

# LTC2604

## Quad 16-Bit Rail-to-Rail DAC with SPI Interface

### DESCRIPTION

Demonstration circuit 809 features the **LTC®2604** Quad 16-Bit DAC. This device establishes a new board-density benchmark for 16-bit DACs and advances performance standards for output drive, crosstalk and load regulation in single supply, voltage-output multiple DACs.

DC809 has many features for evaluating the performance of the LTC2604. Onboard 5V, 4.096V, and 2.5V precision references are provided. The LTC2604 features separate reference inputs for each DAC, and any of the onboard references can be used for any of the reference inputs.

Another feature of this board is the onboard LTC2428 20-bit ADC for monitoring DAC output voltage. The 16ppm total error of this device is adequate for taking meaningful measurements of various LTC2604 parameters.

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

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

### PERFORMANCE SUMMARY

Specifications are at  $T_A = 25^\circ\text{C}$

PARAMETER	CONDITION	VALUE
Resolution		16 Bits
Monotonicity	$V_{CC} = 5V$ , $V_{REF} = 4.096V$	16 Bits
Differential Nonlinearity	$V_{CC} = 5V$ , $V_{REF} = 4.096V$	$\pm 1\text{LSB}$
Integral Nonlinearity	$V_{CC} = 5V$ , $V_{REF} = 4.096V$	$\pm 12\text{LSB}$ Typical
Load Regulation	$V_{CC} = V_{REF} = 5V$ , Mid-Scale $I_{OUT} = \pm 15\text{mA}$	2LSB/mA Max
DC Crosstalk	Due to Load Current Change on Any Other Channel	3.5 $\mu\text{V}/\text{mA}$

## QUICK START PROCEDURE

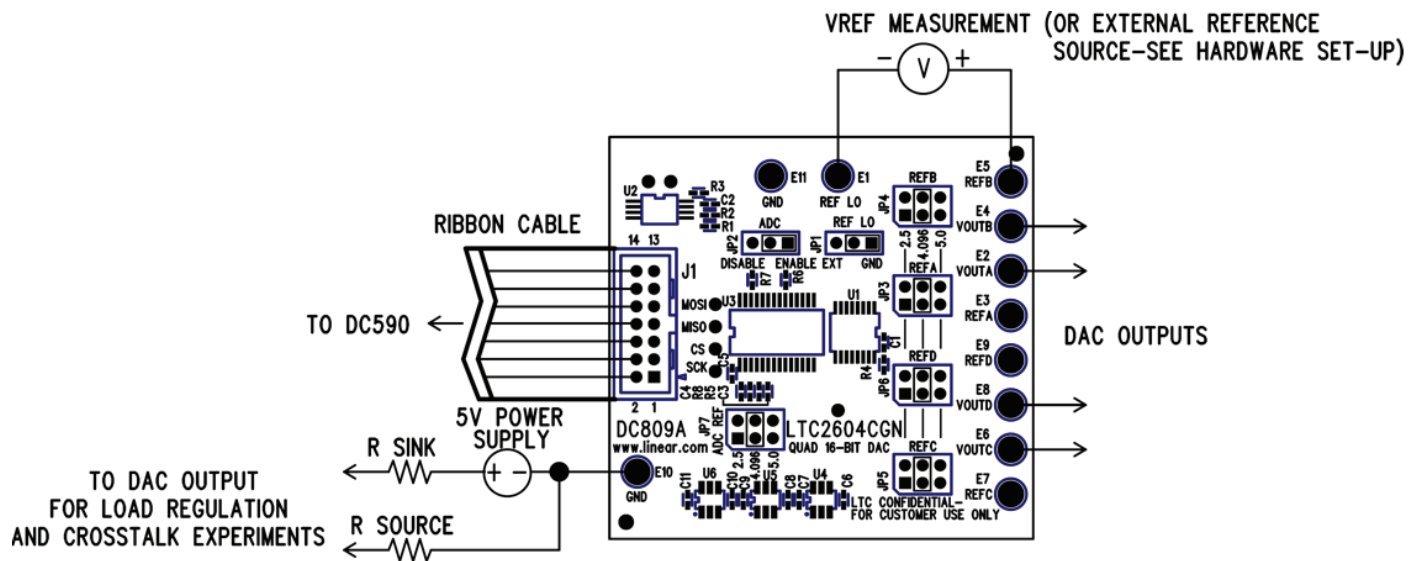


Figure 1. Proper Measurement Equipment Setup

## QUICK START PROCEDURE

Connect DC809A 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 download it from [www.linear.com/software](http://www.linear.com/software). The correct control panel

will be loaded automatically. Click the COLLECT button to begin outputting codes to the DACs and reading back the resulting output voltage for each DAC.

