

## FEATURES

- Improved Direct Replacement for DAC-8043 and MAX543
- **SO-8 Package**
- **DNL and INL Over Temperature:  $\pm 0.5\text{LSB}$**
- Easy, Fast and Flexible Serial Interface
- **$\pm 1\text{LSB}$  Maximum Gain Error**
- 4-Quadrant Multiplication
- Low Power Consumption
- Low Cost

## APPLICATIONS

- Process Control and Industrial Automation
- Remote Microprocessor-Controlled Systems
- Digitally Controlled Filters and Power Supplies
- Programmable Gain Amplifiers
- Automatic Test Equipment

## DESCRIPTION

The LTC<sup>®</sup>8043 is a serial-input 12-bit multiplying digital-to-analog converter (DAC). It is a superior pin compatible replacement for the DAC-8043. Improvements include better accuracy, better stability over temperature and supply variations, lower sensitivity to output amplifier offset, tighter timing specifications and lower output capacitance.

An easy-to-use 3-wire serial interface is well-suited to remote or isolated applications

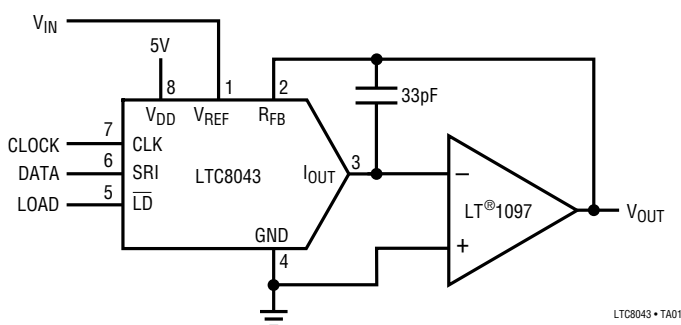
The LTC8043 is extremely versatile. It can be used for 2-quadrant and 4-quadrant multiplying, programmable gain and single supply applications, such as noninverting voltage output mode.

Parts are available in 8-pin SO and PDIP packages and are specified over the extended industrial temperature range,  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

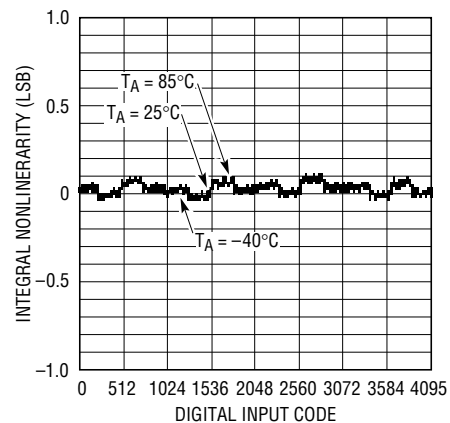
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## TYPICAL APPLICATION

**SO-8 Multiplying DAC Has Easy 3-Wire Serial Interface**



**Integral Nonlinearity Over Temperature**



## ABSOLUTE MAXIMUM RATINGS

|                                            |                              |
|--------------------------------------------|------------------------------|
| $V_{DD}$ to GND .....                      | –0.5V to 7V                  |
| Digital Inputs to GND .....                | –0.5V to ( $V_{DD} + 0.5V$ ) |
| $V_{IOUT}$ to GND .....                    | –0.5V to ( $V_{DD} + 0.5V$ ) |
| $V_{REF}$ to GND .....                     | $\pm 25V$                    |
| $V_{RFB}$ to GND .....                     | $\pm 25V$                    |
| Maximum Junction Temperature .....         | 150°C                        |
| Operating Temperature Range .....          | –40°C to 85°C                |
| Storage Temperature Range .....            | –65°C to 150°C               |
| Lead Temperature (Soldering, 10 sec) ..... | 300°C                        |

## PACKAGE/ORDER INFORMATION

|                                                                                                                                                                                                                                                                                 |  |                                                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------------------------|
| <p>TOP VIEW</p> <p>N8 PACKAGE<br/>8-LEAD PDIP</p> <p>S8 PACKAGE<br/>8-LEAD PLASTIC SO</p> <p><math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 130^{\circ}C/W</math> (N8)<br/> <math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 190^{\circ}C/W</math> (S8)</p> |  | ORDER PART NUMBER                                    |
|                                                                                                                                                                                                                                                                                 |  | LTC8043EN8<br>LTC8043FN8<br>LTC8043ES8<br>LTC8043FS8 |

Consult factory for Military grade parts.

