

## DESCRIPTION

Demonstration circuit 2412A shows the proper way to drive the [LTC<sup>®</sup>2335](#) ADC. The LTC2335 is a low noise, high speed, 8-channel 16-/18-bit successive approximation register (SAR) ADC. The LTC2335 has a flexible SoftSpan™ interface that allows conversion-by-conversion control of the input voltage span on a per-channel basis. An internal 2.048V reference and 2× buffer simplify basic operation while an external reference can be used to increase the input range and the SNR of the ADC.

The DC2412 demonstrates the DC and AC performance of the LTC2335 in conjunction with the DC590/DC2026 and DC890 data collection boards. Use the DC590/DC2026 to

demonstrate DC performance such as peak-to-peak noise and DC linearity. Use the DC890 if precise sampling rates are required or to demonstrate AC performance such as SNR, THD, SINAD and SFDR. The DC2412 is intended to demonstrate recommended grounding, component placement and selection, routing and bypassing for this ADC. A suggested driver circuit for the analog inputs is also presented.

**Design files for this circuit board including schematics, layout and BOM are available at <http://www.linear.com/demo/DC2412A>**

LT, LT, LTC, LTM, Linear Technology and the Linear logo are registered trademarks and SoftSpan, PScope and QuikEval are trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

## DC2412A ASSEMBLY OPTIONS

ASSEMBLY VERSION	U1 PART NUMBER	MAX CONVERSION RATE	NUMBER OF CHANNELS	NUMBER OF BITS	MAX CLK IN FREQUENCY	CLK IN/ $f_s$ RATIO
DC2412A-A	LTC2335-18	1000ksps	8	18	63MHz	63
DC2412A-B	LTC2335-16	1000ksps	8	16	63MHz	63

