

# Dual 12-Bit Rail-to-Rail Micropower DACs

## FEATURES

- 12-Bit Resolution
- **Buffered True Rail-to-Rail Voltage Output**
- 5V Operation,  $I_{CC}$ : 700 $\mu$ A Typ (LTC1454)
- 3V Operation,  $I_{CC}$ : 450 $\mu$ A Typ (LTC1454L)
- Built-In Reference: 2.048V (LTC1454)  
1.220V (LTC1454L)
- $\overline{\text{CLR}}$  Pin
- Power-On Reset
- **16-Lead SO Package**
- 3-Wire Cascadable Serial Interface
- **Maximum DNL Error: 0.5LSB**
- Low Cost

## APPLICATIONS

- Digital Calibration
- Industrial Process Control
- Automatic Test Equipment
- Cellular Telephones

## DESCRIPTION

The LTC<sup>®</sup>1454/LTC1454L are complete single supply, dual rail-to-rail voltage output, 12-bit digital-to-analog converters (DACs) in a 16-lead SO package. They include an output buffer amplifier with variable gain ( $\times 1$  or  $\times 2$ ) and an easy-to-use 3-wire cascadable serial interface.

The LTC1454 has an onboard reference of 2.048V and a full-scale output of 4.095V in a  $\times 2$  gain configuration. It operates from a single 4.5V to 5.5V supply.

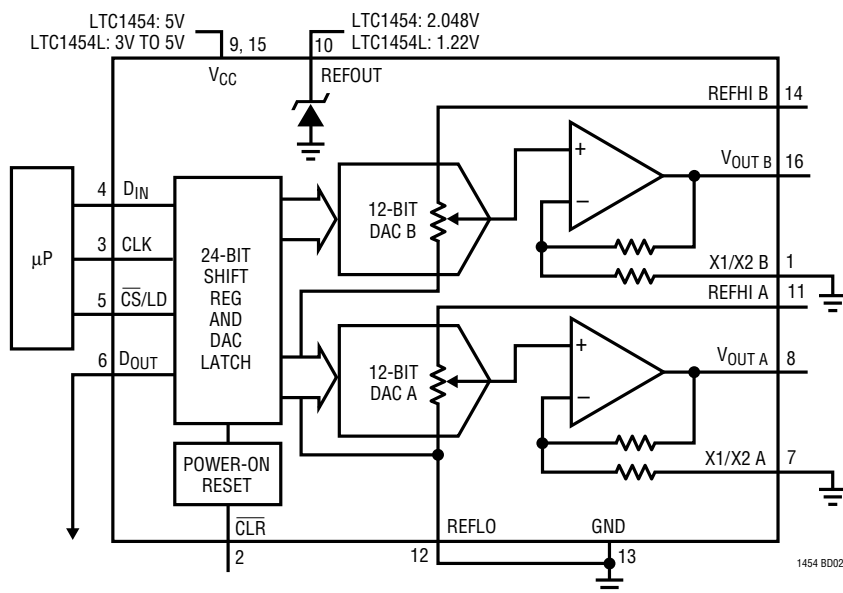
The LTC1454L has an onboard 1.22V reference and a full-scale output of 2.5V in a  $\times 2$  gain configuration. It operates from a single 2.7V to 5.5V supply.

Low power supply current, excellent DNL and small size allow these parts to be used in a host of applications where size, DNL and single supply operation are important.

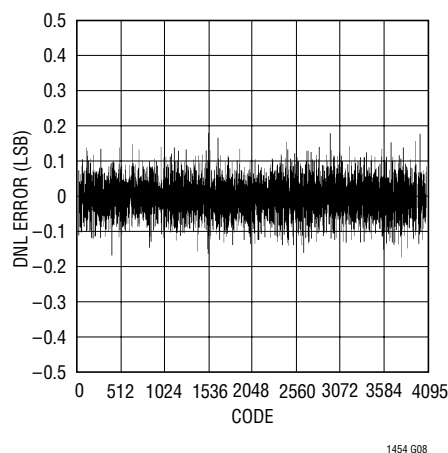
 LTC and LT are registered trademarks of Linear Technology Corporation.

## TYPICAL APPLICATION

Functional Block Diagram: Dual 12-Bit Rail-to-Rail DAC



Differential Nonlinearity vs Input Code



1454 GD02

# LTC1454/LTC1454L

## ABSOLUTE MAXIMUM RATINGS

|                                                       |                          |
|-------------------------------------------------------|--------------------------|
| $V_{CC}$ to GND .....                                 | –0.5V to 7.5V            |
| Logic Inputs to GND .....                             | –0.5V to 7.5V            |
| $V_{OUT A}$ , $V_{OUT B}$ , X1/X2 A,<br>X1/X2 B ..... | –0.5V to $V_{CC} + 0.5V$ |
| REFHI A, REFHI B, REFLO .....                         | –0.5V to $V_{CC} + 0.5V$ |
| Maximum Junction Temperature .....                    | 125°C                    |
| Operating Temperature Range                           |                          |
| LTC1454C/LTC1454LC .....                              | 0°C to 70°C              |
| LTC1454I/LTC1454LI .....                              | –40°C to 85°C            |
| Storage Temperature Range .....                       | –65°C to 150°C           |
| Lead Temperature (Soldering, 10 sec) .....            | 300°C                    |

