



# QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 745

## 16-BIT DIFFERENTIAL INPUT DELTA SIGMA ADC

LTC2433-1

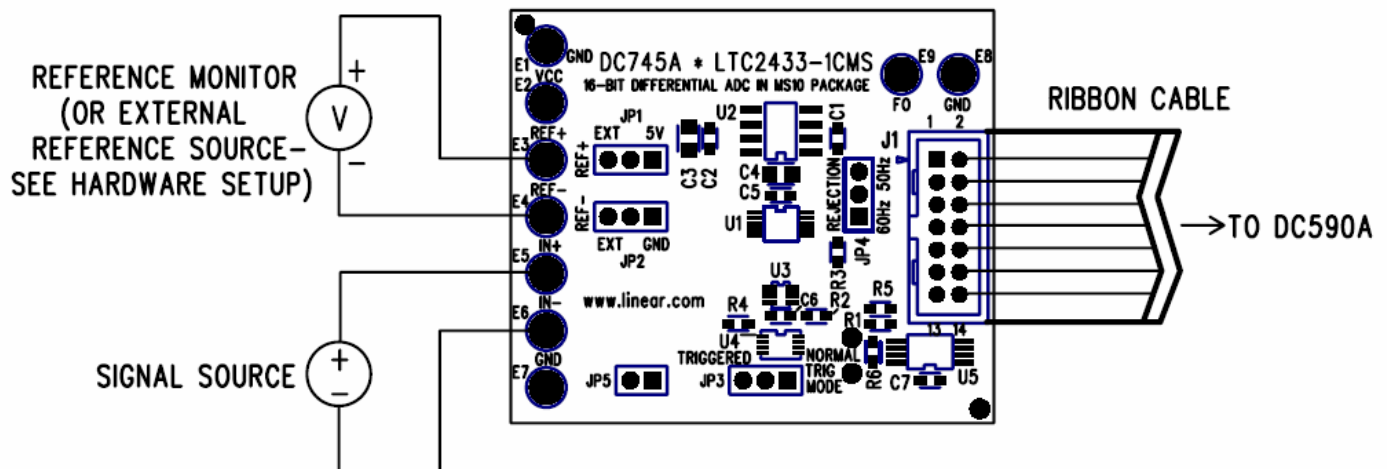
### DESCRIPTION

Demonstration circuit 745 features the LTC2433-1, a 16-bit high performance  $\Delta\Sigma$  analog-to-digital converter (ADC). The LTC2433-1 features 0.12 LSB linearity, 0.16 LSB full-scale accuracy, 5 $\mu$ V offset, and 1.45 $\mu$ V RMS noise. The inputs and reference are fully differential, with input common mode rejection of 140 dB. The LTC2433-1 is available in a 10 pin MSOP package and has an easy to use SPI interface.

DC745 is a member of Linear Technology's QuickEval™ family of demonstration boards. It is designed to allow easy evaluation of the LTC2433-1 and may be connected directly to the target application's

analog signals while using the DC590 USB Serial Controller board and supplied software to measure performance. The exposed ground planes allow proper grounding to prototype circuitry. After evaluating with Linear Technology's software, the digital signals can be connected to the end application's processor / controller for development of the serial interface.

