

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[®]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

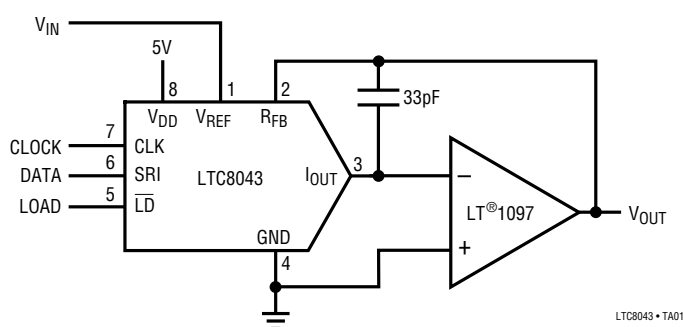
The LTC8043 is extremely versatile. It can be used for 2-quadrant and 4-quadrant multiplying, programmable gain and single supply applications, such as noninverting voltage output mode.

Parts are available in 8-pin SO and PDIP packages and are specified over the extended industrial temperature range, -40°C to 85°C .

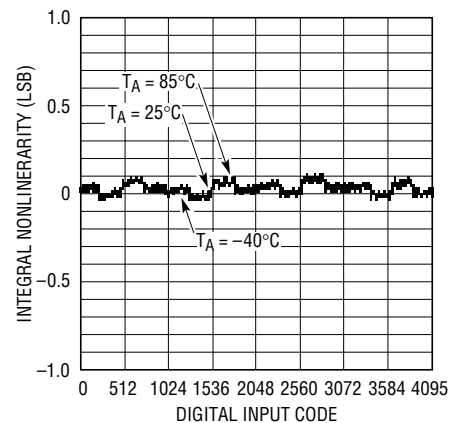
 LTC and LT are registered trademarks of Linear Technology Corporation.

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

TOP VIEW

N8 PACKAGE
8-LEAD PDIP

S8 PACKAGE
8-LEAD PLASTIC SO

$T_{JMAX} = 150^{\circ}C, \theta_{JA} = 130^{\circ}C/W$ (N8)
 $T_{JMAX} = 150^{\circ}C, \theta_{JA} = 190^{\circ}C/W$ (S8)

ORDER PART NUMBER

LTC8043EN8
LTC8043FN8
LTC8043ES8
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) | ● | | ± 0.5 | | ± 1 | LSB | |
| DNL | Differential Nonlinearity | Guaranteed Monotonic, T_{MIN} to T_{MAX} | ● | | ± 0.5 | | ± 1 | LSB | |
| GE | Gain Error | (Note 2) $T_A = 25^{\circ}C$ T_{MIN} to T_{MAX} | ● | | ± 1 | | ± 2 | LSB | |
| | | | ● | | ± 2 | | ± 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) $T_A = 25^{\circ}C$ T_{MIN} to T_{MAX} | ● | | ± 5 | | ± 5 | nA | |
| | | | ● | | ± 25 | | ± 25 | nA | |
| | Zero-Scale Error | $T_A = 25^{\circ}C$ T_{MIN} to T_{MAX} | ● | | ± 0.03 ± 0.15 | | ± 0.03 ± 0.15 | LSB LSB | |
| PSRR | Power Supply Rejection Ratio | $V_{DD} = 5V \pm 5\%$ | ● | ± 0.0001 | ± 0.002 | ± 0.0001 | ± 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_{REF} | V_{REF} Input Resistance | (Note 5) | ● | 7 | 11 | 15 | k Ω |
| AC Performance (Note 3) | | | | | | | |
| | Output Current Settling Time | (Notes 6, 7) | ● | 0.25 | 1 | | μs |
| | Multiplying Feedthrough Error | $V_{REF} = \pm 10V, 10kHz$ Sinewave | ● | 0.7 | 1 | | mV _{P-P} |
| | 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/ \sqrt{Hz} |
| Analog Outputs (Note 3) | | | | | | | |
| C_{OUT} | 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_{IH} | Digital Input High Voltage | | ● | 2.4 | | V | |
| V_{IL} | Digital Input Low Voltage | | ● | | 0.8 | V | |
| I_{IN} | Digital Input Current | $V_{IN} = 0V$ to V_{DD} | ● | 0.001 | ± 1 | μA | |
| C_{IN} | Digital Input Capacitance | $V_{IN} = 0V$, (Note 3) | ● | | 8 | pF | |
| Timing Characteristics (Note 3) | | | | | | | |
| t_{DS} | Serial Input to Clock Setup Time | | ● | 30 | -5 | ns | |
| t_{DH} | Serial Input to Clock Hold Time | | ● | 60 | 25 | ns | |
| t_{SRI} | Serial Input Data Pulse Width | | ● | 80 | | ns | |
| t_{CH} | Clock Pulse Width High | | ● | 80 | | ns | |
| t_{CL} | Clock Pulse Width Low | | ● | 80 | | ns | |
| t_{LD} | Load Pulse Width | | ● | 140 | | ns | |
| t_{ASB} | LSB Clocked into Input Register to Load DAC Register Time | | ● | 0 | | ns | |
| Power Supply | | | | | | | |
| V_{DD} | Supply Voltage | | ● | 4.75 | 5 | 5.25 | V |
| I_{DD} | Supply Current | Digital Inputs = 0V or V_{DD} Digital Inputs = V_{IH} or V_{IN} | ● ● | | 100 500 | μA 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 = 100 Ω in parallel with 13pF.

