Load Cell Digitizer Application

DESCRIPTION

Demonstration circuit 1410A shows a compact, high resolution solution for measuring Wheatstone bridge type sensors for load, pressure, temperature, acceleration, and many other physical quantities.

Assembly type A features the LTC2498, an 8-/16-channel, 24-bit ΔΣ ADC with easy drive inputs. Key DC specifications include 2ppm INL, 1ppm offset, 25ppm full-scale error and 10nV/°C offset drift. In the 6.8Hz/600nV$_{RMS}$ mode, input normal mode rejection of 50Hz and 60Hz noise is better than 87dB.

Assembly type B features the LTC2449, an 8-/16-channel, high speed, 24-bit ΔΣ ADC with ten selectable speed/resolution modes from 6.9Hz/200nV$_{RMS}$ to 3.5kHz/23μV$_{RMS}$ (4kHz with external oscillator). Key DC specifications include 5ppm INL, 5μV offset, 10ppm full-scale error and 20nV/°C offset drift. In the 6.9Hz/200nV$_{RMS}$ mode, input normal mode rejection of 50Hz and 60Hz noise is better than 80dB.

Both assembly types include a low noise programmable gain amplifier (PGA) and calibration sources to facilitate transparent calibration of gain and offset, resulting in an effective resolution of better than 20nV$_{RMS}$ at 6.8Hz and 6.9Hz respectively.

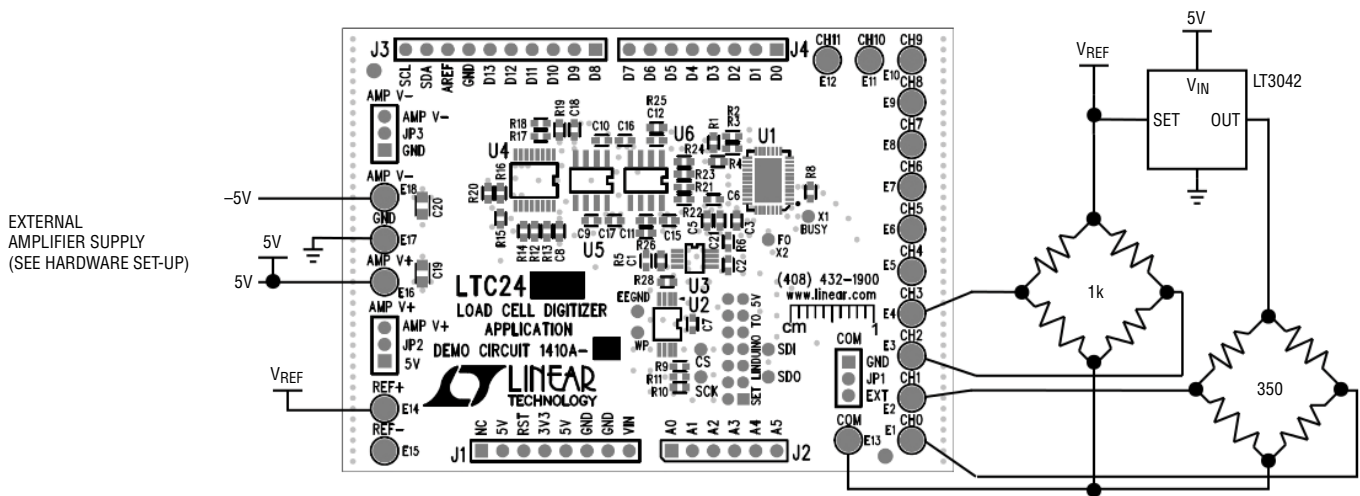**Design files for this circuit board are available at http://www.linear.com/demo/DC1410A**