## ACCURACY CHARACTERISTICS

 $V_{DD} = 5V$ ,  $V_{REF} = 10V$ ,  $V_{IOUT} = GND = 0V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified.

| SYMBOL    | PARAMETER                                                  | CONDITIONS                                                | LTC8043E |              |             | LTC8043F |              |             | UNITS            |
|-----------|------------------------------------------------------------|-----------------------------------------------------------|----------|--------------|-------------|----------|--------------|-------------|------------------|
|           |                                                            |                                                           | MIN      | TYP          | MAX         | MIN      | TYP          | MAX         |                  |
|           | Resolution                                                 |                                                           | 12       |              |             | 12       |              |             | Bits             |
| INL       | Integral Nonlinearity                                      | (Note 1)                                                  |          |              | $\pm 0.5$   |          |              | $\pm 1$     | LSB              |
| DNL       | Differential Nonlinearity                                  | Guaranteed Monotonic, $T_{MIN}$ to $T_{MAX}$              |          |              | $\pm 0.5$   |          |              | $\pm 1$     | LSB              |
| GE        | Gain Error                                                 | (Note 2)<br>$T_A = 25^{\circ}C$<br>$T_{MIN}$ to $T_{MAX}$ |          |              | $\pm 1$     |          |              | $\pm 2$     | LSB              |
|           |                                                            |                                                           |          |              | $\pm 2$     |          |              | $\pm 2$     | LSB              |
|           | Gain Temperature Coefficient ( $\Delta Gain/\Delta Temp$ ) | (Note 3)                                                  |          | 1            | 5           |          | 1            | 5           | ppm/ $^{\circ}C$ |
| $I_{LKG}$ | Output Leakage Current                                     | (Note 4)<br>$T_A = 25^{\circ}C$<br>$T_{MIN}$ to $T_{MAX}$ |          |              | $\pm 5$     |          |              | $\pm 5$     | nA               |
|           |                                                            |                                                           |          |              | $\pm 25$    |          |              | $\pm 25$    | nA               |
|           | Zero-Scale Error                                           | $T_A = 25^{\circ}C$<br>$T_{MIN}$ to $T_{MAX}$             |          |              | $\pm 0.03$  |          |              | $\pm 0.03$  | LSB              |
|           |                                                            |                                                           |          |              | $\pm 0.15$  |          |              | $\pm 0.15$  | LSB              |
| PSRR      | Power Supply Rejection Ratio                               | $V_{DD} = 5V \pm 5\%$                                     |          | $\pm 0.0001$ | $\pm 0.002$ |          | $\pm 0.0001$ | $\pm 0.002$ | %/%              |

## ELECTRICAL CHARACTERISTICS

 $V_{DD} = 5V$ ,  $V_{REF} = 10V$ ,  $V_{IOUT} = GND = 0V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified.

