

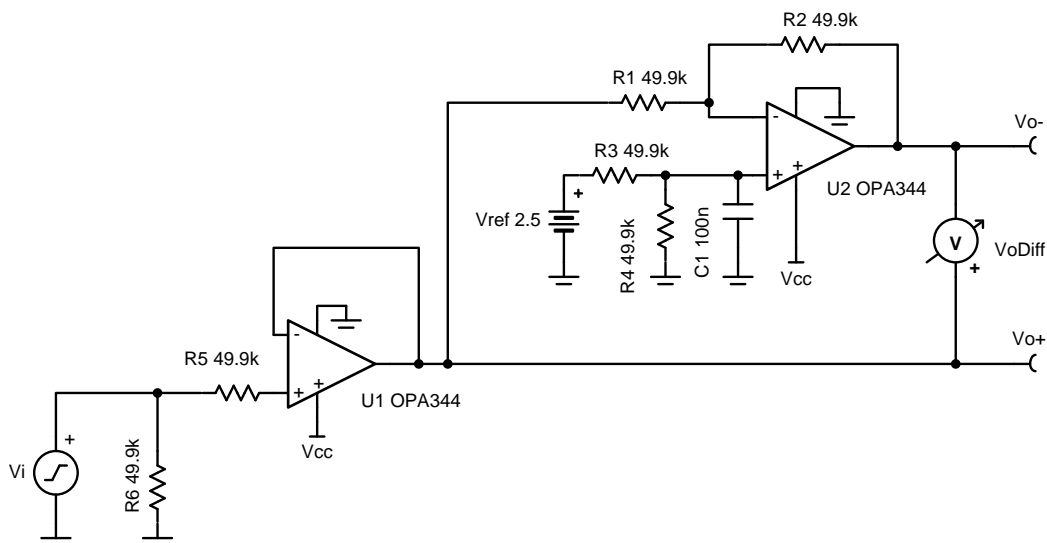
Single-ended input to differential output circuit

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 $\pm 2.3V$ 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_{oI} 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-} .

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

3. Select resistances so that the resistor noise is smaller than the amplifier broadband noise.

$$E_{nv} = 30 \frac{nV}{\sqrt{Hz}} \text{ (Voltage noise from op amp)}$$

If $R_1 = R_2 = R_3 = R_4 = 49.9k\Omega$ then

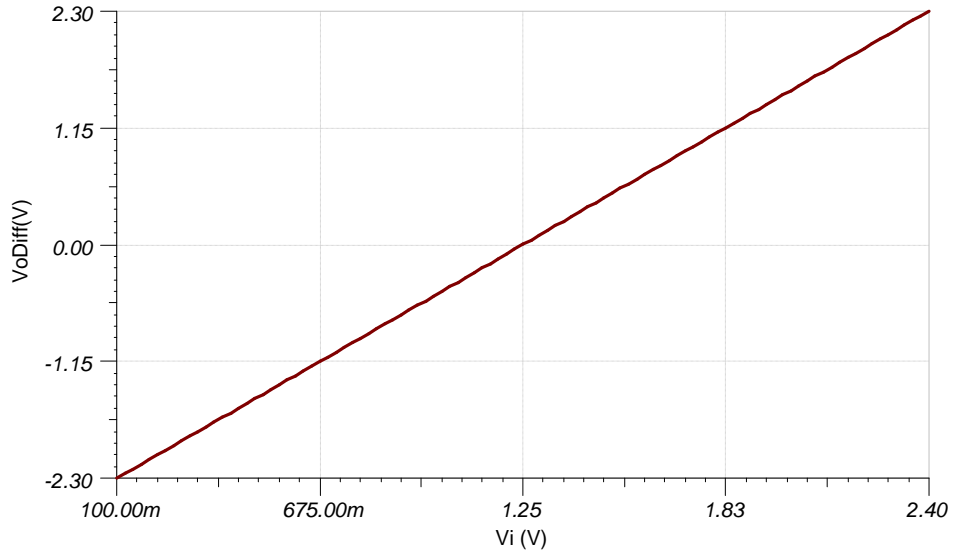
$$E_{nr} = \sqrt{\left(\sqrt{4 \times kB \times T \times (R_1 || R_2)}\right)^2 + \left(\sqrt{4 \times kB \times T \times (R_3 || R_4)}\right)^2} = 28.7 \frac{nV}{\sqrt{Hz}} (< E_{nv})$$

4. Select resistances that protect the input of the amplifier and prevents floating inputs. To simplify the bill of materials (BOM), select $R_5 = R_6$.

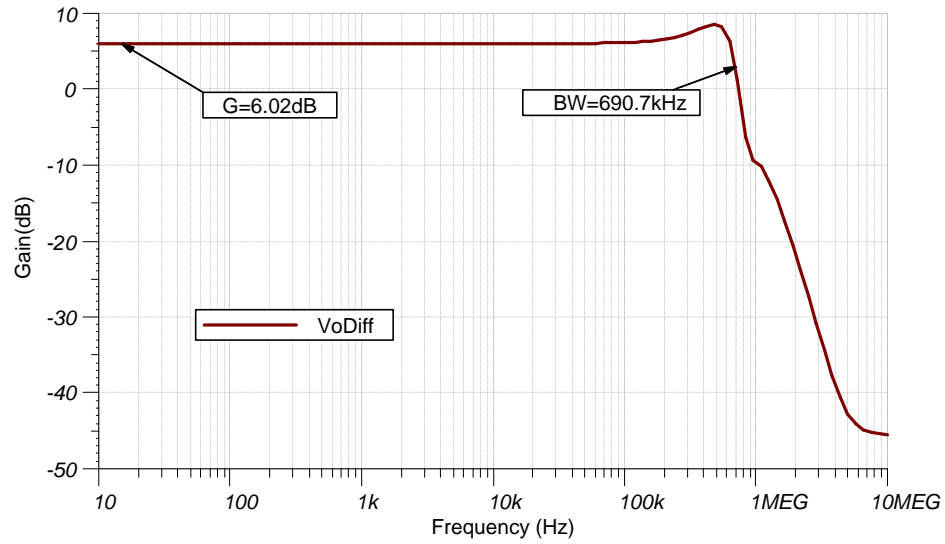
$$R_5 = R_6 = 49.9k\Omega$$

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	150 μ A
I_b	0.2pA
UGBW	1MHz
SR	0.8V/ μ s
#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}	1 μ V
I_q	285 μ A/Ch
I_b	70pA
UGBW	2MHz
SR	1.6V/ μ s
#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.

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