

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

|                                            |                               |
|--------------------------------------------|-------------------------------|
| $AV_{DD}$ , $DV_{DD}$ to DGND .....        | -0.5V to 7.5V                 |
| TTL Input Voltage .....                    | -0.5V to 7.5V                 |
| $V_{OUT}$ , $V_{RST}$ .....                | -0.5V to ( $AV_{DD} + 0.5V$ ) |
| $AV_{SS}$ .....                            | 0.5V to -7.5V                 |
| Operating Temperature Range                |                               |
| LTC1650C .....                             | 0°C to 70°C                   |
| LTC1650I .....                             | -40°C to 85°C                 |
| Maximum Junction Temperature .....         | 125°C                         |
| Storage Temperature Range .....            | -65°C to 150°C                |
| Lead Temperature (Soldering, 10 sec) ..... | 300°C                         |

## PACKAGE/ORDER INFORMATION

| TOP VIEW                                                                                                                        |                          | ORDER PART NUMBER                                                                                        |
|---------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------------|
| $V_{OUT}$ [1]                                                                                                                   | [16] UNI/BIP             | LTC1650ACN<br>LTC1650AIN<br>LTC1650ACS<br>LTC1650AIS<br>LTC1650CN<br>LTC1650IN<br>LTC1650CS<br>LTC1650IS |
| $V_{RST}$ [2]                                                                                                                   | [15] $AV_{DD}$           |                                                                                                          |
| $DV_{DD}$ [3]                                                                                                                   | [14] $AV_{SS}$           |                                                                                                          |
| DGND [4]                                                                                                                        | [13] REFLO S             |                                                                                                          |
| $D_{IN}$ [5]                                                                                                                    | [12] REFLO F             |                                                                                                          |
| $D_{OUT}$ [6]                                                                                                                   | [11] REFHI               |                                                                                                          |
| CLK [7]                                                                                                                         | [10] $\overline{RSTOUT}$ |                                                                                                          |
| $\overline{CS/LD}$ [8]                                                                                                          | [9] $\overline{CLR}$     |                                                                                                          |
| N PACKAGE<br>16-LEAD PDIP                                                                                                       |                          |                                                                                                          |
| S PACKAGE<br>16-LEAD PLASTIC SO                                                                                                 |                          |                                                                                                          |
| $T_{JMAX} = 125^{\circ}C$ , $\theta_{JA} = 85^{\circ}C/W$ (N)<br>$T_{JMAX} = 125^{\circ}C$ , $\theta_{JA} = 130^{\circ}C/W$ (S) |                          |                                                                                                          |

Consult LTC Marketing for parts specified with wider operating temperature ranges.

## ELECTRICAL CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^{\circ}C$ .  $AV_{DD} = 4.75V$  to  $5.25V$ ,  $AV_{SS} = -4.75V$  to  $-5.25V$ ,  $DV_{DD} = 4.75V$  to  $5.25V$ , REFLO = 0V, REFHI = 4.096V,  $V_{OUT}$  unloaded, unless otherwise noted.