## PACKAGE/ORDER INFORMATION

| TOP VIEW           |   | ORDER PART NUMBER                                                                                                                                                           |
|--------------------|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| X1/X2 B            | 1 | <div>LTC1454CN</div> <div>LTC1454IN</div> <div>LTC1454CS</div> <div>LTC1454IS</div> <div>LTC1454LCN</div> <div>LTC1454LIN</div> <div>LTC1454LCS</div> <div>LTC1454LIS</div> |
| CLR                | 2 |                                                                                                                                                                             |
| CLK                | 3 |                                                                                                                                                                             |
| D <sub>IN</sub>    | 4 |                                                                                                                                                                             |
| C <sub>S</sub> /LD | 5 |                                                                                                                                                                             |
| D <sub>OUT</sub>   | 6 |                                                                                                                                                                             |
| X1/X2 A            | 7 |                                                                                                                                                                             |
| V <sub>OUT A</sub> | 8 |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |
|                    |   |                                                                                                                                                                             |

Consult factory for Military grade parts.

## ELECTRICAL CHARACTERISTICS

$V_{CC} = 4.5V$  to  $5.5V$  (LTC1454),  $2.7V$  to  $5.5V$  (LTC1454L), X1/X2 = REFLO = GND, REFHI = REFOUT,  $V_{OUT}$  and REFOUT unloaded,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.

| SYMBOL            | PARAMETER                                  | CONDITIONS                                                                 |        | MIN                | TYP            | MAX            | UNITS      |
|-------------------|--------------------------------------------|----------------------------------------------------------------------------|--------|--------------------|----------------|----------------|------------|
| DAC               |                                            |                                                                            |        |                    |                |                |            |
|                   | Resolution                                 |                                                                            | ●      | 12                 |                |                | Bits       |
| DNL               | Differential Nonlinearity                  | Guaranteed Monotonic (Note 1)                                              | ●      | ± 0.5              |                |                | LSB        |
| INL               | Integral Nonlinearity                      | T <sub>A</sub> = 25°C<br>(Note 1)                                          | ●      |                    | ±2.0<br>±2.5   | ±4.0<br>±4.5   | LSB<br>LSB |
| V <sub>OS</sub>   | Offset Error                               | T <sub>A</sub> = 25°C                                                      | ●      |                    | ±2.0<br>±4.0   | ±12<br>±18     | mV<br>mV   |
| V <sub>OSTC</sub> | Offset Error Temperature Coefficient       |                                                                            |        |                    | ±15            |                | μV/°C      |
| V <sub>FS</sub>   | Full-Scale Voltage                         | When Using Internal Reference, LTC1454, T <sub>A</sub> = 25°C<br>LTC1454   | ●      | 4.065<br>4.045     | 4.095<br>4.095 | 4.125<br>4.145 | V<br>V     |
|                   |                                            | When Using Internal Reference, LTC1454L, T <sub>A</sub> = 25°C<br>LTC1454L | ●      | 2.470<br>2.460     | 2.500<br>2.500 | 2.530<br>2.540 | V<br>V     |
| V <sub>FSTC</sub> | Full-Scale Voltage Temperature Coefficient | When Using Internal Reference                                              |        |                    | ± 24           |                | ppm/°C     |
| Reference         |                                            |                                                                            |        |                    |                |                |            |
|                   | Reference Output Voltage                   | LTC1454<br>LTC1454L                                                        | ●<br>● | 2.008<br>1.195     | 2.048<br>1.220 | 2.088<br>1.245 | V<br>V     |
|                   | Reference Output Temperature Coefficient   |                                                                            |        | ±20                |                |                | ppm/°C     |
|                   | Reference Line Regulation                  |                                                                            | ●      |                    | 0.7            | ±2.0           | LSB/V      |
|                   | Reference Load Regulation                  | 0 ≤ I <sub>OUT</sub> ≤ 100μA, LTC1454<br>LTC1454L                          | ●<br>● |                    | 0.2<br>0.6     | 1.5<br>3.0     | LSB<br>LSB |
|                   | Reference Input Range                      | V <sub>REFHI</sub> ≤ V <sub>CC</sub> − 1.5V                                |        | V <sub>CC</sub> /2 |                |                | V          |
|                   | Reference Input Resistance                 |                                                                            | ●      | 15                 | 24             | 40             | kΩ         |
|                   | Reference Input Capacitance                |                                                                            |        | 15                 |                |                | pF         |
|                   | Short-Circuit Current                      | REFOUT Shorted to GND                                                      | ●      |                    | 40             | 120            | mA         |

## ELECTRICAL CHARACTERISTICS

$V_{CC} = 4.5V$  to  $5.5V$  (LTC1454),  $2.7V$  to  $5.5V$  (LTC1454L),  $X1/X2 = \text{REFLO} = \text{GND}$ ,  $\text{REFHI} = \text{REFOUT}$ ,  $V_{OUT}$  and  $\text{REFOUT}$  unloaded,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.

