CIRCUIT060017

How to Design Dual-Supply, Discrete, Programmable Gain Amplifier Circuit

General Purpose Amplifiers

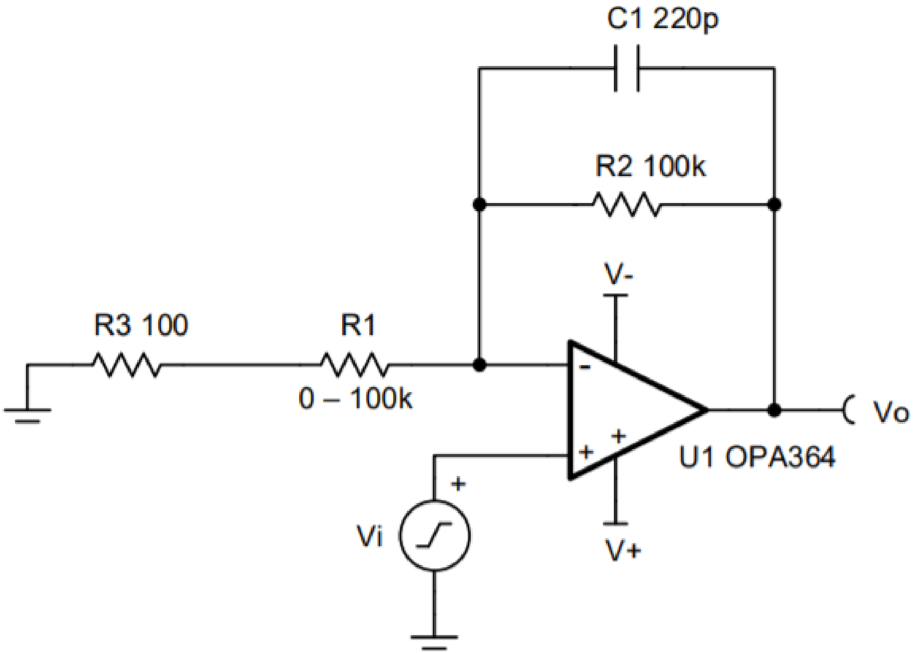
www.ti.com/general-amps

www.ti.com/circuitcookbooks

Analog Engineer's
Circuit Cookbook: Op Amps

Texas Instruments

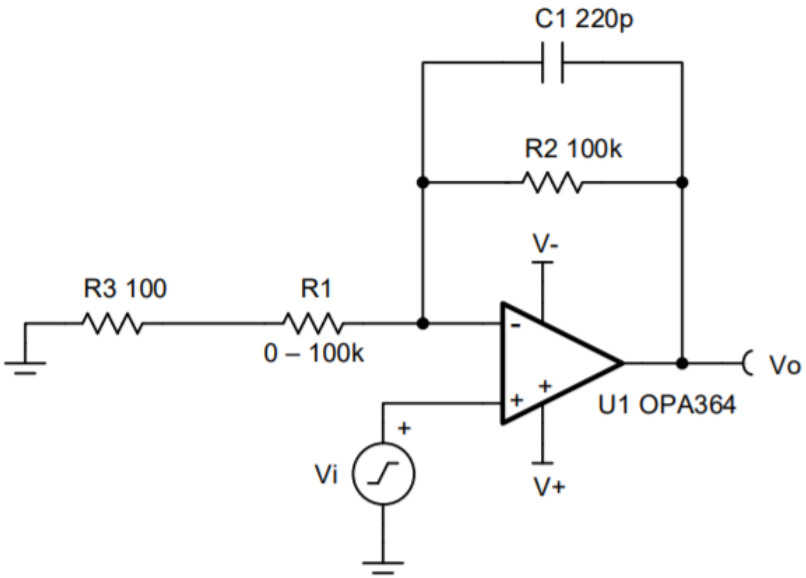
Circuit Description



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

Design Steps

Input		Output		Supply		Gain
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{dd}	V_{ee}	6db to 60db
-1.25V	1.25V	-2.4V	2.4V	2.5V	-2.5V	