## BOARD PHOTO

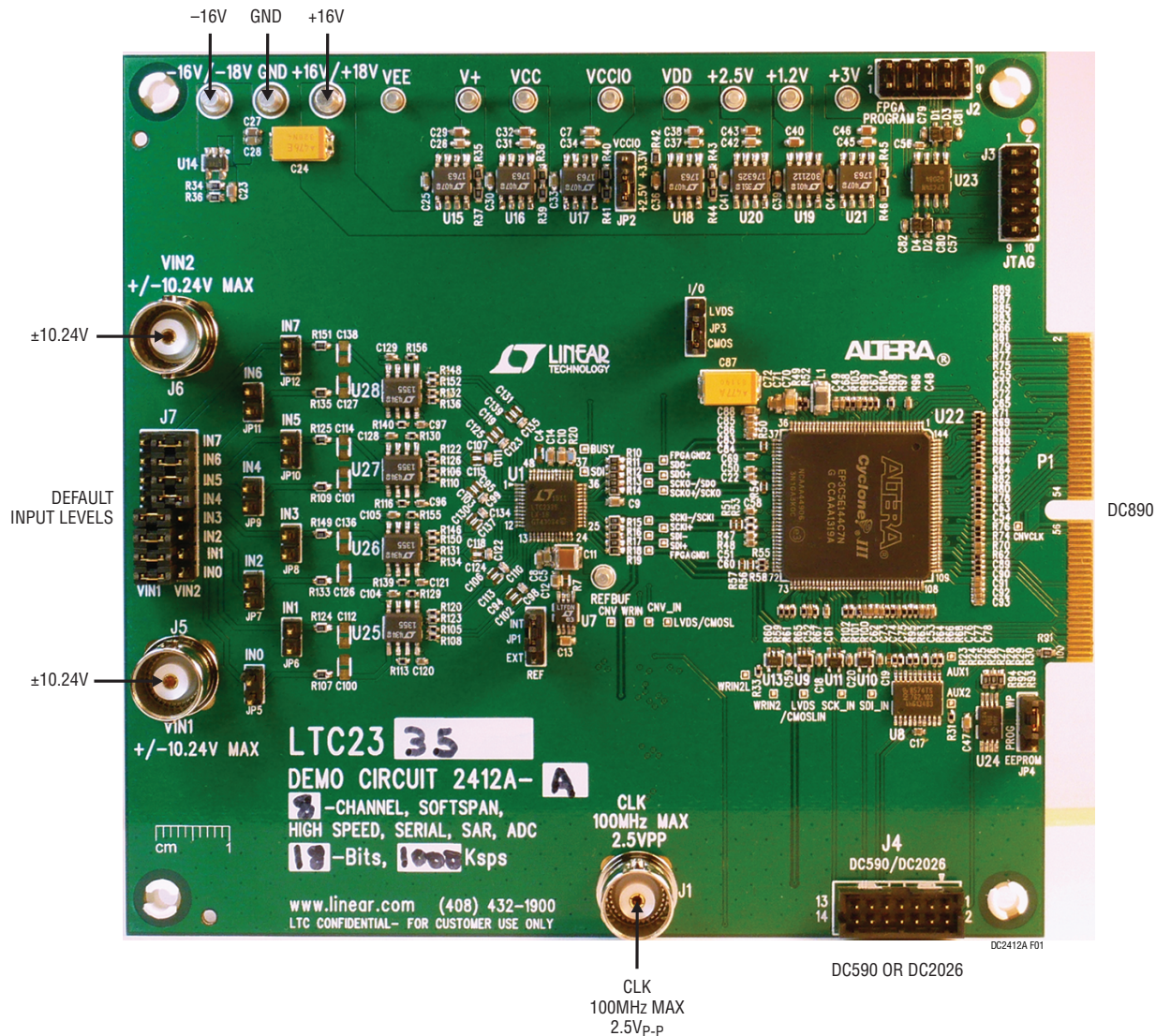


Figure 1. DC2412A Connection Diagram

## DC890 QUICK START PROCEDURE

Check to make sure that all switches and jumpers are set to their default settings as described in the DC2412A Jumpers and Connectors section of this manual. The default connections configure the ADC to use the onboard reference and regulators to generate all the required bias voltages. The analog inputs by default are DC coupled. Connect the DC2412A to a DC890 USB High Speed Data Collection Board using connector P1. Then, connect the DC890 to

a host PC with a standard USB A/B cable. Apply  $\pm 16V$  to the indicated terminals. Then apply a low jitter signal source to J5 and J6. Use J7 to route the signal sources of J5 and J6 to the desired IN0 to IN7 inputs. Observe the recommended input voltage range for each analog input. Connect a low jitter  $2.5V_{P-P}$  sine wave or square wave to connector J1. See DC2412 Assembly Options table for the appropriate clock frequency. Note that J1 has a  $50\Omega$  termination resistor to ground.

## DC890 QUICK START PROCEDURE

Run the PScope™ software (Pscope.exe version K82 or later), which can be downloaded, from:

[www.linear.com/designtools/software](http://www.linear.com/designtools/software)

Complete software documentation is available from the Help menu. Updates can be downloaded from the Tools menu. Check for updates periodically as new features may be added.

The PScope software should recognize the DC2412A and configure itself automatically.

Click the Collect button (see Figure 2) to begin acquiring data. The Collect button then changes to Pause, which can be clicked to stop data acquisition.