| SYMBOL                                                              | PARAMETER                                | CONDITIONS                                                                       | LTC1650CS/CN<br>LTC1650IS/IN |       |      | LTC1650ACS/ACN<br>LTC1650AIS/AIN |      |     | UNITS  |
|---------------------------------------------------------------------|------------------------------------------|----------------------------------------------------------------------------------|------------------------------|-------|------|----------------------------------|------|-----|--------|
|                                                                     |                                          |                                                                                  | MIN                          | TYP   | MAX  | MIN                              | TYP  | MAX |        |
| DAC Characteristics, Unipolar/Bipolar Output Unless Otherwise Noted |                                          |                                                                                  |                              |       |      |                                  |      |     |        |
|                                                                     | Resolution                               |                                                                                  | ●                            | 16    |      | 16                               |      |     | Bits   |
|                                                                     | Monotonicity                             |                                                                                  | ●                            | 16    |      | 16                               |      |     | Bits   |
| DNL                                                                 | Differential Nonlinearity                | Guaranteed Monotonic (Note 2)                                                    | ●                            | ±0.15 | ±0.9 | ±0.15                            | ±0.5 |     | LSB    |
| INL                                                                 | Integral Nonlinearity                    | Integral Nonlinearity (Note 2)                                                   | ●                            | ±4    | ±16  | ±4                               | ±8   |     | LSB    |
|                                                                     | Bipolar Zero Error                       | T <sub>A</sub> = 25°C                                                            |                              | ±5    | ±12  | ±5                               | ±12  |     | LSB    |
|                                                                     | Bipolar Zero Error                       | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>                            | ●                            |       | ±18  |                                  | ±18  |     | LSB    |
| V <sub>OS</sub>                                                     | Unipolar Offset Error                    | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>                            | ●                            | ±0.5  | ±12  | ±0.5                             | ±12  |     | LSB    |
| V <sub>OSTC</sub>                                                   | Offset Error Temperature Coefficient     |                                                                                  |                              | ±0.5  |      | ±0.5                             |      |     | µV/°C  |
|                                                                     | Gain Error                               | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub>                            | ●                            | ±4    | ±18  | ±4                               | ±12  |     | LSB    |
|                                                                     | Gain Error Temperature Coefficient       |                                                                                  |                              | ±0.5  |      | ±0.5                             |      |     | ppm/°C |
|                                                                     | Bipolar Negative Full-Scale Error        | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub><br>See Definitions Section | ●                            | ±1    | ±16  | ±1                               | ±12  |     | LSB    |
|                                                                     | Bipolar Negative Full-Scale Error Tempco | See Definitions Section                                                          |                              | ±0.75 |      | ±0.75                            |      |     | ppm/°C |

**ELECTRICAL CHARACTERISTICS**

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ .  $AV_{DD} = 4.75\text{V}$  to  $5.25\text{V}$ ,  $AV_{SS} = -4.75\text{V}$  to  $-5.25\text{V}$ ,  $DV_{DD} = 4.75\text{V}$  to  $5.25\text{V}$ ,  $REFLO = 0\text{V}$ ,  $REFHI = 4.096\text{V}$ ,  $V_{OUT}$  unloaded, unless otherwise noted.

