

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[®]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.

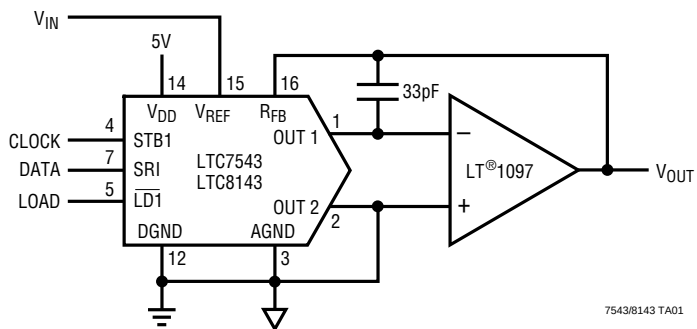
These DACs are extremely versatile. They can be used for 2-quadrant and 4-quadrant multiplying, programmable gain and single supply applications, such as noninverting voltage output and biased or offset ground mode.

Parts are available in 16-pin PDIP and SO packages and are specified over the extended industrial temperature range, -40°C to 85°C .

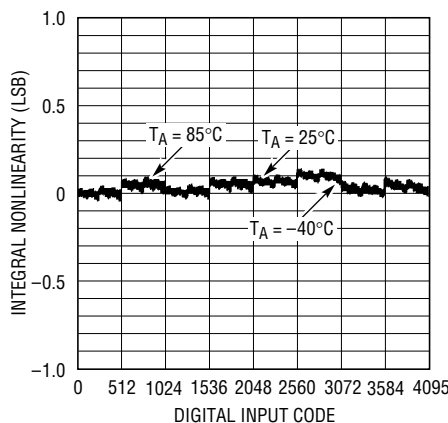
LT, LTC and LT are registered trademarks of Linear Technology Corporation.

TYPICAL APPLICATION

Multiplying DAC Has Easy 3-Wire Serial Interface



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

TOP VIEW		ORDER PART NUMBER
OUT 1	1	16 R_{FB}
OUT 2	2	15 V_{REF}
AGND	3	14 V_{DD}
STB1	4	13 CLR
$LD1$	5	12 DGND
NC (LTC7543) SRO (LTC8143)	6	11 STB4
SRI	7	10 STB3
STB2	8	9 $LD2$
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)		
		LTC7543GKN LTC7543KN LTC7543GKSW LTC7543KSW LTC8143EN LTC8143FN LTC8143ESW LTC8143FSW

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)	●			± 0.5			± 0.5	LSB
DNL	Differential Nonlinearity	Guaranteed Monotonic, T_{MIN} to T_{MAX}	●			± 0.5			± 0.5	LSB
GE	Gain Error	(Note 2) $T_A = 25^{\circ}C$ T_{MIN} to T_{MAX}	●			± 1			± 2	LSB
			●			± 1			± 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}	●			± 1 ± 10			± 1 ± 10	nA nA
			●			± 0.006 ± 0.06			± 0.006 ± 0.06	LSB LSB
PSRR	Power Supply Rejection Ratio	$V_{DD} = 5V \pm 5\%$	●		± 0.0001	± 0.002		± 0.0001	± 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	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			±0.03	LSB
			●			±0.15			±0.15	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	
Reference Input							
R _{REF}	V _{REF} Input Resistance	(Note 5)	●	8	11	15	kΩ
AC Performance (Note 3)							
	Output Current Settling Time	(Notes 6, 7)	●		0.25	1	μs
	Multiplying Feedthrough Error	V _{REF} = ±10V, 10kHz Sinewave	●		0.8	2	mV _{P-P}
	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/√Hz
Analog Outputs (Note 3)							
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
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	(Note 3), V _{IN} = 0V	●			8	pF
Digital Outputs: SRO (LTC8143 Only)							
V _{OH}	Digital Output High	I _{OH} = −200μA	●	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		
Timing Characteristics (Note 3)							
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	
t _{STB1} , t _{STB2} , t _{STB3} , 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	
SRO Timing Characteristics (LTC8143 Only)							
t _{PD}	STB2, 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	
Power Supply							
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 LD1 or LD2.

