

LT1880 SOT-23 Op Amp Saves Board Space in Precision Applications

Introduction

The tiny new LT1880 achieves precision unprecedented in a SOT-23 package without resorting to auto-zeroing techniques. Input offset voltage and drift are typically $40\mu\text{V}$ and $0.3\mu\text{V}/^\circ\text{C}$, respectively, with guarantees of $200\mu\text{V}$ and $1.2\mu\text{V}/^\circ\text{C}$ maximum over temperature. The device operates on total supplies from 2.7V to 40V with rail-to-rail outputs, giving a dynamic range of 120dB. Unlike some competitors' SOT-23 op amps, which claim to maintain good precision, the LT1880 supports its input precision with a high open loop gain of 1.6 million, as well as 135dB CMRR and PSRR. It is available in commercial and industrial temperature grades.

Applications

Getting Rail-to-Rail Operation without Rail-to-Rail Inputs

The LT1880 does not have rail-to-rail inputs, but for most inverting applications and noninverting gain applications, this is largely inconsequential. Figure 1 shows the basic op amp configurations, what happens to the op amp inputs, and whether or not the op amp must have rail-to-rail inputs.

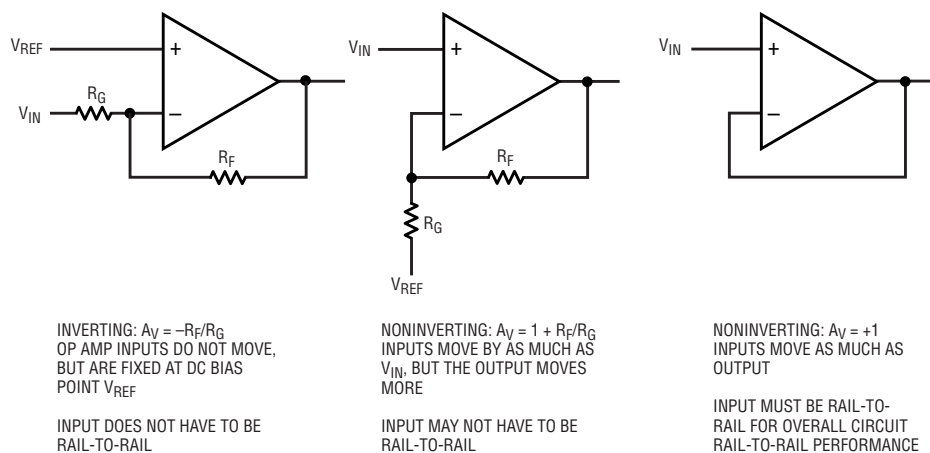


Figure 1. Some op amp configurations do not require rail-to-rail inputs to achieve rail-to-rail outputs.

The circuit of Figure 2 shows an extreme example of the inverting case. The input voltage at the 1M resistor can swing $\pm 13.5\text{V}$ and the LT1880 will output an inverted, divided-by-ten version of the input voltage. The input accuracy is limited by the resistors to 0.2%. Output referred, this error becomes 2.7mV. The $40\mu\text{V}$ input offset voltage contribution, plus the additional error due to input bias current times the $\sim 100\text{k}$ effective source impedance, contribute only negligibly to error.

Precision Photodiode Amplifier

Photodiode amplifiers usually employ JFET op amps because of their low bias current; however, when precision is required, JFET op amps are generally inadequate, due to their relatively high input offset voltage and drift. The LT1880 provides a high degree of precision with very low bias current ($I_B = 150\text{pA}$ typical) and is therefore applicable to this demanding task. Figure 3 shows an LT1880 configured as a transimpedance photodiode amplifier. The transimpedance gain is set to $51.1\text{k}\Omega$ by R_F . The feedback capacitor, C_F , may be as large as desired where response time is not an issue, or it may be selected for maxi-

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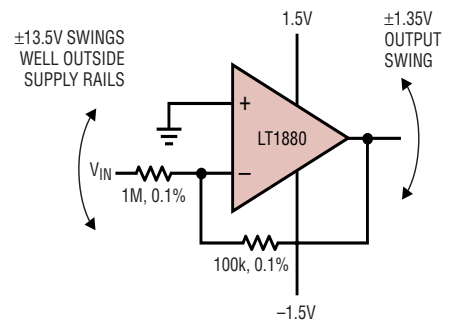


Figure 2. Extreme inverting case: circuit operates properly with input voltage swing well outside op amp supply rails.