| SYMBOL                  | PARAMETER                         | CONDITIONS                              |   | ALL GRADES |      |     | UNITS             |
|-------------------------|-----------------------------------|-----------------------------------------|---|------------|------|-----|-------------------|
|                         |                                   |                                         |   | MIN        | TYP  | MAX |                   |
| Reference Input         |                                   |                                         |   |            |      |     |                   |
| R <sub>REF</sub>        | V <sub>REF</sub> Input Resistance | (Note 5)                                | ● | 7          | 11   | 15  | kΩ                |
| AC Performance (Note 3) |                                   |                                         |   |            |      |     |                   |
|                         | Output Current Settling Time      | (Notes 6, 7)                            | ● |            | 0.25 | 1   | μs                |
|                         | Multiplying Feedthrough Error     | V <sub>REF</sub> = ±10V, 10kHz Sinewave | ● |            | 0.7  | 1   | mV <sub>P-P</sub> |
|                         | Digital-to-Analog Glitch Energy   | (Notes 6, 8)                            | ● |            | 2    | 20  | nVSEC             |
| THD                     | Total Harmonic Distortion         | (Note 9)                                | ● |            | −108 | −92 | dB                |
|                         | Output Noise Voltage Density      | (Note 10)                               | ● |            |      | 17  | nV/√Hz            |
| Analog Outputs (Note 3) |                                   |                                         |   |            |      |     |                   |
| C <sub>OUT</sub>        | Output Capacitance                | DAC Register Loaded to All 1s           | ● |            | 60   | 90  | pF                |
|                         |                                   | DAC Register Loaded to All 0s           | ● |            | 30   | 60  | pF                |

## ELECTRICAL CHARACTERISTICS

$V_{DD} = 5V$ ,  $V_{REF} = 10V$ ,  $V_{IOUT} = GND = 0V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified.

| SYMBOL                          | PARAMETER                                                 | CONDITIONS                                          | ALL GRADES |       |     | UNITS |    |
|---------------------------------|-----------------------------------------------------------|-----------------------------------------------------|------------|-------|-----|-------|----|
|                                 |                                                           |                                                     | MIN        | TYP   | MAX |       |    |
| Digital Inputs                  |                                                           |                                                     |            |       |     |       |    |
| V <sub>IH</sub>                 | Digital Input High Voltage                                |                                                     | ●          | 2.4   |     | V     |    |
| V <sub>IL</sub>                 | Digital Input Low Voltage                                 |                                                     | ●          |       | 0.8 | V     |    |
| I <sub>IN</sub>                 | Digital Input Current                                     | V <sub>IN</sub> = 0V to V <sub>DD</sub>             | ●          | 0.001 | ±1  | μA    |    |
| C <sub>IN</sub>                 | Digital Input Capacitance                                 | V <sub>IN</sub> = 0V,(Note 3)                       | ●          |       | 8   | pF    |    |
| Timing Characteristics (Note 3) |                                                           |                                                     |            |       |     |       |    |
| t <sub>DS</sub>                 | Serial Input to Clock Setup Time                          |                                                     | ●          | 30    | –5  | ns    |    |
| t <sub>DH</sub>                 | Serial Input to Clock Hold Time                           |                                                     | ●          | 60    | 25  | ns    |    |
| t <sub>SRI</sub>                | Serial Input Data Pulse Width                             |                                                     | ●          | 80    |     | ns    |    |
| t <sub>CH</sub>                 | Clock Pulse Width High                                    |                                                     | ●          | 80    |     | ns    |    |
| t <sub>CL</sub>                 | Clock Pulse Width Low                                     |                                                     | ●          | 80    |     | ns    |    |
| t <sub>LD</sub>                 | Load Pulse Width                                          |                                                     | ●          | 140   |     | ns    |    |
| t <sub>ASB</sub>                | LSB Clocked into Input Register to Load DAC Register Time |                                                     | ●          | 0     |     | ns    |    |
| Power Supply                    |                                                           |                                                     |            |       |     |       |    |
| V <sub>DD</sub>                 | Supply Voltage                                            |                                                     | ●          | 4.75  | 5   | 5.25  | V  |
| I <sub>DD</sub>                 | Supply Current                                            | Digital Inputs = 0V or V <sub>DD</sub>              | ●          |       | 100 |       | μA |
|                                 |                                                           | Digital Inputs = V <sub>IH</sub> or V <sub>IN</sub> | ●          |       | 500 |       | μA |