Figure 1. Basic Connections

ASSEMBLY OPTIONS

Table 1. Demonstration Circuit Output Options

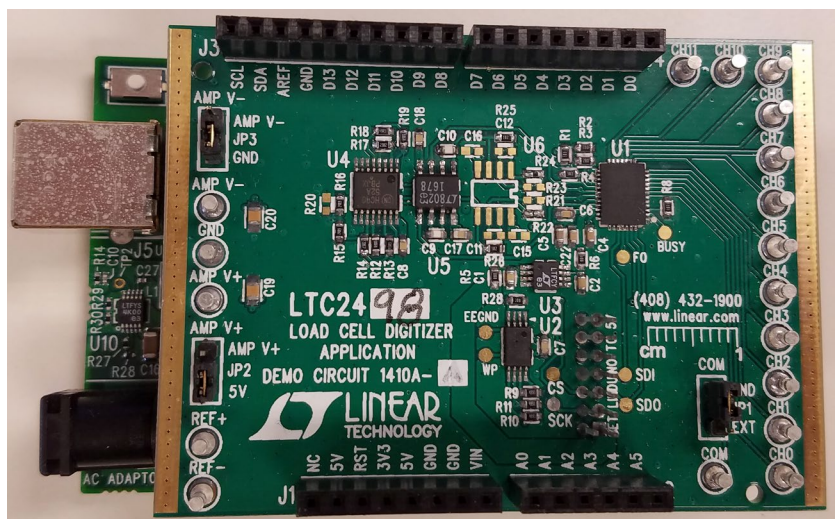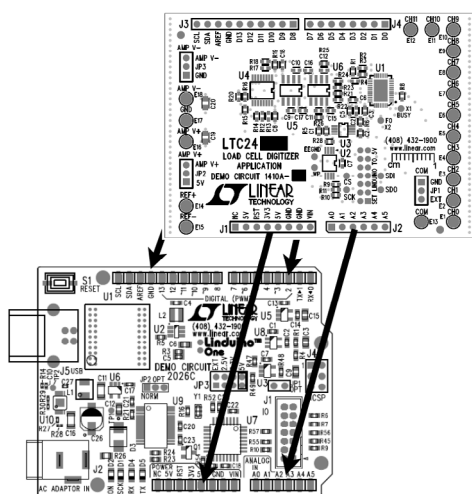| ASSEMBLY TYPE	ADC	OUTPUT RATES	PGA OP AMP, GAIN OPTIONS	FINAL ADC DRIVER OP AMP
DC1410A-A	LTC2498	7.5Hz (1x Mode) 15Hz (2x Mode)	LT1678 G = 1, 8, 16, 32	None
DC1410A-B	LTC2449	4kHz (OSR = 64) 6.9Hz (OSR = 32768)	LT1678 G = 1, 8, 16, 32	LTC6241

QUICK START PROCEDURE

Figure 2. DC1410 Connected to the Linduino

1. Insert the DC1410A on to the Linduino (DC2026). Figure 2 shows the correct orientation.

2. Ensure the COM jumper is set to GND, AMP V⁺ jumper is set to 5V, and AMP V⁻ is set to GND.

3. Connect the sensor to the desired channel inputs (CH0 to CH11). Analog signal connections are made via the row of turret posts along the edge of the board. Also, if you are 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.

4. DC1410 can be controlled either from a GUI control panel that is part of the QuikEval™ program or from a microcontroller program (Sketch) running directly on the

Linduino. Follow the procedure for installing QuikEval and the LTSketchbook in the DC2026 demo manual.

5. Operation with QuikEval GUI: Connect the Linduino to the host PC using a USB cable and upload the DC590_enhanced sketch located in the directory:

   Sketchbook → Utilities → DC590_Enhanced

Run the QuikEval program, which will download the appropriate GUI, refer to Figure 3. Click the collect button to start reading the input voltage. The collect button changes to the stop button when the user is collecting data. Stop the collection and click on the configure button to change the oversample ratio (OSR). Channel gain, custom scaling, and filter parameters can be

dc1410af

QUICK START PROCEDURE

changed in the same menu, shown in Figure 4. Note: The channels are labeled Px-Nx. The Px is the positive channel and the Nx is the negative channel.

