

## 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

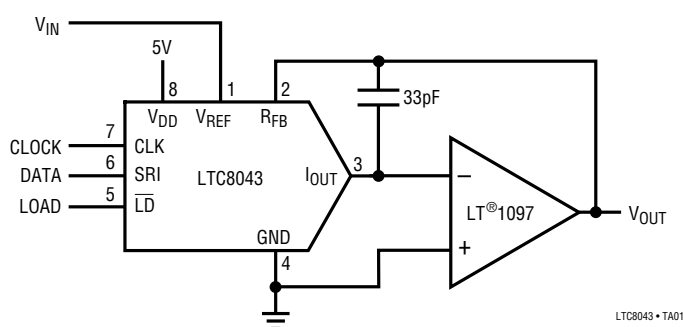
The LTC8043 is extremely versatile. It can be used for 2-quadrant and 4-quadrant multiplying, programmable gain and single supply applications, such as noninverting voltage output mode.

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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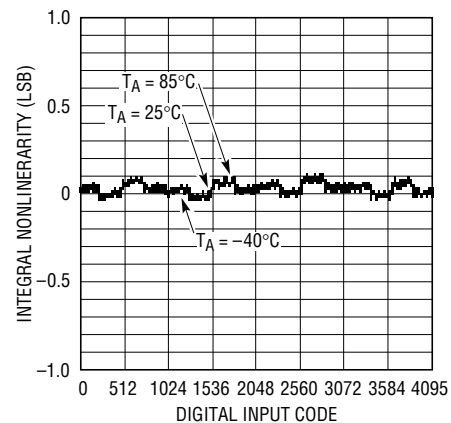
## TYPICAL APPLICATION

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



LTC8043 • TA01

Integral Nonlinearity Over Temperature



LTC8043 • TPC02

**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)	●		$\pm 0.5$		$\pm 1$	LSB	
DNL	Differential Nonlinearity	Guaranteed Monotonic, $T_{MIN}$ to $T_{MAX}$	●		$\pm 0.5$		$\pm 1$	LSB	
GE	Gain Error	(Note 2) $T_A = 25^{\circ}C$ $T_{MIN}$ 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) $T_A = 25^{\circ}C$ $T_{MIN}$ to $T_{MAX}$	●		$\pm 5$		$\pm 5$	nA	
			●		$\pm 25$		$\pm 25$	nA	
	Zero-Scale Error	$T_A = 25^{\circ}C$ $T_{MIN}$ to $T_{MAX}$	●		$\pm 0.03$ $\pm 0.15$		$\pm 0.03$ $\pm 0.15$	LSB 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		
<b>Reference Input</b>							
$R_{REF}$	$V_{REF}$ Input Resistance	(Note 5)	●	7	11	15	k $\Omega$
<b>AC Performance (Note 3)</b>							
	Output Current Settling Time	(Notes 6, 7)	●	0.25	1		$\mu s$
	Multiplying Feedthrough Error	$V_{REF} = \pm 10V, 10kHz$ 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/ $\sqrt{Hz}$
<b>Analog Outputs (Note 3)</b>							
$C_{OUT}$	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		
<b>Digital Inputs</b>							
$V_{IH}$	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	$\pm 1$	$\mu A$	
$C_{IN}$	Digital Input Capacitance	$V_{IN} = 0V$ , (Note 3)	●		8	pF	
<b>Timing Characteristics (Note 3)</b>							
$t_{DS}$	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	
<b>Power Supply</b>							
$V_{DD}$	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	$\mu A$ $\mu A$	

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 $\Omega$  in parallel with 13pF.

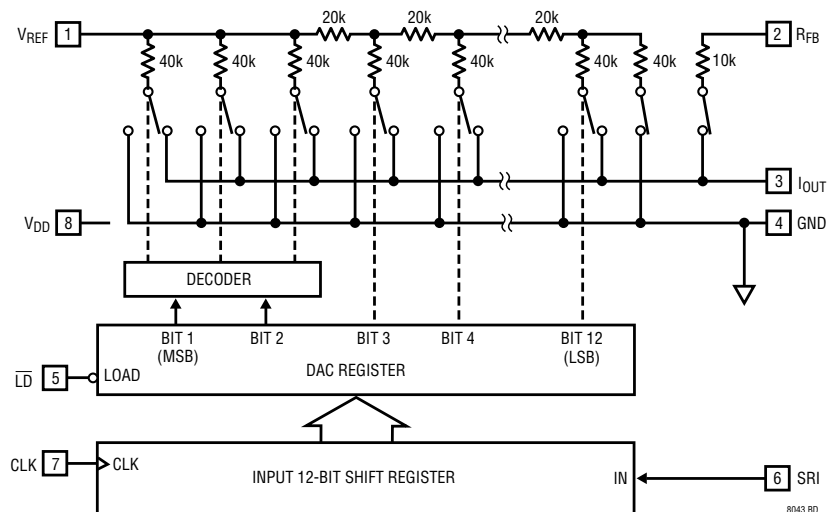
**Note 7:** To 0.01% for a full-scale change, measured from falling edge of  $\overline{LD}$ .

