Universal Balancing Techniques

National Semiconductor
Linear Brief 9

IC op amps are widely accepted as a universal analog component. Although the circuit designs may vary, most devices are functionally interchangeable. However, offset voltage balancing remains a personality trait of the particular amplifier design. The techniques shown here allow offset voltage balancing without regard to the internal circuitry of the amplifier.

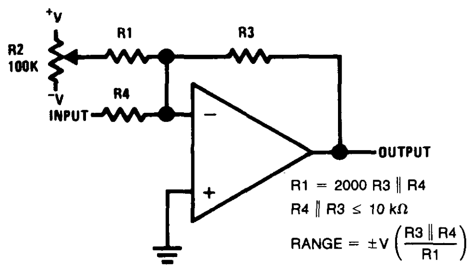

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FIGURE 1. Offset Voltage Adjustment for Inverting Amplifiers Using 10 kΩ Source Resistance or Less

The circuit shown in *Figure 1* is used to balance out the offset voltage of inverting amplifiers having a source resistance of 10 kΩ or less. A small current is injected into the summing node of the amplifier through R_1. Since R_1 is 2000 *times as large as the source resistance* the voltage at the arm of the pot is attenuated by a factor of 2000 at the summing node. With the values given and ±15V supplies the output may be zeroed for offset voltages up to ±7.5 mW.

If the value of the source resistance is much larger than 10 kΩ, the resistance needed for R_1 becomes too large. In this case it is much easier to balance out the offset by supplying a small voltage at the non-inverting input of the amplifier. *Figure 2* shows such a scheme. Resistors R_1 and R_2 divide the voltage at the arm of the pot to supply a ±7.5 mW adjustment range with ±15V supplies.

This adjustment method is also useful when the feedback element is a capacitor or non-linear device.

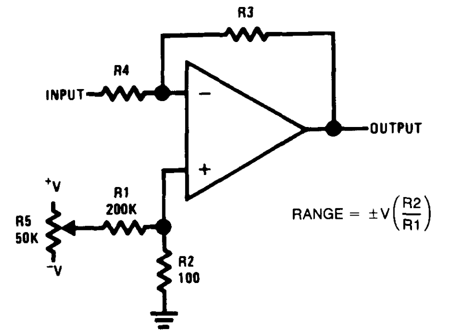

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FIGURE 2. Offset Voltage Adjustment for Inverting Amplifiers Using Any Type of Feedback Element

This technique of supplying a small voltage effectively in series with the input is also used for adjusting non-inverting amplifiers. As is shown in *Figure 3*, divider R_1, R_2 reduces the voltage at the arm of the pot to ±7.5 mW for offset adjustment. Since R_2 appears in series with R_4, R_2 should be considered when calculating the gain. If R_4 is greater than 10 kΩ the error due to R_2 is less than 1%.

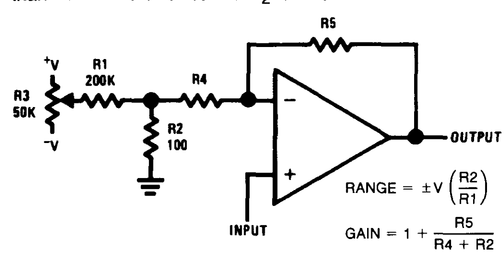

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FIGURE 3. Offset Voltage Adjustment for Non-Inverting Amplifiers

A voltage follower may be balanced by the technique shown in *Figure 4.* R_1 injects a current which produces a voltage drop across R_3 to cancel the offset voltage. The addition of the adjustment resistors causes a gain error, increasing the gain by 0.05%. This small error usually causes no problem. The adjustment circuit essentially causes the offset voltage to appear at full output, rather than at low output levels, where it is a large percentage error.

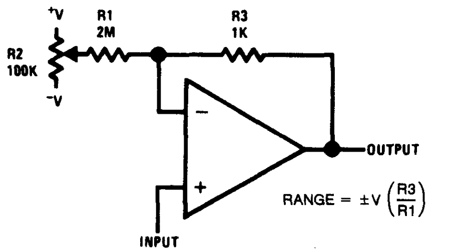

FIGURE 4. Offset Voltage Adjustment for Voltage Followers

Differential amplifiers are somewhat more difficult to balance. The offset adjustment used for a differential amplifier can degrade the common mode rejection ratio. *Figure 5* shows an adjustment circuit which has minimal effect on the common mode rejection. The voltage at the arm of the pot is divided by R_4 and R_5 to supply an offset correction of ± 7.5 mV. R_4 and R_5 are chosen such that the common mode rejection ratio is limited by the amplifer for values of R_3 greater than 1 kΩ. If R_3 is less than 1k the shunting of R_4 by R_5 must be considered when choosing the value of R_3.

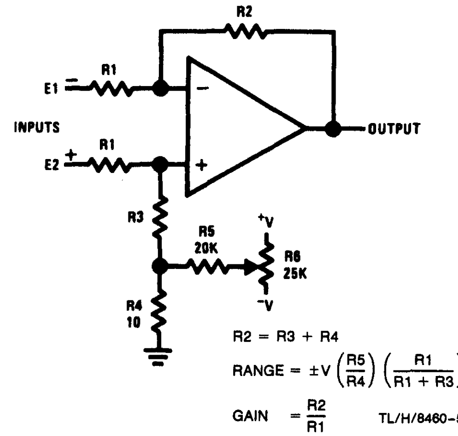

FIGURE 5. Offset Voltage Adjustment for Differential Amplifiers

The techniques described for balancing offset voltage at the input of the amplifier offer two main advantages: First, they are universally applicable to all operational amplifiers and allow device interchangeability with no modifications to the balance circuitry. Second, they permit balancing without interfering with the internal circuitry of the amplifier. The electrical parameters of the amplifiers are tested and guaranteed without balancing. Although it doesn't usually happen, balancing could degrade performance.