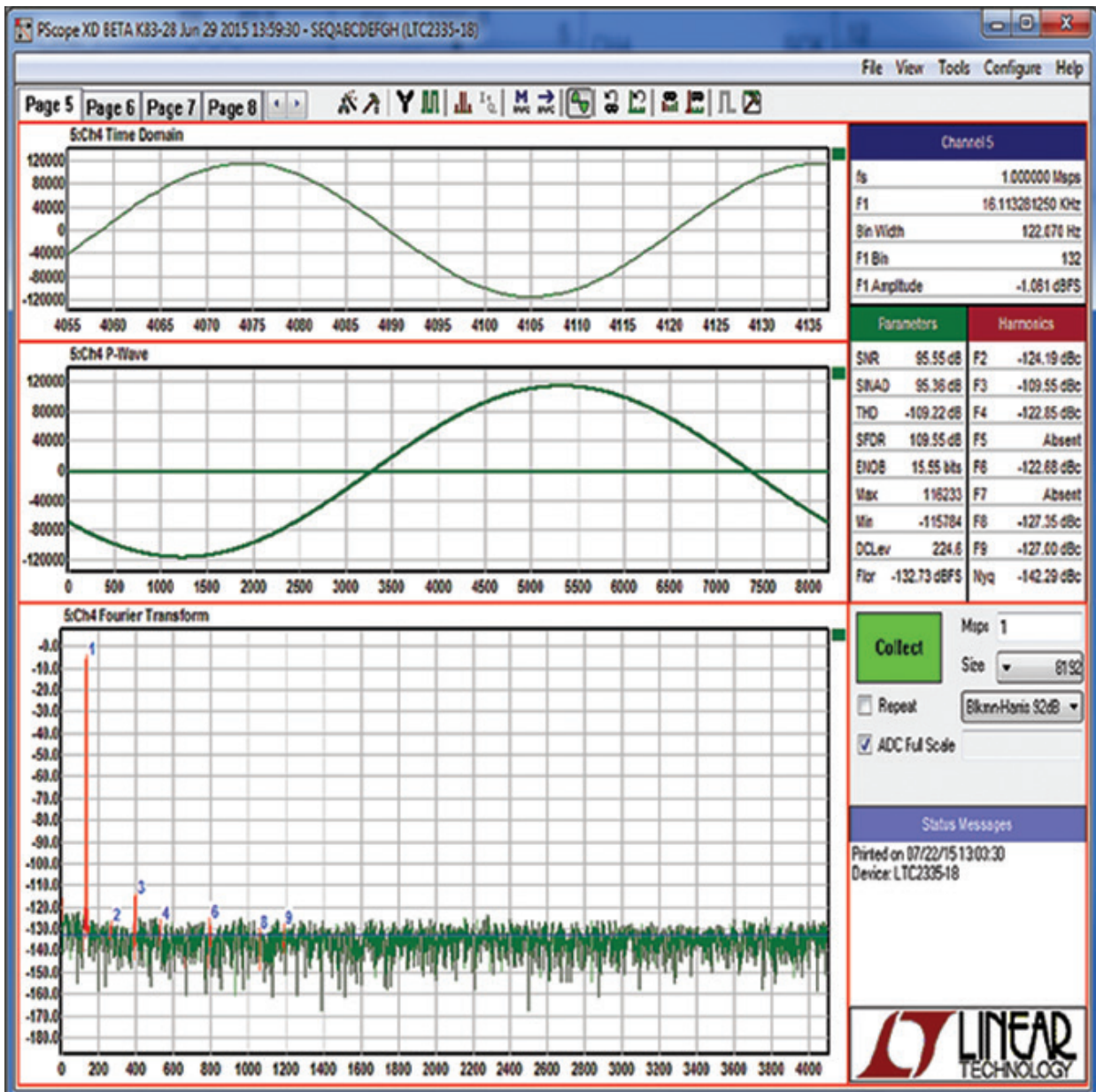


Figure 2. PScope Screen Shot



## DC590/DC2026 QUICK START PROCEDURE

**IMPORTANT!** To avoid damage to the DC2412A, make sure that VCCIO (JP6 of the DC590, JP3 of the DC2026) of the DC590/DC2026 is set to 3.3V before connecting the DC590/DC2026 to the DC2412A.

To use the DC590/DC2026 with the DC2412A, it is necessary to apply  $\pm 16V$  and ground to the  $\pm 16V$  and GND terminals of the DC2412. Connect the DC590/DC2026 to a host PC with a standard USB A/B cable. Connect the DC2412A to a DC590/DC2026 USB serial controller using the supplied 14-conductor ribbon cable. Apply a signal source to J5

and J6. Use J7 to route the signal sources of J5 and J6 to the desired IN0 to IN7 inputs. No Clock is required on J1 when using the DC590/DC2026. The clock signal is provided by the DC590/DC2026.

Run the QuikEval™ software (quikeval.exe version K105 or later), which is available from:

[www.linear.com/designtools/software](http://www.linear.com/designtools/software)

The correct control panel will be loaded automatically. Click the Collect button (Figure 3) to begin reading the ADC.