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

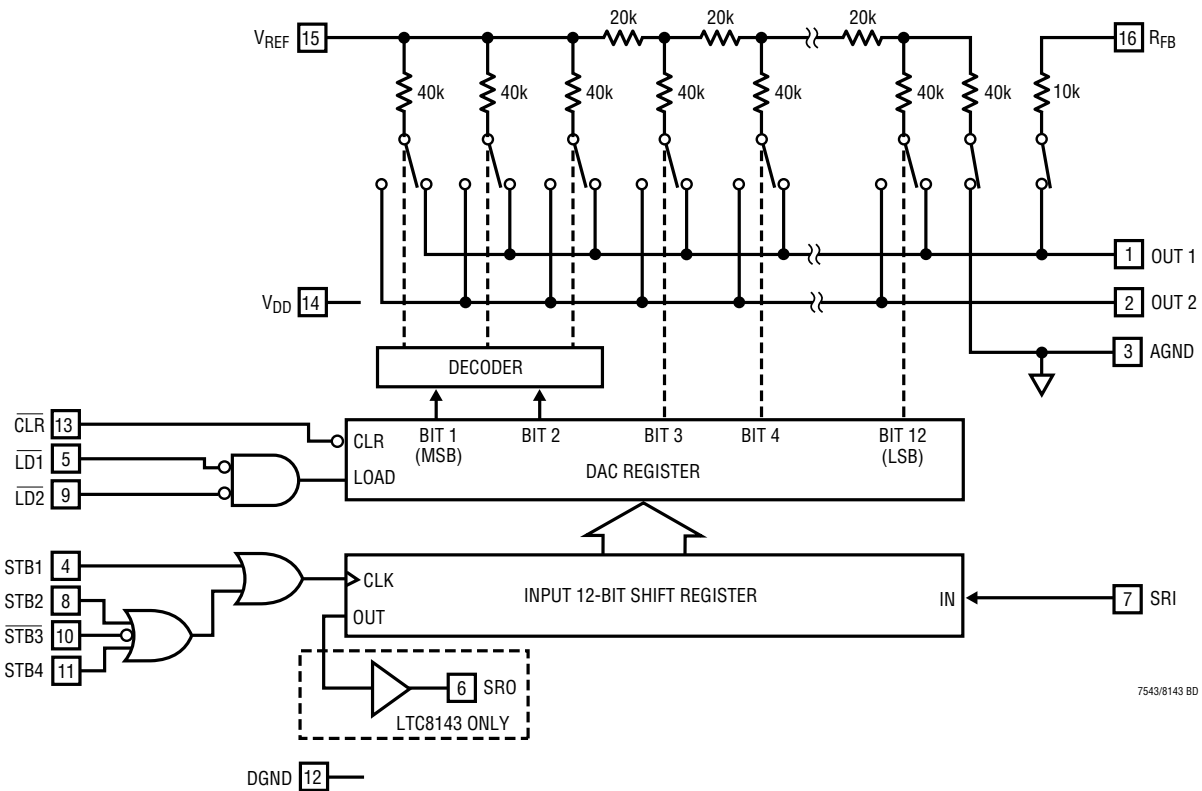
Note 9: $V_{REF} = 6V_{RMS}$ at 1kHz. DAC register loaded with all 1s.

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

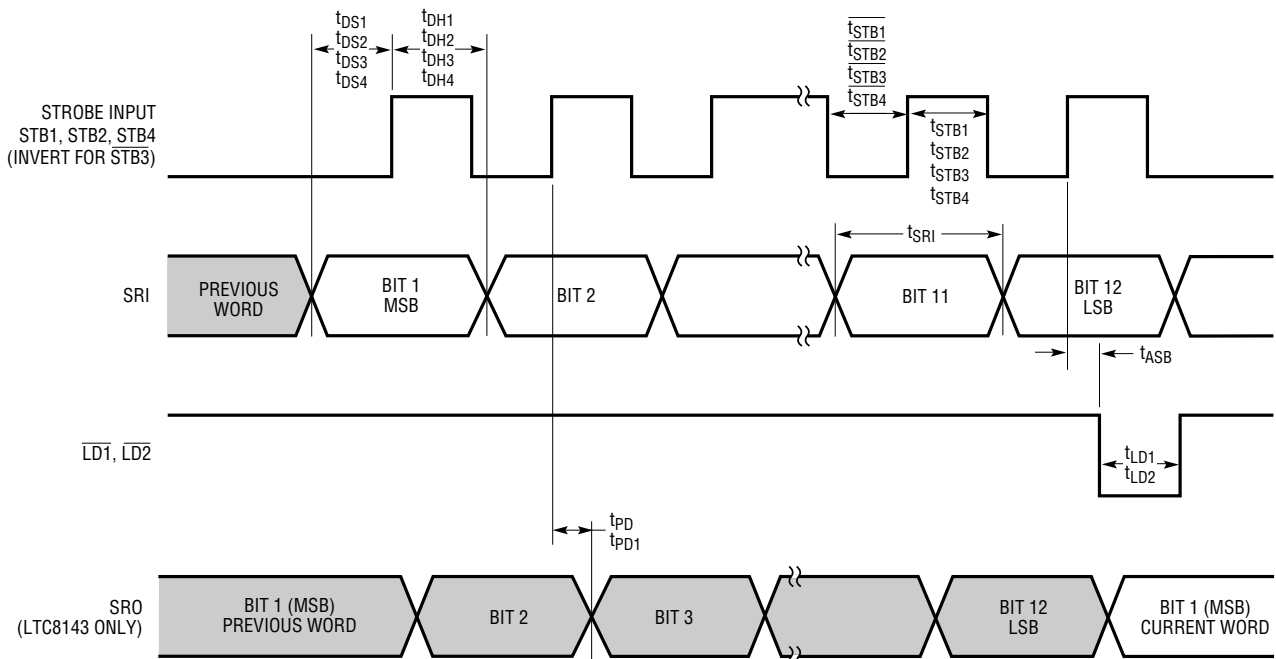
Note 11: Minimum high time for STB1, STB2, STB4. Minimum low time for STB3.

