

## FEATURES

- Improved Direct Replacement for AD7543 and DAC-8143
- Low Cost
- DNL and INL Over Temperature:  $\pm 0.5$ LSB
- Easy, Fast and Flexible Serial Interface
- Daisy-Chain 3-Wire Interface for Multiple DAC Systems (LTC8143)
- 1LSB Maximum Gain Error Over Temperature Eliminates Adjustment
- Asynchronous Clear Input for Initialization
- Four-Quadrant Multiplication
- Low Power Consumption
- 16-Pin PDIP and SO Packages

## 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>7543/LTC8143 are serial-input 12-bit multiplying digital-to-analog converters (DACs). They are superior pin compatible replacements for the AD7543 and DAC-8143. 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 serial interface includes an asynchronous CLEAR input for systems requiring initialization to a known state. The LTC8143 has a serial data output to allow daisy-chaining multiple DACs on a 3-wire interface bus.

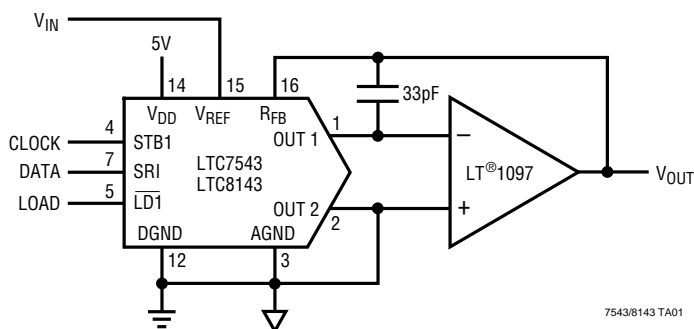
These DACs are extremely versatile. They can be used for 2-quadrant and 4-quadrant multiplying, programmable gain and single supply applications, such as noninverting voltage output and biased or offset ground mode.

Parts are available in 16-pin PDIP and SO packages and are specified over the extended industrial temperature range,  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

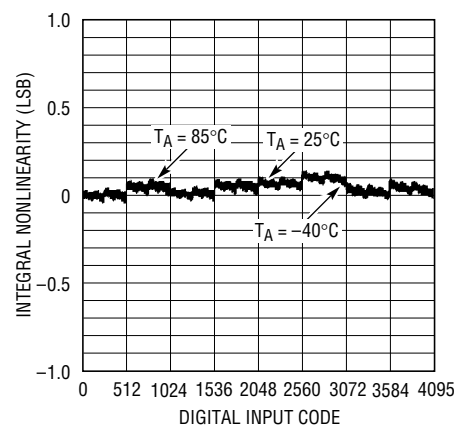
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## TYPICAL APPLICATION

Multiplying DAC Has Easy 3-Wire Serial Interface



Integral Nonlinearity Over Temperature



## ABSOLUTE MAXIMUM RATINGS

$V_{DD}$ to AGND .....	-0.5V to 7V
$V_{DD}$ to DGND .....	-0.5V to 7V
AGND to DGND .....	$V_{DD} + 0.5V$
DGND to AGND .....	$V_{DD} + 0.5V$
Digital Inputs to DGND .....	-0.5V to ( $V_{DD} + 0.5V$ )
$V_{OUT1}$ , $V_{OUT2}$ to AGND .....	-0.5V to ( $V_{DD} + 0.5V$ )
$V_{REF}$ to AGND, DGND .....	$\pm 25V$
$V_{RFB}$ to AGND, DGND .....	$\pm 25V$
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>ORDER PART NUMBER</p> <p>LTC7543GKN LTC7543KN LTC7543GKSW LTC7543KSW LTC8143EN LTC8143FN LTC8143ESW LTC8143FSW</p>
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N PACKAGE  
 16-LEAD PDIP  
 SW PACKAGE  
 16-LEAD PLASTIC SO WIDE  
 $T_{JMAX} = 150^{\circ}C$ ,  $\theta_{JA} = 100^{\circ}C/W$  (N)  
 $T_{JMAX} = 150^{\circ}C$ ,  $\theta_{JA} = 130^{\circ}C/W$  (SW)

Consult factory for Military grade parts.

