



**THE DATASHEET OF
LTC7543GKN#PBF**



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.

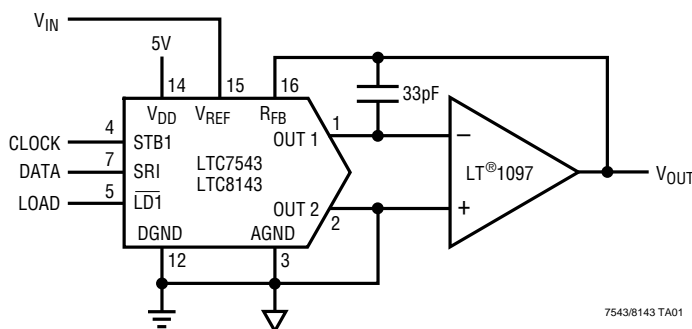
These DACs are extremely versatile. They can be used for 2-quadrant and 4-quadrant multiplying, programmable gain and single supply applications, such as noninverting voltage output and biased or offset ground mode.

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

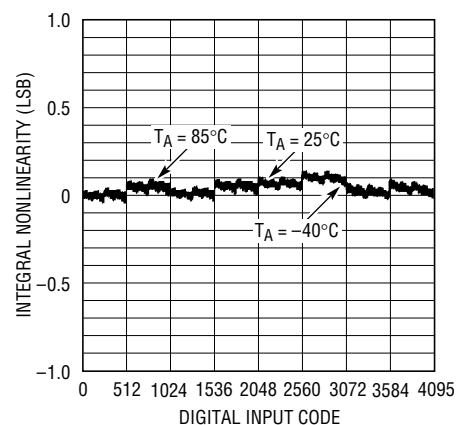
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TYPICAL APPLICATION

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>N PACKAGE 16-LEAD PDIP SW PACKAGE 16-LEAD PLASTIC SO WIDE</p> <p>$T_{JMAX} = 150^{\circ}C$, $\theta_{JA} = 100^{\circ}C/W$ (N) $T_{JMAX} = 150^{\circ}C$, $\theta_{JA} = 130^{\circ}C/W$ (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) | ● | | ± 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/°C |
| I_{LKG} | Output Leakage Current | (Note 4) $T_A = 25^{\circ}C$ T_{MIN} to T_{MAX} | ● | | ± 1 | | | ± 1 | nA |
| | | | ● | | ± 10 | | | ± 10 | nA |
| | Zero-Scale Error | $T_A = 25^{\circ}C$ T_{MIN} to T_{MAX} | ● | | ± 0.006 | | | ± 0.006 | LSB |
| | | | ● | | ± 0.06 | | | ± 0.06 | 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 | | ±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 | | |
| Reference Input | | | | | | | |
| R _{REF} | V _{REF} Input Resistance | (Note 5) | ● | 8 | 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 | ● | | 0.8 | 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/ \sqrt{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} = -200 μA | ● | 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 | |
| $\overline{t_{STB1}}$, $\overline{t_{STB2}}$, $\overline{t_{STB3}}$, $\overline{t_{STB4}}$ | 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 | |
| SRO Timing Characteristics (LTC8143 Only) | | | | | | | |
| 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 | |
| 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 = 100 Ω 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.