| SYMBOL                | PARAMETER                    | CONDITIONS                                                                                          |        | MIN        | TYP        | MAX          | UNITS    |
|-----------------------|------------------------------|-----------------------------------------------------------------------------------------------------|--------|------------|------------|--------------|----------|
| Power Supply          |                              |                                                                                                     |        |            |            |              |          |
| V <sub>CC</sub>       | Positive Supply Voltage      | For Specified Performance, LTC1454<br>LTC1454L                                                      | ●<br>● | 4.5<br>2.7 |            | 5.5<br>5.5   | V<br>V   |
| I <sub>CC</sub>       | Supply Current               | 4.5V ≤ V <sub>CC</sub> ≤ 5.5V (Note 4), LTC1454<br>2.7V ≤ V <sub>CC</sub> ≤ 5.5V (Note 4), LTC1454L | ●<br>● |            | 700<br>450 | 1250<br>1100 | μA<br>μA |
| Op Amp DC Performance |                              |                                                                                                     |        |            |            |              |          |
|                       | Short-Circuit Current Low    | V <sub>OUT</sub> Shorted to GND                                                                     | ●      |            | 70         | 120          | mA       |
|                       | Short-Circuit Current High   | V <sub>OUT</sub> Shorted to V <sub>CC</sub>                                                         | ●      |            | 80         | 120          | mA       |
|                       | Output Impedance to GND      | Input Code = 0                                                                                      | ●      |            | 40         |              | Ω        |
| AC Performance        |                              |                                                                                                     |        |            |            |              |          |
|                       | Voltage Output Slew Rate     | (Note 2)                                                                                            | ●      | 0.5        | 1.0        |              | V/μs     |
|                       | Voltage Output Settling Time | (Notes 2, 3) to ±0.5LSB                                                                             |        |            | 14         |              | μs       |
|                       | Digital Feedthrough          |                                                                                                     |        |            | 0.3        |              | nV•s     |
|                       | AC Feedthrough               | REFHI = 1kHz, 2V <sub>P-P</sub> , (Code: All 0s)                                                    |        |            | −95        |              | dB       |
| SINAD                 | Signal-to-Noise + Distortion | REFHI = 1kHz, 2V <sub>P-P</sub> , (Code: All 1s)                                                    |        |            | 85         |              | dB       |

$V_{CC} = 5V$  (LTC1454),  $3V$  (LTC1454L),  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted.

| SYMBOL            | PARAMETER                   | CONDITIONS                               | LTC1454 |                       |     | LTC1454L |                       |     | UNITS |
|-------------------|-----------------------------|------------------------------------------|---------|-----------------------|-----|----------|-----------------------|-----|-------|
|                   |                             |                                          | MIN     | TYP                   | MAX | MIN      | TYP                   | MAX |       |
| Digital I/O       |                             |                                          |         |                       |     |          |                       |     |       |
| V <sub>IH</sub>   | Digital Input High Voltage  |                                          | ●       | 2.4                   |     |          | 2.0                   |     | V     |
| V <sub>IL</sub>   | Digital Input Low Voltage   |                                          | ●       |                       | 0.8 |          |                       | 0.6 | V     |
| V <sub>OH</sub>   | Digital Output High Voltage | I <sub>OUT</sub> = −1mA                  | ●       | V <sub>CC</sub> − 1.0 |     |          | V <sub>CC</sub> − 0.7 |     | V     |
| V <sub>OL</sub>   | Digital Output Low Voltage  | I <sub>OUT</sub> = 1mA                   | ●       |                       | 0.4 |          |                       | 0.4 | V     |
| I <sub>LEAK</sub> | Digital Input Leakage       | V <sub>IN</sub> = GND to V <sub>CC</sub> | ●       |                       | ±10 |          |                       | ±10 | μA    |
| C <sub>IN</sub>   | Digital Input Capacitance   | Guaranteed by Design                     | ●       |                       | 10  |          |                       | 10  | pF    |

### Switching

|       |                                   |                          |   |    |  |     |    |  |     |    |
|-------|-----------------------------------|--------------------------|---|----|--|-----|----|--|-----|----|
| $t_1$ | $D_{IN}$ Valid to CLK Setup       |                          | ● | 40 |  |     | 60 |  |     | ns |
| $t_2$ | $D_{IN}$ Valid to CLK Hold        |                          | ● | 0  |  |     | 0  |  |     | ns |
| $t_3$ | CLK High Time                     |                          | ● | 40 |  |     | 60 |  |     | ns |
| $t_4$ | CLK Low Time                      |                          | ● | 40 |  |     | 60 |  |     | ns |
| $t_5$ | $\overline{CS}/LD$ Pulse Width    |                          | ● | 50 |  |     | 80 |  |     | ns |
| $t_6$ | LSB CLK to $\overline{CS}/LD$     |                          | ● | 40 |  |     | 60 |  |     | ns |
| $t_7$ | $\overline{CS}/LD$ Low to CLK     |                          | ● | 20 |  |     | 30 |  |     | ns |
| $t_8$ | $D_{OUT}$ Output Delay            | $C_{LOAD} = 15\text{pF}$ | ● |    |  | 150 |    |  | 220 | ns |
| $t_9$ | CLK Low to $\overline{CS}/LD$ Low |                          | ● | 20 |  |     | 30 |  |     | ns |

The ● denotes specifications which apply over the full operating temperature range.

