LTC2400 Differential to Single-Ended Converter for Single 5V Supply

This Converter Has High Accuracy, Very Low Offset and Offset Drift, Rail-to-Rail Input Common Mode Range and is "Live at Zero"

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SPECIFICATIONS

V_{CC} = V_{REF} = LT®1019-2.5; R_{SOURCE} = 175Ω (Balanced)

PARAMETER	CIRCUIT (MEASURED)	LTC2400	TOTAL (UNITS)
Input Voltage Range	−0.5 to 5		mV
Zero Error	2	1.5	μV
Input Current	See Text		
Nonlinearity	±5	4	ppm
Noise (without averaging)	0.21*	1.5	μV_{RMS}
Noise (averaged 64 readings)	0.026*		μV_{RMS}
Resolution (with averaged readings)	17.6		Bits
Overall Accuracy (uncalibrated**)	17.6		Bits
Supply Voltage	5	5	V
Supply Current	2.6	0.2	mA
CMRR	120		dB
Common Mode Range	0 to 5		V

*Input referred noise with a gain of 101
**Does not include gain setting resistors, offset and gain error removed

OPERATION

The circuit in Figure 1 is ideal for low level differential signals, typically 2mV/V, in single supply applications and features a "live at zero" operation. The circuit combines an LTC®1043 and LTC1050 as a differential to single-ended amplifier that has 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, completing the conversion to single-ended. The voltage on C_H is applied to the LTC1050's noninverting input and amplified by the gain set by resistors R1 and R2 (101X for the values shown). The amplifier's output is then converted to a digital value by the LTC2400.

The circuit uses a simple voltage reference (the Schottky diode and NPN transistor) to bias the single-ended signal approximately 270mV above ground. For single supply applications, this bias voltage and the circuit's "live at zero" operation allows the LTC1050 and the LTC2400 to amplify and convert signals that include inputs below ground.

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.

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 tenfold.

The LTC1050's closed-loop gain accuracy is affected by the tolerance of the ratio of the gain-setting resistors. If cost considerations preclude using low tolerance resistors (0.02% or better), the processor to which the LTC2400 is connected can be used to perform software correction. Operated as a follower, the LTC1050's gain and linearity error is less than 0.001%.

The circuit uses 2.5V to excite the 2mV/V bridge, producing a low level output. Best performance is achieved using bandwidth limiting as shown and the attenuator at the LTC2400's input to reduce the input-referred noise. The LTC1050's noise gain of 100 allows adequate headroom for the expected signal magnitude. This is followed by an attenuator that reduces the signal for an overall gain of 16.8. This gain is the typical point where the input-referred noise is minimized.

A source of errors is thermocouple effects that occur in soldered connections. Their effects are most pronounced in the circuit's low level portion, before the LTC1050's output. Any temperature changes in any of the low level circuitry's connections will cause linearity perturbations in the final conversion result. There effects can be minimized by balancing the thermocouple connections with reversed redundant connections and by sealing 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 $V_{IN(CM)}$ = 5V, dropping to zero 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.

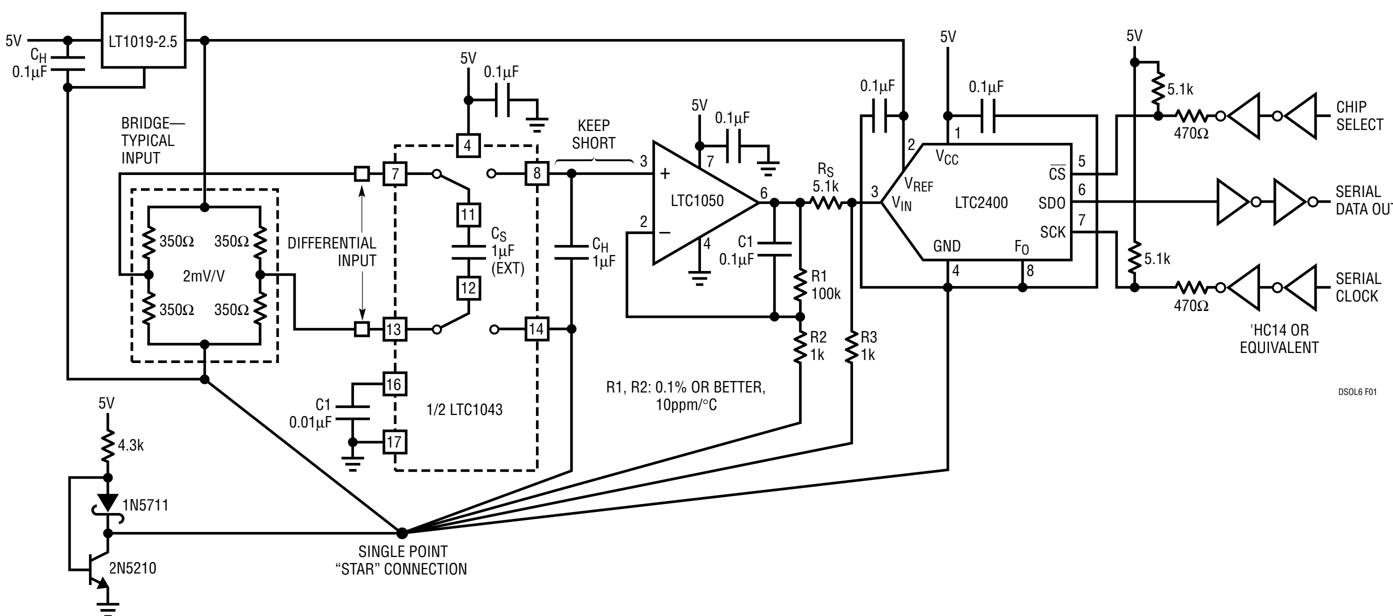

Figure 1. Single Supply Differential to Single-Ended Converter for Low Level Inputs with "Live at Zero" Operation

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