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# LTC2606

## 16-Bit Rail-to-Rail V<sub>OUT</sub> DAC with I<sup>2</sup>C Interface

### DESCRIPTION

Demonstration circuit 812A features the **LTC<sup>®</sup>2606** 16-bit DAC with I<sup>2</sup>C interface. This device establishes a new board-density benchmark for 16-bit DACs and advances performance standards for output drive and load regulation in single-supply, voltage output DACs.

DC812A has many features for evaluating the performance of the LTC2606. Onboard 5V, 4.096V and 2.5V precision references are provided, and the LTC2606 may be powered by the 5V reference for evaluating rail-to-rail operation.

Another feature of this board is the onboard LTC2421 20-bit ADC for monitoring DAC output voltage. The 16ppm total error of this device is adequate for taking meaningful measurements of various LTC2606 parameters.

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

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### PERFORMANCE SUMMARY Specifications are at T<sub>A</sub> = 25°C

SYMBOL	PARAMETER	CONDITIONS
Resolution		16 Bits
Monotonicity	V <sub>CC</sub> = 5V, V <sub>REF</sub> = 4.096V	16 Bits
Differential Nonlinearity	V <sub>CC</sub> = 5V, V <sub>REF</sub> = 4.096V	±1 LSB
Integral Nonlinearity	V <sub>CC</sub> = 5V, V <sub>REF</sub> = 4.096V	±12 LSB Typical
Load Regulation	V <sub>CC</sub> = V <sub>REF</sub> = 5V, Mid-Scale, I <sub>OUT</sub> = ±15mA	2 LSB/mA Max

### BOARD PHOTO

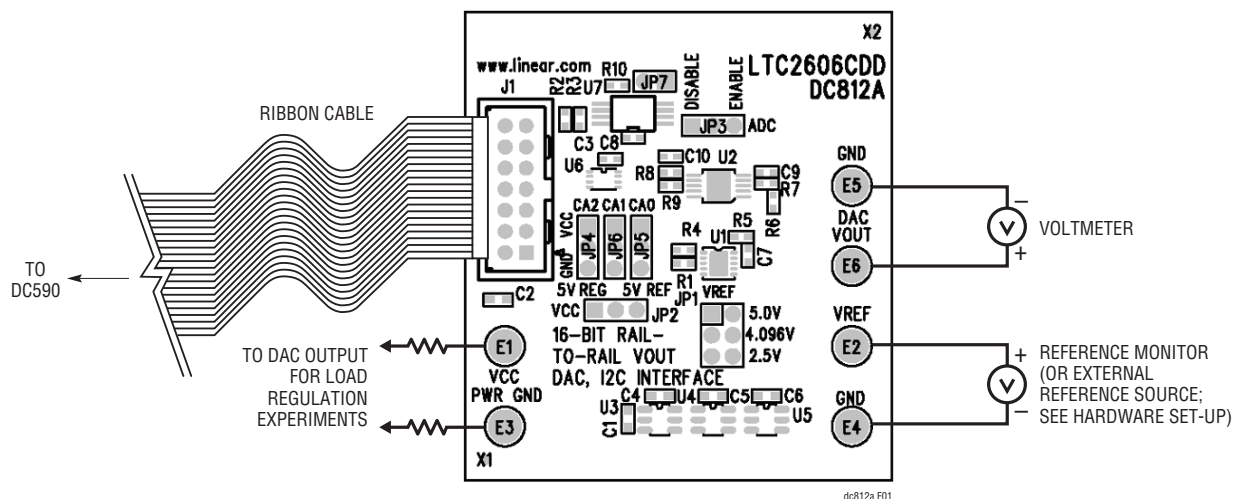


Figure 1. DC812A Connection Diagram

## QUICK START PROCEDURE

1. Connect the DC812A to a DC590 USB serial controller using the supplied 14-conductor ribbon cable.
2. Connect the DC590 to a host PC with a standard USB A/B cable.
3. Run the QuikEval™ evaluation software supplied with the DC590 or download it from [www.linear.com/software](http://www.linear.com/software). The correct control panel will be loaded automatically.
4. Click the Collect button to begin outputting codes to the DAC and reading back the resulting output voltage.