## ACCURACY CHARACTERISTICS – LTC7543

$V_{DD} = 5V$ ,  $V_{REF} = 10V$ ,  $V_{OUT1} = V_{OUT2} = AGND = DGND = 0V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	LTC7543GK			LTC7543K			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
	Resolution		●	12			12		Bits
INL	Integral Nonlinearity (Relative Accuracy)	(Note 1)	●		$\pm 0.5$			$\pm 0.5$	LSB
DNL	Differential Nonlinearity	Guaranteed Monotonic, $T_{MIN}$ to $T_{MAX}$	●		$\pm 0.5$			$\pm 0.5$	LSB
GE	Gain Error	(Note 2) $T_A = 25^{\circ}C$ $T_{MIN}$ to $T_{MAX}$	●		$\pm 1$			$\pm 2$	LSB
			●		$\pm 1$			$\pm 2$	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 $T_{MAX}$	●		$\pm 1$			$\pm 1$	nA
			●		$\pm 10$			$\pm 10$	nA
	Zero-Scale Error	$T_A = 25^{\circ}C$ $T_{MIN}$ to $T_{MAX}$	●		$\pm 0.006$			$\pm 0.006$	LSB
			●		$\pm 0.06$			$\pm 0.06$	LSB
PSRR	Power Supply Rejection Ratio	$V_{DD} = 5V \pm 5\%$	●	$\pm 0.0001$	$\pm 0.002$		$\pm 0.0001$	$\pm 0.002$	%/%

**ACCURACY CHARACTERISTICS – LTC8143** $V_{DD} = 5V$ ,  $V_{REF} = 10V$ ,  $V_{OUT1} = V_{OUT2} = AGND = DGND = 0V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	LTC8143E			LTC8143F			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
	Resolution		●	12			12		Bits
INL	Integral Nonlinearity (Relative Accuracy)	(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		±2 ±2	LSB 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 ±25		±5 ±25	nA 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 – LTC7543/LTC8143** $V_{DD} = 5V$ ,  $V_{REF} = 10V$ ,  $V_{OUT1} = V_{OUT2} = AGND = DGND = 0V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	LTC7543/LTC8143 ALL GRADES			UNITS	
			MIN	TYP	MAX		
<b>Reference Input</b>							
$R_{REF}$	$V_{REF}$ Input Resistance	(Note 5)	●	8	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	●		0.8	2	mV <sub>p-p</sub>
	Digital-to-Analog Glitch Energy	(Notes 6, 8)	●		2	20	nV-sec
THD	Total Harmonic Distortion	(Note 9)	●		-108	-92	dB
	Output Noise Voltage Density	(Note 10)	●			13	nV/ $\sqrt{Hz}$
<b>Analog Outputs (Note 3)</b>							
$C_{OUT}$	Output Capacitance	DAC Register Loaded to All 1s	$C_{OUT1}$	●	60	90	pF
			$C_{OUT2}$	●	20	60	pF
		DAC Register Loaded to All 0s	$C_{OUT1}$	●	30	60	pF
			$C_{OUT2}$	●	50	90	pF
<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	±1	$\mu A$
$C_{IN}$	Digital Input Capacitance	(Note 3), $V_{IN} = 0V$	●			8	pF
<b>Digital Outputs: SRO (LTC8143 Only)</b>							
$V_{OH}$	Digital Output High	$I_{OH} = -200\mu A$	●	4			V
$V_{OL}$	Digital Output Low	$I_{OL} = 1.6mA$	●			0.4	V