**Design files for this circuit board are available. Call the LTC factory.**

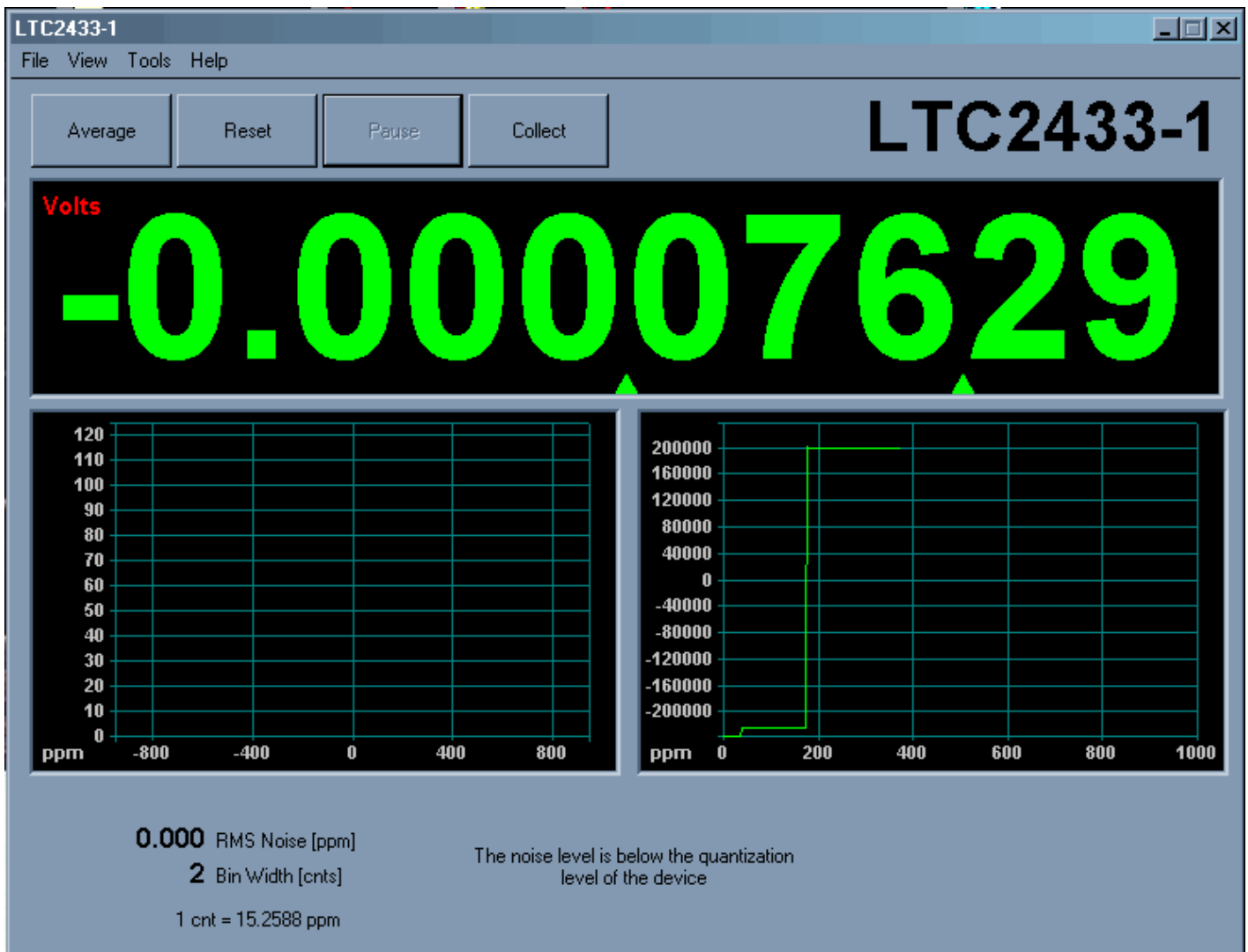


## QUICK START PROCEDURE

Connect DC745 to a DC590 USB Serial Controller using the supplied 14 conductor ribbon cable. Connect DC590 to a host PC with a standard USB A/B cable. Run the evaluation software supplied with DC590 or downloaded from <http://www.linear.com/software>. The correct program will be loaded automatically. Click the COLLECT button to start reading the input

voltage. Details on software features are documented in the control panel's help menu.

Tools are available for logging data, changing reference voltage, changing the number of points in the strip chart and histogram, and changing the number of points averaged for the DVM display.



## HARDWARE SET-UP

### JUMPERS

JP1 – Select the source for REF+, either external or 5.00 volts from the onboard LT1236 reference (default.)

JP2 – Select the source for REF-, either external or Ground (0 volts, default.)

JP3 – Trigger mode, either normal (default) or externally triggered.

JP4 – Notch frequency. Connect to 60Hz for normal operation ( $F_o = \text{GND}$ .) The LTC2433-1 is trimmed to reject both 50Hz and 60Hz by at least 87dB when  $F_o$  is grounded. Remove this jumper when supplying an external clock to the  $F_o$  turret.

JP5 – Trigger input signal. Pin 1 is a 5 volt logic signal, pin 2 is ground. When triggered mode is selected on JP3, a rising edge starts a new conversion. Note that a conversion in progress cannot be stopped, so this signal can only be used to slow down the rate at which samples are read from the LTC2433-1. When  $F_o$  is grounded, the maximum trigger frequency is 5Hz.

### CONNECTION TO DC590 SERIAL CONTROLLER

J2 is the power and digital interface connector. Connect to DC590 serial controller with supplied 14 conductor ribbon cable.

An external conversion clock may be applied to the  $F_o$  turret to modify the frequency rejection charac-

teristics or data output rate of the LTC2433-1. Be sure to remove JP4 before applying an external clock. This should be a square wave with a low level equal to ground and a high level equal to  $V_{cc}$ . While up to a 2MHz clock can be used, performance may be compromised. Refer to the LTC2433-1 data sheet.

