IC references are popular with circuit designers because they are accurate and exhibit low drift. Some of my future columns will cover the three types of IC references: buried zener, bandgap, and XFET. You develop the reference-design procedure with a zener diode; the zener's simplicity illustrates the design procedure, and its problems make you appreciate IC references. The circuit specifications are $V_{CC}=30V\pm10\%$, $8.445\leq V_{REF}\leq 9.555$, $\Delta V_{REF}\leq 200\,mV$, $100\,k\Omega \leq R_{LOAD}\leq 200\,k\Omega$, and $0\degree C \leq T_{A} \leq 80\degree C$.

Select a 1N757 9.1V zener for the first try. Note that the maximum temperature coefficient is 6 mV/°C, and the zener-voltage tolerance is ±5%. The calculated reference voltage equals the maximum specification, $V_{REF}=(1.05)(9.1)=9.555V$, but the temperature-induced drift is $\Delta V_{REF}=(80-25)(6\,mV)=0.330V$, thus exceeding the maximum-drift voltage specification.

Connect a signal diode in series with a 1N756 8.2V zener so that the diode's negative-temperature coefficient cancels part of the zener's positive-temperature coefficient (Figure 1). The diode's temperature coefficient ranges from -2.1 to -2.3 mV/°C, and the 8.2V zener's temperature coefficient is 5.4 mV/°C, so the combination's maximum temperature coefficient is 3.3 mV/°C. This scenario yields $\Delta V_{REF}=181.5\,mV$, which meets specifications, but the minimum reference voltage, $V_{REF}=(0.95)(8.2)+0.5=8.29V$, is less than the specified limit of 8.445V.

This analysis is incomplete because additional zener characteristics, such as zener impedance and bias current, affect $\Delta V_{REF}$. Now's the time to give up on a pure zener diode and go to a temperature-compensated zener. The 1N935 has a zener voltage of 9.075V; a tolerance of 5%; a temperature coefficient of 2 mV/°C; and a zener impedance of 20Ω at $I_{Z}=7.5\,mA$, where $I_{Z}$ is the zener-test current. The reference-voltage range is $8.62\leq V_{REF}\leq 9.53$. A quick calculation of the temperature-coefficient error yields a maximum voltage change of $\Delta V_{REF}=110\,mV$. So far, so good, but you need to do further calculations to get the complete picture.

Calculate $R_{BIAS}$ as $R_{BIAS}=(V_{CC}-V_{REF})/I_{Z}=(30-9)/7.5=2885\,\Omega$; select $R_{BIAS}=2800\,\Omega\pm 2\%$. (The temperature-compensated zener includes the diode in Figure 1.) Because of power-supply and resistor tolerances, the change in $I_{Z}$ ranges from $(30)(0.9)-9.53-0.11)/2.8(1.02)=6.07\,mA$ to $(30)(1.1)-8.62-0.05)/2.8(0.98)=8.86\,mA$. The load-resistance change causes about 90 μA of change in $I_{Z}$, which is insignificant. This change in the temperature-compensated-zener current corresponds to a zener-impedance change of approximately $\pm 5\Omega$ (Reference 1), but $\Delta V_{REF}$ changes only about $\pm 37.5\,mV$. You should also consider the zener-voltage change: Because of the $I_{Z}$ shift, the zener-operating point changes when $V_{REF}$ varies by $\pm 50\,mV$. Also, keep in mind that the maximum wideband semiconductor noise that the dc voltage contains is 20 μV.
The final voltage-reference change is $110 + 37.5 + 50 = 197.5$ mV. Some people say that this analysis is not the most rigorous, and they are right, but it gives you an idea of what using a zener reference involves. If $V_{CC}$ had been as low as 12V, a zener diode would fail to meet specifications. The load-resistance variation does not affect design calculations, because $R_{LOAD}$ is large. A smaller, 2-kΩ load resistance with a variation of 1 kΩ causes a great change in $I_z$, necessitating a zener-diode buffer. If the zener diode is part of an IC, then you can trim $R_{BIAS}$ with a laser, and adding a buffer is trivial. This buried-zener-voltage-reference method seems like a better way to build a voltage reference.

Reference