High Accuracy, Differential to Single-Ended Conversion for Wide Range Bipolar Input Signals

Bipolar Differential to Single-Ended Converter Drives the LTC2400's Input Rail-to-Rail

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SPECIFICATIONS

V_{CC} = V_{REF} = LT®1236-5; V_{FS} = ±2.45V; R_{SOURCE} = 175Ω (Balanced)

PARAMETER	CIRCUIT (MEASURED)	LTC2400	TOTAL (UNITS)
Input Voltage Range	±2.45		V
Zero Error	22	1.5	μV
Input Current	See Text		
Nonlinearity	±2.5	4	ppm
Input-Referred Noise (without averaging)	6.5	1.5	μV_{RMS}
Input-Referred Noise (averaged 64 readings)	1		μV_{RMS}
Resolution (with averaged readings)	22.2		Bits
Overall Accuracy (uncalibrated)	17.1		Bits
Supply Voltage	5	5	V
Supply Current	2.1	0.2	mA
CMRR	118		dB
Common Mode Range	0 to 5		V

OPERATION

The circuit in Figure 1 is ideal for wide dynamic range differential signals in applications that have a 5V supply. 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. This half of the LTC1043 samples a differential input voltage, holds it on C_{S1} and transfers it to capacitor C_{H1}. The voltage on C_{H1} is buffered, applied to the LTC2400's input and converted to a digital value.

A reference voltage is applied to the LTC2400's V_{REF} pin and the LTC1043's Pin 6. The remaining half of the LTC1043 divides the reference voltage by two with a high degree of accuracy. This $V_{REF}/2$ voltage is applied to the bottom of C_{H1}, centering the LTC1043's output voltage at midscale. This allows the converter to accept bipolar input voltages that swing about a $V_{REF}/2$ point when operating on a single supply.

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_{S1}, C_{S2}, C_{H1} and C_{H2}. Each of these four capacitors should be a film type such as mylar or polypropylene. Conversion accuracy is enhanced by placing a guard shield around C_{S1} and connecting the shield to Pin 10 of the LTC1043. This minimizes nonlinearity that results from stray capacitance transfer errors associated with C_{S1}. 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.

The circuit in Figure 1 improves on unbuffered LTC1043 circuits, providing an order of magnitude improvement in linearity (±2.5ppm) by buffering the voltage on C_{H1}. The circuit also improves linearity by buffering the voltage on C_{H1} with an LTC1152 operating at unity gain. If a 10V supply is available, the LTC1050 can be used instead of the LTC1152.

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 degrade CMRR by an order of magnitude.

Another source of error is thermocouple effects that occur in soldered connections starting with the LTC1043's input traces and ending with the connections to the LTC2400's input and ground pins. Any temperature changes in any of the low level circuitry's connections will cause perturbations in the final conversion result. Their effects can be minimized by controlling thermal gradients between pairs of connection by judicious placement of heat sources, components and copper heat spreaders under the pads and by insulating the circuit against moving air.

The circuit's input current is dependent on the input signal's common mode voltage. The input current is approximately –100nA at $V_{IN(CM)}$ = –2.5V, 100nA at $V_{IN(CM)}$ = 2.5V and 0µA at $V_{IN(CM)}$ = 0V. The values may vary from part to part. Figure 1's input is analogous to a 2µF capacitor in parallel with a 25MΩ connected to ground. The LTC1043's nominal 800Ω switch resistance is between the source and the 2µF capacitance.

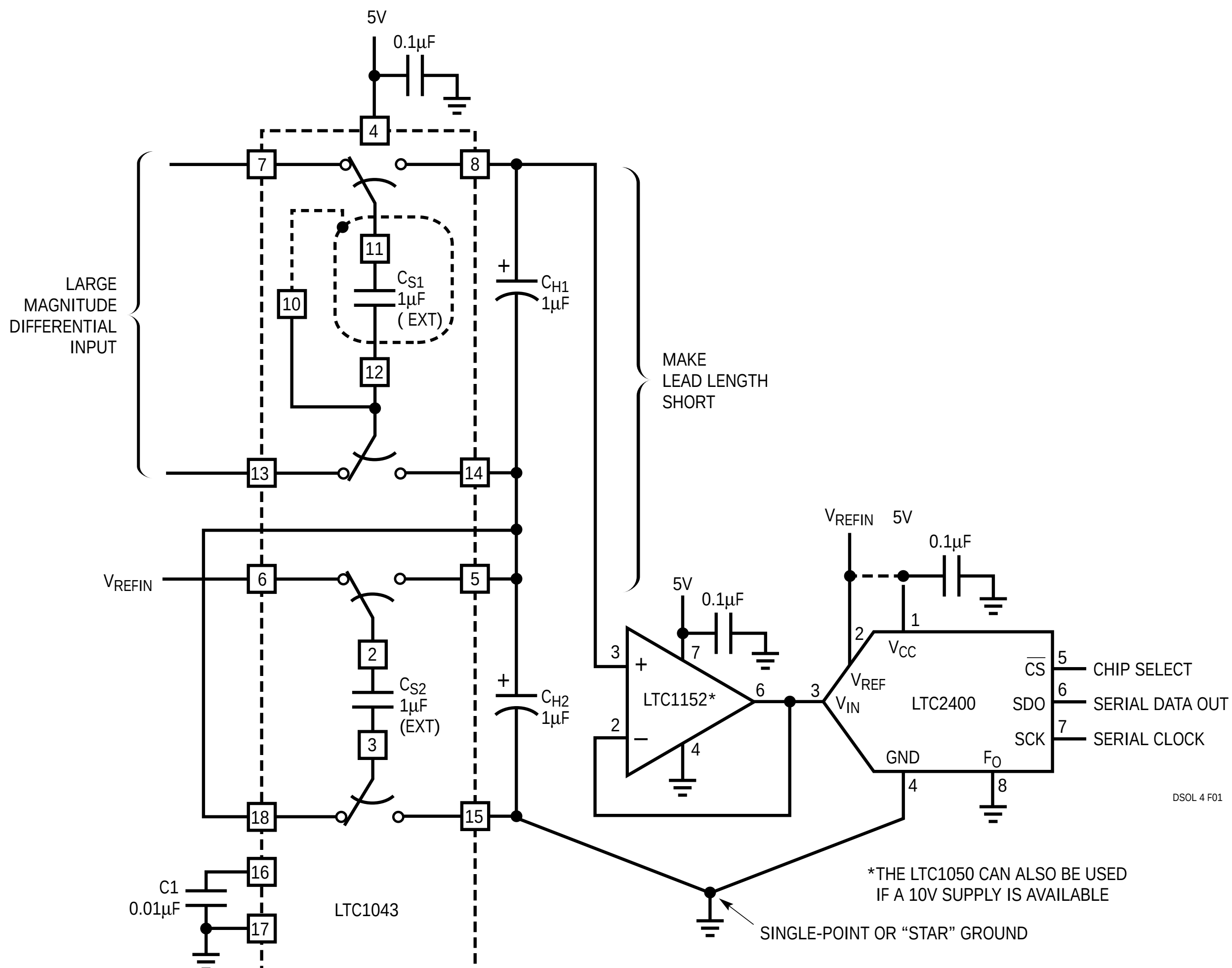

Figure 1. High Accuracy, Bipolar Differential to Single-Ended Converter Drives the LTC2400's Input Rail-to-Rail

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