

# Improved Industry Standard CMOS 12-Bit Multiplying DAC

## FEATURES

- Improved Direct Replacement for AD7541A and AD7541
- 4-Quadrant Multiplication
- **12-Bit End-Point Linearity:  $\pm 0.5\text{LSB}$  DNL and INL Over Temperature**
- All Grades Guaranteed Monotonic
- **Maximum Gain Error:  $\pm 1\text{LSB}$**
- Single 5V to 15V Supply
- TTL and CMOS Logic Compatible
- Reduced Sensitivity to Op Amp Offset
- Low Power Consumption
- Virtually Latch-Up Proof
- Low Cost

## APPLICATIONS

- Motion Control Systems
- Microprocessor-Controlled Calibration
- Automatic Test Equipment
- Programmable Gain Amplifiers
- Digitally Controlled Filters

## DESCRIPTION

The LTC<sup>®</sup>7541A is a 12-bit resolution multiplying digital-to-analog converter (DAC).

Laser-trimmed thin-film resistors provide excellent absolute accuracy. Precision matched resistors and CMOS circuitry result in remarkable stability with temperature and supply variations.

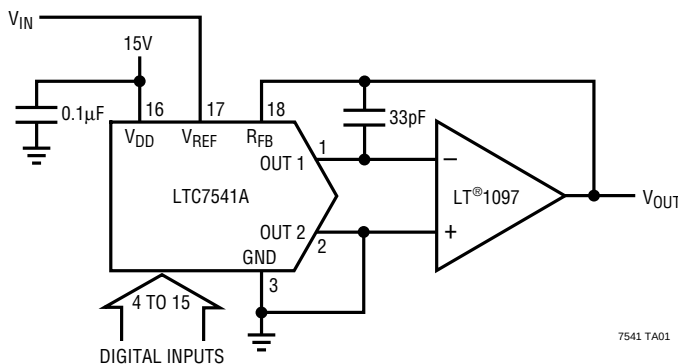
The LTC7541A is a superior pin compatible replacement for the industry standard AD7541A/AD7541. Improvements include better typical accuracy and stability and reduced sensitivity to output amplifier offset. The LTC7541A is also very resistant to latch-up.

In addition to 2-quadrant and 4-quadrant multiplying configurations, the LTC7541A performs well in digitally programmable gain and noninverting voltage output applications. Low cost, improved performance and versatility make the LTC7541A the best choice for many new designs and for upgrading existing systems. Parts are available in 18-pin PDIP and 18-pin SO Wide packages.

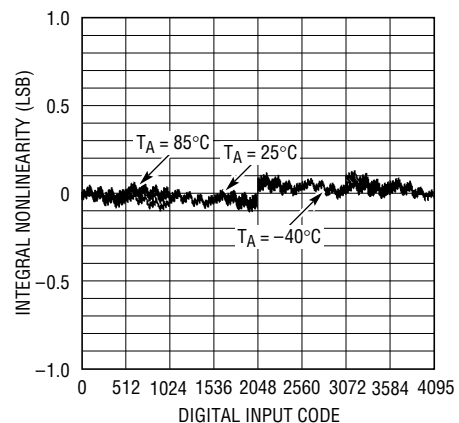
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## TYPICAL APPLICATION

**2-Quadrant Multiplying DAC Has Less Than  
0.5LSB (Typ) Total Unadjusted Error**



**Integral Nonlinearity Over Temperature**



7541A TA02

## ABSOLUTE MAXIMUM RATINGS

|                                            |                                     |
|--------------------------------------------|-------------------------------------|
| $V_{DD}$ to GND .....                      | -0.5V to 17V                        |
| $V_{REF}$ to GND .....                     | $\pm 25V$                           |
| $R_{FB}$ to GND .....                      | $\pm 25V$                           |
| Digital Inputs to GND .....                | -0.5V to ( $V_{DD} + 0.5V$ )        |
| OUT 1, OUT 2 to GND .....                  | -0.5V to ( $V_{DD} + 0.5V$ )        |
| Power Dissipation .....                    | 450mW<br>(Derate 6mW/°C Above 75°C) |
| Maximum Junction Temperature .....         | -65°C to 125°C                      |
| Operating Temperature Range                |                                     |
| Commercial (J, K Versions) .....           | 0°C to 70°C                         |
| Industrial (B Version) .....               | -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 | 18 $R_{FB}$             |
| OUT 2                                                                              | 2 | 17 $V_{REF}$            |
| GND                                                                                | 3 | 16 $V_{DD}$             |
| BIT 1 (MSB)                                                                        | 4 | 15 BIT 12 (LSB)         |
| BIT 2                                                                              | 5 | 14 BIT 11               |
| BIT 3                                                                              | 6 | 13 BIT 10               |
| BIT 4                                                                              | 7 | 12 BIT 9                |
| BIT 5                                                                              | 8 | 11 BIT 8                |
| BIT 6                                                                              | 9 | 10 BIT 7                |
|  |   |                         |
| N PACKAGE                                                                          |   | SW PACKAGE              |
| 18-LEAD PDIP                                                                       |   | 18-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.