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

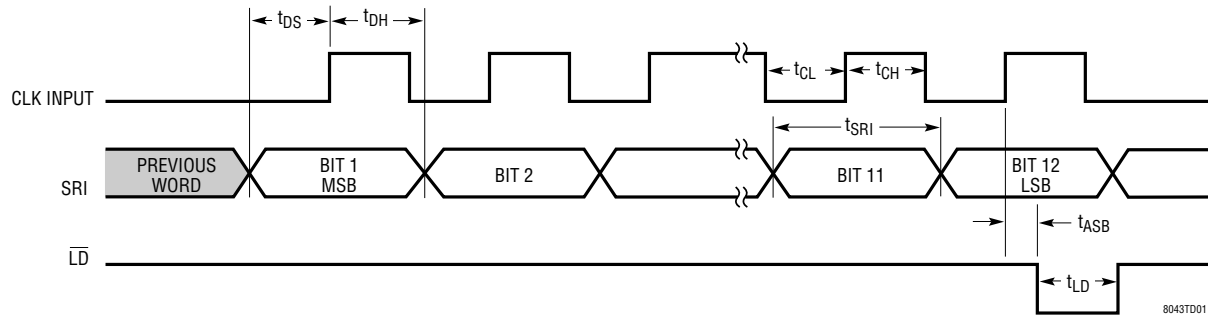
**Note 9:**  $V_{REF} = 6V_{RMS}$  at 1kHz. DAC register loaded with all 1s.

**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 ( $\Omega$ ); T = resistor temperature (°K); B = bandwidth (Hz).

## BLOCK DIAGRAM



## TIMING DIAGRAM



## TYPICAL APPLICATIONS

### Unipolar Operation (2-Quadrant Multiplication)

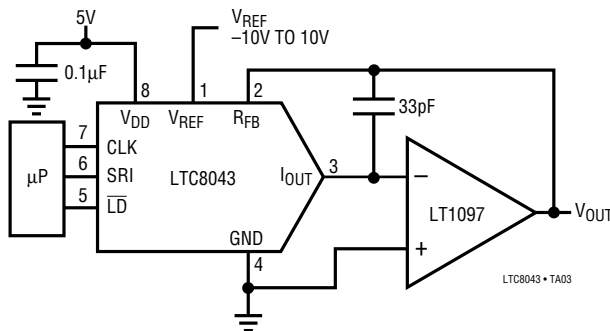


Table 1. Unipolar Binary Code Table

DIGITAL INPUT 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)

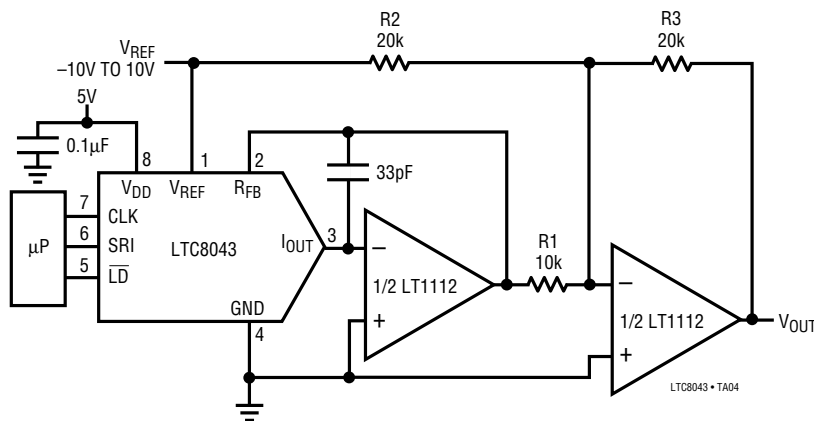


Table 2. Bipolar Offset Binary Code Table

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)