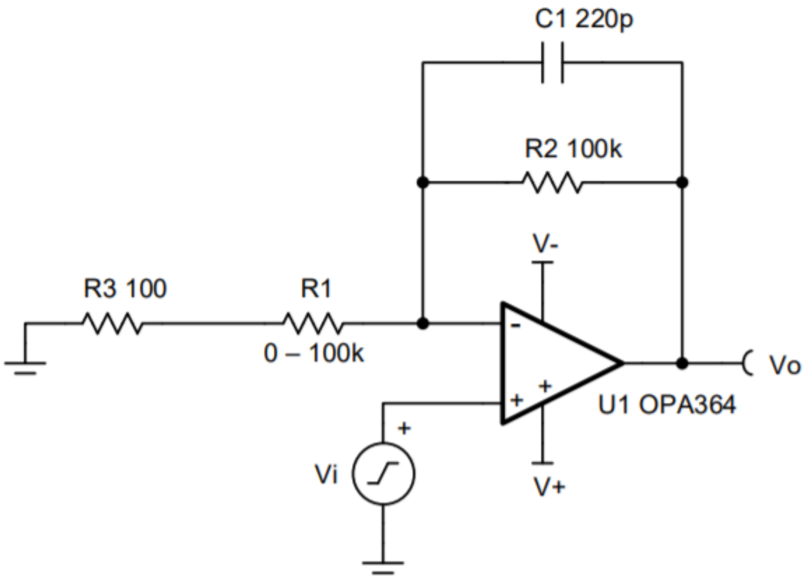
Non-Inverting Gain

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

Variable Resistor

Design Steps

Input		Output		Supply		Gain
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{dd}	V_{ee}	6db to 60db
-1.25V	1.25V	-2.4V	2.4V	2.5V	-2.5V	



$$G_{Max} = \frac{R_2}{R_3} + 1$$

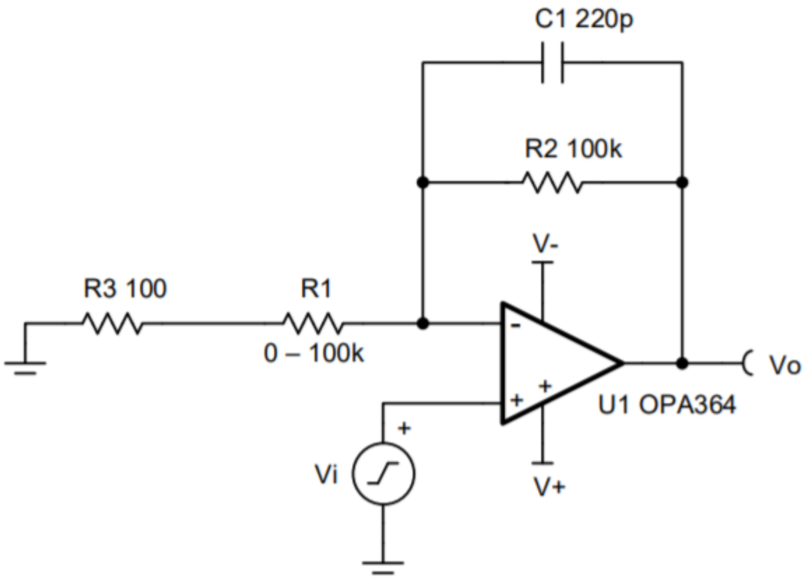
$$R_2 = (G_{Max} - 1) \times R_3$$

$$R_3 = 100\Omega$$

$$R_2 = 99k\Omega \rightarrow 100k\Omega$$

Design Steps

Input		Output		Supply		Gain
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{dd}	V_{ee}	6db to 60db
-1.25V	1.25V	-2.4V	2.4V	2.5V	-2.5V	



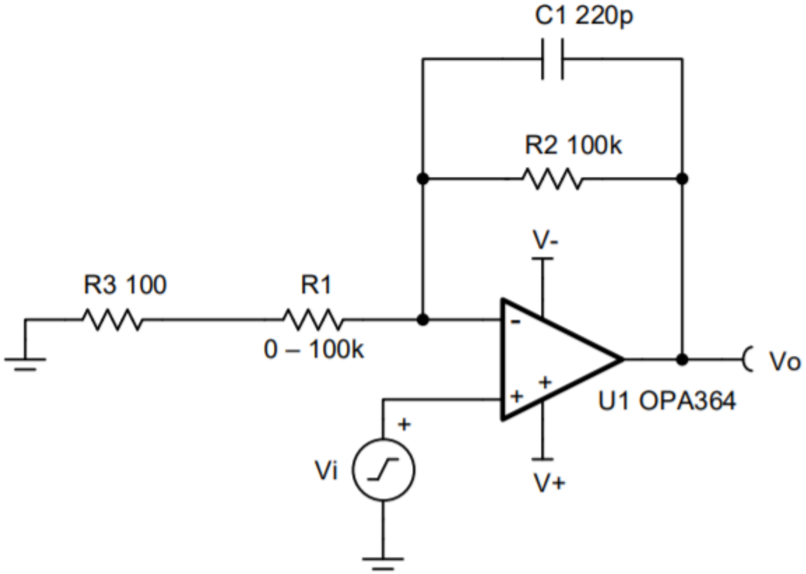
$$G_{Min} = \frac{R_2}{R_{1Max} + R_3} + 1$$

