

## FEATURES

- Improved Direct Replacement for AD7543 and DAC-8143
- Low Cost
- DNL and INL Over Temperature:  $\pm 0.5\text{LSB}$
- 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.

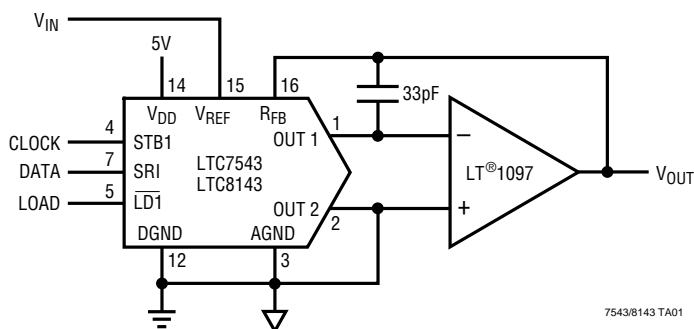
These DACs are extremely versatile. They can be used for 2-quadrant and 4-quadrant multiplying, programmable gain and single supply applications, such as noninverting voltage output and biased or offset ground mode.

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

LT, LTC and LT are registered trademarks of Linear Technology Corporation.

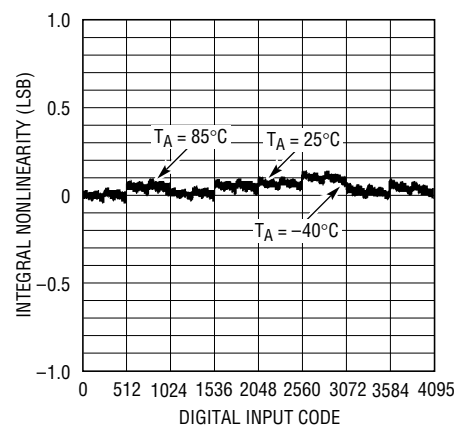
## TYPICAL APPLICATION

Multiplying DAC Has Easy 3-Wire Serial Interface



7543/8143 TA01

Integral Nonlinearity Over Temperature



7543/8143 TA02

**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>             N PACKAGE              16-LEAD PDIP              SW PACKAGE              16-LEAD PLASTIC SO WIDE           </p> <p> <math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 100^{\circ}C/W</math> (N)  <math>T_{JMAX} = 150^{\circ}C</math>, <math>\theta_{JA} = 130^{\circ}C/W</math> (SW)           </p>	<p>ORDER PART NUMBER</p> <p>             LTC7543GKN              LTC7543KN              LTC7543GKSW              LTC7543KSW              LTC8143EN              LTC8143FN              LTC8143ESW              LTC8143FSW           </p>
--	--

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/°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 $T_{MAX}$	●		$\pm 0.006$ $\pm 0.06$			$\pm 0.006$ $\pm 0.06$	LSB 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 = 100 $\Omega$  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.