6. Operation with dedicated sketch: Quit the QuikEval GUI if it is running and run the Arduino IDE. Open the appropriate sketch, either:

Sketchbook → Part Number → 2000 → 2400 → 2449 → DC1410AA

Or

Sketchbook → Part Number → 2000 → 2400 → 2498 → DC1410AB

Upload the sketch and open the serial monitor. A text-based menu will appear, which is used to interact with the program.
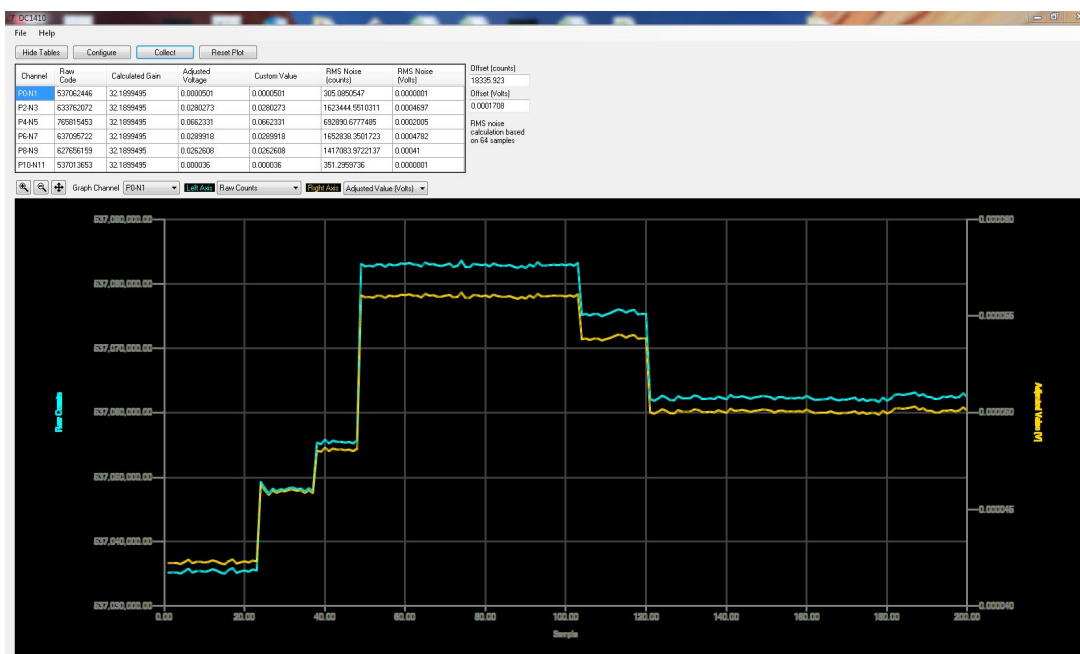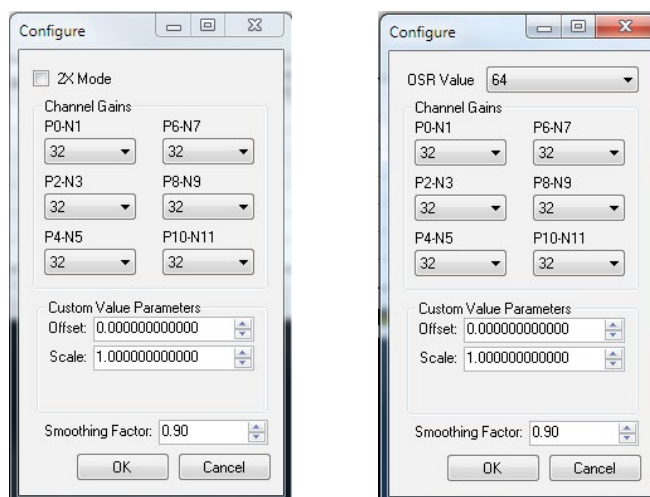

Figure 3. DC1410 QuikEval GUI

Figure 4. DC1410A-A (Left), DC1410A-B (Right) Configuration Sub-Menu

QUICK START PROCEDURE

JUMPER AND HEADER DEFINITIONS

J1, J2, J3, J4: Linduino/Arduino headers. These are stacking style connectors, allowing additional Arduino boards to be connected. Carefully review the pinout of additional boards for conflicts.