Complete software documentation is available from the Help menu item, as features may be added periodically.



Figure 2. QuikEval Software



## HARDWARE SETUP

### JUMPER SETTINGS

**V<sub>REF</sub>:** V<sub>REF</sub> Select. Select 5V, 4.096V, or 2.5V reference. To apply an external reference through the V<sub>REF</sub> turret, remove this jumper.

**V<sub>CC</sub>:** V<sub>CC</sub> Select. V<sub>CC</sub> is taken either from the onboard 5V reference or the 5V regulated supply from the controller board. Selecting the 5V reference for both the V<sub>CC</sub> jumper and V<sub>REF</sub> jumper allows characterization of rail-to-rail operation of the LTC2606.

**ADC:** ADC Enable/Disable. Set to ENABLE for operation with DC590 serial controller. When using in customer's end application, the ADC can be completely disabled by setting jumper to DISABLE.

For very sensitive noise measurements when using LTC supplied software, set the output voltage and stop reading the voltage via the collect button on the control panel. This will stop the ADC from converting.

### ANALOG CONNECTIONS

**DAC V<sub>OUT</sub>:** LTC2606 Output.

**V<sub>REF</sub>:** The V<sub>REF</sub> turret is connected directly to the reference terminals of the LTC2606 and LTC2421 ADC. When one of the onboard references is being used, the reference voltage may be monitored at this point. An external reference may also be applied to this turret after removing JP1.

### GROUNDING AND POWER CONNECTIONS

**Power (V<sub>CC</sub>):** Normally the DC812A is powered by the DC590 controller. V<sub>CC</sub> can be supplied to this turret, however the power supply on the DC590 must be disabled! Refer to the DC590 Quick Start guide for more details on this mode of operation.

**Grounding:** Separate power and signal grounds are provided. Any large currents drawn from the DAC outputs should be returned to power ground. Also, if an external power supply is connected, power ground should be used. Signal ground is connected to the exposed ground planes at the top and bottom edges of the board, and to the two turrets labeled GND. Use signal ground as the reference point for measurements and connections to external circuits.

## EXPERIMENTS

The following experiments are intended to demonstrate some of the outstanding features of the LTC2606. All can be performed using the onboard LTC2421 to monitor the DAC output voltage. The indicated output voltage will typically agree with an HP3458A voltmeter to five digits. If a DAC will be sinking or sourcing a significant current, then the output voltage should be measured as close to the DAC as possible.

Most of the data sheet specifications use a 4.096V reference, so this is the preferred reference to use for these experiments. Using the 5V reference has the limitation that V<sub>CC</sub> may be slightly lower than V<sub>REF</sub>, which may affect the full-scale error. Selecting the 5V reference as the source for V<sub>CC</sub> overcomes this, however the total current that the LTC2606 can source will be limited to approximately 5mA.

Using an external power supply is highly recommended for these experiments, especially those that draw significant current. Refer to the DC590 Quick Start guide for details.

### Resolution

The onboard LTC2421 ADC has an input resolution of 6 $\mu$ V. This will easily resolve a 1 LSB (76 $\mu$ V for V<sub>REF</sub> = 5V, 62.5 $\mu$ V for V<sub>REF</sub> = 4.096V) change in the LTC2606 output. Set the DAC output to a voltage close to mid-scale. Select the FINE slider on the control panel with the mouse and use the right and left arrow keys to step the output by single LSBs. The change should be clearly visible in the output graph. Note: It may be necessary to wait for the graph to clear if a large step has just occurred.

# DEMO MANUAL DC812A

## EXPERIMENTS

### Integral Nonlinearity

A rough measurement of INL can be taken using the onboard ADC. Measure the LTC2606 output at code 256 and 65,535 and calculate the slope and intercept using a spreadsheet. Next, take several readings at intermediate points. The readings should not deviate from the calculated line by more than 64 LSBs, and they will typically be within 12 LSBs.

