CIRCUIT060019

How to Design Inverting Op Amp with Non-Inverting Positive Reference Voltage Circuit

General Purpose Amplifiers

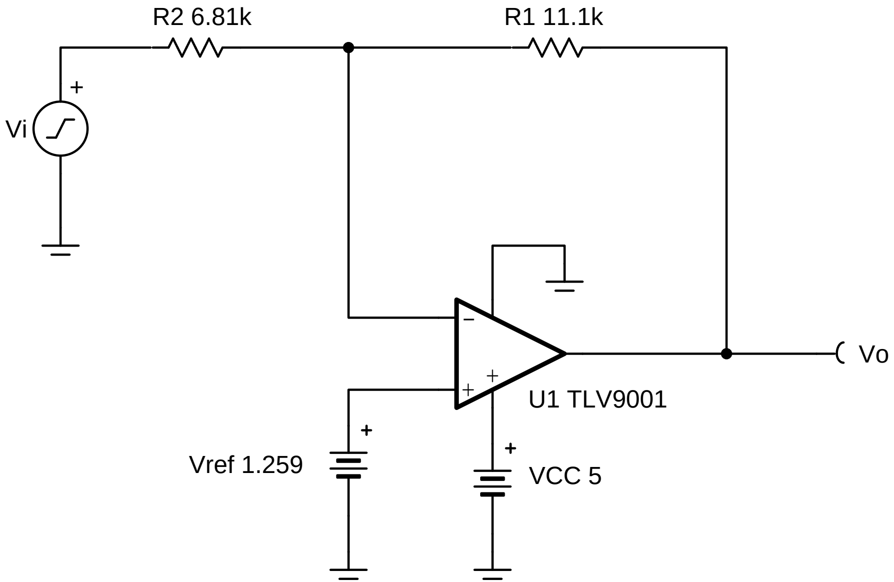
www.ti.com/general-amps

www.ti.com/circuitcookbooks

Analog Engineer's Circuit Cookbook: Op Amps

Texas Instruments

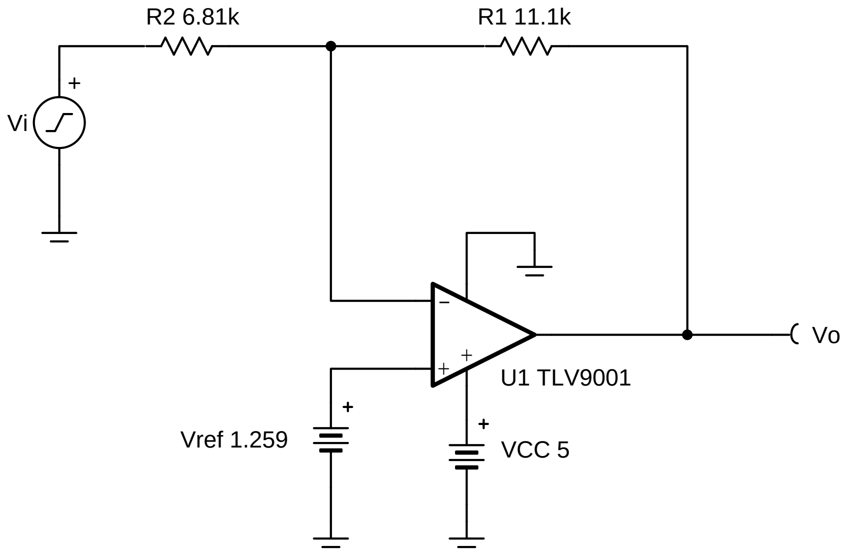
Circuit Description



$$V_o = -V_i \times \frac{R_1}{R_2} + V_{ref} \times \left(1 + \frac{R_1}{R_2}\right)$$

Design Steps

Input		Output		Supply		
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}	V_{ref}
-1V	2V	0.05V	4.95V	5V	0V	1.259V