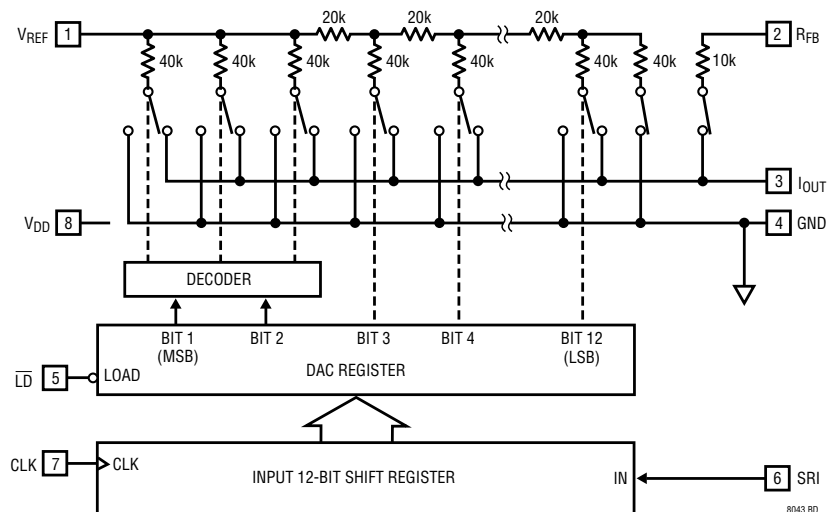
Note 7: To 0.01% for a full-scale change, measured from falling edge of \overline{LD} .

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

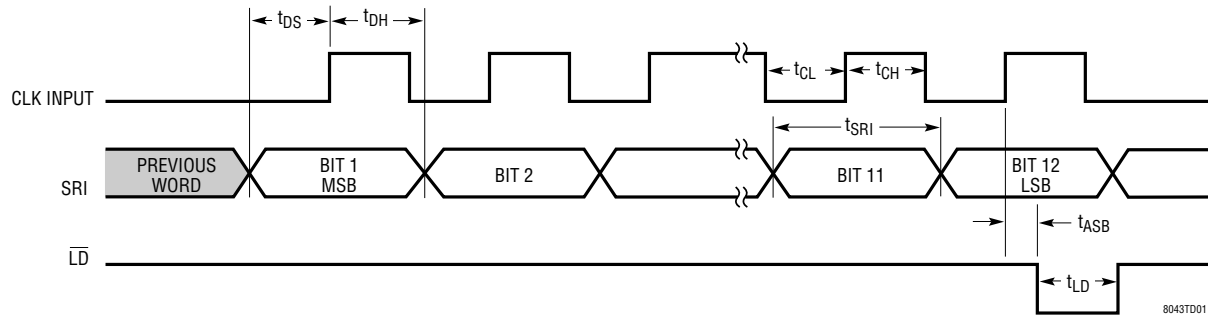
Note 9: $V_{REF} = 6V_{RMS}$ at 1kHz. DAC register loaded with all 1s.

Note 10: 10Hz to 100kHz between R_{FB} and I_{OUT} . Calculation from $e_n = \sqrt{4KTRB}$ where: K = Boltzmann constant (J/K²); R = resistance (Ω); T = resistor temperature ($^{\circ}K$); B = bandwidth (Hz).

BLOCK DIAGRAM



TIMING DIAGRAM



TYPICAL APPLICATIONS

Unipolar Operation (2-Quadrant Multiplication)

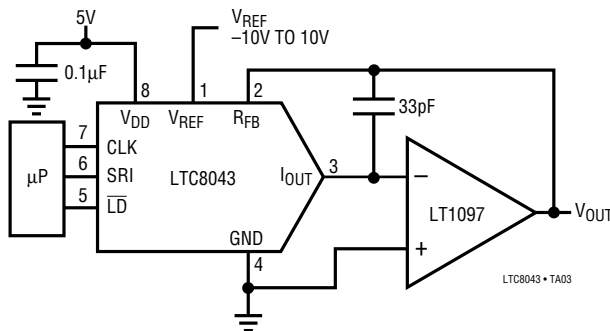


Table 1. Unipolar Binary Code Table

| DIGITAL INPUT BINARY NUMBER IN DAC REGISTER | | ANALOG OUTPUT 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)

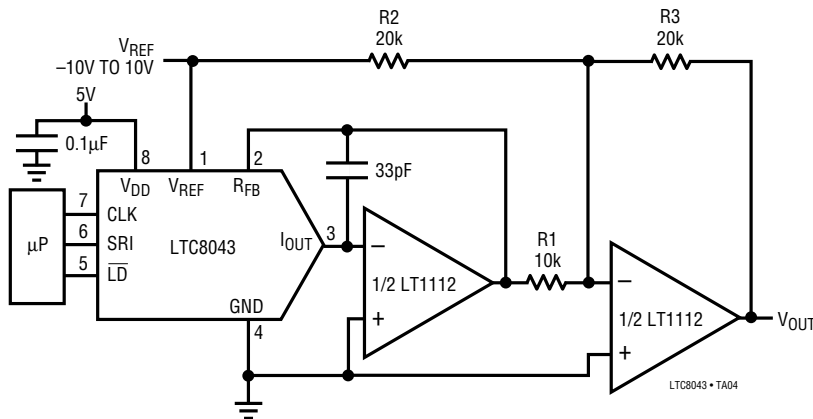


Table 2. Bipolar Offset Binary Code Table

| DIGITAL INPUT BINARY NUMBER IN DAC REGISTER | | ANALOG OUTPUT 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) |