### Load Regulation/DC Output Impedance

Select “5V REG” for the  $V_{CC}$  source. Set one of the outputs to mid-scale (code 32768). Source or sink 15mA from one of the DAC outputs by pulling it to power ground or  $V_{CC}$  with an appropriate value resistor. The voltage change should be less than 2.25mV, corresponding to an output impedance of 0.15 $\Omega$ . Output impedance is typically less

than 0.030 $\Omega$  (measure DAC voltage at the output pin if using a voltmeter).

### Zero-Scale Error

Set the DAC output to code 0. The measured output should be less than 9mV and will typically be less than 1mV.

### Offset Error

Set the DAC output to code 256. The output voltage should be within 9mV of the correct value, or  $V_{REF} \times 256/65535$ .

### Gain Error

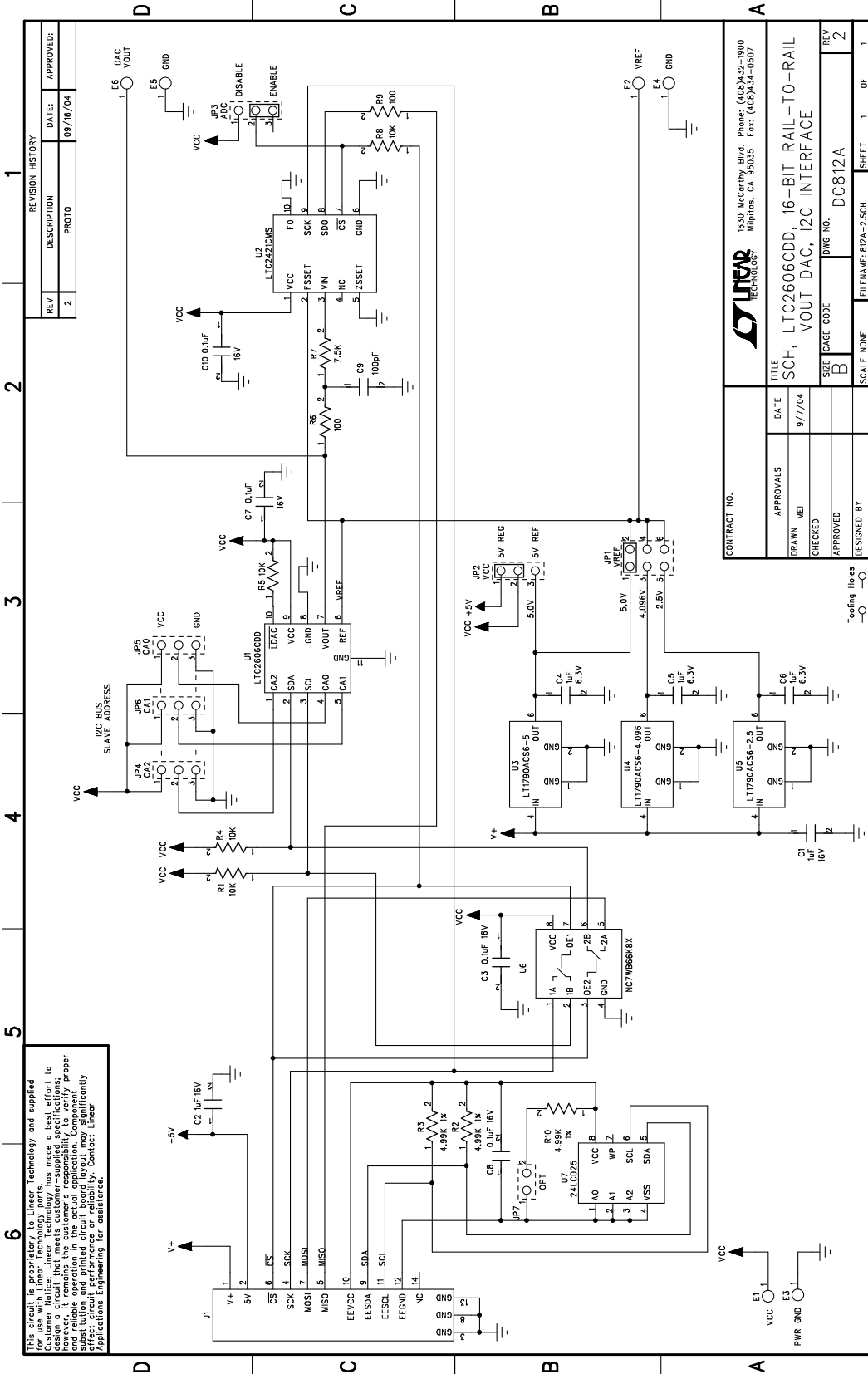
Set the DAC output to code 65,535. The output voltage should be within 0.7% of  $V_{REF}$ , and will typically be within 0.2%.