**ELECTRICAL CHARACTERISTICS – LTC7543/LTC8143**

$V_{DD} = 5V$ ,  $V_{REF} = 10V$ ,  $V_{OUT1} = V_{OUT2} = AGND = DGND = 0V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	LTC7543/LTC8143 ALL GRADES			UNITS	
			MIN	TYP	MAX		
<b>Timing Characteristics (Note 3)</b>							
$t_{DS1}$	Serial Input to Strobe Setup Time ( $t_{STB} = 80ns$ )	STB1 Used as the Strobe	●	50	5	ns	
$t_{DS2}$		STB2 Used as the Strobe	●	20	-5	ns	
$t_{DS3}$		STB3 Used as the Strobe	●	0	-30	ns	
$t_{DS4}$		STB4 Used as the Strobe	●	0	-30	ns	
$t_{DH1}$	Serial Input to Strobe Hold Time ( $t_{STB} = 80ns$ )	STB1 Used as the Strobe	●	30	10	ns	
$t_{DH2}$		STB2 Used as the Strobe	●	50	25	ns	
$t_{DH3}$		STB3 Used as the Strobe	●	80	55	ns	
$t_{DH4}$		STB4 Used as the Strobe	●	80	55	ns	
$t_{SRI}$	Serial Input Data Pulse Width		●	80		ns	
$t_{STB1}$ , $t_{STB2}$ , $t_{STB3}$ , $t_{STB4}$	Strobe Pulse Width	(Note 11)	●	80		ns	
$\overline{t_{STB1}}$ , $\overline{t_{STB2}}$ , $\overline{t_{STB3}}$ , $\overline{t_{STB4}}$	Strobe Pulse Width	(Note 12)	●	80		ns	
$t_{LD1}$ , $t_{LD2}$	Load Pulse Width		●	140		ns	
$t_{ASB}$	LSB Strobed into Input Register to Load DAC Register Time		●	0		ns	
$t_{CLR}$	Clear Pulse Width		●	80		ns	
<b>SRO Timing Characteristics (LTC8143 Only)</b>							
$t_{PD}$	STB2, $\overline{STB3}$ , STB4 Strobe to SRO Propagation Delay	$C_L = 50pF$	●	220	120	ns	
$t_{PD1}$	STB1 to SRO Propagation Delay	$C_L = 50pF$	●	150	80	ns	
<b>Power Supply</b>							
$V_{DD}$	Supply Voltage		●	4.75	5	5.25	V
$I_{DD}$	Supply Current	Digital Inputs = 0V or $V_{DD}$	●			0.1	mA
		Digital Inputs = $V_{IH}$ or $V_{IL}$	●			2	mA

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:**  $I_{OUT1}$  with DAC register loaded with all 0s or  $I_{OUT2}$  with DAC register loaded with all 1s.

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

**Note 6:** OUT 1 load = 100Ω in parallel with 13pF.

**Note 7:** To 0.01% for a full-scale change, measured from falling edge of  $\overline{LD1}$  or  $\overline{LD2}$ .

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

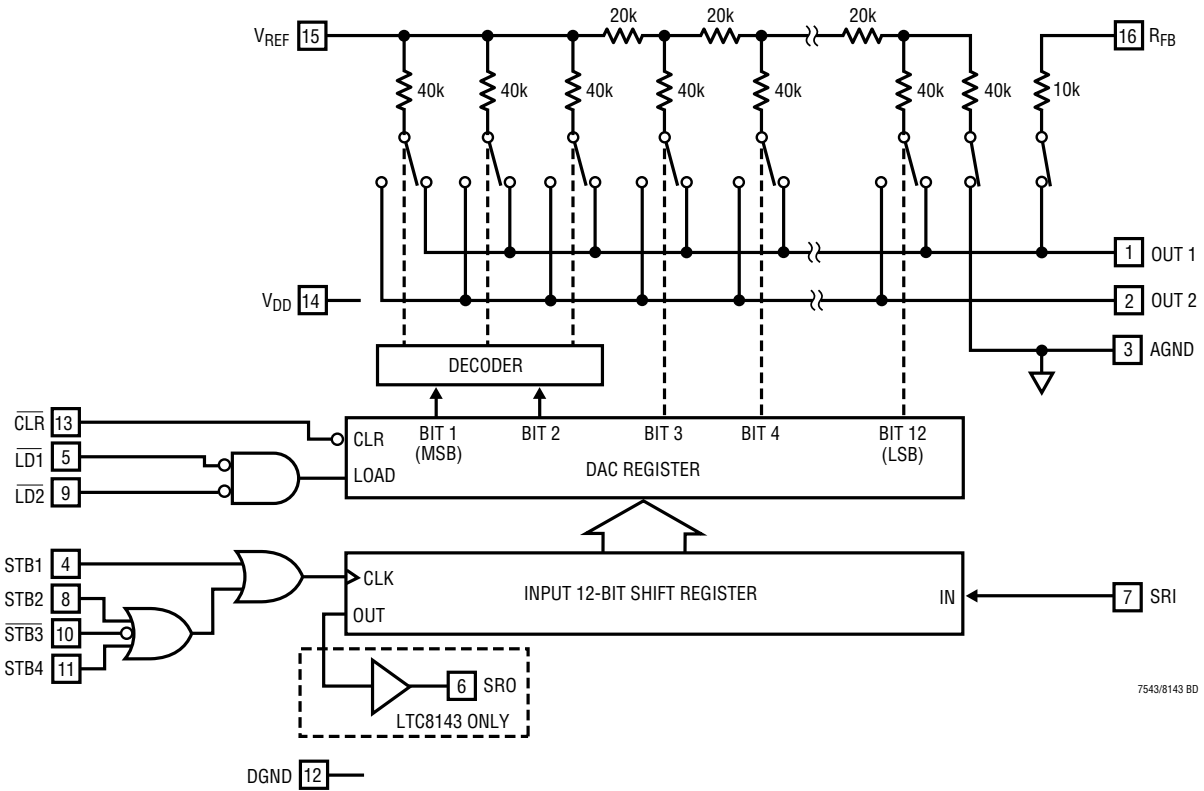
**Note 9:**  $V_{REF} = 6V_{RMS}$  at 1kHz. DAC register loaded with all 1s.