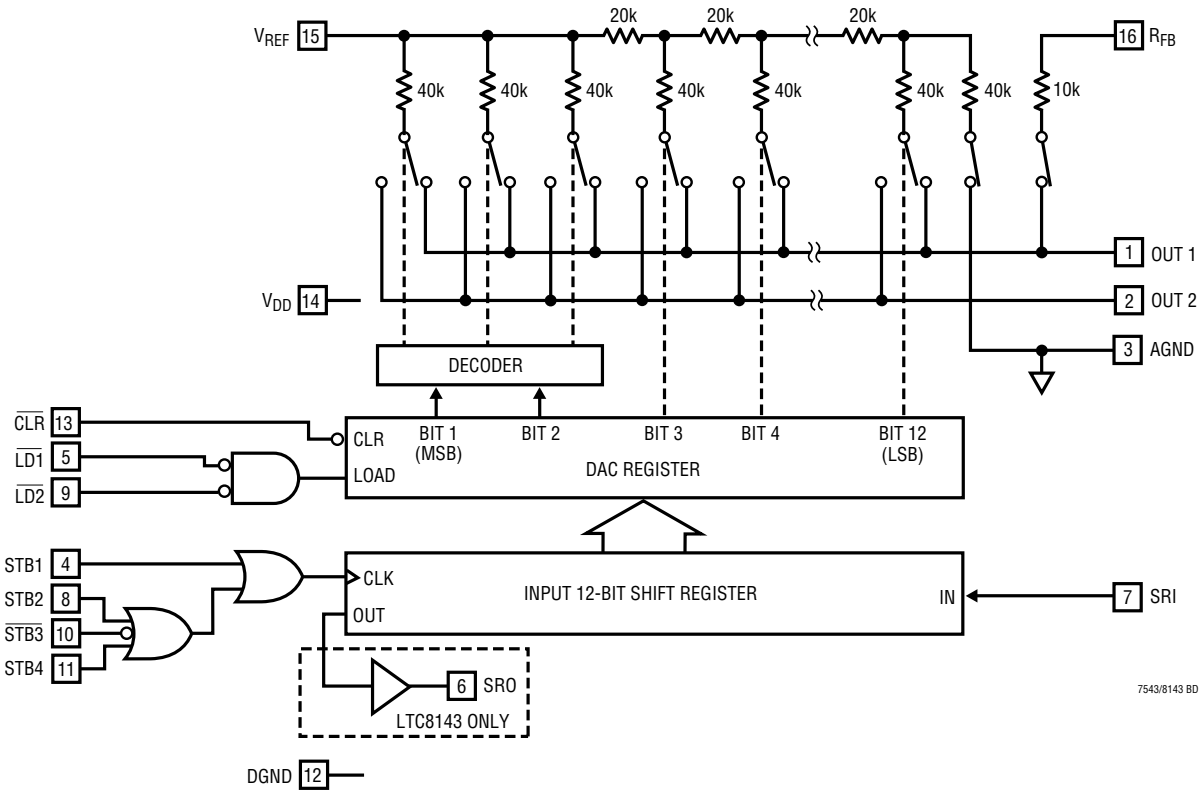
**Note 9:**  $V_{REF} = 6V_{RMS}$  at 1kHz. DAC register loaded with all 1s.

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

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

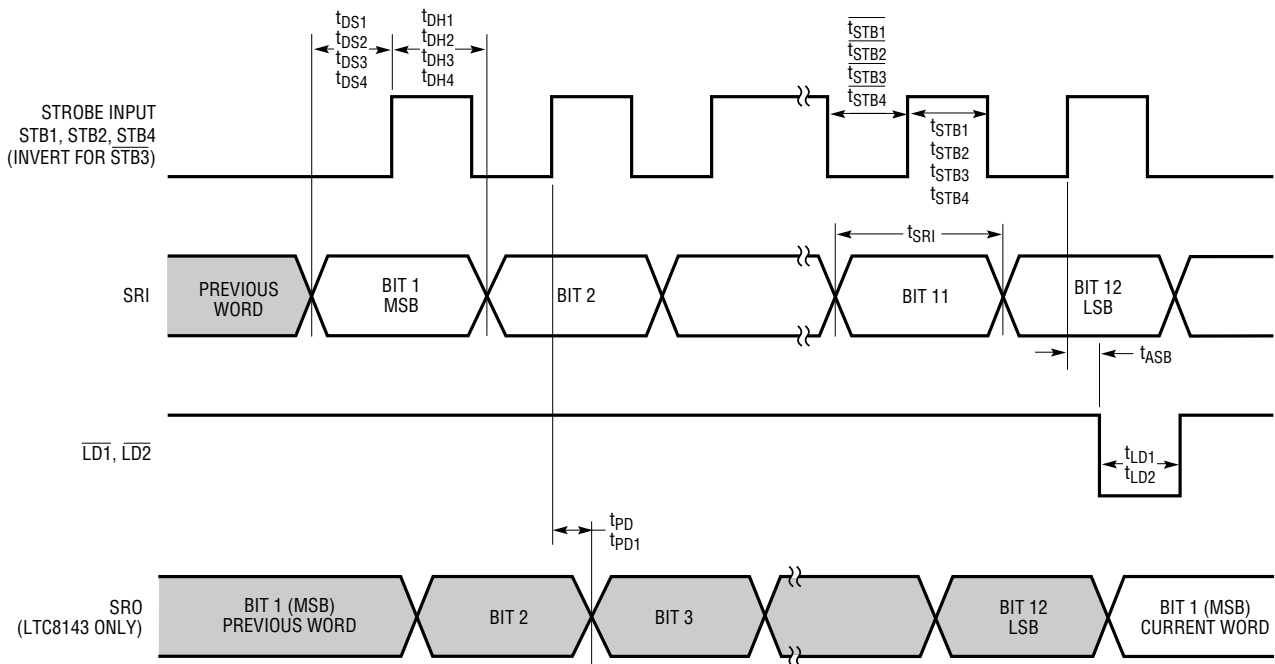
**Note 12:** Minimum low time for STB1, STB2, STB4. Minimum high time for STB3.