| SYMBOL                              | PARAMETER                              | CONDITIONS                                                |   | MIN   | TYP                              | MAX   | UNITS                  |
|-------------------------------------|----------------------------------------|-----------------------------------------------------------|---|-------|----------------------------------|-------|------------------------|
| <b>Power Supply Characteristics</b> |                                        |                                                           |   |       |                                  |       |                        |
| $AV_{DD}$                           | Positive Supply Voltage                |                                                           | ● | 4.75  | 5.0                              | 5.25  | V                      |
| $DV_{DD}$                           | Positive Supply Voltage                |                                                           | ● | 4.75  | 5.0                              | 5.25  | V                      |
| $AV_{SS}$                           | Negative Supply Voltage                |                                                           | ● | -4.75 | -5.0                             | -5.25 | V                      |
| $I_{AVDD}$                          | $AV_{DD}$ Supply Current               | $4.75\text{V} \leq AV_{DD} \leq 5.25\text{V}$ (Note 5)    | ● |       | 5                                | 7.5   | mA                     |
| $I_{AVSS}$                          | $AV_{SS}$ Supply Current               | $-5.25\text{V} \leq AV_{SS} \leq -4.75\text{V}$ (Note 5)  | ● | -7.5  | -5                               |       | mA                     |
| $I_{DVDD}$                          | $DV_{DD}$ Supply Current               | $4.75\text{V} \leq DV_{DD} \leq 5.25\text{V}$ (Note 5)    | ● |       | 0.1                              | 0.25  | mA                     |
| PSRR                                | $AV_{DD}$ , $DV_{DD}$ Supply Rejection | $4.75\text{V} \leq AV_{DD}$ , $DV_{DD} \leq 5.25\text{V}$ | ● |       | 0.5                              | 1.5   | LSB/V                  |
|                                     | $AV_{SS}$ Supply Rejection             | $-5.25\text{V} \leq AV_{SS} \leq -4.75\text{V}$           | ● |       | 0.5                              | 1.5   | LSB/V                  |
| <b>Reference Input</b>              |                                        |                                                           |   |       |                                  |       |                        |
| $R_{IN}$                            | Reference Input Resistance             |                                                           | ● | 2.5   | 5                                | 7.5   | $k\Omega$              |
|                                     | REFHI Range                            |                                                           | ● | -4.0  | 4.0                              | 4.5   | V                      |
|                                     | REFLO Range                            |                                                           | ● | -1.0  | 0                                | 1.0   | V                      |
| <b>Op Amp DC Performance</b>        |                                        |                                                           |   |       |                                  |       |                        |
|                                     | Short-Circuit Current Low              | $V_{OUT}$ Shorted to GND                                  | ● |       | 25                               | 50    | mA                     |
|                                     | Short-Circuit Current High             | $V_{OUT}$ Shorted to $V_{CC}$                             | ● |       | 25                               | 50    | mA                     |
|                                     | Output Impedance                       | Measured at Midscale                                      |   |       | 0.15                             |       | $\Omega$               |
|                                     | DAC Output Range                       | Unipolar Mode (Note 9)<br>Bipolar Mode (Note 9)           |   |       | 0V to $V_{REF}$<br>$\pm V_{REF}$ |       | V<br>V                 |
| <b>AC Performance</b>               |                                        |                                                           |   |       |                                  |       |                        |
|                                     | Voltage Output Slew Rate               |                                                           | ● | 0.8   | 2.0                              |       | V/ $\mu\text{s}$       |
|                                     | Voltage Output Settling Time           | Unloaded (Note 4)                                         |   |       | 4                                |       | $\mu\text{s}$          |
|                                     | Midscale Glitch Impulse                |                                                           |   |       | 1.8                              |       | nV-s                   |
|                                     | Digital Feedthrough                    |                                                           |   |       | 0.05                             |       | nV-s                   |
|                                     | Output Noise Voltage Density           | 1kHz to 100kHz (Note 6)                                   |   |       | 30                               |       | nV/ $\sqrt{\text{Hz}}$ |
| SINAD                               | Signal-to-Noise + Distortion Ratio     | REFHI = 1kHz $4V_{P-P}$                                   |   |       | 96                               |       | dB                     |