**Note 10:** Calculation from  $e_n = \sqrt{4KTRB}$  where: K = Boltzmann constant (J/K°); R = resistance (Ω); T = resistor temperature (°K); B = bandwidth (Hz).

**Note 11:** Minimum high time for STB1, STB2, STB4. Minimum low time for STB3.

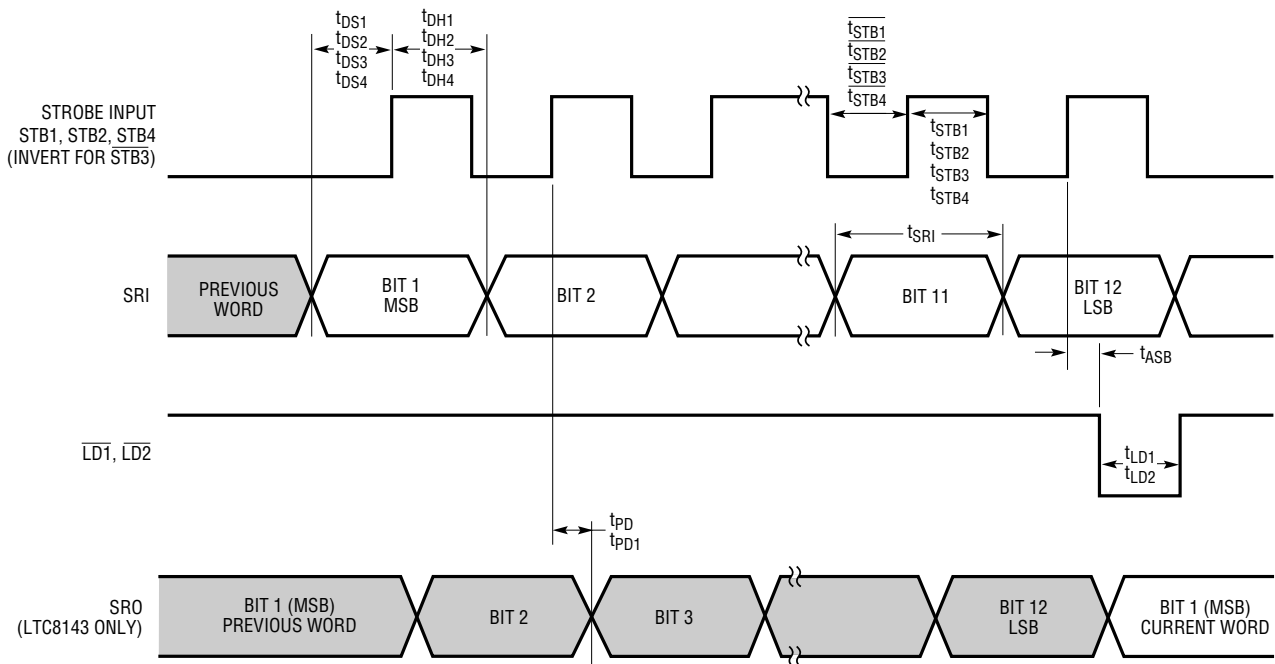
**Note 12:** Minimum low time for STB1, STB2, STB4. Minimum high time for STB3.

