Input Filtering

An obvious and straightforward location for filtering is at the output of the INA210-INA214. However, this location negates the advantage of the low output impedance of the internal buffer. The only other option for filtering is at the input pins of the INA210-INA214. This location, though, does require consideration of the +/-30% tolerance of the internal resistances. Figure 24 shows a filter placed at the inputs pins.

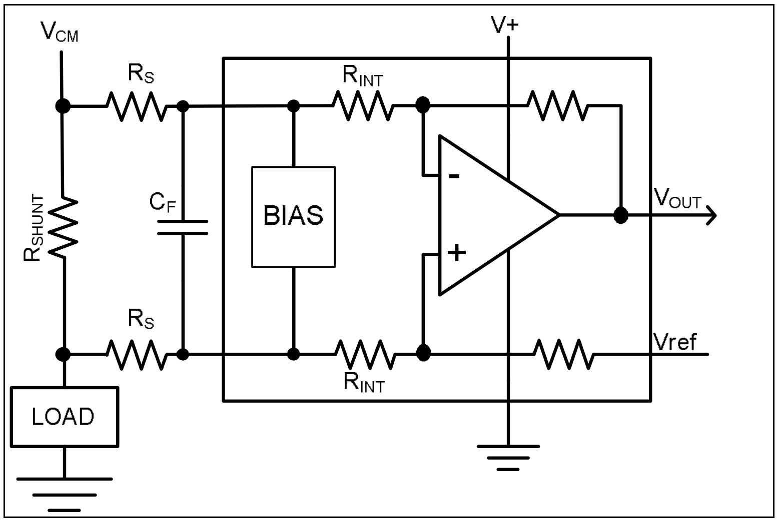

Figure 24. Input Filter

The addition of external series resistance, though, creates an additional error that is not present under normal operating conditions. The internal bias network shown connected to the input pins create a mismatch in input bias currents when a differential voltage is applied to the device's input pins. This results in a mismatch of voltage drops on the input lines due to the mismatch of input bias currents flowing through the additional external series filter resistors. This creates a differential error voltage that subtracts from the voltage developed at the shunt resistor. The result is a reduced differential voltage at the device's input pins relative to the expected shunt voltage created by the load current flowing through the shunt resistor. Without the additional series resistance, the mismatch in input bias currents has little effect on the operation of the device.

The amount of variance in the differential voltage present at the devices input relative to the voltage developed at the shunt resistor is based both on value of external series resistance as well as the internal input resistors, R3 and R4 (or R_{INT} as shown in Figure 24). The reduction of the shunt voltage reaching the device's input pins will appear as a gain error when looking at the output voltage relative to the shunt voltage. A factor can be calculated to determine the amount of gain error that will be introduced by the addition of external series resistance.

The equation used to calculate the expected deviation from the shunt voltage to what will be seen at the device's input pins is given in Equation 1:

$$\text{Gain Error Factor} = \frac{(1250 \cdot R_{INT})}{(1250 \cdot R_S) + (1250 \cdot R_{INT}) + (R_S \cdot R_{INT})} \tag{1}$$

Where R_{INT} is the internal input resistor, R3 and R4, and R_S is the external series resistance. With the adjustment factor equation including the device's internal input resistance, this factor will vary with each gain version.

Table 1.

Product	Gain	R_{INT}
INA210	200	5k
INA211	500	2k
INA212	1000	1k
INA213	50	20k
INA214	100	10k

Each individual device's Gain Error Factor is shown in equations 2 through 6.

$$\textbf{Gain Error Factor (INA210)} = \frac{1000}{R_S + 1000} \tag{2}$$

$$\textbf{Gain Error Factor (INA211)} = \frac{10000}{(13 \times R_S) + 10000} \tag{3}$$

$$\textbf{Gain Error Factor (INA212)} = \frac{5000}{(9 \times R_S) + 5000} \tag{4}$$

$$\textbf{Gain Error Factor (INA213)} = \frac{20000}{(17 \times R_S) + 20000} \tag{5}$$

$$\textbf{Gain Error Factor (INA214)} = \frac{10000}{(9 \times R_S) + 10000} \tag{6}$$

These Gain Errors, though, assume the nominal value for the individual internal resistors. These internal resistors can have up to 30% of variance from their nominal value. The Gain Error Factors can be easily modified to account for the tolerance of these components. By reducing the numerator and the portion of the denominator of the Gain Error Factor not pertaining to the input series resistance by the maximum tolerance of the internal resistors, the equation is altered to account for the maximum variance of these internal components. For example, using equation 3 for the INA211 and the maximum 30% variance results in a Gain Error Factor as shown in equation 7:

$$\textbf{Worst Case Gain Error Factor (INA211)} = \frac{(0.7 \times 10000)}{(13 \times R_S) + (0.7 \times 10000)} = \frac{7000}{(13 \times R_S) + 7000} \qquad (7)$$

The Gain Error that can be expected due to the addition of the external series resistors can then be calculated based on equation 8:

$$\text{Gain Error \%} = 100 - (100 \cdot \text{Gain Error Factor}) \qquad (8)$$

Using an INA212 and equation 4; for example, a series resistance of 10Ω results in a Gain Error Factor of 0.982. The corresponding Gain Error is then calculated using equation 8 resulting in a Gain Error of approximately 1.77% due solely to the external 10Ω series resistors. Using an INA213 with the same 10Ω series resistor results in a Gain Error Factor of 0.991 and a Gain Error of 0.84% due solely to these 10Ω resistors. Using the method shown in equation 7 for determining the worst case Gain Error Factor results in a worst case Gain Error of 1.2% due to the external 10Ω resistors using an INA213.