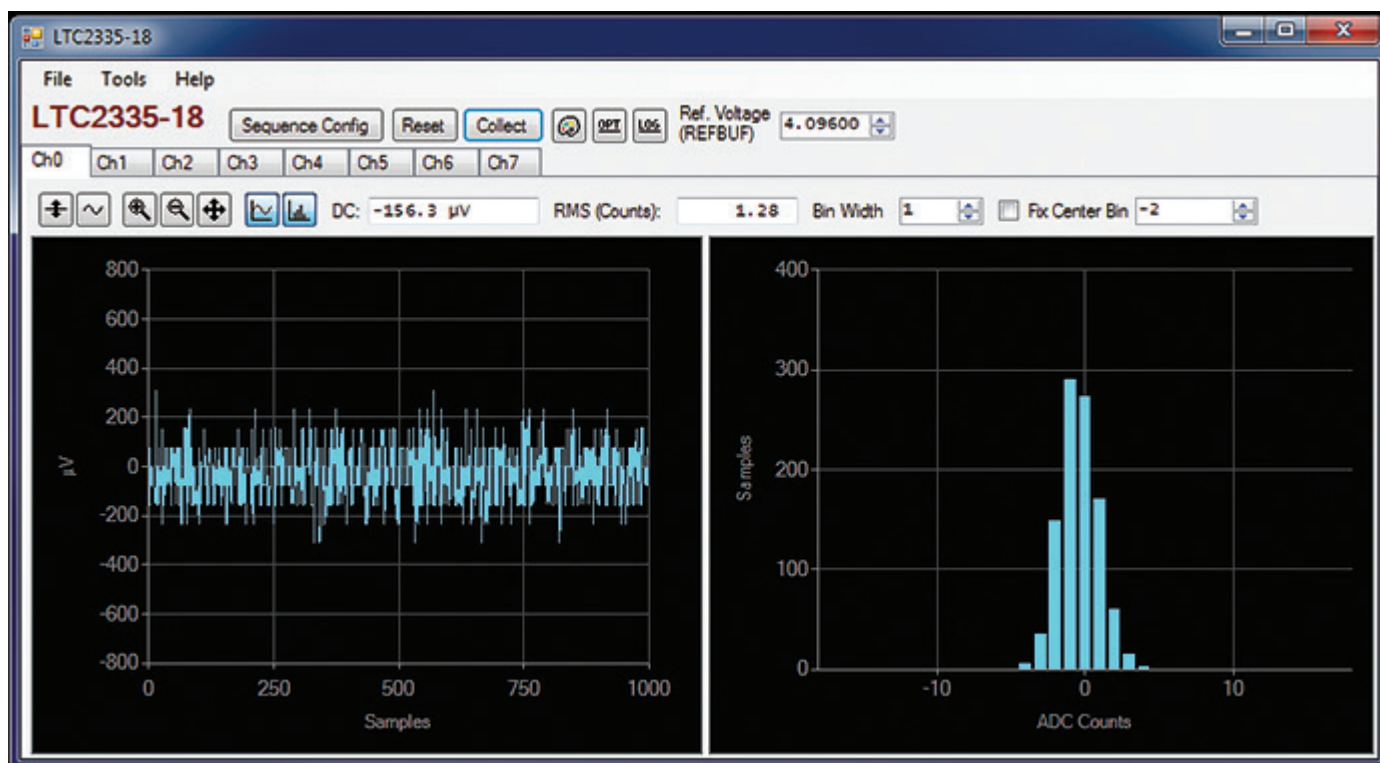


Figure 3. QuikEval Screen Shot

## DC2412A SETUP

### DC Power

The DC2412A requires  $\pm 16\text{VDC}$  and draws  $+175\text{mA}/-12\text{mA}$ . Most of the supply current is consumed by the FPGA, op amps, regulators and discrete logic on the board. The  $\pm 16\text{VDC}$  input voltage powers the ADC through LT1763 regulators, which provide protection against accidental reverse bias. Additional regulators provide power for the FPGA and op amps.

### Clock Source

You must provide a low jitter  $2.5\text{V}_{\text{P-P}}$  sine or square wave to the clock input, J1 when using the DC890. The clock input is AC coupled so the DC level of the clock signal is not important. A generator such as the Rohde & Schwarz SMB100A high speed clock source is recommended to drive the clock input. Even a good generator can start to produce noticeable jitter at low frequencies. Therefore, it is recommended for lower sample rates to divide down a higher frequency clock to the desired sample rate. The ratio of clock frequency to conversion rate is shown in the DC2412 Assembly Options table. If the clock input is to be driven with logic, it is recommended that the  $49.9\Omega$  termination resistor (R4) be removed. Driving R4 with discrete logic may result in slow rising edges. These slow rising edges may compromise the SNR of the converter in the presence of high-amplitude higher frequency input signals.