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

BLOCK DIAGRAM



TIMING DIAGRAM



TRUTH TABLES

Table 1. LTC7543/LTC8143 Input Register

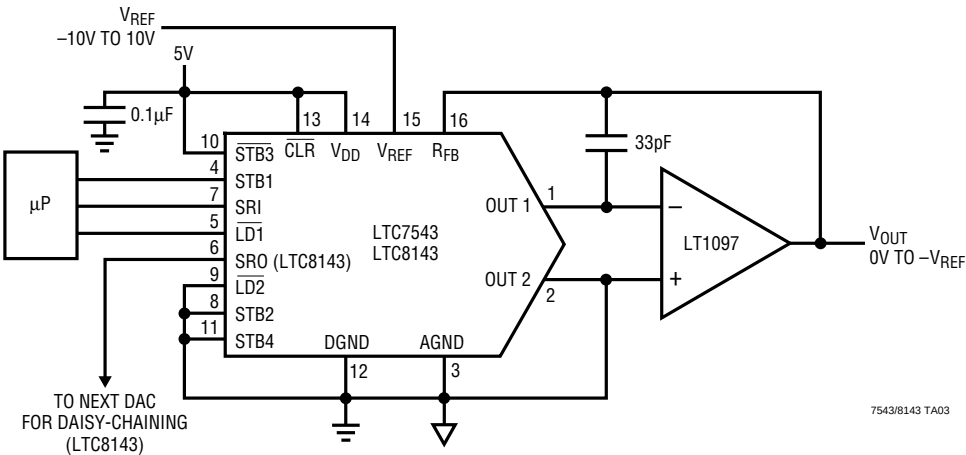
CONTROL INPUTS				Input Register Operation (LTC8143: SRO Operation)
STB1	STB2	STB3	STB4	
$\overline{1}$	0	1	0	Serial Data Bit on SRI Loaded into Input Register, MSB First (LTC8143: Data Bit or SRI Appears on SRO Pin After 12 Clocked Bits)
0	$\overline{1}$	1	0	
0	0	$\overline{1}$	0	
0	0	1	$\overline{1}$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

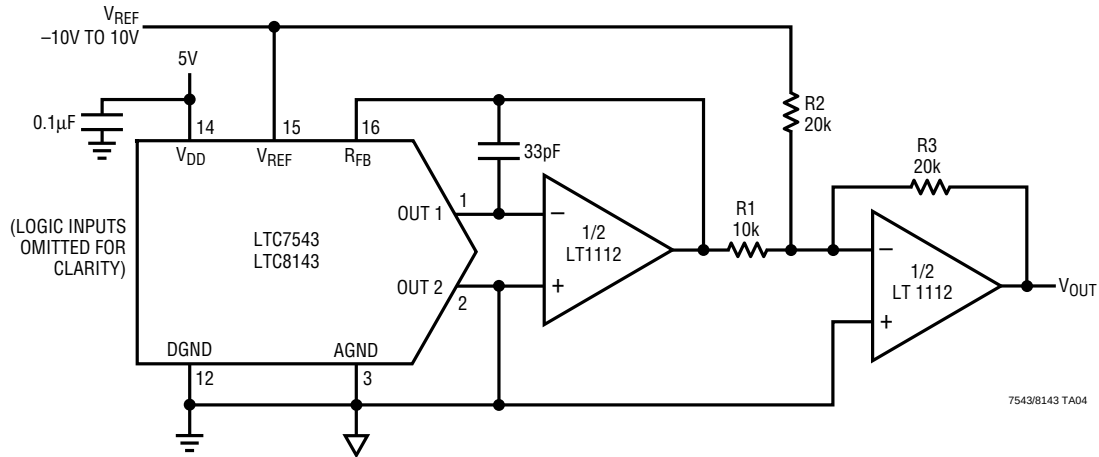


Unipolar Binary Code Table

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)