J5: (Reverse side of board) - Connection to QuikEval header on Linduino board. Make no external connections.

JP1: COM: Select the connection for the ADC COM input, either ground or floating, allowing the COM turret post to be driven by an external source.

JP2: AMPV$^+$ source, either 5V (supplied by the Linduino board), or externally supplied on the AMPV$^+$ turret post.

JP3: AMPV$^-$ source, either ground, or externally supplied on the AMPV$^-$ turret post.

TURRET POST DEFINITIONS

AMPV$^+$: Amplifier positive supply. Set JP2 to EXT to drive from an external supply.

AMPV$^-$: Amplifier negative supply. Set JP3 to EXT to drive from an external supply.

REF$^+$: Output of the onboard LTC6655 5V reference, which is connected to the REF$^+$ input of the ADC. Reference voltage can be monitored at this point or it can be used to excite external sensors. External circuitry can draw a maximum of 5mA. If more current is required, an LT3042 can be used as a buffer to supply up to 200mA.

REF$^-$: Connection to the ADC's REF$^-$ pin, tied to ground through R35 (zero Ω).

CH0 to CH11: Analog inputs.

QUICK START PROCEDURE

OPERATING PRINCIPLES

One unique feature of the LTC2498 and the LTC2449 is that the analog inputs are routed to the MUXOUT pins, and an external buffer isolates these signals from the switched capacitor ADC inputs. This has a distinct advantage over integrated buffers by reason of the analog inputs are truly rail-to-rail, and slightly beyond, with appropriate buffer supply voltages. The goal is to select a gain such that the sensor noise dominates the ADC input noise. This demo board takes advantage of the external amplifier and is set up to have software selectable gain shown in Figure 5. The available gains are unity, 8, 16, 32. Figure 6 shows the difference gain equation and simplified circuit.
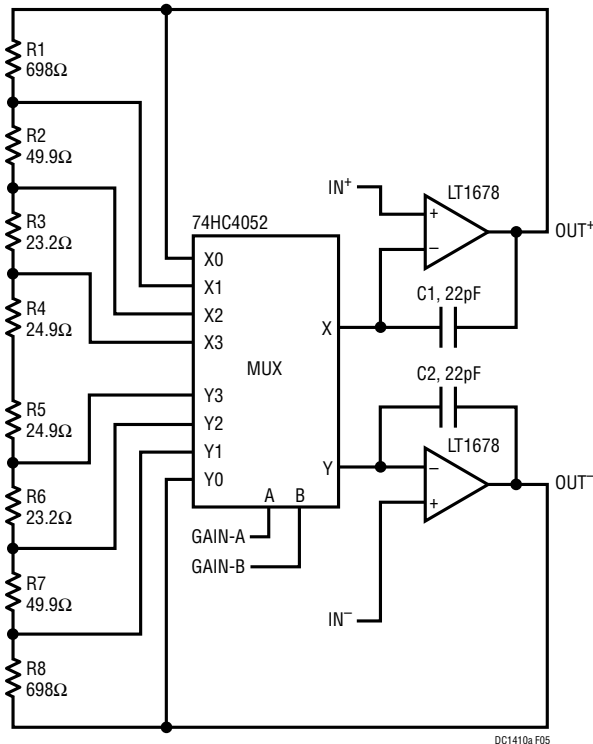
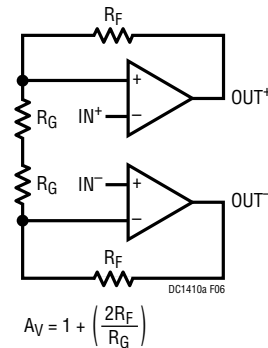$$A_V = 1 + \left(\frac{2R_F}{R_G}\right)$$