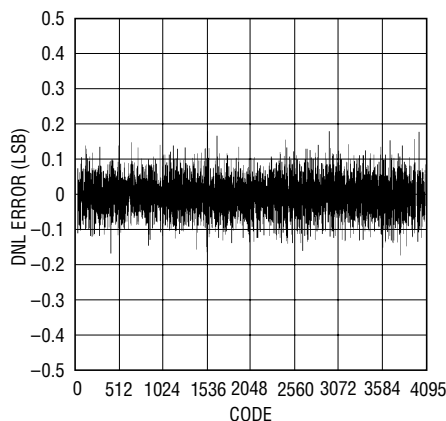
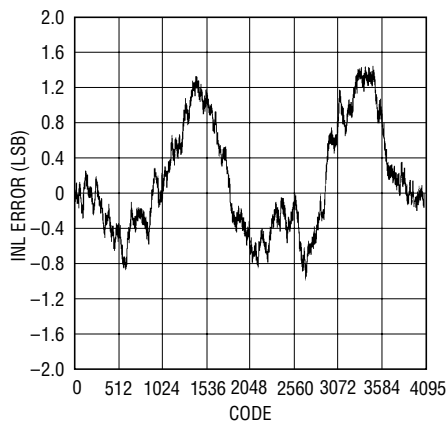
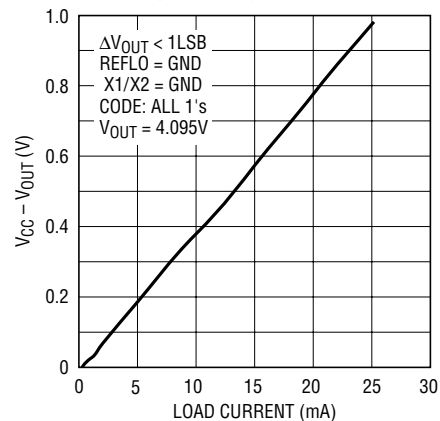
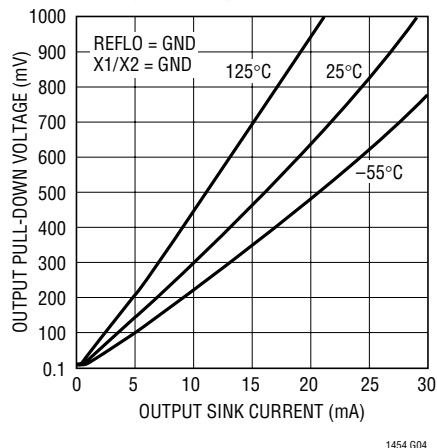
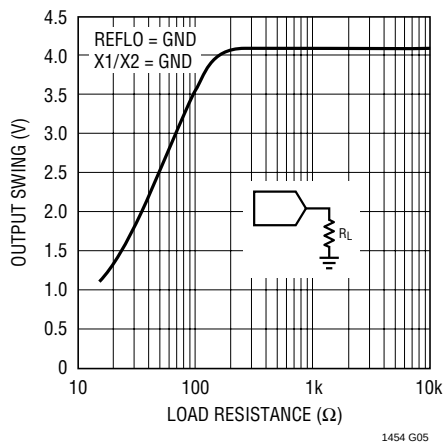
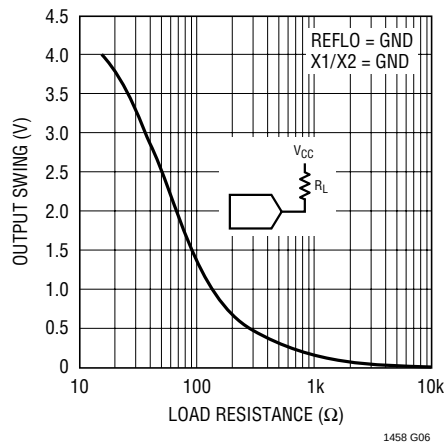
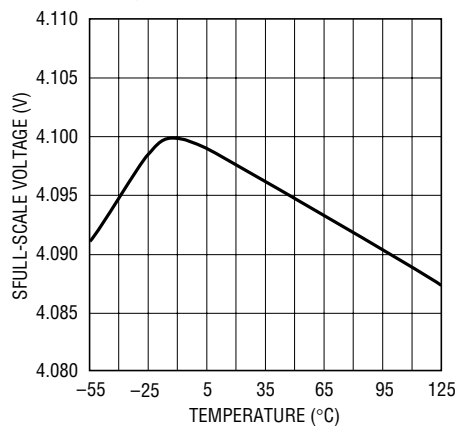
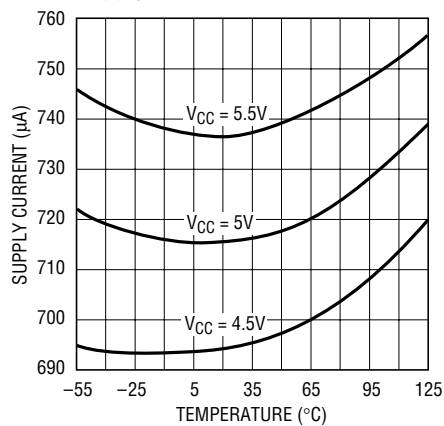
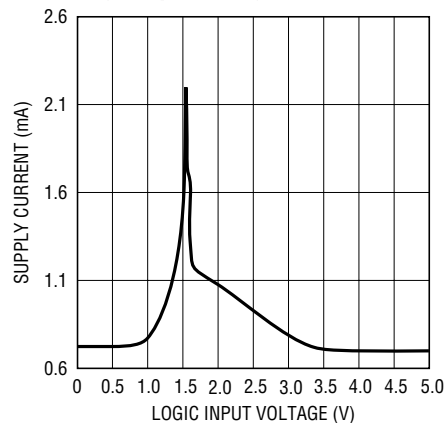
**Note 1:** Nonlinearity is defined from the first code that is greater than or equal to the maximum offset specification to code 4095 (full scale).

