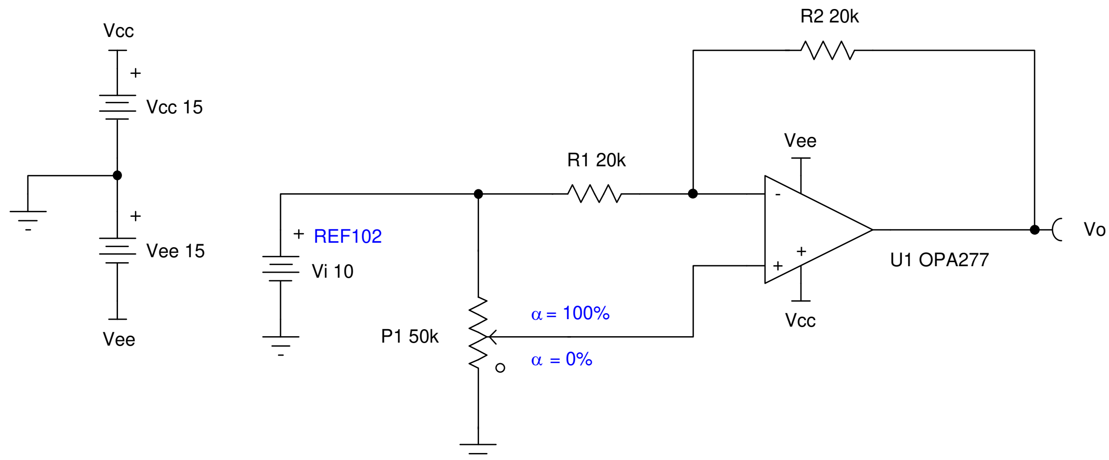
Adjustable Reference Voltage Circuit

Design Goals

Input	Output		Supply	
V_i	V_{oMin}	V_{oMax}	V_{cc}	V_{ee}
10 V	–10 V	10 V	15 V	–15 V

Design Description

This circuit combines an inverting and non-inverting amplifier to make a reference voltage adjustable from the negative of the input voltage up to the input voltage. Gain can be added to increase the maximum negative reference level.

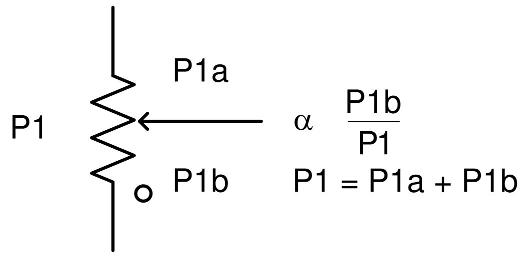


Design Notes

1. Observe the common-mode and output swing limitations of the op amp.
2. Mismatch in R_1 and R_2 results in a gain error. Selecting $R_2 > R_1$ increases the maximum negative voltage, and selecting $R_2 < R_1$ decreases the maximum negative voltage. In either case, the maximum positive voltage is always equal to the input voltage. This relationship is inverted if a negative input reference voltage is used.
3. Select the potentiometer based on the desired resolution of the reference. Generally, the potentiometers can be set accurately to within one-eighth of a turn. For a 10-turn pot this means alpha (∝) may be off by as much as 1.25%.

Design Steps

Alpha represents the potentiometer setting relative to ground. This is the fraction of the input voltage that will be applied to the non-inverting terminal of the op amp and amplified by the non-inverting gain.



The transfer function of this circuit follows:

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

1. If $R_2 = R_1 = 20\ k\Omega$, then the equation for V_o simplifies as the following shows:

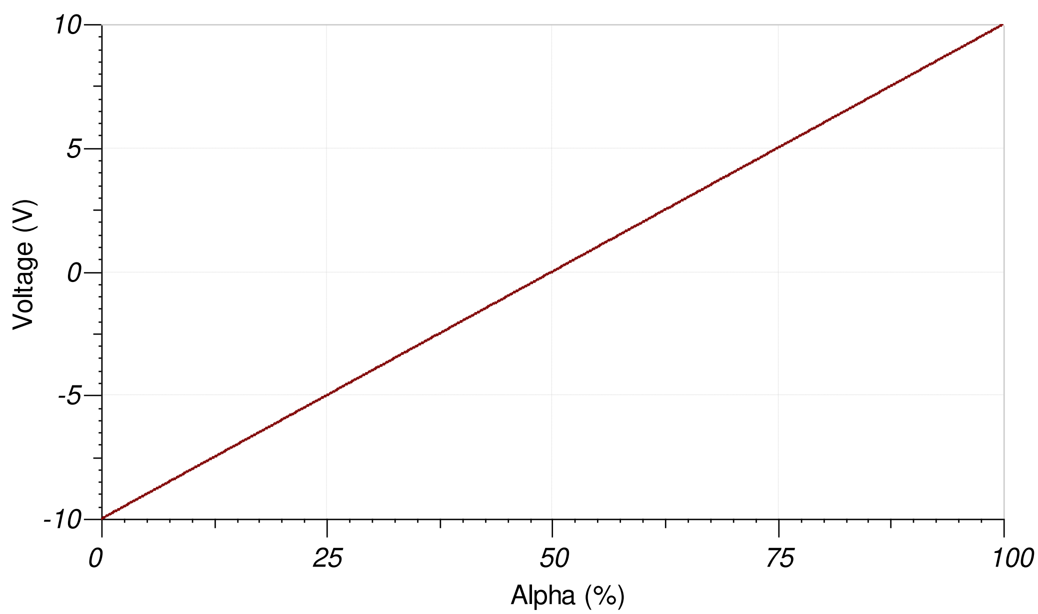
$$V_o = (2\alpha - 1) \times V_i$$

2. If $V_i = 10V$ and $\propto = 0.75$, the value of V_o can be determined.

$$V_o = (2 \times 0.75 - 1) \times 10 = 5V$$

Design Simulations

DC Simulation Results



Design References

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

See the TINA-TI™ circuit simulation file, SBOMAU2.

See TI Precision Labs - Op Amps.

Design Featured Op Amp

OPA277	
V_{ss}	4 V to 36 V
V_{inCM}	V_{ee}+2 V to V_{cc}–2 V
V_{out}	V_{ee}+0.5 V to V_{cc}–1.2 V
V_{os}	10 µV
I_q	790 µA/Ch
I_b	500 pA
UGBW	1 MHz
SR	0.8 V/µs
#Channels	1, 2, and 4
OPA277	

Design Alternate Op Amp

OPA172	
V_{ss}	4.5 V to 36 V
V_{inCM}	V_{ee}–0.1 V to V_{cc}–2 V
V_{out}	Rail-to-rail
V_{os}	200 µV
I_q	1.6 mA/Ch
I_b	8 pA
UGBW	10 MHz
SR	10 V/µs
#Channels	1, 2, and 4
OPA172	