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

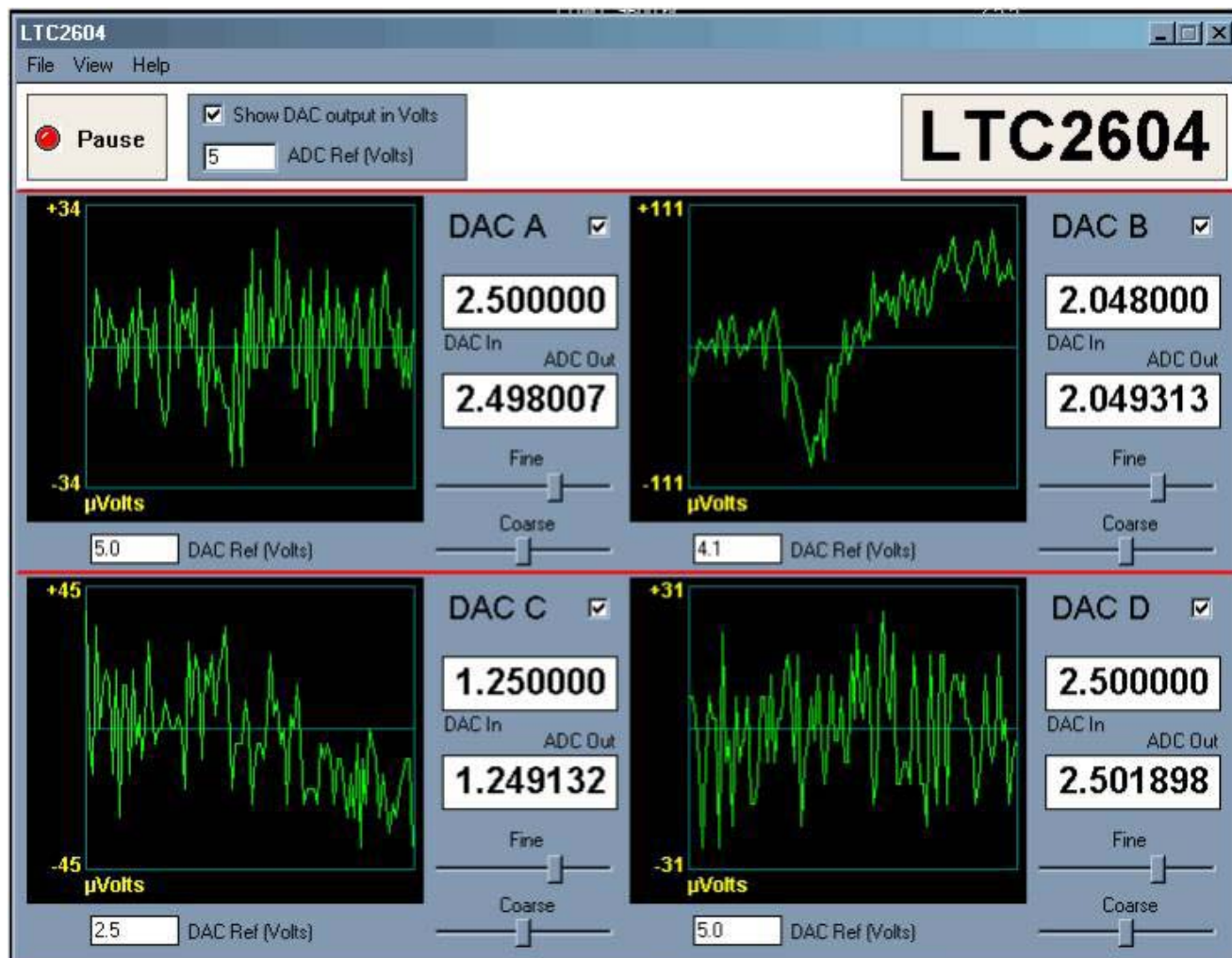


Figure 2. DC809A QuikEval™ Screen Shot

## HARDWARE SETUP

### Jumpers

**JP1** – REFLO Selection. Either tied to ground or supplied externally to the REFLO turret post.

**JP2** – ADC Disable. Set to ON for normal operation, with the onboard ADC enabled. For very sensitive noise measurements, the ADC may be disabled. The software will then display a positive full-scale reading.

**JP7** –  $V_{REF}$  Select for ADC. This selects which onboard reference is used for the LTC2428 ADC. If all DAC references are set to the same voltage, set the ADC reference to the same voltage. If different DAC reference voltages are used, set the ADC reference to the highest DAC reference voltage.