**Note 2:** Load is 5k $\Omega$  in parallel with 100pF.

**Note 3:** DAC switched between all 1s and the code corresponding to  $V_{OS}$  for the part.

**Note 4:** Digital inputs at 0V or  $V_{CC}$ .

## TYPICAL PERFORMANCE CHARACTERISTICS

LTC1454  
Differential NonlinearityLTC1454  
Integral NonlinearityMinimum Supply Headroom for  
Full Output Swing vs Load CurrentLTC1454 Minimum Output  
Voltage vs Output Sink CurrentLTC1454 Output Swing vs  
Load ResistanceLTC1454 Output Swing vs  
Load ResistanceLTC1454 Full-Scale Voltage vs  
TemperatureLTC1454  
Supply Current vs TemperatureLTC1454 Supply Current vs  
Logic Input Voltage

## PIN FUNCTIONS

**X1/X2 B, X1/X2 A (Pins 1, 7):** For LTC1454, when this pin is grounded, the gain will be 2. When connected to  $V_{OUT}$  the gain will be 1. In a gain of 2 configuration, the output full scale will be  $2 \times REF_{HI}$ . When using the internal reference, this value is 4.096V. For the LTC1454L, when this pin is grounded, the gain will be 2.05. When connected to  $V_{OUT}$  the gain will be 1. In a gain of 2 configuration, the output full scale will be  $2.05 \times REF_{HI}$ . When using the internal reference this value is 2.5V.

**CLR (Pin 2):** The Clear Pin for the DAC. Clears both DACs to zero scale when pulled low. This pin should be tied to  $V_{CC}$  for normal operation.

**CLK (Pin 3):** The Serial Interface Clock Input.

**D<sub>IN</sub> (Pin 4):** The Serial Data Input. Data on the D<sub>IN</sub> pin is latched into the shift register on the rising edge of the serial clock. Data is loaded as one 24-bit word. The first 12 bits are for DAC A, MSB-first and the second 12 bits are for DAC B, MSB-first.

**$\overline{CS/LD}$  (Pin 5):** The Serial Interface Enable and Load Control Input. When  $\overline{CS/LD}$  is low the CLK signal is enabled so the data can be clocked in. When  $\overline{CS/LD}$  is pulled high, data is loaded from the shift register into the DAC register, updating the DAC output.

**D<sub>OUT</sub> (Pin 6):** The Output of the Shift Register which Becomes Valid on the Rising Edge of the Serial Clock.

**V<sub>OUT A</sub>, V<sub>OUT B</sub> (Pins 8, 16):** The Buffered DAC Outputs.

**V<sub>CC</sub> (Pins 9, 15):** The Positive Supply Input.  $4.5 \leq V_{CC} \leq 5.5V$  (LTC1454),  $2.7V \leq V_{CC} \leq 5.5V$  (LTC1454L). Requires a bypass capacitor to ground.

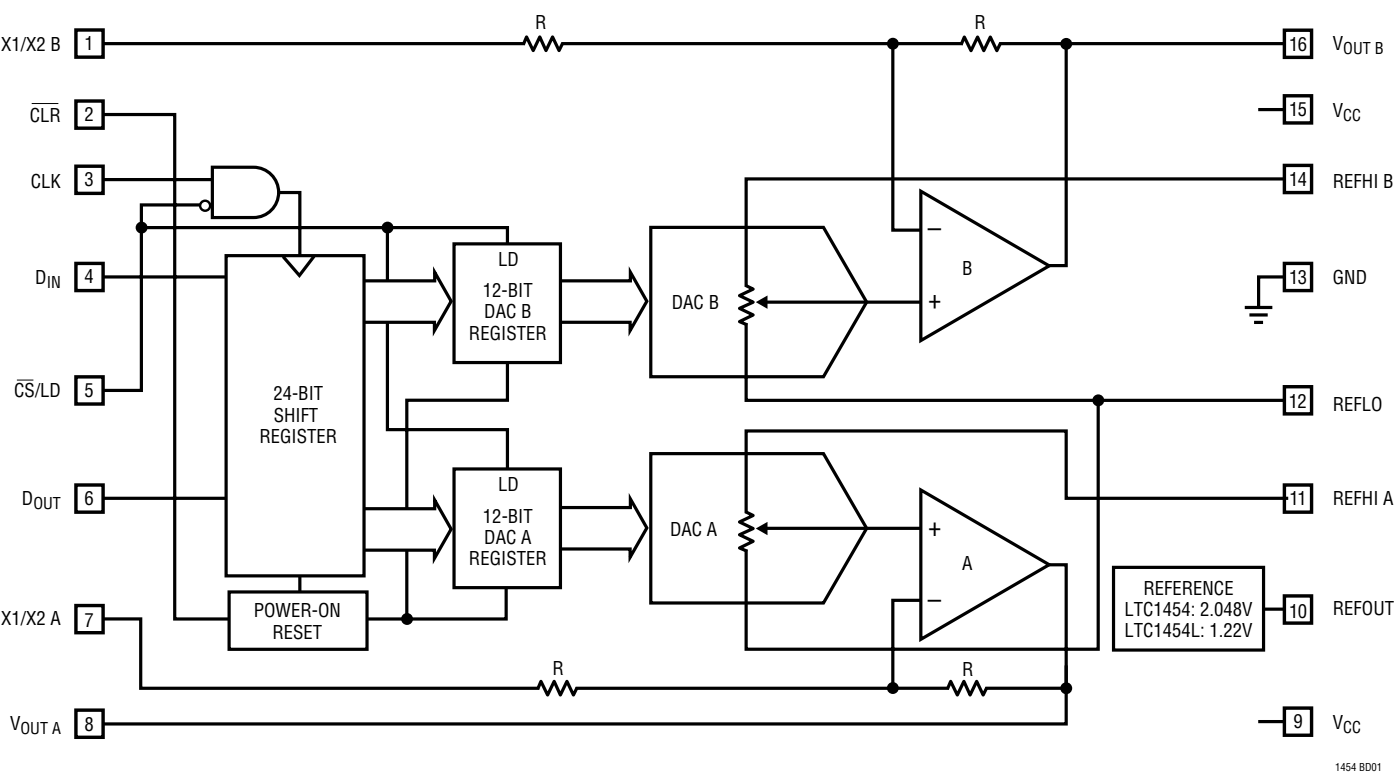
**REF<sub>OUT</sub> (Pin 10):** The Output of the Internal Reference.