Inverting Gain

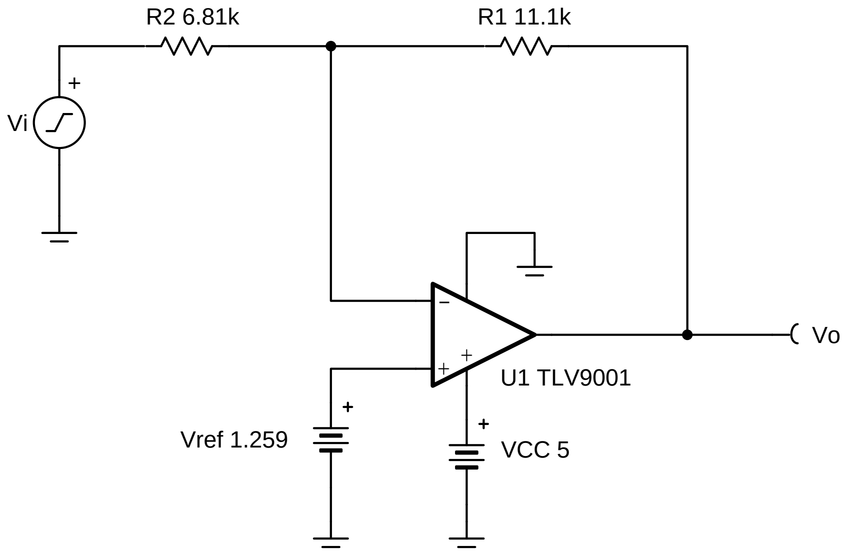
Non-Inverting Gain

$$V_o = V_i \times \frac{-R_1}{R_2} + V_{ref} \times \left(1 + \frac{R_1}{R_2}\right)$$

Positive Reference Voltage

Design Steps

Input		Output		Supply		
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}	V_{ref}
-1V	2V	0.05V	4.95V	5V	0V	1.259V

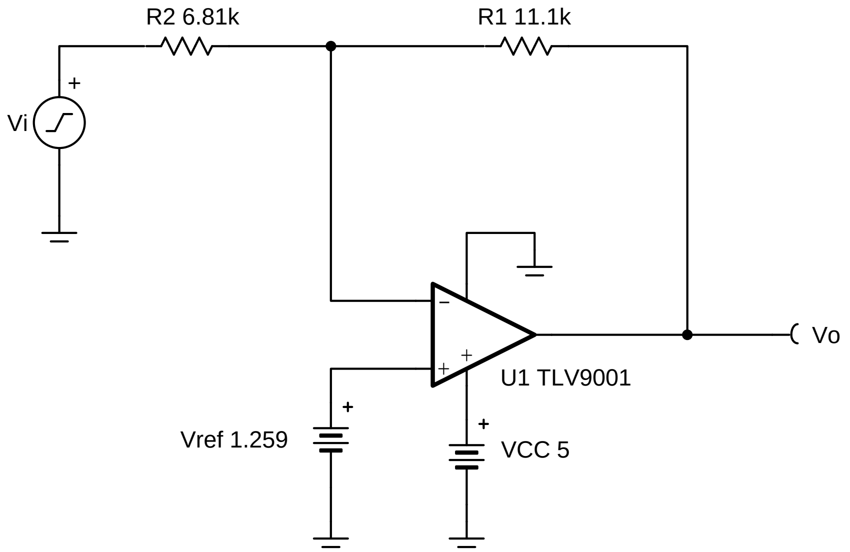


$$G_{input} = -\frac{V_{oMax} - V_{oMin}}{V_{iMax} - V_{iMin}}$$

$$G_{input} = -\frac{4.95V - 0.05V}{2V - (-1V)} = -1.633V/V$$

Design Steps

Input		Output		Supply		
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}	V_{ref}
-1V	2V	0.05V	4.95V	5V	0V	1.259V