$$R_{1Max} = \frac{R_2}{G_{Min} - 1} - R_3$$

$$R_{1Max} = 99.9k\Omega \rightarrow 100k\Omega$$

Design Steps

Input		Output		Supply		Gain
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{dd}	V_{ee}	6db to 60db
-1.25V	1.25V	-2.4V	2.4V	2.5V	-2.5V	



$$f_c = \frac{GBW}{G_{Max}} = \frac{7MHz}{1000V/V} = 7kHz$$

$$C_1 = \frac{1}{2 \times \pi \times R_2 \times f_c} = 227pF \rightarrow 220pF$$

Design Steps

Input		Output		Supply		Gain
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{dd}	V_{ee}	6db to 60db
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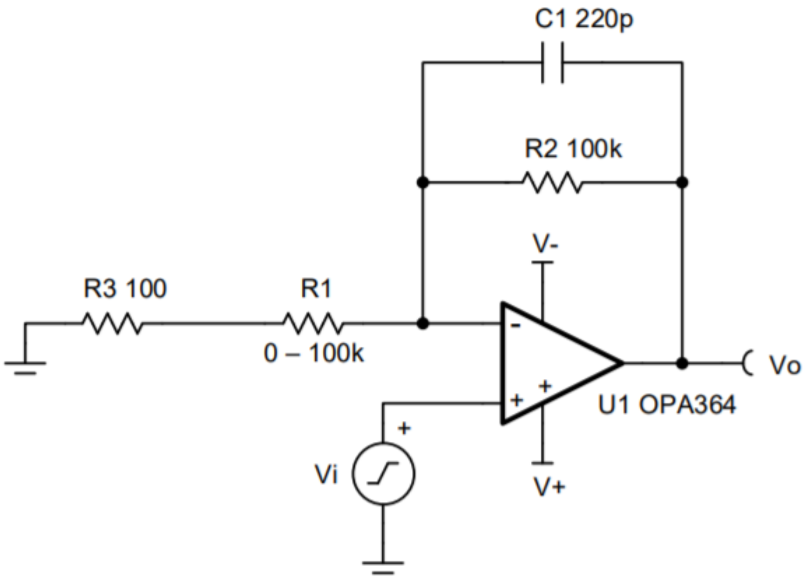


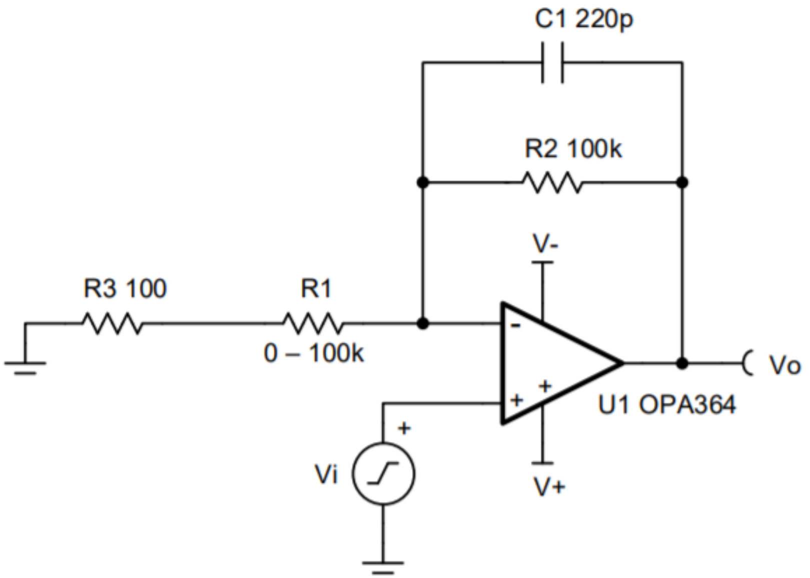
$$f_{zero} = \frac{1}{2 \times \pi \times (C_{cm} + C_{diff}) \times (R_2 || R_1)}$$