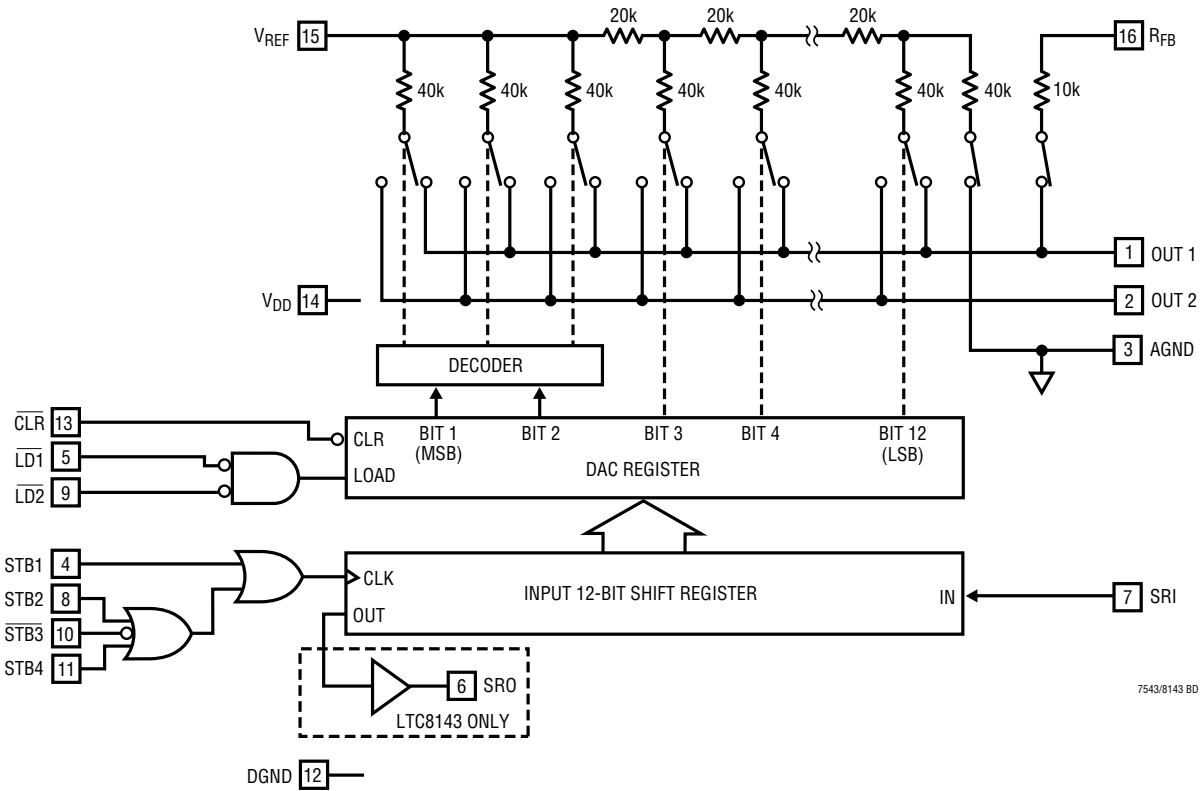
Note 9: $V_{REF} = 6V_{RMS}$ at 1kHz. DAC register loaded with all 1s.

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.

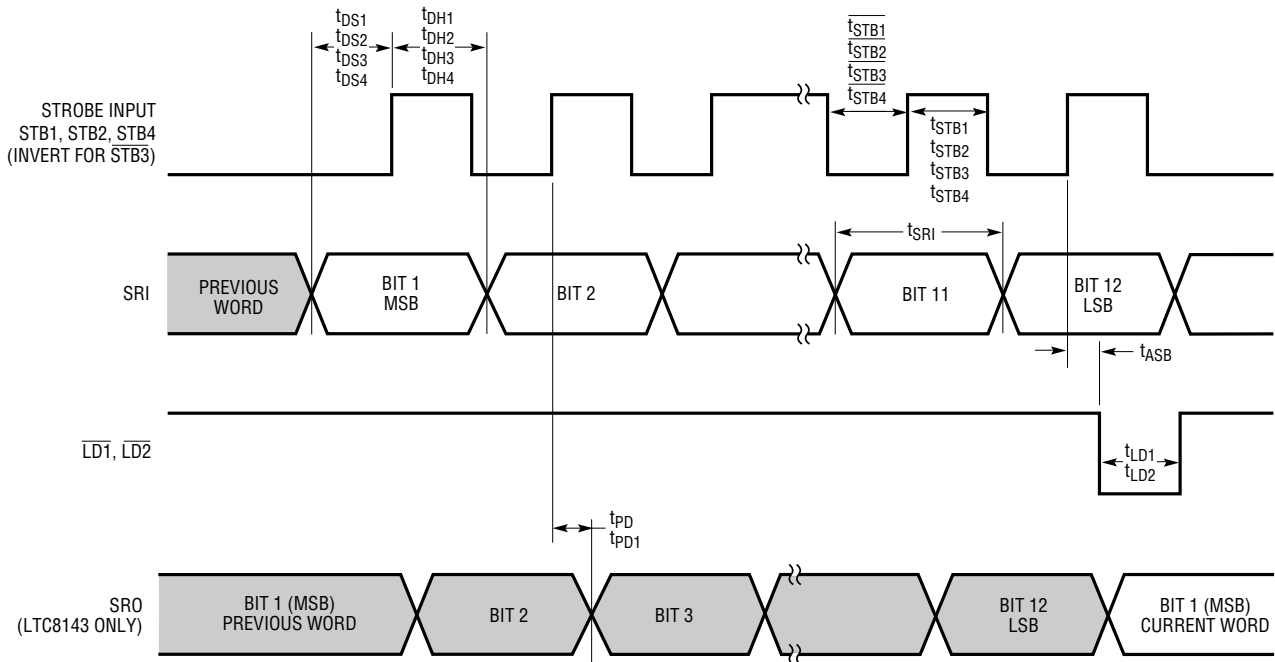
Note 12: Minimum low time for STB1, STB2, STB4. Minimum high time for STB3.