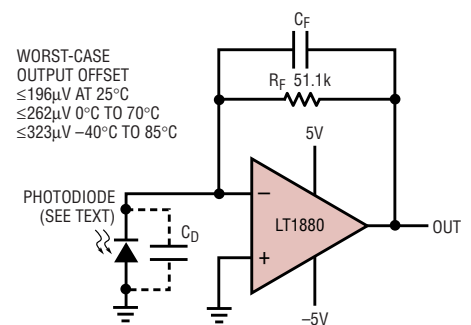


Figure 3. Precision photodiode amplifier

mally flat response and highest possible bandwidth given a photodiode capacitance C_D . Figure 4 shows a chart of C_F and rise time versus C_D for maximally flat response. Total output offset is below $262\mu\text{V}$, worst-case, over temperature (0°C – 70°C). With a 5V output swing this implies an 86dB

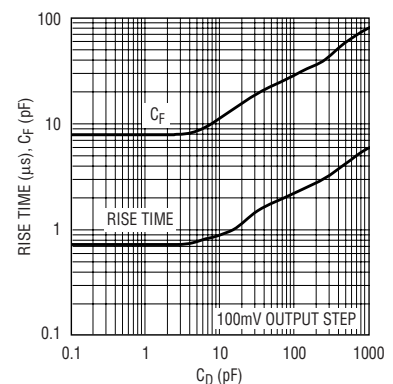


Figure 4. Feedback C_F and rise time vs photodiode C_D

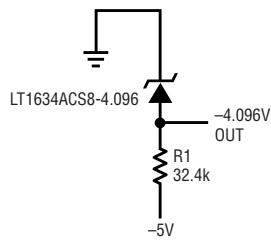


Figure 5. Simple, precision -4.096V reference: output is not buffered. PSRR is compromised by low value of R1.

dynamic range, worst-case, sustained over temperature (0°C – 70°C), and a full-scale photodiode current of $98\mu\text{A}$.

Invert, Buffer Your Shunt Reference and Improve PSRR

Figure 5 shows a negative 4.096V precision LT1634 shunt reference operating on a -5V supply. R1 is set at 32.4k to give $20\mu\text{A}$ of bias current to the reference with a minimum negative supply of -4.75V. Although this is an excellent way to achieve a precision negative reference, the circuit can be compromised in some applications in two ways. One is by its high, large signal output impedance and the other is by its 70dB PSRR dictated by the 32.4k resistor from the negative supply and the $\sim 10\Omega$ dynamic impedance of the LT1634 at $20\mu\text{A}$ bias. The circuit in Figure 6 uses the LT1880 to solve both problems. The op amp is configured as an inverter with the LT1634 in the feedback path. The bias current of the LT1634 is thus maintained at a constant level by the 249k resistor and the LT1880. The power supply rejection, now positive-supply referred, is improved by

18dB by the higher value set resistor. The output impedance is much lower, being determined by the output impedance of the LT1880. The circuit of Figure 7 achieves essentially the same function, but is stabilized into a $10\mu\text{F}$ reservoir capacitor.

