Simple Differential Front-End for the LTC2400

Simple Rail-to-Rail Circuit Converts Differential Signals to Single-Ended Signals and Operates on Single or Dual Supplies Where Resolution Is More Important Than Accuracy

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SPECIFICATIONS

$V_{CC} = V_{REF} = LT^®1236\text{-}5$; $V_{FS} = 5V$; $R_{SOURCE} = 175\Omega$ (Balanced)

PARAMETER	CIRCUIT (MEASURED)	LTC2400	TOTAL (UNITS)
Input Voltage Range	−0.3 to 5.3		V
Zero Error	2.75		mV
Input Current	See Text		
Nonlinearity	±35	4	ppm
Input-Referred Noise (without averaging)	10	1.5	μV_{RMS}
Input-Referred Noise (averaged 64 readings)	1.5		μV_{RMS}
Resolution (with averaged readings)	21.7		Bits
Supply Voltage	5	5	V
Supply Current	0.45	0.2	mA
CMRR	118		dB
Common Mode Range*	−5 to 5		V

*0V to 5V for single 5V supply

OPERATION

The circuit in Figure 1 is ideal for wide dynamic range differential signals in applications that have a 5V or ±5V supply where absolute accuracy is secondary to high resolution. The circuit uses one-half of an LTC®1043 to perform a differential to single-ended conversion over an input common mode range that includes the power supplies. It uses the LTC1043 to sample a differential input voltage, holds it on C_S and transfers it to a ground-referred capacitor C_H. The voltage on C_H is applied to the LTC2400's input and converted to a digital value.

The LTC1043 achieves its best differential to single-ended conversion when its internal switching frequency operates at a nominal 300Hz, as set by the 0.01µF capacitor C1 and when 1µF capacitors are used for C_S and C_H. C_S and C_H should be a film type such as mylar or polypropylene.

Conversion accuracy is enhanced by placing a guard shield around C_S and connecting the shield to Pin 10 of the LTC1043. This minimizes nonlinearity that results from stray capacitance transfer errors associated with C_S. Consult the LTC1043 data sheet for more information. As is good practice in all high precision circuits, keep all lead lengths as short as possible to minimize stray capacitance and noise pickup.

Like all delta-sigma converters, the LTC2400's input circuitry causes small current spikes on the input signal. These current spikes perturb the voltage on the LTC1043's C_H, which results in an effective increase in offset voltage and gain error. These errors remain constant and can be removed through software. Without this end-point correction that reduces the effects of zero and full-scale error, the overall accuracy is degraded. The input dynamic range, however, is not compromised and the overall linearity remains at ±35ppm, or 14.5bits.

For inputs with common mode voltages that swing above and below ground, connect Pin 17 to a negative supply, as shown in Figure 1. When applying differential voltages with common mode voltages between ground and the LTC1043's positive supply, connect Pin 17 (V⁻) to ground for single supply operation.

As stated above, the LTC1043 has the highest transfer accuracy when using 1µF capacitors. Using any other value will compromise the accuracy. For example, 0.1µF will typically increase the circuit's overall nonlinearity and decrease the CMRR by a factor of 10.

The LTC1043's internal oscillator's frequency will vary with changes in supply voltage. This variation shows up as increased noise and/or gain error. For example, a 100mV change in the LTC1043's supply voltage causes 14ppm gain error in the LTC2400. If this variation is short term,

this error appears as noise. The LTC1043 shows the largest gain error at a nominal common mode input of 3V. These errors can be reduced by using an external clock. As the LTC1043's V_{CC} increases from a nominal 5V, gain errors are most significant and below 5V, linearity errors become more significant.

The circuit's input current is dependent on the input signal's magnitude and the reference voltage. For a 5V reference, the input current is approximately –1µA at zero scale, 1µA at full scale and 0µA at midscale. The values may vary from part to part. Figure 1's input is analogous to a 2µF capacitor in parallel with a 2.5MΩ connected to $V_{REF}/2$. The LTC1043's nominal 800Ω switch resistance is between the source and the 2µF capacitance. This description applies to cases where a capacitor is connected in parallel to the LTC2400's input.

This circuit is best suited to applications with large signal swings, and source impedances under 500Ω.
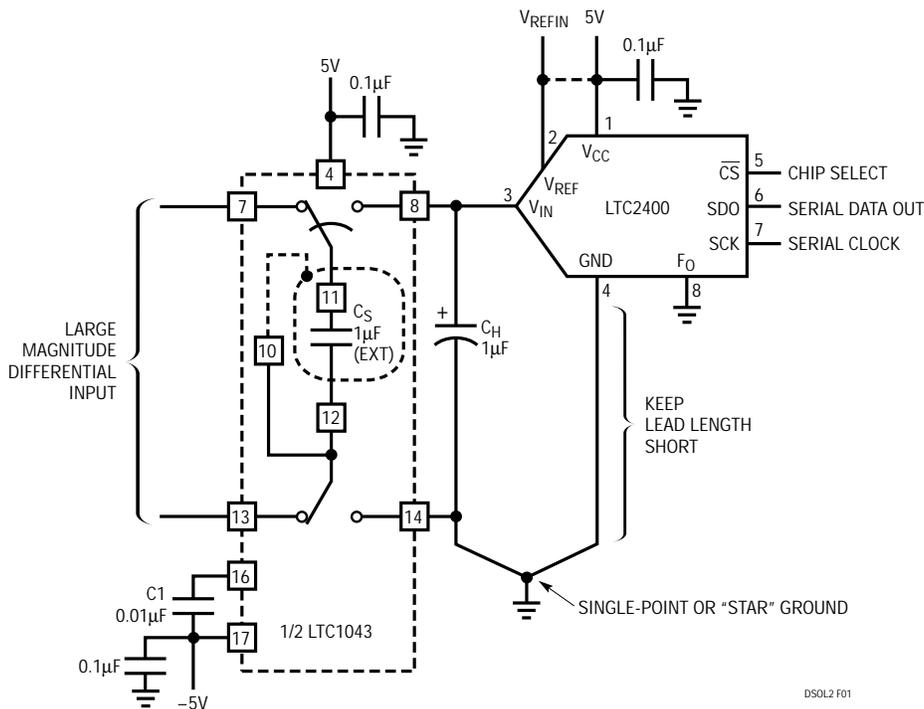

Figure 1. Simple Rail-to-Rail Circuit Converts Differential Signals to Single-Ended Signals