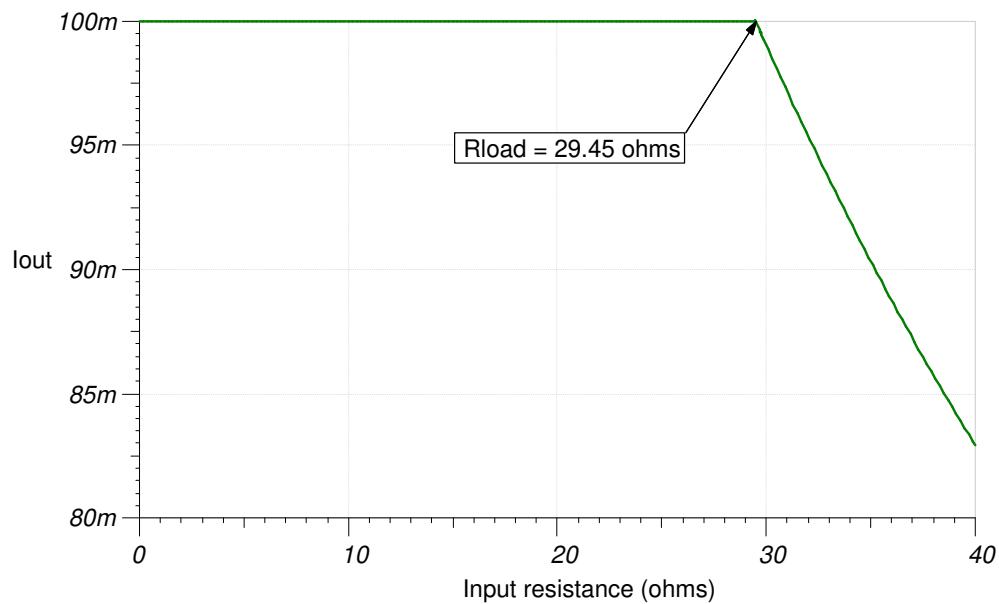


Step Response



Compliance Voltage

Set output to full-scale (100 mA) and test the maximum load resistance.



Design References

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

Design Featured Op Amp

TLV9062	
V_{ss}	1.8 V to 5.5 V
V_{inCM}	Rail-to-rail
V_{out}	($V_{cc} + 60\text{mV}$) to ($V_{ee} - 60\text{mV}$) at $R_L = 2\text{k}\Omega$
V_{os}	1.6mV
I_q	0.538mA
I_b	0.5pA
UGBW	10MHz
SR	6.5V/ μs
#Channels	1, 2, 4
www.ti.com/product/TLV9062	

Design Alternate Op Amp

	TLV9042	OPA2182
V_{ss}	1.2V to 5.5V	4.5V to 36V
V_{inCM}	Rail-to-rail	($V_{ee} - 0.1\text{V}$) to ($V_{cc} - 2.5\text{V}$)
V_{out}	Rail-to-rail	Rail-to-rail
V_{os}	$\pm 0.6\text{mV}$	$\pm 0.45\mu\text{V}$
I_q	0.01mA	0.85mA
I_b	$\pm 1\text{pA}$	$\pm 50\text{pA}$
UGBW	350kHz	5MHz
SR	0.2V/ μs	10V/ μs
#Channels	1,2,4	2
	www.ti.com/product/TLV9042	www.ti.com/product/OPA2182

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