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	1	U7	IC, 24LC025	MICROCHIP, 24LC025
2	3	C3, C7, C10	CAP, X7R, 0.1 $\mu$ F, 16V, 10%, 0402	TDK, C1005X7R1C104KT
3	1	C9	CAP, NPO, 100pF, 50V, 10%, 0402	AVX, 04025A101KAT
4	3	C4-C6	CAP, X5R, 1 $\mu$ F, 6.3V, 20%, 0603	AVX, 06036D105MAT
5	2	C1-C2	CAP, X7R, 1 $\mu$ F, 16V, 20%, 0603	TDK, C1608X7R1C105M
6	1	J1	HEADER, 2x7P, 2mm	MOLEX, 87831-1420
7	0	JP7	DO NOT STUFF	OPTION
8	1	JP1	HEADER, 2x3P, 2mm	COMM CON, 2202S-06-G2
9	5	JP2-JP6	JUMPER, 3-PIN, 2mm	COMM CON, 2802S-03G2
10	1	U5	IC, LT1790ACS6-2.5	LINEAR TECHNOLOGY, LT1790ACS6-2.5
11	1	U4	IC, LT1790ACS6-4.096	LINEAR TECHNOLOGY, LT1790ACS6-4.096
12	1	U3	IC, LT1790ACS6-5	LINEAR TECHNOLOGY, LT1790ACS6-5
13	1	U2	IC, LTC2421CMS	LINEAR TECHNOLOGY, LTC2421CMS
14	1	U1	IC, LTC2606CDD	LINEAR TECHNOLOGY, LTC2606CDD
15	1	U6	IC, NC7WB66 DUAL LOGIC SWITCH	FAIRCHILD SEMI., NC7WB66K8X
16	2	R6, R9	RES, 100 $\Omega$ , 5%, 1/16W, 0402	AAC, CR05-101JM
17	4	R1, R4-R5, R8	RES, 10k $\Omega$ , 5%, 1/16W, 0402	AAC, CR05-103JM
18	3	R2-R3, R10	RES, 4.99k $\Omega$ , 1%, 1/16W, 0402	AAC, CR05-4991FM
19	1	R7	RES, 7.5k $\Omega$ , 5%, 1/16W, 0402	AAC, CR05-752JM
20	6	E1-E6	TURRET	MILL-MAX, 2308-2
21	7	JP1-JP7	SHUNT	COMM CON, CCIJ2MM-138G

dc812af

**SCHEMATIC DIAGRAM**



REVISION HISTORY	
REV	DESCRIPTION
2	PROTD

REVISION HISTORY	
REV	DATE
2	09/16/04

APPROVALS	
DATE	APPROVED
9/7/04	MEI

DRAWN	
DATE	BY
9/7/04	MEI

CHECKED	
DATE	BY
9/7/04	MEI

DESIGNED BY	
DATE	BY
9/7/04	MEI

TITLE	
FILE NO.	REV
SCH, LTC2606CDD, 16-BIT RAIL-TO-RAIL VOUT DAC, I2C INTERFACE	2

CONTRACT NO.	
SCALE	SHEET
1630 McCarthy Blvd. Phone: (408)321-1800 Milpitas, CA 95035 Fax: (408)321-0507	1 OF 1

Figure 3. LTC2606CDD, 16-Bit Rail-to-Rail Vout DAC, I2C Interface



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# DEMO MANUAL DC812A

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