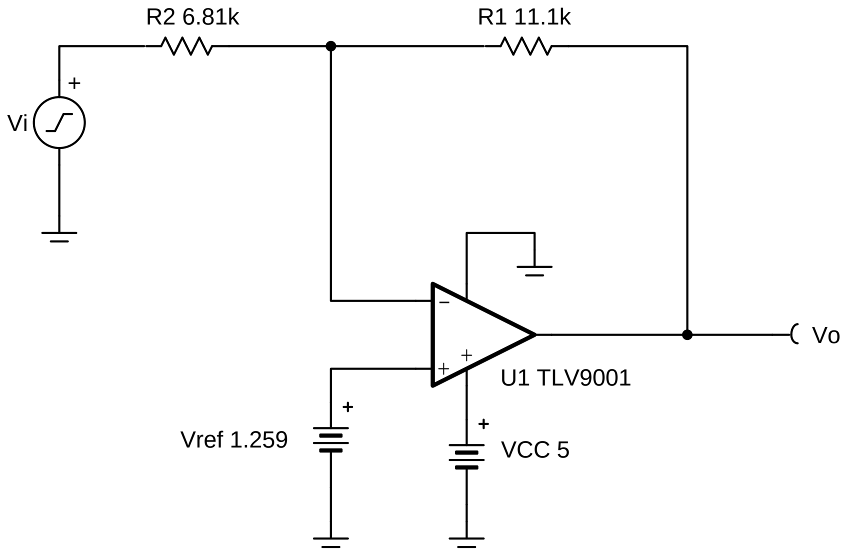
$$G_{input} = -\frac{R_1}{R_2}$$

$$R_1 = -G_{input} \times R_2 \rightarrow G_{input} \times R_2$$

$$R_1 = 1.633\frac{V}{V} \times 6.81k\Omega = 11.123k\Omega \approx 11.1k\Omega$$

Design Steps

Input		Output		Supply		
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}	V_{ref}
-1V	2V	0.05V	4.95V	5V	0V	1.259V