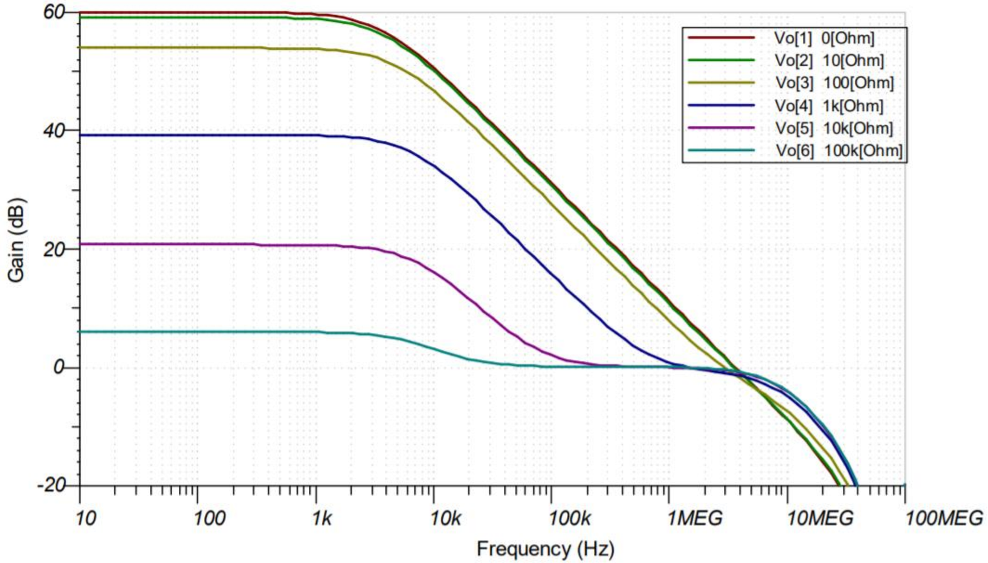
$$f_{zero} = 637\text{kHz}$$

$$7kHz < 637kHz \rightarrow f_c < f_{zero}$$

AC Results

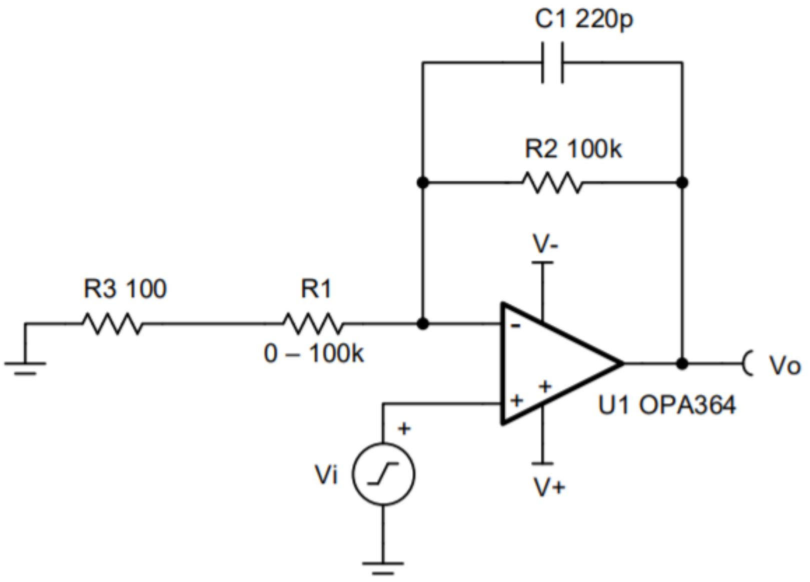
Input		Output		Supply		Gain
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{dd}	V_{ee}	6db to 60db
-1.25V	1.25V	-2.4V	2.4V	2.5V	-2.5V	





Design Notes

Input		Output		Supply		Gain
V_{iMin}	V_{iMax}	V_{oMin}	V_{oMax}	V_{dd}	V_{ee}	6db to 60db
-1.25V	1.25V	-2.4V	2.4V	2.5V	-2.5V	



Design Notes:

1. R_3 sets the maximum gain when R_1 approaches 0Ω.
2. Stability should be evaluated across the selected gain range. The minimum gain setting will likely be most sensitive to stability issues.
3. Choose a digital potentiometer, such as TPL0102 for R1 to design a low-cost digital programmable gain amplifier.

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
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