Figure 6. Simplified Circuit

The DC1410 and accompanying software/firmware implement a continuous calibration technique to account for the initial tolerance and temperature drift of the gain setting resistors. This is done by applying a calibration signal to a dedicated ADC input, CH14 to CH15, as shown in Figure 7. A reading is then taken in unity gain, as well as the other gain options. The unity gain measurement is assumed to be correct (as it is not dependent on resistor ratios), the actual gain of the other options can be accurately calculated. The CH12 to CH13 inputs are shorted together and held at the same common mode as CH14 to CH15 to facilitate offset calibration as well, as may be required when using the LTC2498 in 2X speed mode. The calibration sequence is done at every read to achieve maximum accuracy.
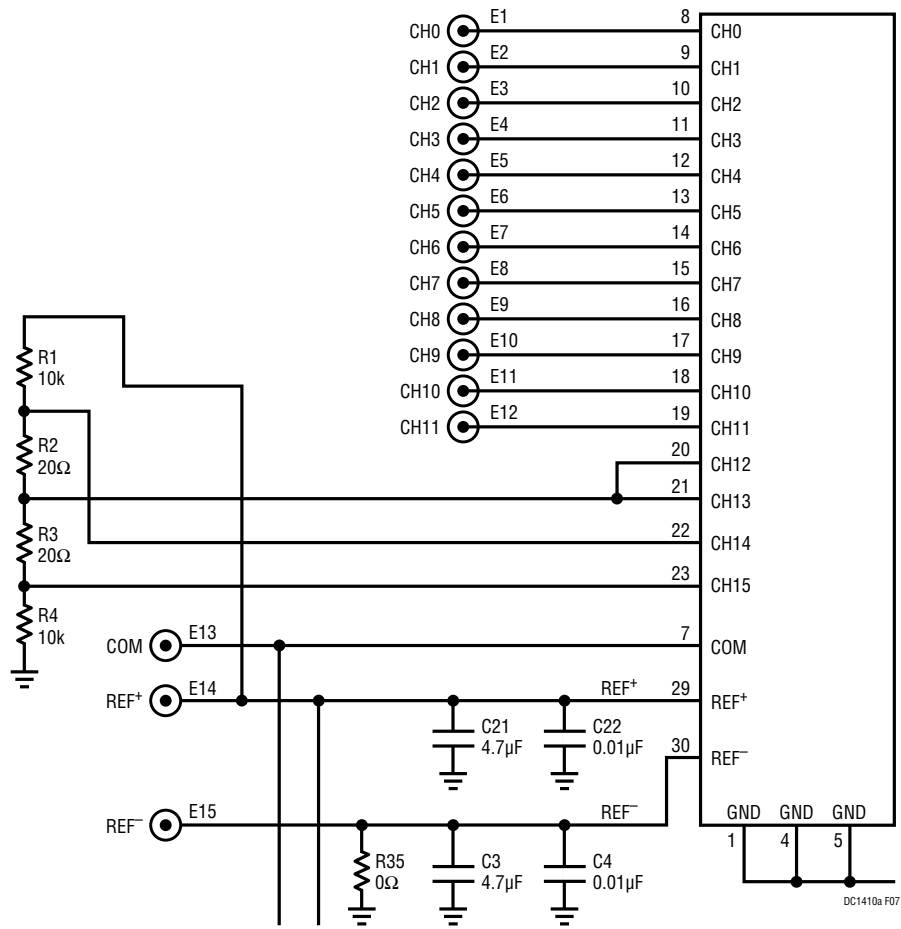
Figure 5. Software Selectable Gain