### ANALOG CONNECTIONS

Analog signal connections are made via the row of turret posts along the edge of the board. Also, when connecting the board to an existing circuit, the exposed ground planes along the edges of the board may be used to form a solid connection between grounds.

GND – Ground turrets are connected directly to the internal ground planes.

VCC – This is the supply for the ADC. Do not draw any power from this point.

REF+, REF- – These are connected to the LTC2433-1 REF+ and REF- pins. If the onboard reference is being used, the reference voltage may be monitored from this point. An external reference may be connected to these terminals if JP1 and JP2 are configured for external reference.

IN+, IN- – These are the differential inputs to the LTC2433-1.

## EXPERIMENTS

### INPUT NOISE

One of the characteristics of the LTC2433-1 is that the  $1.45\mu\text{V}$  input noise floor is far below the quantization level of  $76\mu\text{V}$  when a 5-volt reference is used. This means that the output will be stable if the input noise level is also below  $76\mu\text{V}$ . In this sense, the LTC2433-1 is a true 16 effective bit part, whereas many 16-bit SAR converters have several LSBs of noise.

Solder a short wire from the IN- turret post to the IN+ turret post. Noise should be below the quantization level of the LTC2433-1. This will result in a noise reading of zero on the control software.

Applying an external reference of  $100\text{mV}$  results in a  $1.52\mu\text{V}$  LSB, and the noise reading will be approximately 250ppm of  $100\text{mV}$ , or  $2.5\mu\text{V}$ . This is slightly higher than the  $1.45\mu\text{V}$  input thermal because quantization noise is also a factor.

### COMMON MODE REJECTION

Tie the two inputs (still connected together) to ground through a short wire and note the indicated voltage. Tie the inputs to REF+; the difference should be less than 1LSB due to the 130 dB CMRR of the LTC2433-1.

### BIPOLAR SYMMETRY

To demonstrate the symmetry of the ADCs transfer function, connect a stable, low noise, floating voltage source (with a voltage less than  $V_{\text{ref}}/2$ ) from

IN+ to IN- and note the indicated voltage. Reverse the polarity; the indicated voltage will typically be within one LSB of the first reading multiplied by  $-1$ .

One convenient voltage source for this experiment is a single alkaline battery. While a battery has fairly low noise, it is sensitive to temperature drift. It is best to use a large (D-size) battery that is insulated from air currents. A better source is a battery powered series reference such as the LT1790. This part is available with output voltages of 1.25V, 2.048V, 2.5V, 3V, 3.3V, 4.096V and 5V.