**ELECTRICAL CHARACTERISTICS**

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| SYMBOL                             | PARAMETER                                 | CONDITIONS                               |   | MIN            | TYP | MAX      | UNITS         |
|------------------------------------|-------------------------------------------|------------------------------------------|---|----------------|-----|----------|---------------|
| <b>Digital I/O Characteristics</b> |                                           |                                          |   |                |     |          |               |
| $V_{IH}$                           | Digital Input High Voltage                |                                          | ● | 2.4            |     |          | V             |
| $V_{IL}$                           | Digital Input Low Voltage                 |                                          | ● |                |     | 0.8      | V             |
| $V_{OH}$                           | Digital Output High Voltage               | $I_{OUT} = -1\text{mA}$ , $D_{OUT}$ Only | ● | $V_{CC} - 1.0$ |     |          | V             |
| $V_{OL}$                           | Digital Output Low Voltage                | $I_{OUT} = 1\text{mA}$ , $D_{OUT}$ Only  | ● |                |     | 0.4      | V             |
| $I_{LK}$                           | Digital Input Leakage                     | $V_{IN} = \text{GND to } V_{CC}$         | ● |                |     | $\pm 10$ | $\mu\text{A}$ |
| $C_{IN}$                           | Digital Input Capacitance                 | (Note 3)                                 |   |                |     | 10       | pF            |
| <b>Reset Characteristics</b>       |                                           |                                          |   |                |     |          |               |
| $R_{ON}$                           | $V_{OUT}$ and $V_{RST}$ Switch Resistance | $V_{RST} = 0.5\text{V}$ (Note 7)         | ● |                | 200 | 500      | $\Omega$      |
|                                    | Threshold Voltage for Reset               | $AV_{DD}$ or $DV_{DD}$ (Note 8)          | ● | 1.5            | 2.5 | 3.2      | V             |
|                                    |                                           | $ AV_{SS} $ (Note 8)                     | ● | 1.5            | 2.5 | 3.2      | V             |
| <b>Switching Characteristics</b>   |                                           |                                          |   |                |     |          |               |
| $t_1$                              | $D_{IN}$ Valid to CLK Setup               |                                          | ● | 40             |     |          | ns            |
| $t_2$                              | $D_{IN}$ Valid to CLK Hold                |                                          | ● | 0              |     |          | ns            |
| $t_3$                              | CLK High Time                             | (Note 3)                                 | ● | 40             |     |          | ns            |
| $t_4$                              | CLK Low Time                              | (Note 3)                                 | ● | 40             |     |          | ns            |
| $t_5$                              | $\overline{CS}/LD$ Pulse Width            | (Note 3)                                 | ● | 50             |     |          | ns            |
| $t_6$                              | LSB CLK to $\overline{CS}/LD$             | (Note 3)                                 | ● | 40             |     |          | ns            |
| $t_7$                              | $\overline{CS}/LD$ Low to CLK             | (Note 3)                                 | ● | 20             |     |          | ns            |
| $t_8$                              | $D_{OUT}$ Output Delay                    | $C_{LOAD} = 100\text{pF}$                | ● | 5              | 45  | 150      | ns            |
| $t_9$                              | CLK Low to $\overline{CS}/LD$ Low         | (Note 3)                                 | ● | 20             |     |          | ns            |
| $t_{10}$                           | CLR Pulse Width                           |                                          | ● | 50             |     |          | ns            |

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** Nonlinearity is defined from code 0 to code 65535 (full scale) (end point INL, see Definitions section).

**Note 3:** Guaranteed by design. Not subject to test.

**Note 4:** To  $\pm 1\text{LSB}$ . Unipolar mode. DAC switched between all 1s and all 0s.

**Note 5:** Digital Inputs at 0V or  $DV_{DD}$ .

**Note 6:** Measured at  $V_{OUT}$ .  $REFHI = REFLO = 0\text{V}$ , unipolar mode.

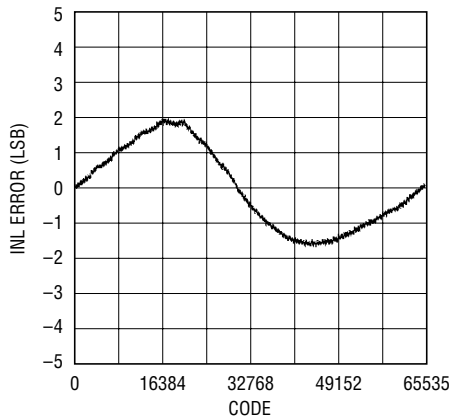
**Note 7:** When part powers up or when it is reset, the output is connected to  $V_{RST}$  through this switch.

**Note 8:** Reset is active when any supply goes below this threshold.

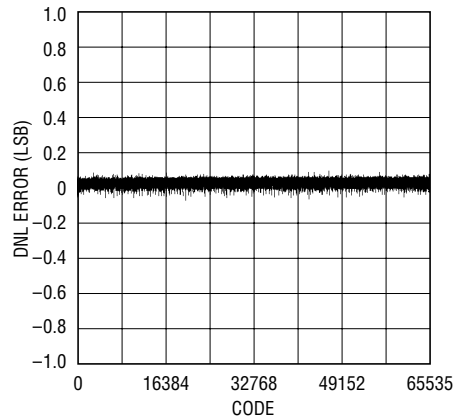
**Note 9:**  $REFLO = 0\text{V}$ ,  $REFHI = V_{REF}$ . For  $REFLO \neq 0\text{V}$  see Operation section.