**REF<sub>HI A</sub>, REF<sub>HI B</sub> (Pins 11, 14):** The Inputs to the DAC Resistor Ladder for DAC A/B.

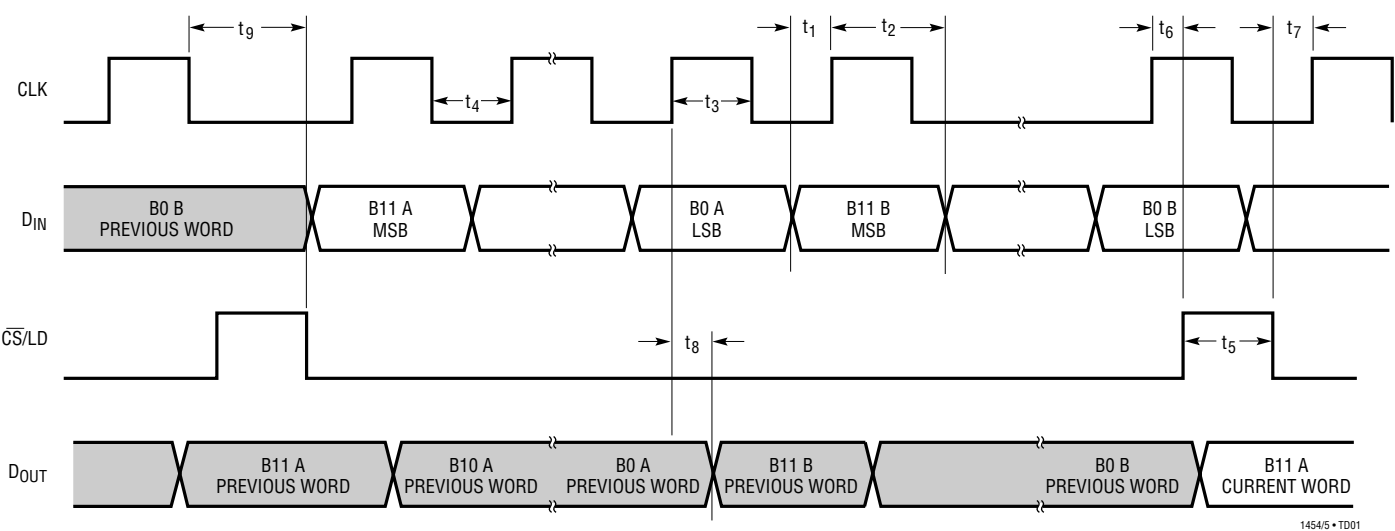
**REF<sub>LO</sub> (Pin 12):** The Bottom of the DAC Resistor Ladder for Both DACs. This can be used to offset zero-scale above ground. REF<sub>LO</sub> should be connected to ground when no offset is required.

**GND (Pin 13):** Ground.

BLOCK DIAGRAM



TIMING DIAGRAM



## DEFINITIONS

**Resolution (n):** Resolution is defined as the number of digital input bits, n. It defines the number of DAC output states ( $2^n$ ) that divide the full-scale range. The resolution does not imply linearity.

**Full-Scale Voltage ( $V_{FS}$ ):** This is the output of the DAC when all bits are set to 1.

**Voltage Offset Error ( $V_{OS}$ ):** The theoretical voltage at the output when the DAC is loaded with all zeros. The output amplifier can have a true negative offset, but because the part is operated from a single supply, the output cannot go below zero. If the offset is negative, the output will remain near 0V resulting in the transfer curve shown in Figure 1.