BLOCK DIAGRAM



7543/8143 BD

TIMING DIAGRAM



7543/8143 TD01

TRUTH TABLES

Table 1. LTC7543/LTC8143 Input Register

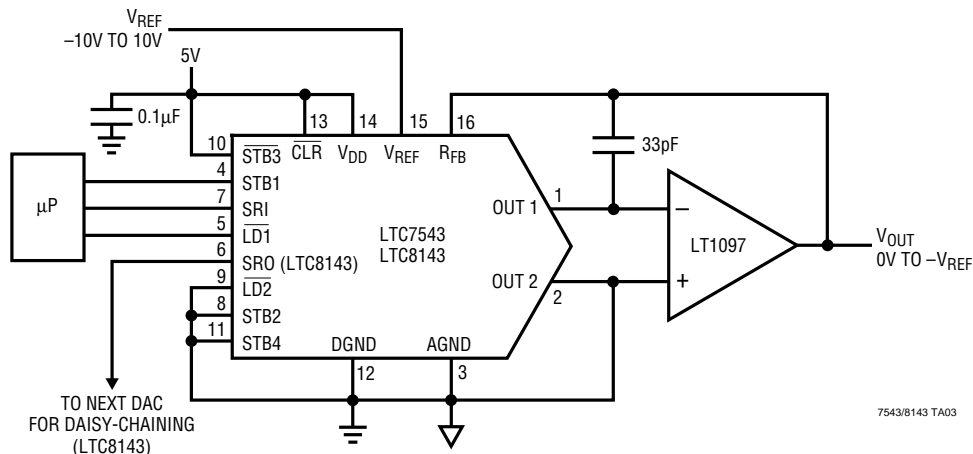
| CONTROL INPUTS | | | | Input Register Operation (LTC8143: SRO Operation) |
|-----------------------|-----------------------|-----------------------|-----------------------|---|
| STB1 | STB2 | STB3 | STB4 | |
| $\overline{\text{A}}$ | 0 | 1 | 0 | Serial Data Bit on SRI Loaded into Input Register, MSB 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)

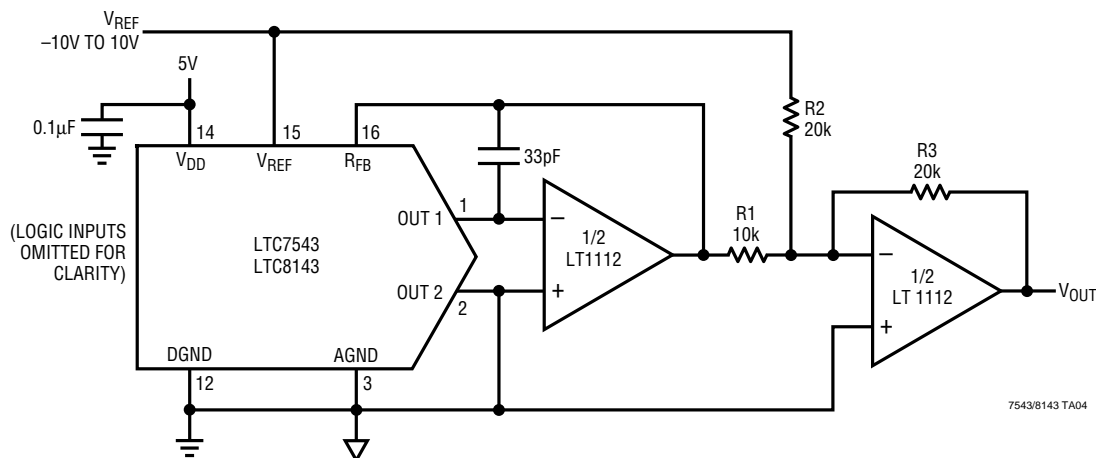


Unipolar Binary Code Table

| 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)