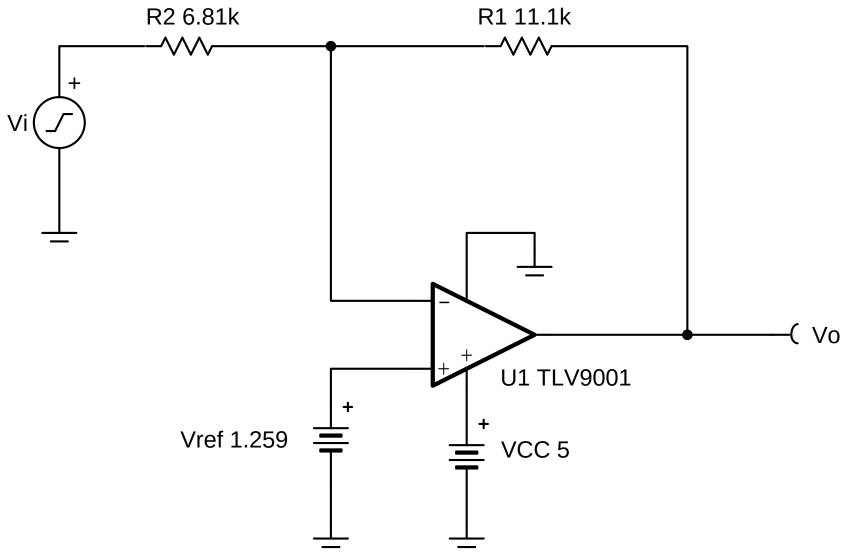


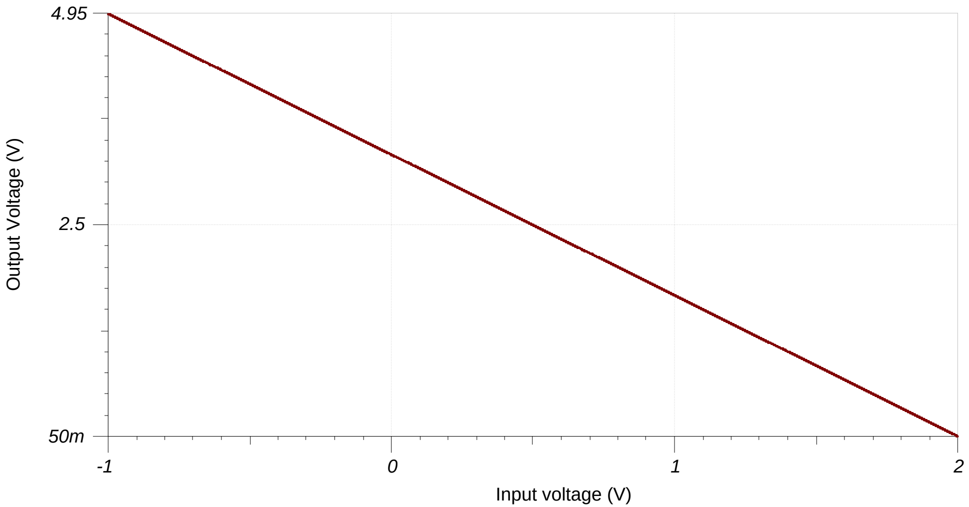
$$V_{ref} = \frac{V_{oMin} + V_{iMax} \times \left(\frac{R_1}{R_2}\right)}{1 + \frac{R_1}{R_2}}$$

$$V_{ref} = 1.259V$$

DC Results

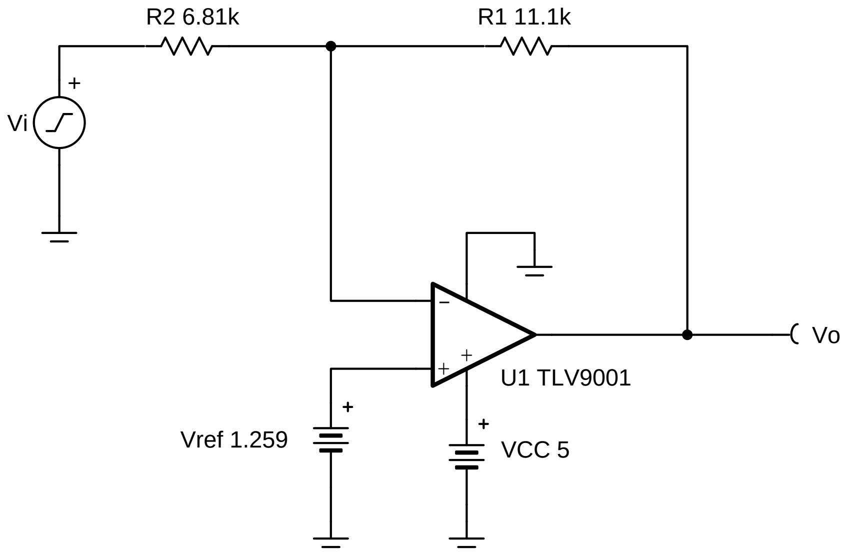
Input		Output		Supply		
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}	V_{ref}
-1V	2V	0.05V	4.95V	5V	0V	1.259V