## ELECTRICAL CHARACTERISTICS

 $V_{DD} = 15V$ ,  $V_{REF} = 10V$ , OUT 1 = OUT 2 = GND = 0V,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise specified.

| SYMBOL           | PARAMETER                                                    | CONDITIONS                                                                |   | LTC7541AJ |     |     | LTC7541AK/LTC7541AB |     |     | UNITS  |
|------------------|--------------------------------------------------------------|---------------------------------------------------------------------------|---|-----------|-----|-----|---------------------|-----|-----|--------|
|                  |                                                              |                                                                           |   | MIN       | TYP | MAX | MIN                 | TYP | MAX |        |
| Accuracy         |                                                              |                                                                           |   |           |     |     |                     |     |     |        |
|                  | Resolution                                                   |                                                                           | ● | 12        |     |     | 12                  |     |     | Bits   |
| INL              | Integral Nonlinearity<br>(Relative Accuracy)                 | (Note 1)                                                                  | ● | ±1        |     |     | ±0.5                |     |     | LSB    |
| DNL              | Differential Nonlinearity                                    | Guaranteed Monotonic, T <sub>MIN</sub> to T <sub>MAX</sub>                | ● | ±1        |     |     | ±0.5                |     |     | LSB    |
| GE               | Gain Error                                                   | (Note 2)<br>T <sub>A</sub> = 25°C<br>T <sub>MIN</sub> to T <sub>MAX</sub> | ● | ±6        |     |     | ±1                  |     |     | LSB    |
|                  |                                                              |                                                                           | ● | ±8        |     |     | ±2                  |     |     | LSB    |
|                  | Gain Temperature Coefficient                                 | (Note 3)                                                                  | ● | 1         |     | 5   | 1                   |     | 5   | ppm/°C |
| I <sub>LKG</sub> | Output Leakage Current                                       | (Note 4)<br>T <sub>A</sub> = 25°C<br>T <sub>MIN</sub> to T <sub>MAX</sub> | ● | ±5        |     |     | ±5                  |     |     | nA     |
|                  |                                                              |                                                                           | ● | ±10       |     |     | ±10                 |     |     | nA     |
| PSRR             | Power Supply Rejection                                       | V <sub>DD</sub> = 15V ±5%                                                 | ● | ±0.002    |     |     | ±0.002              |     |     | %/%    |
| Reference Input  |                                                              |                                                                           |   |           |     |     |                     |     |     |        |
| R <sub>REF</sub> | V <sub>REF</sub> Input Resistance                            |                                                                           | ● | 7         | 11  | 15  | 7                   | 11  | 15  | kΩ     |
|                  | V <sub>REF</sub> Input Resistance<br>Temperature Coefficient |                                                                           |   | −100      |     |     | −100                |     |     | ppm/°C |

**V<sub>DD</sub> = 15V, V<sub>REF</sub> = 10V, OUT 1 = OUT 2 = GND = 0V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise specified.**