QUICK START PROCEDURE

Figure 7. Resistive Divider for Calibration

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QUICK START PROCEDURE

The DC1410 calibration sequence is as follows:

1. Measure CH14, CH15 differentially with the buffers in unity gain, *(Unity$_{measured}$)*.

2. Measure CH14, CH15 differentially with the buffers in gain of 8, *(G8$_{measured}$)*.

3. Measure CH14, CH15 differentially with the buffers in gain of 16, *(G16$_{measured}$)*.

4. Measure CH14, CH15 differentially with the buffers in gain of 32, *(G32$_{measured}$)*.

5. Measure CH0 to CH11 differentially with the buffers in the desired gains, *(ChX$_{measured\ code}$)*.

6. *Gain Factor$_8$ = G8$_{measured}$/Unity$_{measured}$*

7. *Gain Factor$_{16}$ = G16$_{measured}$/Unity$_{measured}$*

8. *Gain Factor$_{32}$ = G32$_{measured}$/Unity$_{measured}$*

9. *Gain Compensated Differential Code$_{Px-Nx}$ = ChX$_{measured\ code}$/Gain Factor$_X$*

With the amplifier gain known, the *Gain Factor$_X$* is applied to the analog input channels that are configured to that gain.

The *Gain Factor$_X$* represents an accurate gain of the amplifier, but it is a noise source. Essentially, the test signals are derived from the reference, and by applying the *Gain Factor$_X$* equation, this results in multiplication of the reference noise. In an effort to reduce this noise, an option is provided to apply an exponential averaging filter to the *Gain Factor$_X$* readings. Figure 8 shows the location to adjust the smoothing factor. The smoothing factor of the exponential filter can be adjusted between 0 and 1. Zero represents no smoothing on the gains, and one represents maximum smoothing. Note a smoothing factor of one is not recommended, since it will not average any new measured gains.
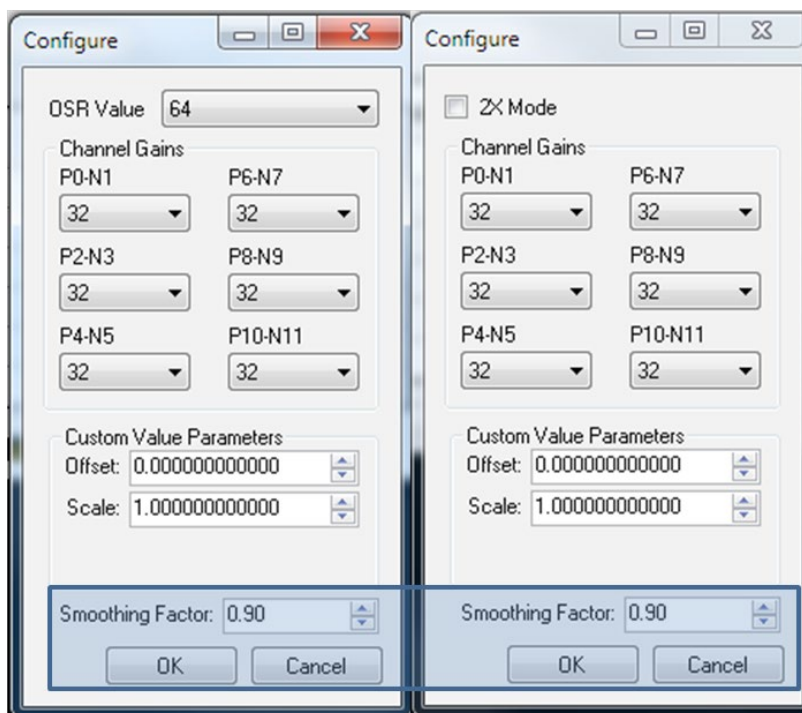

Figure 8. Gain Smoothing Factor Option

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LT 0117 • PRINTED IN USA