### Data Output

The serial data from the LTC2335 is de-serialized by the FPGA (U22) and output on connector P1. Parallel data output from this board (0V to 2.5V default), if not connected to the DC890, can be acquired by a logic analyzer, and subsequently imported into a spreadsheet, or mathematical package depending on what form of digital signal processing is desired. Alternatively, the data can be fed directly into an application circuit. Use pin 50 of P1 to latch the data. The data should be latched using the negative edge of this signal. The data output signal levels at P1 can also be increased to 0V to 3.3V if the application circuit requires a higher voltage. This is accomplished by moving JP2 to the 3.3V position.

### Reference

The default reference is the LTC2335's internal 4.096V reference. Alternatively, if a higher reference voltage is desired, the LTC6655-5 reference (U7) can be used by setting the REF jumper (JP1) to the EXT position and installing a  $0\Omega$  resistor in the R7 position as shown in Figure 4. This should result in better SNR performance but may slightly degrade the THD performance of the LTC2335.

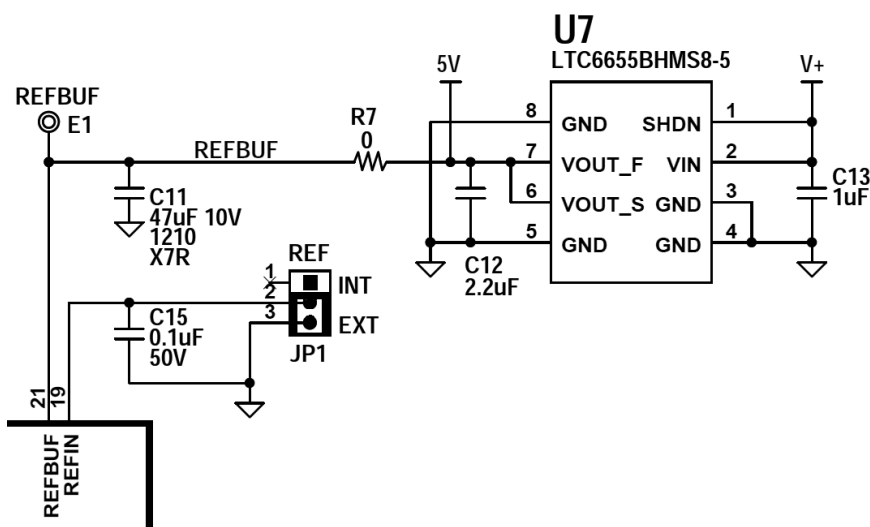


Figure 4. External Reference Circuit

## DC2412A SETUP

### Analog Inputs

All eight inputs have the same driver circuitry. An example of the default driver circuit for the analog inputs of the LTC2335 on the DC2412A is shown in Figure 5. The circuit of Figure 5 provides a pseudo-differential output to channel 2 and channel 3 of the LTC2335 with a maximum  $\pm 10.24V$  single-ended input voltage. Alternatively, the two single-ended channels shown can be combined to form a fully differential driver. In the circuit of Figure 5, this is done by removing R131 and changing R141 to  $0\Omega$ . At this point both IN2 and IN3 must be driven to  $\pm 5.12V$  to achieve the full-scale input voltage for IN2<sup>+</sup> and IN2<sup>-</sup> of the LTC2335. Changing R146 and R142 in a similar way would also allow IN3<sup>+</sup> and IN3<sup>-</sup> of the LTC2335 to be driven fully differentially. Fully differential drive should provide a slight improvement in THD performance.

### DC890 Data Collection

For SINAD, THD or SNR testing, a low noise, low distortion generator such as the B&K Type 1051 or Stanford Research SR1 should be used. A low jitter RF oscillator such as the Rohde & Schwarz SMB100A is used to drive the clock input. This demo board is tested in house by attempting to duplicate the FFT plot shown in Typical Performance Characteristics section of the LTC2335 data sheet. This involves using a 63MHz clock source, along with a sinusoidal generator at a frequency of approximately 2kHz. The input signal level is approximately  $-1dBFS$ . A typical FFT obtained with DC2412A is shown in Figure 2. Note that to calculate the real SNR, the signal level (F1 amplitude =  $-1.061dB$ ) has to be added back to the SNR that PScope displays. With the example shown in Figure 2, this means that the actual SNR would be 96.61dB instead of the 95.55dB that PScope displays. Taking the RMS sum of the recalculated SNR and the THD yields a SINAD of 96.5dB, which is fairly close to the typical number for this ADC.