| SYMBOL           | PARAMETER                        | CONDITIONS                                          | ALL GRADES |     |       | UNIT |                   |
|------------------|----------------------------------|-----------------------------------------------------|------------|-----|-------|------|-------------------|
|                  |                                  |                                                     | MIN        | TYP | MAX   |      |                   |
| Power Supply     |                                  |                                                     |            |     |       |      |                   |
| V <sub>DD</sub>  | Operating Supply Range           |                                                     | ●          | 5   | 15    | 16   | V                 |
| I <sub>DD</sub>  | Supply Current                   | Digital Inputs = V <sub>IH</sub> or V <sub>IL</sub> | ●          |     |       | 2    | mA                |
|                  |                                  | Digital Inputs = 0V or V <sub>DD</sub>              | ●          |     |       | 100  | μA                |
| Digital Inputs   |                                  |                                                     |            |     |       |      |                   |
| V <sub>IH</sub>  | Digital Input High Voltage       |                                                     | ●          | 2.4 |       |      | V                 |
| V <sub>IL</sub>  | Digital Input Low Voltage        |                                                     | ●          |     |       | 0.8  | V                 |
| I <sub>IN</sub>  | Digital Input Current            |                                                     | ●          |     | 0.001 | ±1   | μA                |
| C <sub>IN</sub>  | Digital Input Capacitance        | (Note 3), V <sub>IN</sub> = 0V                      | ●          |     |       | 8    | pF                |
| AC Performance   |                                  |                                                     |            |     |       |      |                   |
|                  | Propagation Delay                | (Notes 5, 6)                                        |            |     | 100   |      | ns                |
|                  | Digital-to-Analog Glitch Impulse | (Notes 5, 7)                                        |            |     | 1000  |      | nV-sec            |
|                  | Multiplying Feedthrough Error    | V <sub>REF</sub> = ±10V, 10kHz Sinewave             |            |     | 1.0   |      | mV <sub>P-P</sub> |
|                  | Output Current Settling Time     | (Note 5), To 0.01% for Full-Scale Change            |            |     | 0.6   |      | μs                |
| C <sub>OUT</sub> | Output Capacitance (Note 3)      | Digital Inputs = V <sub>IH</sub>                    | ●          |     |       | 200  | pF                |
|                  |                                  |                                                     | ●          |     |       | 70   | pF                |
|                  |                                  | Digital Inputs = V <sub>IL</sub>                    | ●          |     |       | 70   | pF                |
|                  |                                  |                                                     | ●          |     |       | 200  | pF                |

The ● denotes specifications which apply over the full operating temperature range.

**Note 1:**  $\pm 0.5\text{LSB} = \pm 0.012\%$  of full scale.

**Note 2:** Using internal feedback resistor.

**Note 3:** Guaranteed by design, not subject to test.

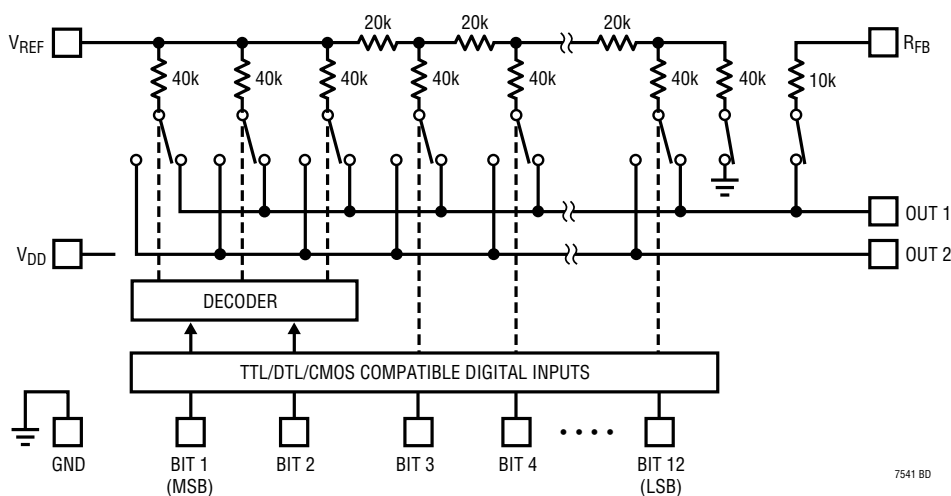
**Note 4:**  $I_{OUT1}$  with all digital inputs = 0V or  $I_{OUT2}$  with all digital inputs =  $V_{DD}$ .

**Note 5:** OUT 1 load =  $100\Omega$  in parallel with 13pF.

**Note 6:** Measured from digital input change to 90% of final analog value.  
Digital inputs = 0V to  $V_{DD}$  or  $V_{DD}$  to 0V.

**Note 7:**  $V_{REF} = 0V$ . All digital inputs 0V to  $V_{DD}$  or  $V_{DD}$  to 0V. Measured using LT1363 as output amplifier.