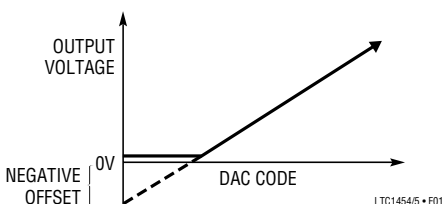


Figure 1. Effect of Negative Offset

The offset of the part is measured at the code that corresponds to the maximum offset specification:

$$V_{OS} = V_{OUT} - (\text{Code})(V_{FS})/(2^n - 1)$$

**Least Significant Bit (LSB):** One LSB is the ideal voltage difference between two successive codes.

$$\text{LSB} = (V_{FS} - V_{OS})/(2^n - 1) = (V_{FS} - V_{OS})/4095$$

Nominal LSBs:

$$\text{LTC1454} \quad \text{LSB} = 4.095\text{V}/4095 = 1\text{mV}$$

$$\text{LTC1454L} \quad \text{LSB} = 2.5\text{V}/4095 = 0.610\text{mV}$$

**Integral Nonlinearity (INL):** End-point INL is the maximum deviation from a straight line passing through the end-points of the DAC transfer curve. Because the part operates from a single supply and the output cannot go below zero, the linearity is measured between full scale and the code corresponding to the maximum offset specification. The INL error at a given input code is calculated as follows:

$$\text{INL} = [V_{OUT} - V_{OS} - (V_{FS} - V_{OS})(\text{Code}/4095)]/\text{LSB}$$

$V_{OUT}$  = The output voltage of the DAC measured at the given input code

**Differential Nonlinearity (DNL):** DNL is the difference between the measured change and the ideal 1LSB change between any two adjacent codes. The DNL error between any two codes is calculated as follows:

$$\text{DNL} = (\Delta V_{OUT} - \text{LSB})/\text{LSB}$$

$\Delta V_{OUT}$  = The measured voltage difference between two adjacent codes

**Digital Feedthrough:** The glitch that appears at the analog output caused by AC coupling from the digital inputs when they change state. The area of the glitch is specified in (nV)(sec).

## OPERATION

### Serial Interface

The data on the  $D_{IN}$  input is loaded into the shift register on the rising edge of the clock. Data is loaded as one 24-bit word, DAC A first, then DAC B. The MSB is loaded first for each DAC. The DAC registers load the data from the shift register when  $\overline{CS}/LD$  is pulled high. The CLK is disabled internally when  $\overline{CS}/LD$  is high. Note: CLK must be low before  $\overline{CS}/LD$  is pulled low to avoid an extra internal clock pulse.

The buffered output of the 24-bit shift register is available on the  $D_{OUT}$  pin which swings from ground to  $V_{CC}$ .

Multiple LTC1454/LTC1454Ls may be daisy-chained together by connecting the  $D_{OUT}$  pin to the  $D_{IN}$  pin of the next chip, while the CLK and  $\overline{CS}/LD$  signals remain common to all chips in the daisy-chain. The serial data is clocked to all of the chips, then the  $\overline{CS}/LD$  signal is pulled high to update all of them simultaneously.

### Reference

The LTC1454L has an internal reference of 1.22V with a full scale of 2.5V (gain of 2 configuration). The LTC1454 includes an internal 2.048V reference, making 1LSB equal to 1mV (gain of 2 configuration). When the buffer gain is 2, the external reference must be less than  $V_{CC}/2$  and be capable of driving the 15k minimum DAC resistor ladder. With a gain of 1 configuration the external reference must be less than  $V_{CC} - 1.5V$ .

### Voltage Output

The rail-to-rail buffered output of the LTC1454 family can source or sink 5mA when operating with a 5V supply while pulling to within 300mV of the positive supply voltage or ground. The output swings to within a few millivolts of either supply rail when unloaded and has an equivalent output resistance of 40 $\Omega$  when driving a load to the rails. The output can drive 1000pF without going into oscillation.

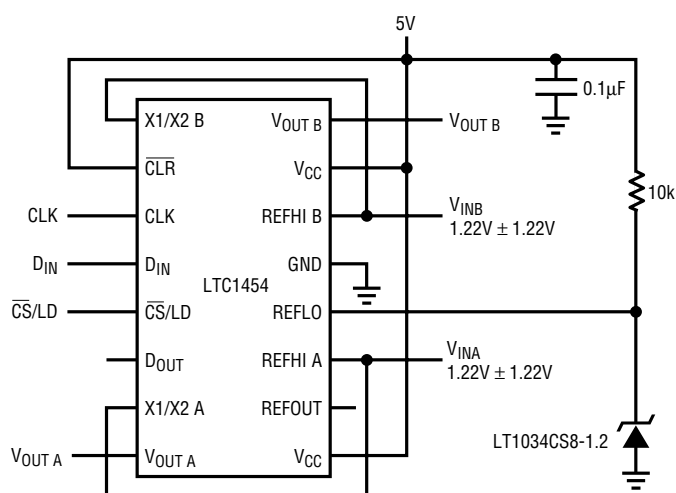


## APPLICATIONS INFORMATION

### A Single Supply, 4-Quadrant Multiplying DAC

The LTC1454 can also be used for 4-quadrant multiplying with an offset signal ground of 1.22V. This application is shown in Figure 2. The inputs are connected to REFHI B or REFHI A and have a 1.22V amplitude around a signal

ground of 1.22V. The outputs will swing from 0V to 2.44V, as shown by the equation with the figure. Since the signal ground is around 1.22V, REFLO is offset above ground by using an LT1034CS8-1.2 as shown.