# BLOCK DIAGRAM



7543/8143 BD

# TIMING DIAGRAM



7543/8143 TD01

## TRUTH TABLES

**Table 1. LTC7543/LTC8143 Input Register**

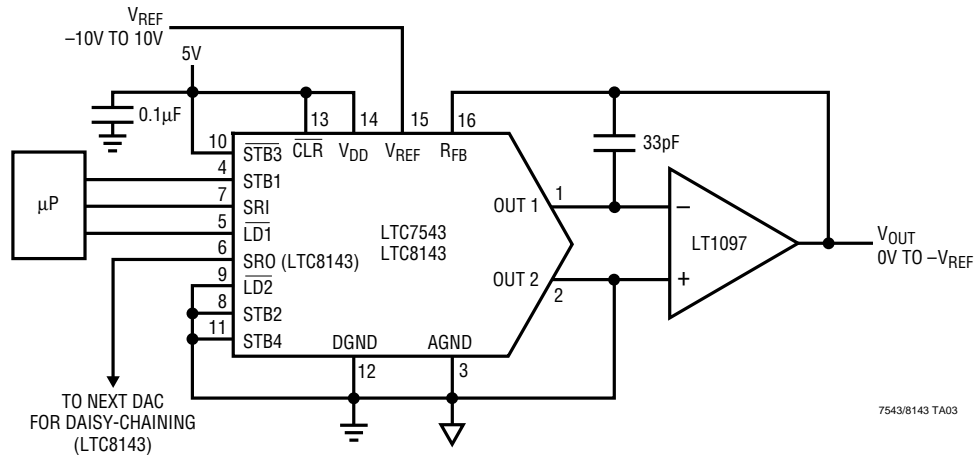
CONTROL INPUTS				Input Register Operation (LTC8143: SRO Operation)
STB1	STB2	STB3	STB4	
$\overline{\text{A}}$	0	1	0	Serial Data Bit on SRI Loaded into Input Register, MSB First (LTC8143: Data Bit or SRI Appears on SRO Pin After 12 Clocked Bits)
0	$\overline{\text{A}}$	1	0	
0	0	$\overline{\text{A}}$	0	
0	0	1	$\overline{\text{A}}$	
1	X	X	X	No Input Register Operation (LTC8143: No SRO Operation)
X	1	X	X	
X	X	0	X	
X	X	X	1	

**Table 2. LTC7543/LTC8143 DAC Register**

CONTROL INPUTS			DAC Register Operation
CLR	LD1	LD2	
0	X	X	Reset DAC Register to All 0s (Asynchronous Operation; No Effect on Input Register)
1	1	X	No DAC Register Operation
1	X	1	
1	0	0	Load DAC Register with the Contents of Input Register