**JP3, JP4, JP5, JP6** – Select reference for DAC A, B, C, and D, respectively. Onboard references are 2.5V, 4.096V, and 5.0V. Remove jumper entirely to apply an external reference.

### Analog Connections

**DAC Outputs** – The four DAC outputs from the LTC2604 are brought out to turrets labeled DAC A through DAC D. These may be connected to external instruments or other circuitry.

DAC outputs are not in alphabetical order on the circuit board.

**DAC References** – The REFA, REFB, REFC, and REFD turrets are connected directly to the reference terminals of the LTC2604. 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 the associated reference selection jumper.

**REFLO** – This is connected to the LTC2604 REFLO pin and can be used to raise the zero-code output of all of the DACs above ground potential. This is normally set to ground, but may be raised up to 1V above ground. Refer to the LTC2604 data sheet for details.

### Ground Connections

**Grounding** – Separate power and signal grounds are provided. Any large currents drawn from the DAC outputs should be returned to the power ground turret closest to Pin 1 on the 14-pin header. 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 LTC2604. All can be performed using the onboard LTC2428 to monitor the DAC output voltage. The indicated output voltage will typically agree with an HP3458A voltmeter to 5 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 4.096 volt reference, so this is the preferred reference to use for these experiments. Using the 5V reference has the limitation that  $V_{CC}$  may be slightly lower than  $V_{REF}$ , which may affect the full-scale error.

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 LTC2428 ADC has an input resolution of  $6\mu\text{V}$ . This will easily resolve a 1LSB ( $76\mu\text{V}$  for  $V_{REF} = 5\text{V}$ ,  $62.5\mu\text{V}$  for  $V_{REF} = 4.096\text{V}$ ) change in the LTC2604 output. Set one of the DAC channels 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. (It may be necessary to wait for the graph to clear if a large step has just occurred. This can be sped up by disabling all other DAC channels in the software by unchecking them.)

### Integral Nonlinearity

A rough measurement of INL can be taken using the onboard ADC. Measure one of the LTC2604 outputs 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 64LSBs, and they will typically be within 12LSBs.

### Load Regulation/DC Output Impedance

Set one of the outputs to mid-scale (code 32768) source or sink 15mA from this output 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 one of the DACs to code 0. The measured output should be less than 9mV and will typically be less than 1mV.

### Offset Error

Set one of the DACs to code 256. The output voltage should be within 1mV of the correct value, or  $V_{REF} \cdot 256/65535$ .

### Gain Error

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

### DC Crosstalk

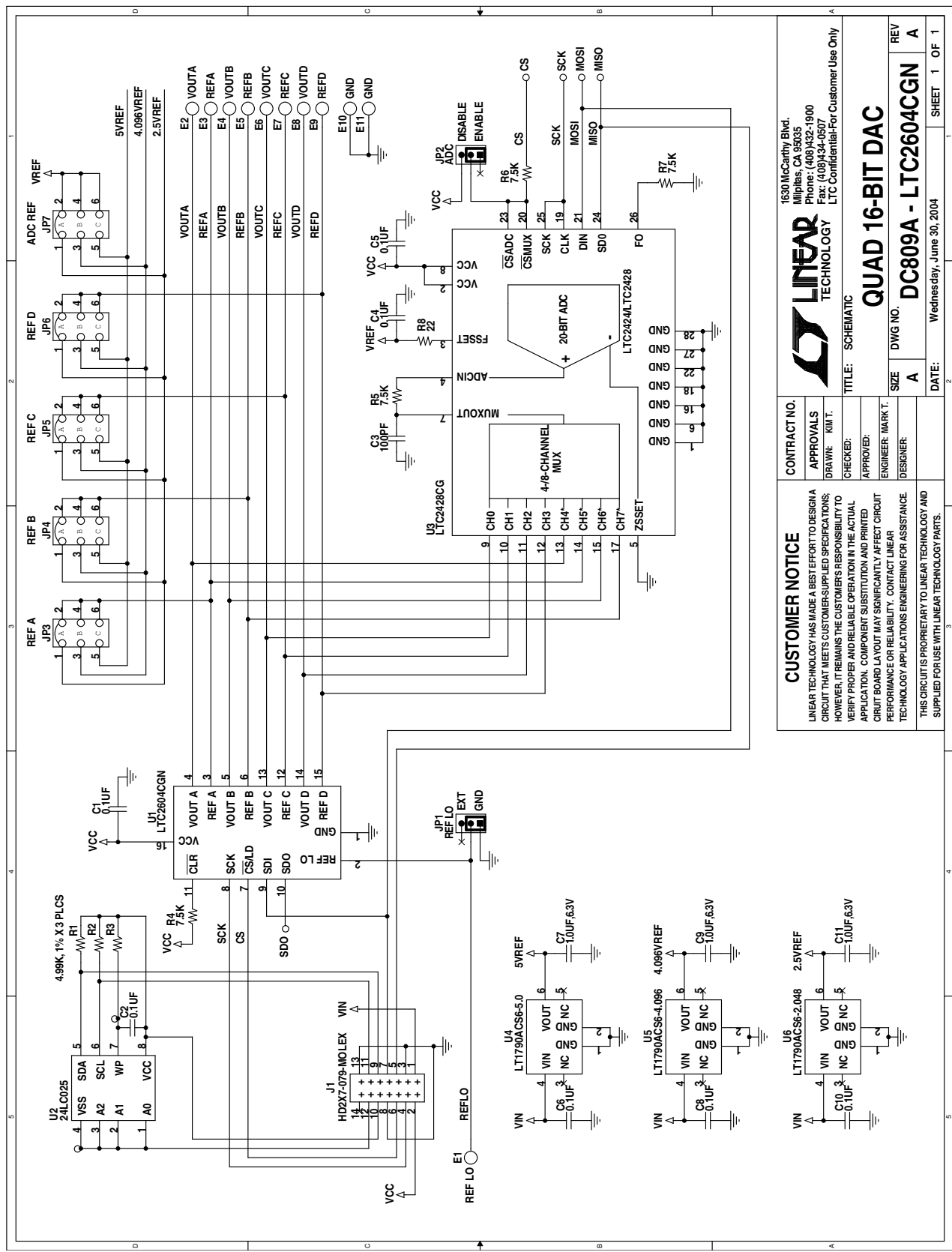
Set all DACs to mid-scale. Connect a  $250\Omega$  resistor from one output to  $V_{CC}$  or Power Ground (to sink or source 10mA, respectively, when the 5V reference is being used.) A given output should not change by more than  $3.5\mu\text{V}$  per milliamp of output current in all other DACs combined.