$$V_{OA/B} = (V_{IN} - V_{REFLO}) \left[ \text{GAIN} \left( \frac{D_{IN}}{4096} - 1 \right) + 1 \right] + V_{REFLO}$$

$$= (V_{IN} - 1.22) \left( 2.0 \frac{D_{IN}}{4096} - 1.0 \right) + 1.22V$$

1454 F02

Figure 2

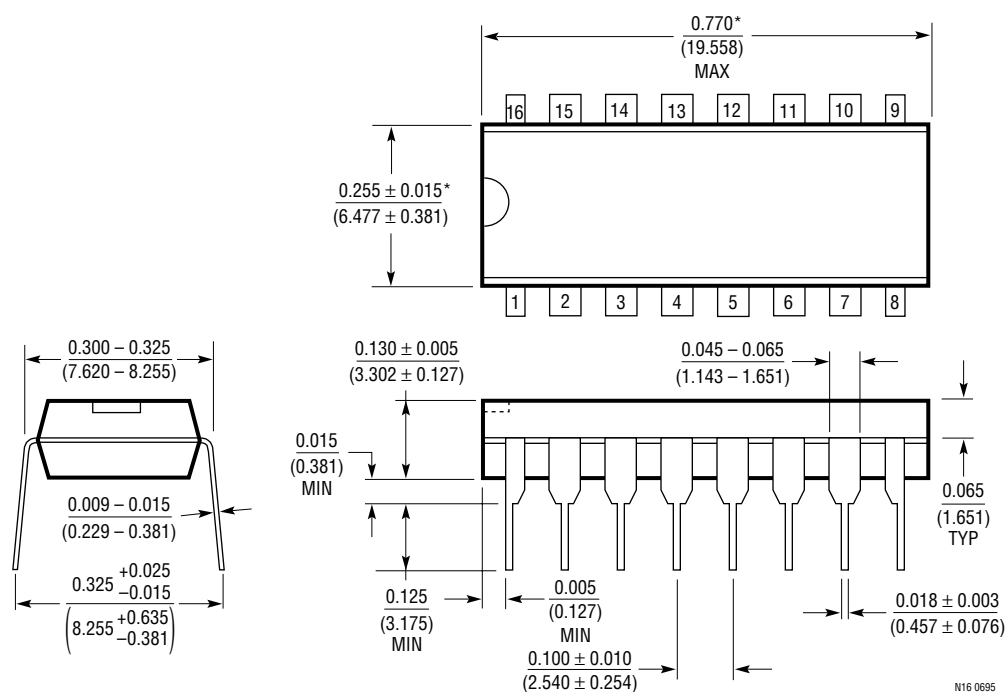
# PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

## N Package

### 16-Lead PDIP (Narrow 0.300)

(LTC DWG # 05-08-1510)



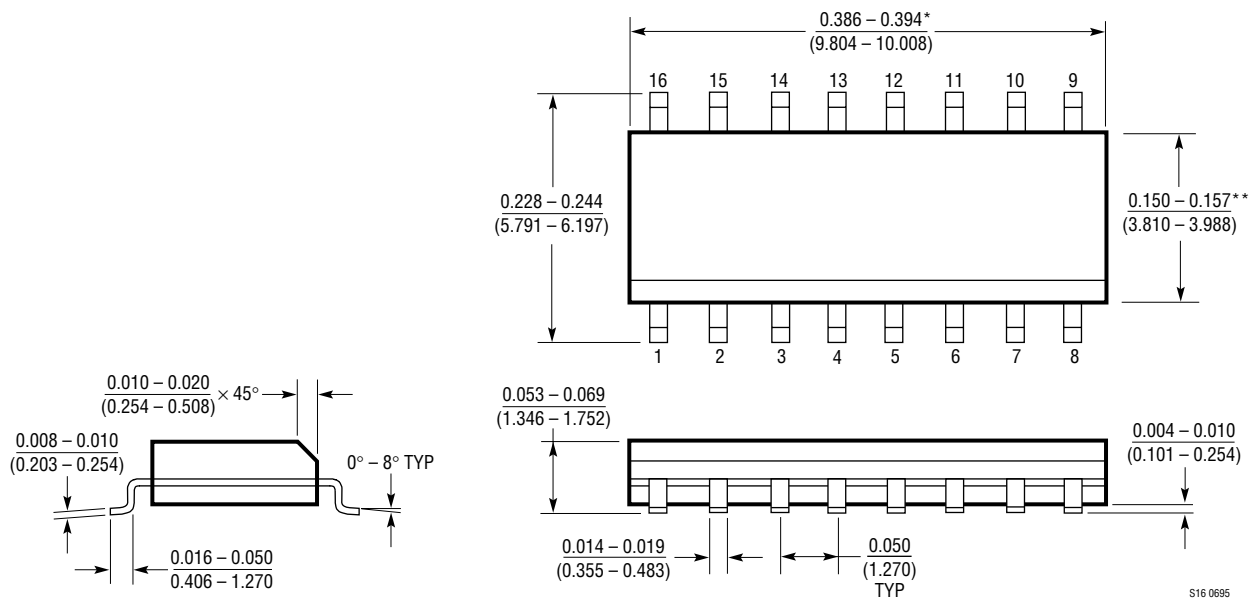
\*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.  
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.254mm)

N16 0695

# PACKAGE DESCRIPTION

Dimensions in inches (millimeters) unless otherwise noted.

## S Package 16-Lead Plastic Small Outline (Narrow 0.150) (LTC DWG # 05-08-1610)



\*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006\* (0.152mm) PER SIDE

\*\*DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010\* (0.254mm) PER SIDE