# BLOCK DIAGRAM



7543/8143 BD

# TIMING DIAGRAM



7543/8143 TD01

## TRUTH TABLES

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

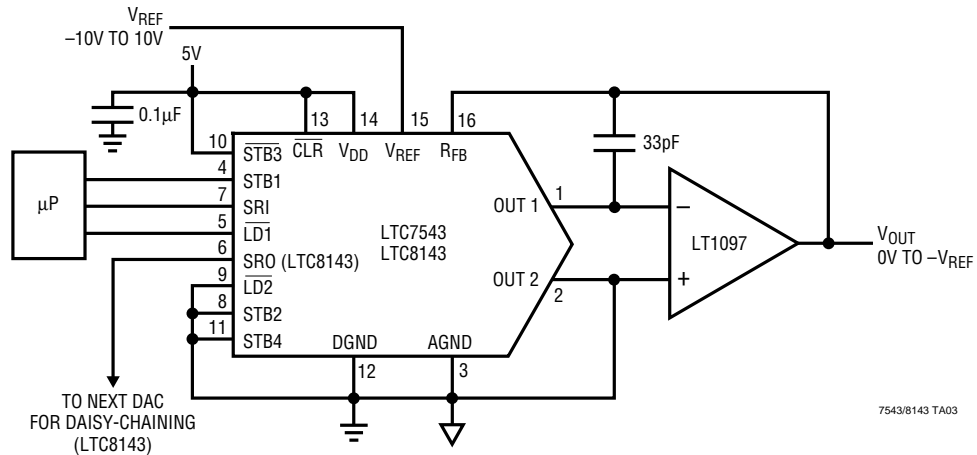
CONTROL INPUTS				Input Register Operation (LTC8143: SRO Operation)
STB1	STB2	STB3	STB4	
$\overline{\downarrow}$	0	1	0	Serial Data Bit on SRI Loaded into Input Register, MSB First (LTC8143: Data Bit or SRI Appears on SRO Pin After 12 Clocked Bits)
0	$\overline{\downarrow}$	1	0	
0	0	$\overline{\downarrow}$	0	
0	0	1	$\overline{\downarrow}$	
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)

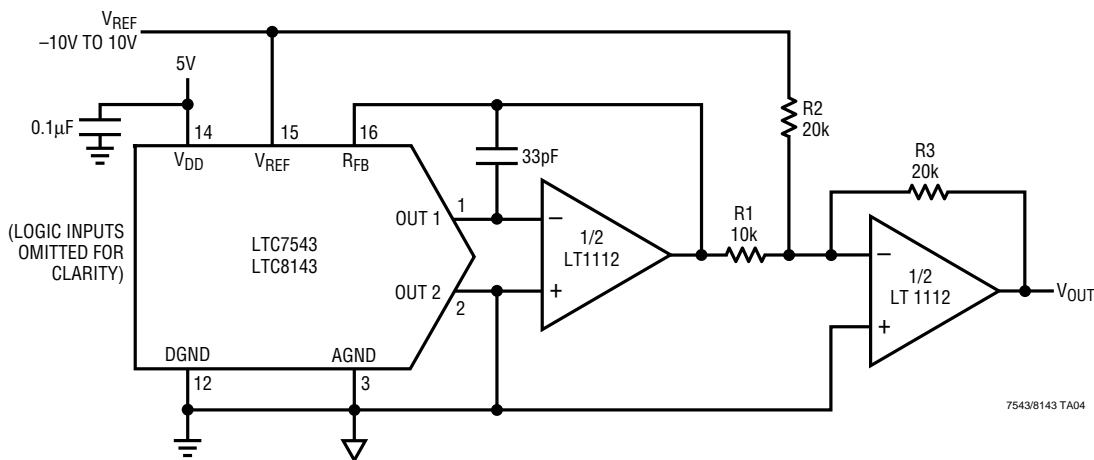


### Unipolar Binary Code Table

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)