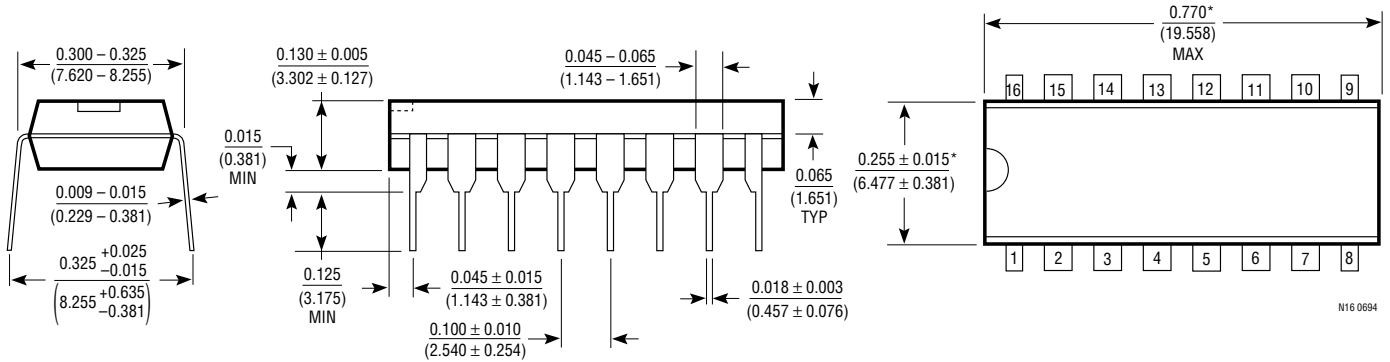


Bipolar Offset Binary Code Table

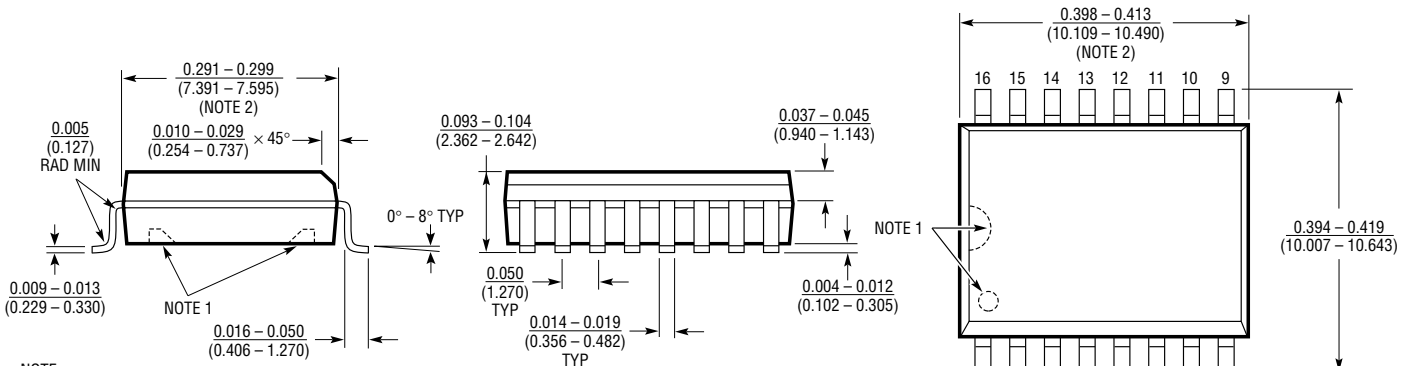
DIGITAL INPUT BINARY NUMBER IN DAC REGISTER			ANALOG OUTPUT V_{OUT}
MSB		LSB	
1111	1111	1111	$V_{REF} (2047/2048)$
1000	0000	0001	$V_{REF} (1/2048)$
1000	0000	0000	0V
0111	1111	1111	$-V_{REF} (1/2048)$
0000	0000	0000	$-V_{REF} (2048/2048) = -V_{REF}$

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