## BLOCK DIAGRAM



TYPICAL APPLICATIONS

Unipolar Operation (2-Quadrant Multiplication)

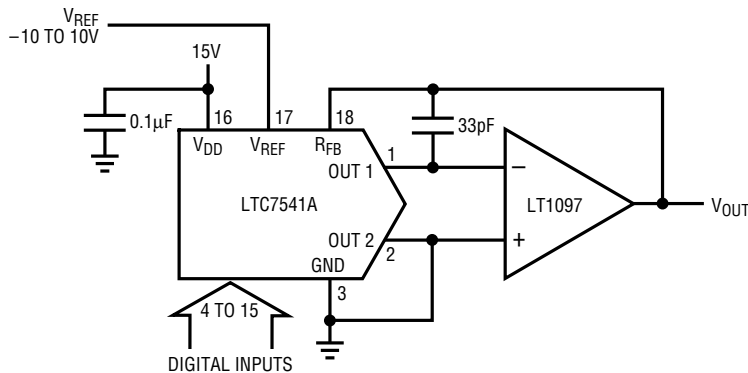


Table 1. Unipolar Binary Code Table

| DIGITAL INPUT |           | ANALOG OUTPUT<br>V <sub>OUT</sub>                    |
|---------------|-----------|------------------------------------------------------|
| MSB           | LSB       |                                                      |
| 1111          | 1111 1111 | -V <sub>REF</sub> (4095/4096)                        |
| 1000          | 0000 0000 | -V <sub>REF</sub> (2048/4096) = -V <sub>REF</sub> /2 |
| 0000          | 0000 0001 | -V <sub>REF</sub> (1/4096)                           |
| 0000          | 0000 0000 | 0V                                                   |

7541 TA03

Bipolar Operation (4-Quadrant Multiplication)

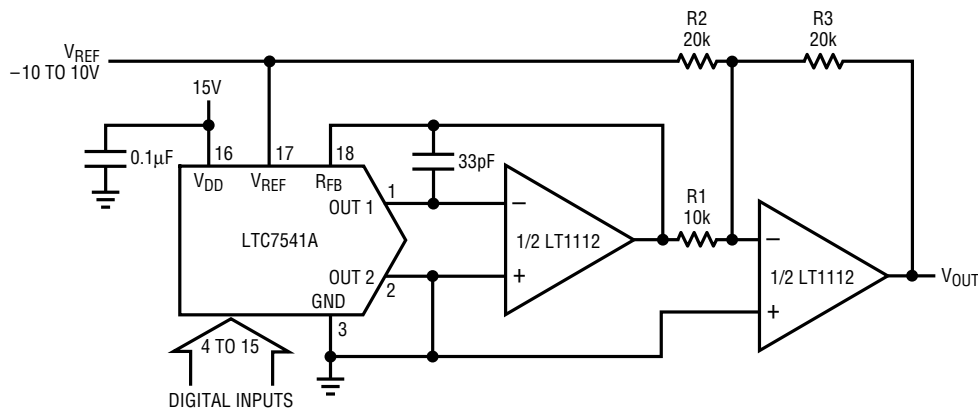


Table 2. Bipolar Offset Binary Code Table

| DIGITAL INPUT |           | ANALOG OUTPUT<br>V <sub>OUT</sub> |
|---------------|-----------|-----------------------------------|
| MSB           | LSB       |                                   |
| 1111          | 1111 1111 | V <sub>REF</sub> (2047/2048)      |
| 1000          | 0000 0001 | V <sub>REF</sub> (1/2048)         |
| 1000          | 0000 0000 | 0V                                |
| 0111          | 1111 1111 | -V <sub>REF</sub> (1/2048)        |
| 0000          | 0000 0000 | -V <sub>REF</sub>                 |

7541 TA04

RELATED PARTS

| PART NUMBER             | DESCRIPTION                                      | COMMENTS                                     |
|-------------------------|--------------------------------------------------|----------------------------------------------|
| LTC1257                 | Complete Serial I/O V <sub>OUT</sub> 12-Bit DAC  | 5V to 15V Single Supply in 8-Pin SO and PDIP |
| LTC1451/LTC1452/LTC1453 | Complete Serial I/O V <sub>OUT</sub> 12-Bit DACs | 3V/5V Single Supply in 8-Pin SO and PDIP     |
| LTC7543/LTC8143         | Serial I/O Multiplying 12-Bit DACs               | Clear Pin, Serial Data Output (LTC8143)      |
| LTC8043                 | Serial Multplying 12-Bit DAC                     | 8-Pin SO and PDIP                            |

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