### INPUT NORMAL MODE REJECTION

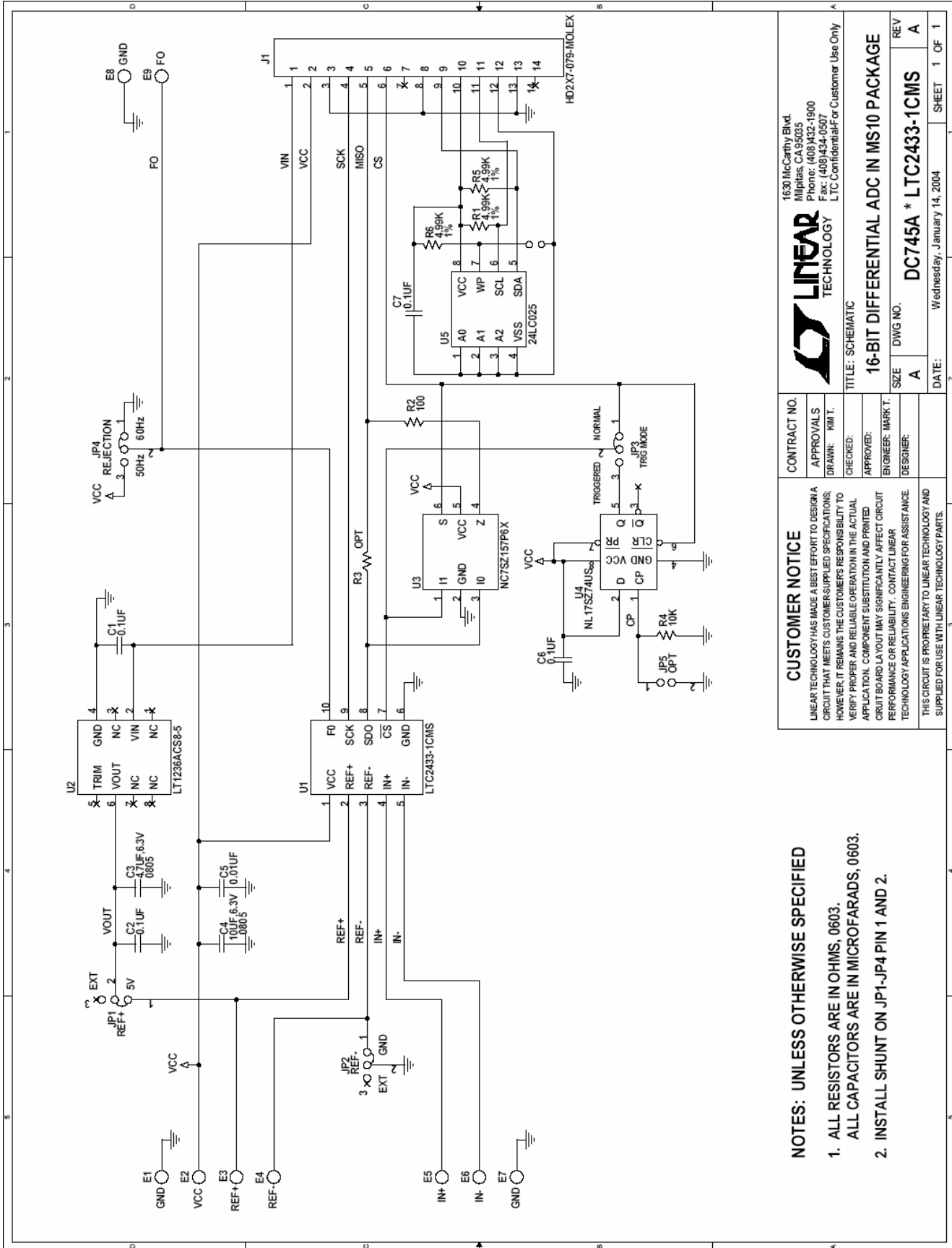
The LTC2433-1's SINC4 digital filter is trimmed to strongly reject 50 or 60Hz line noise when operated with the internal conversion clock. To measure input normal mode rejection, connect IN- to a 2.5 volt source such as an LT1790-2.5 reference or a power supply. Apply a 10Hz, 2V peak-to-peak sine wave to IN+ through a  $1\mu\text{F}$  capacitor. No DC bias is required because the  $2\text{-}3\text{M}\Omega$  input impedance of the LTC2433-1 tends to self-bias the input to mid-reference (see datasheet applications information for details.)

Start taking data. The input noise will be quite large, and the graph of output vs. time should show large variations.

Next, slowly increase the frequency to 60Hz. The noise should be almost undetectable in the graph. Note that the indicated noise in ppm may still be above that of the datasheet specification because the inputs are not connected to a DC source.

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**CUSTOMER NOTICE**  
 LINEAR TECHNOLOGY HAS MADE A BEST EFFORT TO DESIGN A CIRCUIT THAT MEETS CUSTOMER-SUPPLIED SPECIFICATIONS; HOWEVER, IT REMAINS THE CUSTOMER'S RESPONSIBILITY TO VERIFY PROPER AND RELIABLE OPERATION IN THE ACTUAL APPLICATION. COMPONENT SUBSTITUTION AND PRINTED CIRCUIT BOARD LAYOUT MAY SIGNIFICANTLY AFFECT CIRCUIT PERFORMANCE OR RELIABILITY. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE.  
 THIS CIRCUIT IS PROPRIETARY TO LINEAR TECHNOLOGY AND SUPPLIED FOR USE WITH LINEAR TECHNOLOGY PARTS.



- NOTES: UNLESS OTHERWISE SPECIFIED**
1. ALL RESISTORS ARE IN OHMS, 0603.
  2. ALL CAPACITORS ARE IN MICROFARADS, 0603.
  3. INSTALL SHUNT ON JP1-JP4 PIN 1 AND 2.

CONTRACT NO.  
 APPROVALS  
 DRAWN: KMT  
 CHECKED:  
 APPROVED:  
 ENGINEER: JARR.T.  
 DESIGNER:

TITLE: SCHEMATIC		DATE: Wednesday, January 14, 2004
16-BIT DIFFERENTIAL ADC IN MS10 PACKAGE		SHEET 1 OF 1
SIZE: A	DWG NO.: DC745A * LTC2433-1CMS	REV: A

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