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

**Note 1:**  $\pm 0.5LSB = \pm 0.012\%$  of full scale.

**Note 2:** Using internal feedback resistor.

**Note 3:** Guaranteed by design, not subject to test.

**Note 4:**  $I_{OUT}$  with DAC register loaded with all 0s.

**Note 5:** Typical temperature coefficient is 100ppm/°C.

**Note 6:**  $I_{OUT}$  load = 100Ω in parallel with 13pF.

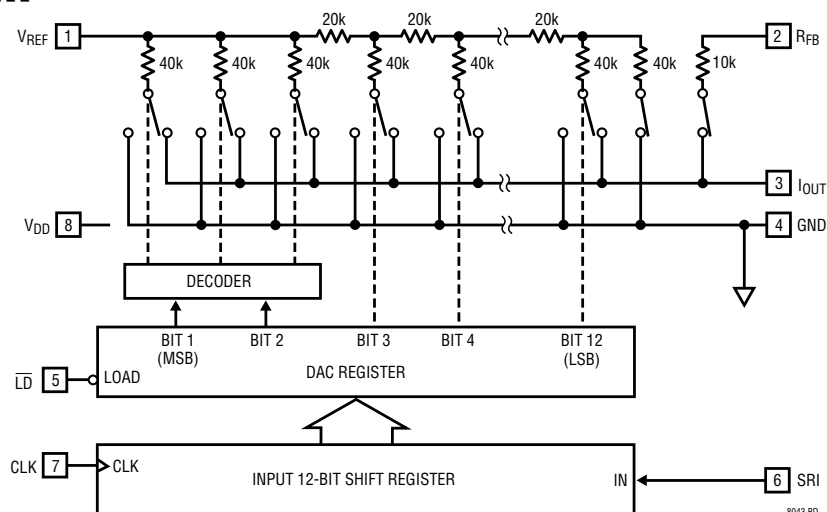
**Note 7:** To 0.01% for a full-scale change, measured from falling edge of  $\overline{LD}$ .

**Note 8:**  $V_{REF} = 0V$ . DAC register contents changed from all 0s to all 1s or from all 1s to all 0s.

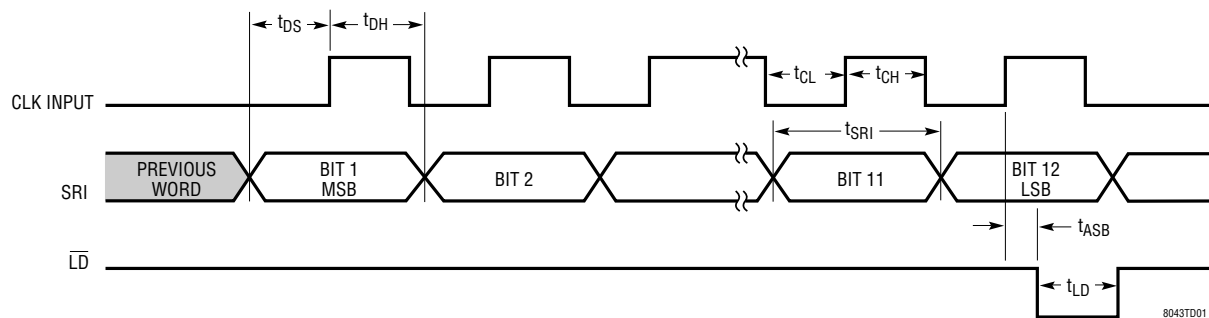
**Note 9:**  $V_{REF} = 6V_{RMS}$  at 1kHz. DAC register loaded with all 1s.

**Note 10:** 10Hz to 100kHz between  $R_{FB}$  and  $I_{OUT}$ . Calculation from  $e_n = \sqrt{4KTRB}$  where: K = Boltzmann constant (J/K°); R = resistance (Ω); T = resistor temperature (°K); B = bandwidth (Hz).