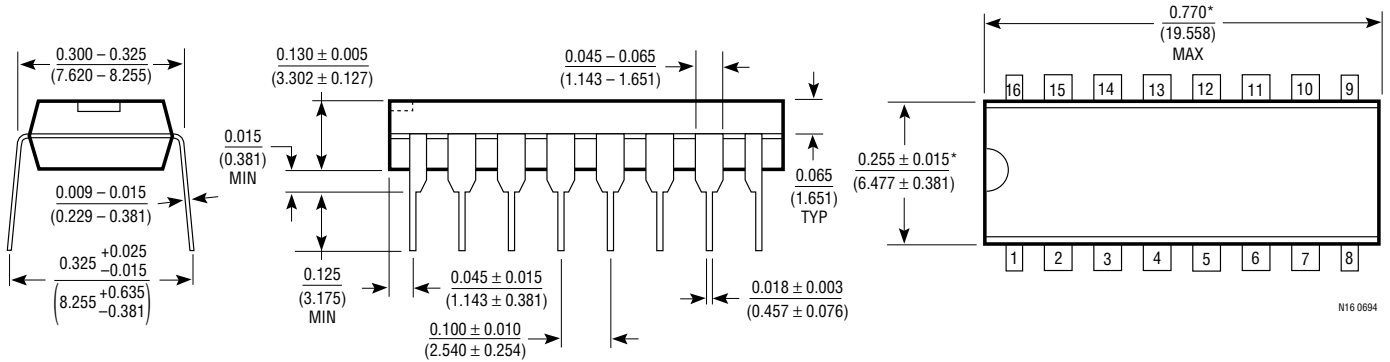


Bipolar Offset Binary Code Table

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

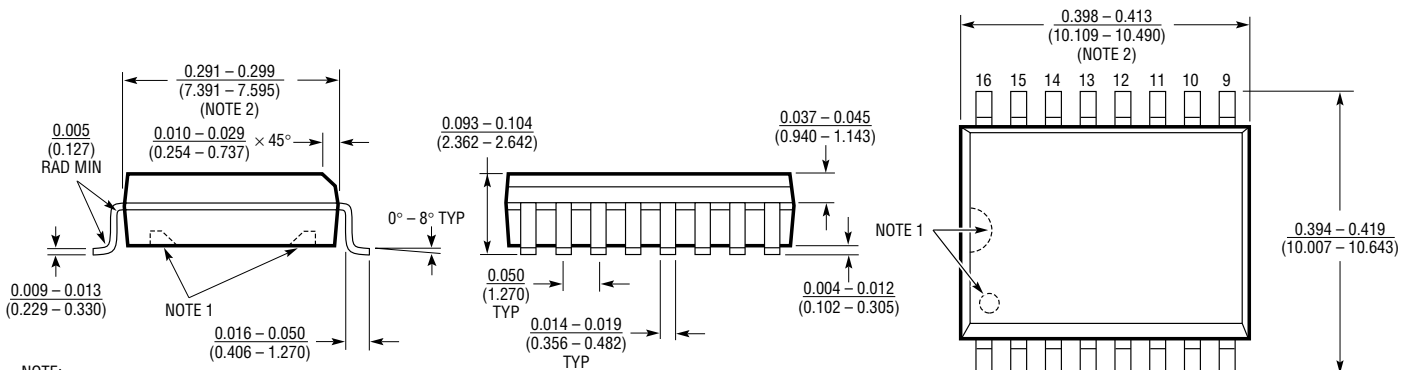
PACKAGE DESCRIPTION Dimension in inches (millimeters) unless otherwise noted.

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 |

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