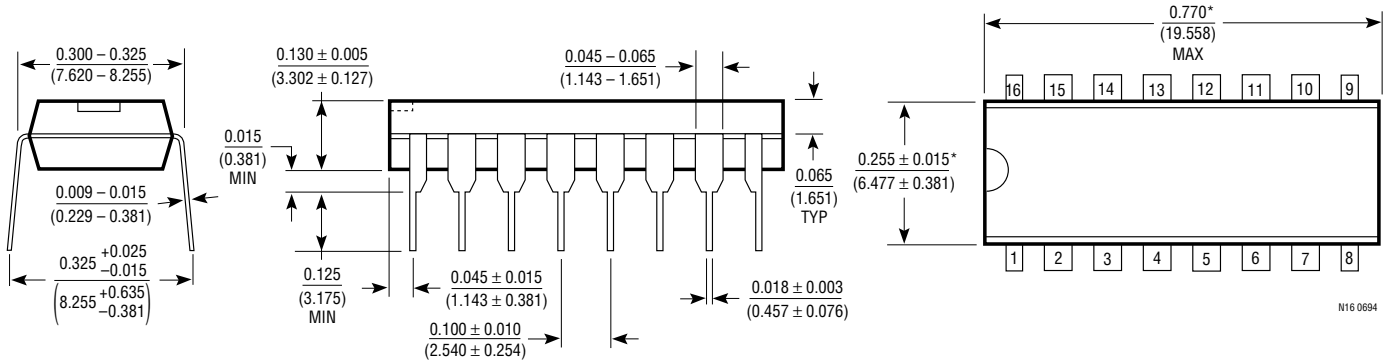


## Bipolar Offset Binary Code Table

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	$-V_{REF} (2048/2048) = -V_{REF}$

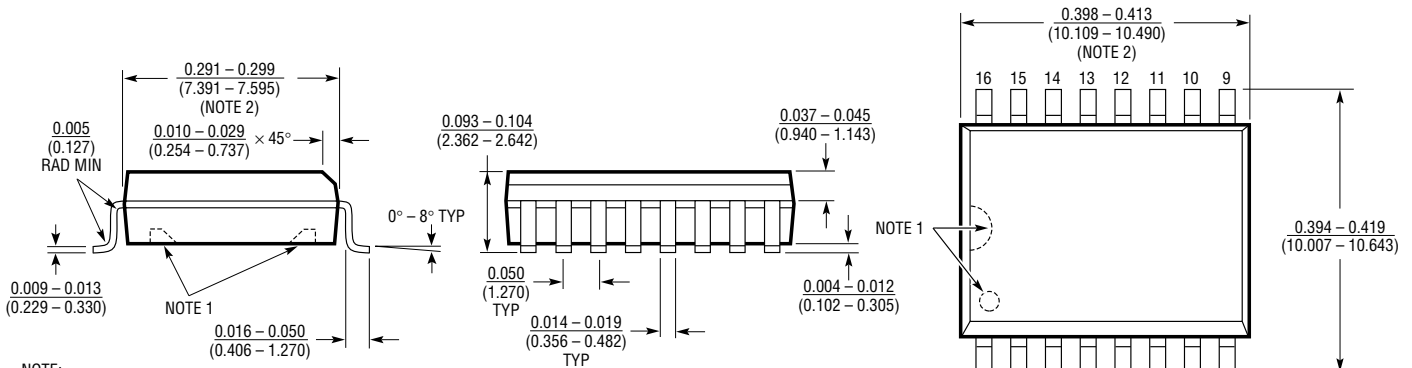
## PACKAGE DESCRIPTION Dimension in inches (millimeters) unless otherwise noted.

### 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:  
1. 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.  
2. 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