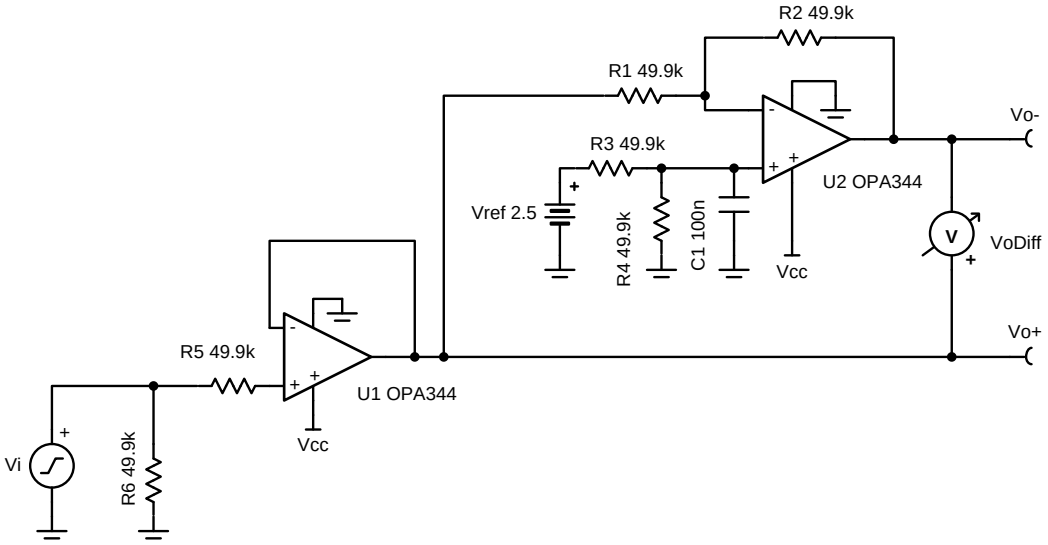
Single-ended input to differential output circuit

Design Goals

Input		Output		Supply		
V_{iMin}	V_{iMax}	$V_{oDiffMin}$	$V_{oDiffMax}$	V_{cc}	V_{ee}	V_{ref}
0.1V	2.4V	–2.3V	2.3V	2.7V	0V	2.5V

Design Description

This circuit converts a single ended input of 0.1V to 2.4V into a differential output of ±2.3V on a single 2.7-V supply. The input and output ranges can be scaled as necessary as long as the op amp input common-mode range and output swing limits are met.



Design Notes

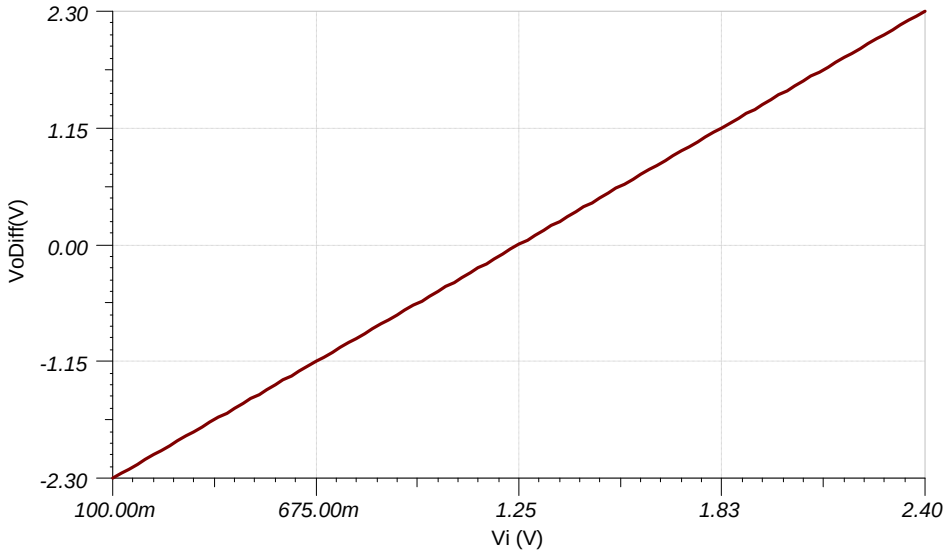
1. Op amps with rail-to-rail input and output will maximize the input and output range of the circuit.
2. Op amps with low V_{os} and offset drift will reduce DC errors.
3. Use low tolerance resistors to minimize gain error.
4. Set output range based on linear output swing (see A_{ol} specification).
5. Keep feedback resistors low or add capacitor in parallel with R_2 for stability.