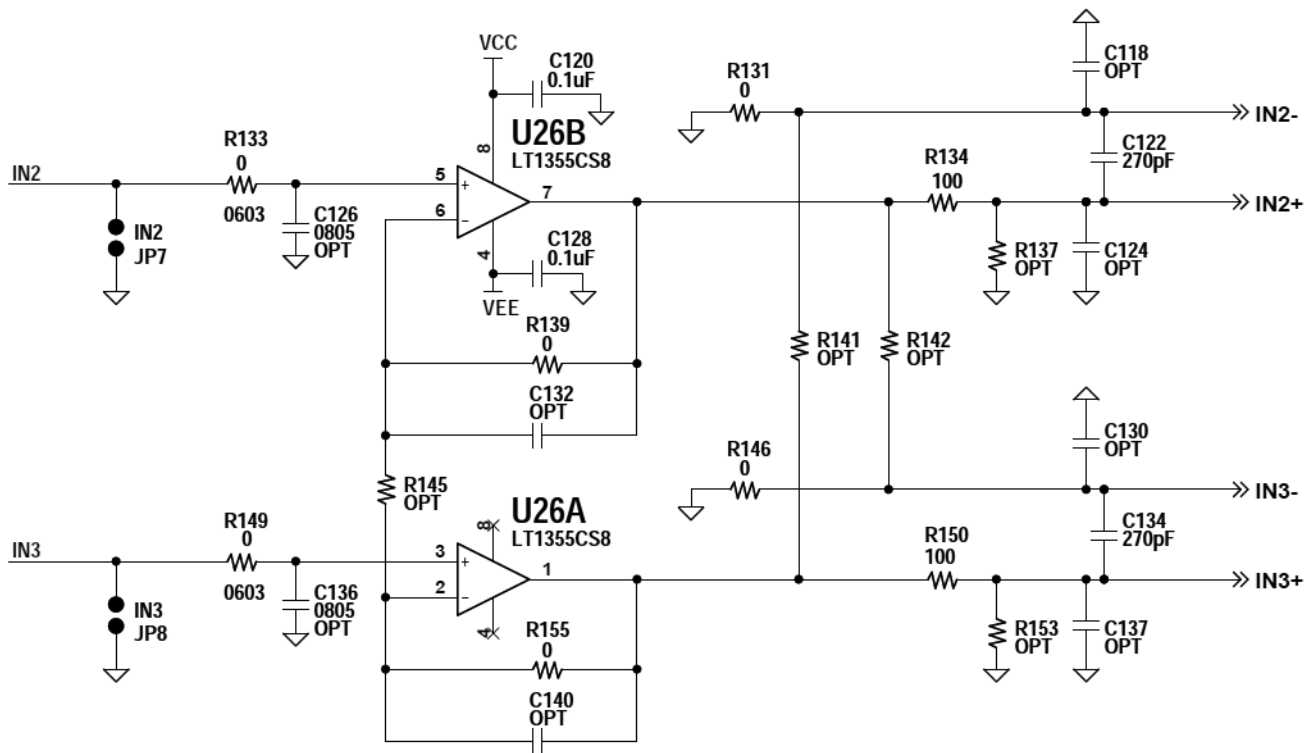


Figure 5.  $\pm 10.24V$  Pseudo-Differential DC-Coupled Driver

## DC2412A SETUP

To change the default settings for the LTC2335 in PScope, click on the Set Demo Bd Options button in the PScope tool bar shown in Figure 6. This will open the Configure Sequencer menu of Figure 7. In this menu it is possible to set the SoftSpan input range for each channel. There is also a button to return PScope to the default DC2412 settings, which are optimized for the default hardware settings of the DC2412A.

There are a number of scenarios that can produce misleading results when evaluating an ADC. One that is common is feeding the converter with an input frequency that is a sub-multiple of the sample rate, and which will only

exercise a small subset of the possible output codes. The proper method is to pick an M/N frequency for the input sine wave frequency. N is the number of samples in the FFT. M is a prime number between one and N/2. Multiply M/N by the sample rate to obtain the input sine wave frequency. Another scenario that can yield poor results is if you do not have a signal generator capable of ppm frequency accuracy or if it cannot be locked to the clock frequency. You can use an FFT with windowing to reduce the “leakage” or spreading of the fundamental to get a close approximation of the ADC performance. If an amplifier or clock source with poor phase noise is used, the windowing will not improve the SNR.