# DEMO MANUAL DC809A

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
1	7	C1, C2, C4, C5, C6, C8, C10	CAP., X7R, 0.1µF 16V,0402	TDK, C1005X7R1C104M
2	1	C3	CAP., NPO, 100pF 50V,0402	AVX, 04025A101MAT
3	3	C7, C9, C11	CAP., X5R, 1.0µF 6.3V,0402	TDK, C1005X5R0J105M
4	11	E1-E11	TESTPOINT, TURRET, 0.064"	MILL-MAX, 2308-2
5	2	JP1, JP2	JMP, 3 PIN 1 ROW 0.079CC	COMM-CON, 2802S-03-G1
6	5	JP3, JP4, JP5, JP6, JP7	HEADER, 2×3 PIN, 0.079CC	COMM CON, 2202S-06G2
7	7	ON JP1-JP7 PIN 1 AND 2	SHUNT, .079" CENTER	COMM-CON CCIJ2MM-138G
8	1	J1	HEADER, 2×7 PIN, 0.079CC	MOLEX, 87331-1420
9	3	R1, R2, R3	RES., CHIP, 4.99k, 1%,0402	AAC, CR05-4991FM
10	4	R4, R5, R6, R7	RES., CHIP, 7.5k, 5%,0402	AAC, CR05-752JM
11	1	R8	RES., CHIP, 22, 5%,0402	AAC, CR05-220JM
12	1	U1	I.C., LTC2604CGN,SSOP16GN	LINEAR TECH., LTC2604CGN
13	1	U2	I.C., 24LC025, TSSOP8	MICROCHIP, 24LC025
14	1	U3	I.C., LTC2428CG,SSOP28G	LINEAR TECH., LTC2428CG
15	1	U4	I.C., LT1790ACS6-5,SOT23-6	LINEAR TECH., LT1790ACS6-5
16	1	U5	I.C., LT1790ACS6-4.096,SOT23-6	LINEAR TECH., LT1790ACS6-4.096
17	1	U6	I.C., LT1790ACS6-2.5,SOT23-6	LINEAR TECH., LT1790ACS6-2.5

SCHEMATIC DIAGRAM





1630 McCarthy Blvd.  
Milpitas, CA 95035  
Phone: (408) 432-1900  
Fax: (408) 434-0507  
LTC Confidential For Customer Use Only

CONTRACT NO.

APPROVALS

DRAWN: KMT

CHECKED:

APPROVED:

ENGINEER: MARK T.

DESIGNER:

**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.

**QUAD 16-BIT DAC**

**DC809A - LTC2604CGN**

SIZE: A

DWG NO. A

REV: A

DATE: Wednesday, June 30, 2004

SHEET 1 OF 1



# DEMO MANUAL DC809A

---

## 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