Design Steps

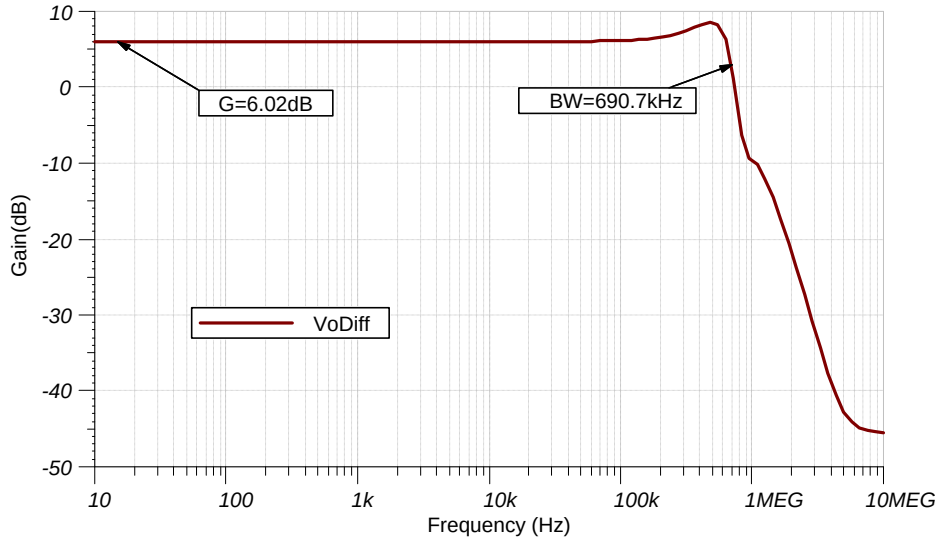
1. Buffer V_i signal to generate V_{o+}.
   $V_{O+} = V_i$
2. Invert and level shift V_{o+} using a difference amplifier to create V_{o-}.
   $V_{o-} = (V_{ref} - V_{o+}) \times (\frac{R_2}{R_1})$
3. Select resistances so that the resistor noise is smaller than the amplifier broadband noise.
   $E_{nv} = 30 \frac{nV}{\sqrt{Hz}}$ (Voltage noise from op amp)
   If $R_1 = R_2 = R_3 = R_4 = 49.9k\Omega$ then
   $E_{nr} = \sqrt{(\sqrt{4 \times kB \times T \times (R_1 || R_2)})^2 + (\sqrt{4 \times kB \times T \times (R_3 || R_4)})^2} = 28.7 \frac{nV}{\sqrt{Hz}} (< E_{nv})$
4. Select resistances that protect the input of the amplifier and prevents floating inputs. To simplify the bill of materials (BOM), select R_5 = R_6.
   $R_5 = R_6 = 49.9k\Omega$

Design Simulations

DC Simulation Results



AC Simulation Results



Design References

See Analog Engineer's Circuit Cookbooks for TI's comprehensive circuit library.

See the circuit SPICE simulation file SBOC510.

See TIPD131, www.ti.com/tool/tipd131.

Design Featured Op Amp

OPA344	
V_{ss}	1.8V to 5.5V
V_{inCM}	Rail-to-rail
V_{out}	Rail-to-rail
V_{os}	0.2mV
I_q	150µA
I_b	0.2pA
UGBW	1MHz
SR	0.8V/µs
#Channels	1, 2, 4
www.ti.com/product/opa344	

Design Alternate Op Amp

OPA335	
V_{ss}	2.7V to 5.5V
V_{inCM}	V_{ee}–0.1V to V_{cc}–1.5V
V_{out}	Rail-to-rail
V_{os}	1µV
I_q	285µA/Ch
I_b	70pA
UGBW	2MHz
SR	1.6V/µs
#Channels	1, 2
www.ti.com/product/opa335	

Revision History

Revision	Date	Change
A	February 2019	Downscale the title and changed title role to 'Amplifiers'. Added links to circuit cookbook landing page and SPICE simulation file.