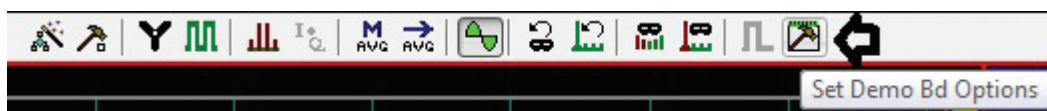


Figure 6. PScope Tool Bar

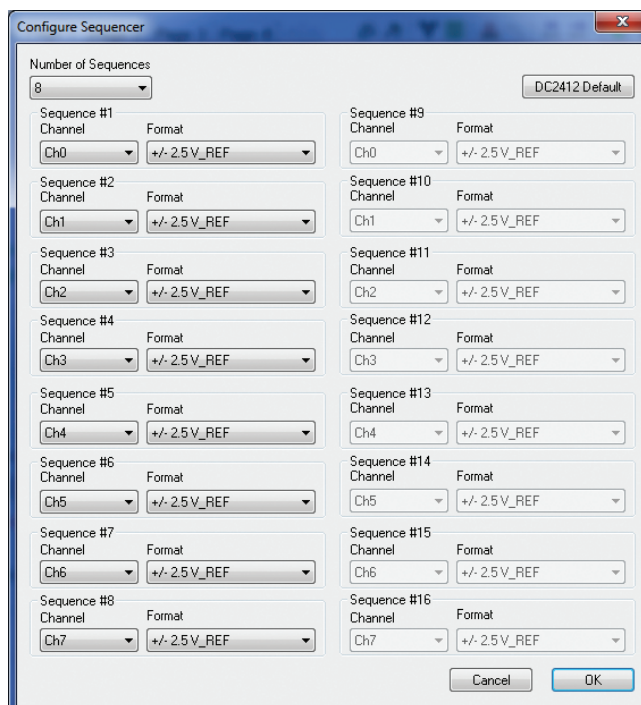


Figure 7. PScope Configure Sequencer Menu

## DC2412A SETUP

### DC590/DC2026 Data Collection

Due to the relatively low and somewhat unpredictable sample rate of the DC590/DC2026, its usefulness is limited to noise measurement and data collection of slowly moving signals. A typical data capture and histogram are shown in Figure 3. To change the default settings of the LTC2335 in QuikEval click on the Sequence Config. button. This will open the Sequence Configuration menu of Figure 8. In this menu it is possible to set the SoftSpan input range and channel for each of up to 16 sequences. There is also a button to return QuikEval to the default DC2412 settings, which are optimized for the default hardware settings of the DC2412A.

### Layout

As with any high performance ADC, this part is sensitive to layout. The area immediately surrounding the ADC on the DC2412A should be used as a guideline for placement, and routing of the various components associated with

the ADC. Here are some things to remember when laying out a board for the LTC2335. A ground plane is necessary to obtain maximum performance. Keep bypass capacitors as close to supply pins as possible. Use individual low impedance returns for all bypass capacitors. Use of a symmetrical layout around the analog inputs will minimize the effects of parasitic elements. Shield analog input traces with ground to minimize coupling from other traces. Keep traces as short as possible.

### Component Selection

When driving a low noise, low distortion ADC such as the LTC2335, component selection is important so as to not degrade performance. Resistors should have low values to minimize noise and distortion. Metal film resistors are recommended to reduce distortion caused by self-heating. Because of their low voltage coefficients, to further reduce distortion NPO or silver mica capacitors should be used. Any buffer used to drive the LTC2335 should have low distortion, low noise and a fast settling time such as the LT1355.

