

## LTC2400 High Accuracy Differential to Single-Ended Converter for $\pm 5V$ Supplies

Differential to Single-Ended Converter Has Very High Uncalibrated Accuracy and Low Offset and Drift

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### SPECIFICATIONS

$V_{CC} = V_{REF} = LT^{\circ}1236-5$ ;  $V_{FS} = 40mV$ ;  
 $R_{SOURCE} = 175\Omega$  (Balanced)

PARAMETER	CIRCUIT (MEASURED)	LTC2400	TOTAL (UNITS)
Input Voltage Range	-3 to 40		mV
Zero Error	12.7	1.5	$\mu V$
Input Current	See Text		
Nonlinearity	$\pm 1$	4	ppm
Input-Referred Noise (without averaging)	0.3*	1.5	$\mu V_{RMS}$
Input-Referred Noise (averaged 64 readings)	0.05*		$\mu V_{RMS}$
Resolution (with averaged readings)	19.6		Bits
Overall Accuracy (uncalibrated**)	18.1		Bits
Supply Voltage	$\pm 5$	5	V
Supply Current	1.6	0.2	mA
CMRR	120		dB
Common Mode Range	$\pm 5$		V

\* Input-referred noise with a gain of 101.

\*\* Does not include gain setting resistors.

### OPERATION

The circuit in Figure 1 is ideal for low level differential signals in applications that have a  $\pm 5V$  supply and need high accuracy without calibration. The circuit combines an LTC<sup>®</sup>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,  $C_H$ . The voltage on  $C_H$  is applied to the LTC1050's noninverting input and amplified by the gain set by resistors R1 and R2 (101 for the values shown). The amplifier's output is then converted to a digital value by the LTC2400.

The LTC1043 achieves its best differential to single-ended conversion when its internal switching frequency operates at a nominal 300Hz, as set by the 0.01 $\mu F$  capacitor C1 and when 1 $\mu F$  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  $C_S$ . To minimize the possibility of PCB leakage currents introducing an error source into  $C_H$ , an optional guard circuit could be added as shown. The common point of these two resistors produces the potential for the guard ring. 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 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%.

As stated above, the LTC1043 has the highest transfer accuracy when using 1.0 $\mu F$  capacitors. The input current is approximately -100nA at  $V_{IN(CM)} = -5V$ , 100nA at  $V_{IN(CM)} = 5V$  and 0 $\mu A$  at  $V_{IN(CM)} = 0V$ . For example, 0.1 $\mu F$  will typically increase the circuit's overall nonlinearity tenfold.

Another 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

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