## TYPICAL APPLICATIONS

### Unipolar Operation (2-Quadrant Multiplication)

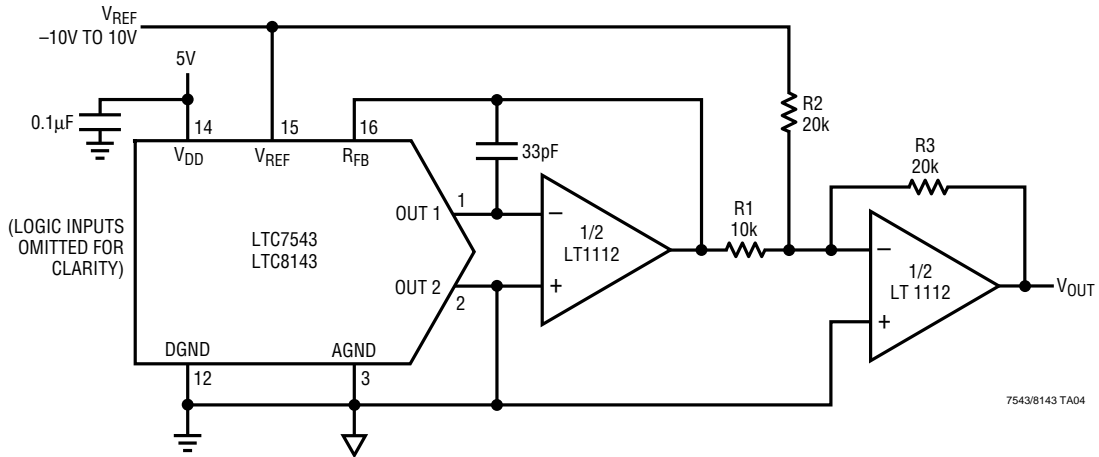


### Unipolar Binary Code Table

DIGITAL INPUT BINARY NUMBER IN DAC REGISTER			ANALOG OUTPUT $V_{OUT}$
MSB		LSB	
1111	1111	1111	$-V_{REF}$ (4095/4096)
1000	0000	0000	$-V_{REF}$ (2048/4096) = $-V_{REF}/2$
0000	0000	0001	$-V_{REF}$ (1/4096)
0000	0000	0000	0V

# TYPICAL APPLICATIONS

## Bipolar Operation (4-Quadrant Multiplication)



## Bipolar Offset Binary Code Table

DIGITAL INPUT BINARY NUMBER IN DAC REGISTER			ANALOG OUTPUT $V_{OUT}$
MSB		LSB	
1111	1111	1111	$V_{REF} (2047/2048)$
1000	0000	0001	$V_{REF} (1/2048)$
1000	0000	0000	0V
0111	1111	1111	$-V_{REF} (1/2048)$
0000	0000	0000	$-V_{REF} (2048/2048) = -V_{REF}$

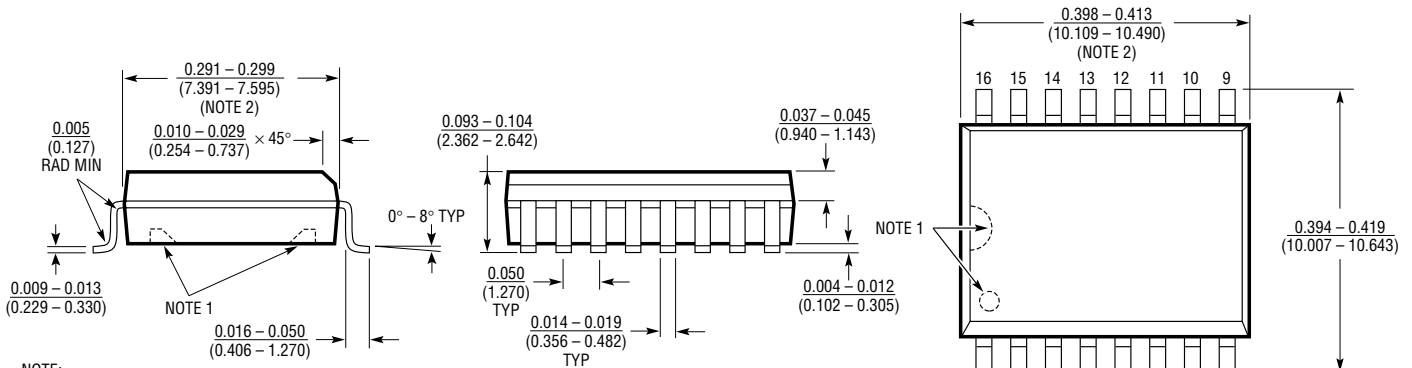
## PACKAGE DESCRIPTION Dimension in inches (millimeters) unless otherwise noted.

### N Package 16-Lead Plastic DIP



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

### S Package 16-Lead Plastic SOL



**NOTE:**

- PIN 1 IDENT, NOTCH ON TOP AND CAVITIES ON THE BOTTOM OF PACKAGES ARE THE MANUFACTURING OPTIONS. THE PART MAY BE SUPPLIED WITH OR WITHOUT ANY OF THE OPTIONS.
- THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED 0.006 INCH (0.15mm).

## 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
LTC8043	Serial Multiplying 12-Bit DAC	8-Pin SO and PDIP