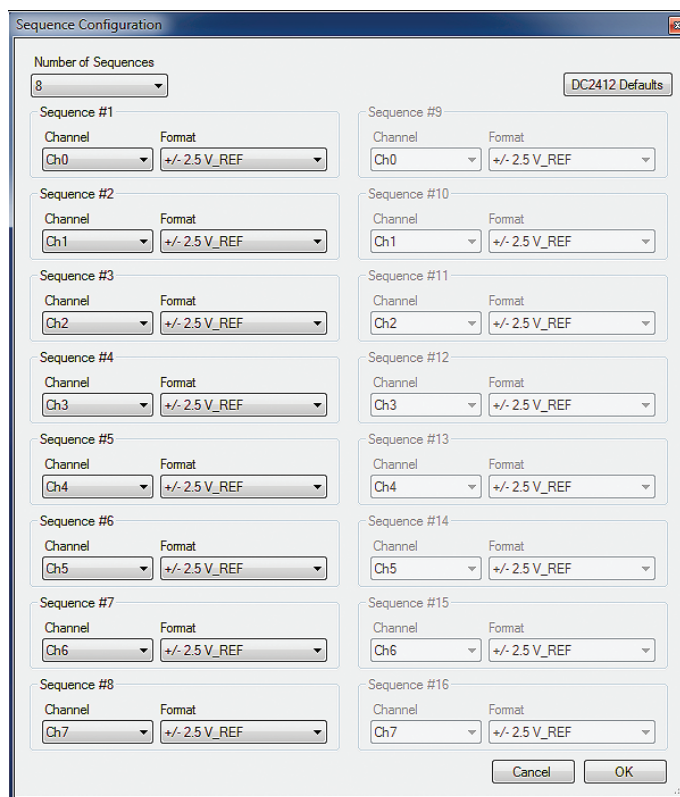


Figure 8. QuikEval Sequence Configuration Menu



## DC2412A JUMPERS AND CONNECTORS

### Jumpers Definitions

**JP1:** REF Selects INT or EXT reference for the ADC. The default setting is INT.

**JP2:** VCCIO sets the output levels at P1 to either 3.3V or 2.5V. Use 2.5V to interface to the DC890, which is the default setting. Use 3.3V to interface to the DC2026.

**JP3:** I/O Selects LVDS or CMOS logic levels. The default setting is CMOS. LVDS is for future use only.

**JP4:** EEPROM is for factory use only. The default position is WP.

**JP5 – JP12:** IN0 – IN7 can be used to short individual IN inputs to ground or can be used to drive the individual IN inputs. The default is to leave these open.

### Connectors Definitions

**P1:** DC890 interface is used to communicate with the DC890 controller.

**J1:** CLK provides the master clock for the DC2412 when interfaced to the DC890. Do not use for QuikEval controllers.

**J2:** FPGA PROGRAM is used to program the FPGA. This is for factory use only.

**J3:** JTAG is for factory use only.

**J4:** DC590/DC2026 interface is used to communicate with the DC590 or DC2026 QuikEval controller.

**J5 and J6:** Provide analog input voltages to IN0 – IN7 of the ADC.

**J7:** Routes the signals of J5 and J6 to IN0 – IN7.

# DEMO MANUAL DC2412A

---

## DEMONSTRATION BOARD IMPORTANT NOTICE

Linear Technology Corporation (LTC) provides the enclosed product(s) under the following **AS IS** conditions:

This demonstration board (DEMO BOARD) kit being sold or provided by Linear Technology is intended for use for **ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY** and is not provided by LTC for commercial use. As such, the DEMO BOARD herein may not be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including but not limited to product safety measures typically found in finished commercial goods. As a prototype, this product does not fall within the scope of the European Union directive on electromagnetic compatibility and therefore may or may not meet the technical requirements of the directive, or other regulations.

If this evaluation kit does not meet the specifications recited in the DEMO BOARD manual the kit may be returned within 30 days from the date of delivery for a full refund. **THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY THE SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THIS INDEMNITY, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.**

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user releases LTC from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge. Also be aware that the products herein may not be regulatory compliant or agency certified (FCC, UL, CE, etc.).

No License is granted under any patent right or other intellectual property whatsoever. **LTC assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or any other intellectual property rights of any kind.**

LTC currently services a variety of customers for products around the world, and therefore this transaction **is not exclusive**.

**Please read the DEMO BOARD manual prior to handling the product.** Persons handling this product must have electronics training and observe good laboratory practice standards. **Common sense is encouraged.**

This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

Mailing Address:

Linear Technology  
1630 McCarthy Blvd.  
Milpitas, CA 95035

Copyright © 2004, Linear Technology Corporation