Single-Supply Current Source for Platinum RTD

The precision, low bias current input stage of the LT1880 makes it ideal for precision integrators and current sources. Figure 8 shows the LT1880 providing a simple precision current source for a remote $1\text{k}\Omega$ RTD on a 4-wire connection. The LT1634 reference places 1.25V at the noninverting input of the LT1880, which then maintains its inverting input at the same voltage by driving 1mA of current through the RTD and the total $1.25\text{k}\Omega$ of resistance set by R1 and R2. Imprecise components R4 and C1 ensure circuit stability, which would otherwise be excessively dependant on the cable characteristics. R5 is also non-critical and is included to improve ESD immunity and decouple any cable capacitance from the LT1880's output. The 4-wire cable allows Kelvin sensing of the RTD voltage while excluding the cable IR drops from the voltage reading. With 1mA excitation, a $1\text{k}\Omega$ RTD will have 1V across it at 0°C , and $+3.85\text{mV}/^{\circ}\text{C}$ temperature

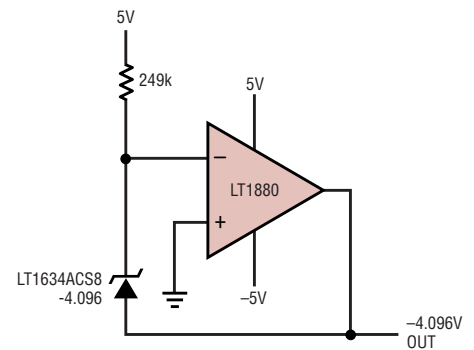



Figure 6. Precision -4.096V reference: LT1880 buffers the output voltage, improves PSRR.

response. This voltage can be easily read in myriad ways, with the best method depending on the temperature region to be emphasized and the particular ADC that will be reading the voltage.

Conclusion

The precision, low bias current input stage of the LT1880 makes it ideal for precision and high impedance circuits. The rail-to-rail output stage renders the op amp capable of driving other devices as simply as possible with extended dynamic range, while the 2.7V to 40V operation means that it will work on almost all supplies. The small SOT-23 package makes it a compelling choice where board space is at a premium, or where a composite amplifier is competing against a larger single-chip solution. 

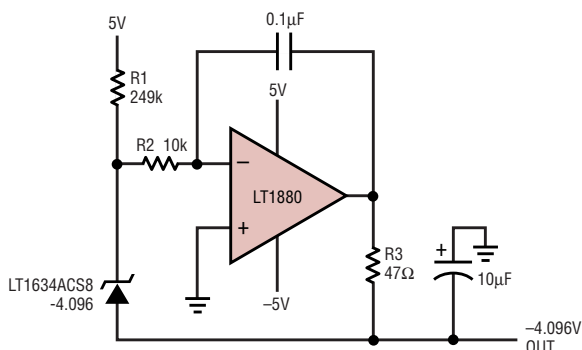
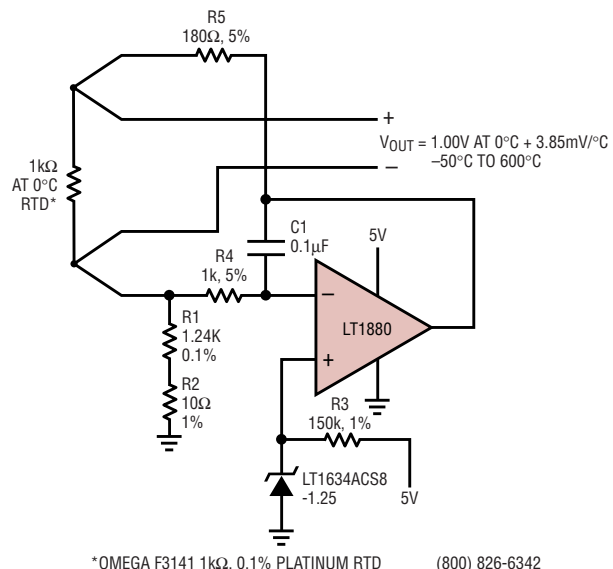


Figure 7. Same as Figure 6 except the circuit is stabilized into a large capacitance.



*OMEGA F3141 $1\text{k}\Omega$, 0.1% PLATINUM RTD

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Figure 8. Single-supply current source for platinum RTD