## BLOCK DIAGRAM



TIMING DIAGRAM



TYPICAL APPLICATIONS

Unipolar Operation (2-Quadrant Multiplication)

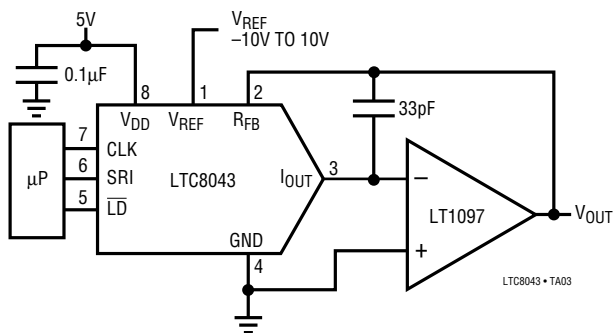


Table 1. Unipolar Binary Code Table

| DIGITAL INPUT<br>BINARY NUMBER<br>IN DAC REGISTER |      | ANALOG OUTPUT<br>$V_{OUT}$            |
|---------------------------------------------------|------|---------------------------------------|
| MSB                                               | LSB  |                                       |
| 1111                                              | 1111 | $-V_{REF}$ (4095/4096)                |
| 1000                                              | 0000 | $-V_{REF}$ (2048/4096) = $-V_{REF}/2$ |
| 0000                                              | 0000 | $-V_{REF}$ (1/4096)                   |
| 0000                                              | 0000 | 0V                                    |

Bipolar Operation (4-Quadrant Multiplication)

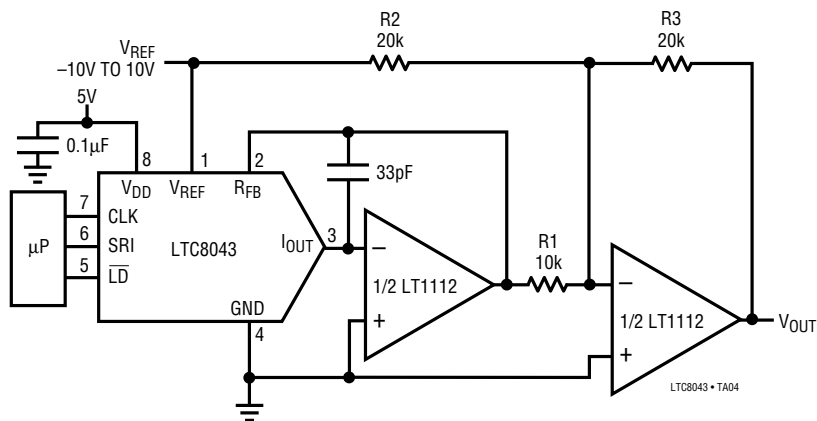


Table 2. Bipolar Offset Binary Code Table

| DIGITAL INPUT<br>BINARY NUMBER<br>IN DAC REGISTER |      | ANALOG OUTPUT<br>$V_{OUT}$          |
|---------------------------------------------------|------|-------------------------------------|
| MSB                                               | LSB  |                                     |
| 1111                                              | 1111 | $+V_{REF}$ (2047/2048)              |
| 1000                                              | 0000 | $+V_{REF}$ (1/2048)                 |
| 1000                                              | 0000 | 0V                                  |
| 0111                                              | 1111 | $-V_{REF}$ (1/2048)                 |
| 0000                                              | 0000 | $-V_{REF}$ (2048/2048) = $-V_{REF}$ |

RELATED PARTS

| PART NUMBER             | DESCRIPTION                               | COMMENTS                                     |
|-------------------------|-------------------------------------------|----------------------------------------------|
| LTC1257                 | Complete Serial I/O $V_{OUT}$ 12-Bit DAC  | 5V to 15V Single Supply in 8-Pin SO and PDIP |
| LTC1451/LTC1452/LTC1453 | Complete Serial I/O $V_{OUT}$ 12-Bit DACs | 3V/5V Single Supply in 8-Pin SO and PDIP     |
| LTC7541A                | Parallel I/O Multiplying 12-Bit DAC       | 12-Bit Wide Input                            |
| LTC7543/LTC8143         | Serial I/O Multiplying 12-Bit DACs        | Clear Pin and Serial Data Output (LTC8143)   |

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