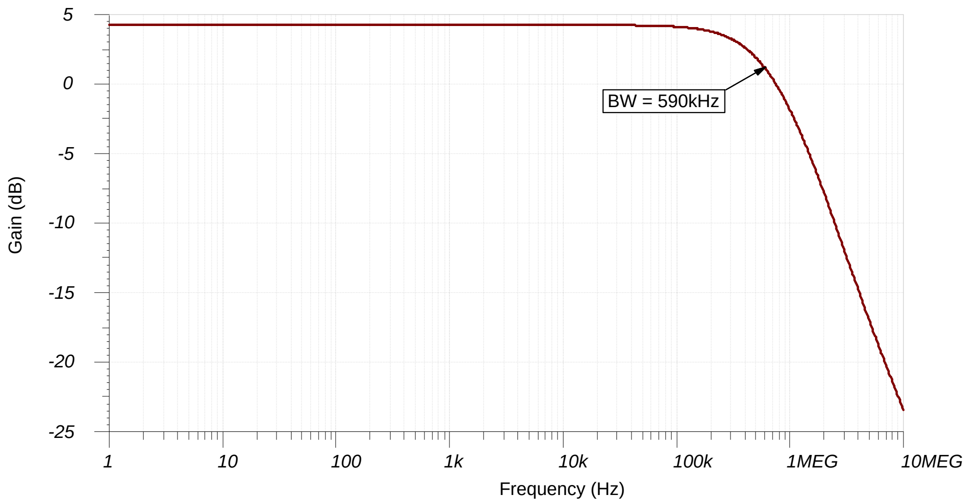




AC Results

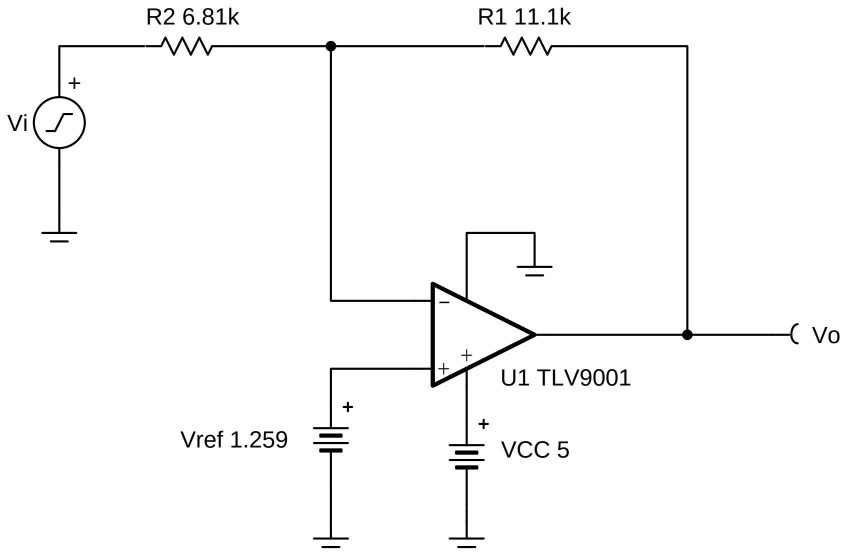
Input		Output		Supply		
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}	V_{ref}
-1V	2V	0.05V	4.95V	5V	0V	1.259V





Design Notes

Input		Output		Supply		
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}	V_{ref}
-1V	2V	0.05V	4.95V	5V	0V	1.259V



Design Notes:

1. V_{ref} can be created with a voltage divider.
2. Input impedance of the circuit is equal to R2. Therefore Vi should be low impedance.
3. The cutoff frequency of the circuit is dependent on the gain bandwidth product (GBP) of the amplifier. Additional filtering can be accomplished by adding a capacitor in parallel with R1.

Design Resources

EE Cookbook: Op Amp
www.ti.com/circuitcookbooks
Step-by-step circuit design of common op amp building block circuits.

TI Designs
www.TI.com/tidesigns
Ready-to-use reference designs with
theory, calculations, simulations
schematics, PCB files, bench test results

Analog Engineer's Pocket Reference
www.TI.com/analogrefguide
PDF, iTunes app and hardcopy available
PCB, analog, mixed signal design formulae
Conversions, tables, equations

TI Precision Labs
www.TI.com/precisionlabs
Quiz questions, problems, solutions
Labs and evaluation module (EVM) available

TINA-TI™ simulation software
www.TI.com/tool/tina-ti
Complete SPICE simulator DC, AC, transient, noise analysis
Schematic entry and post-processor for waveform math

DIYAMP-EVM
www.TI.com/DIYAMP-EVM
Evaluation module providing engineers with SC70, SOT23, SOIC packaging and 12 popular amplifier configurations

The Signal
www.TI.com/thesignal
PDF, iTunes app and hardcopy available
A compendium of blog posts on op amp design topics including
offset voltage, input bias current, stability, noise and more

***Analog Wire* Blog**
www.TI.com/analogwire
Technical blogs written by analog experts
Tips, tricks, and design techniques

TI E2E™ Community
www.TI.com/e2e
Support forums for all TI products

Op Amp Parametric Quick Search
www.TI.com/amplifiers
Search for precision, high-speed, general-purpose, ultra-low-power, audio and power op amps

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