# TYPICAL PERFORMANCE CHARACTERISTICS

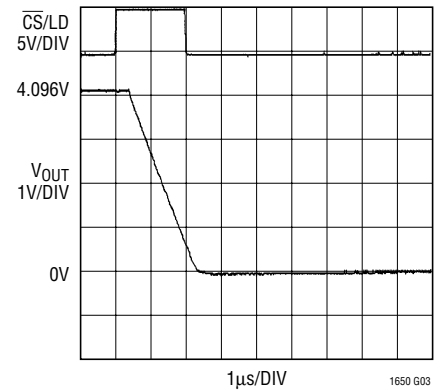
**Integral Nonlinearity (INL) vs Input Code**



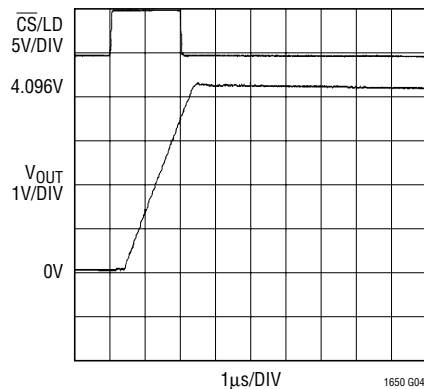
**Differential Nonlinearity (DNL) vs Input Code**



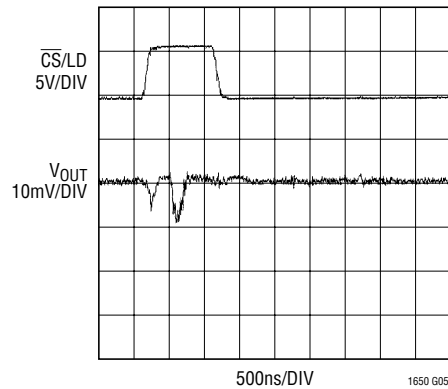
**Large Signal Settling Time**



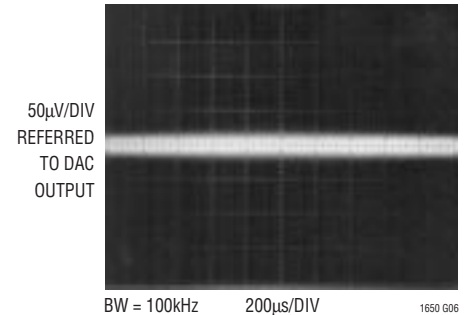
**Large Signal Settling Time**



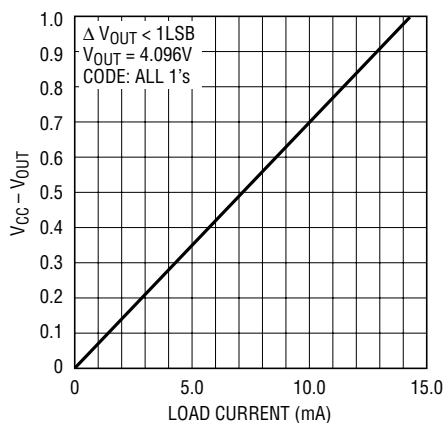
**Mid-Scale Glitch**



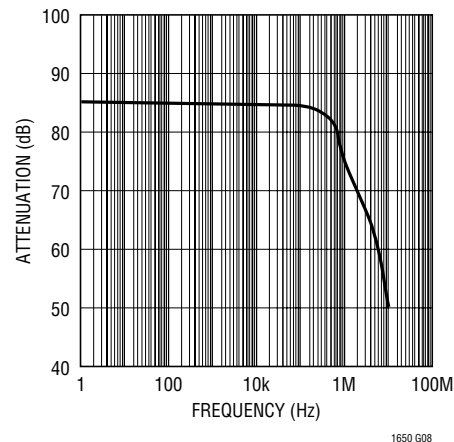
**Broadband Noise**



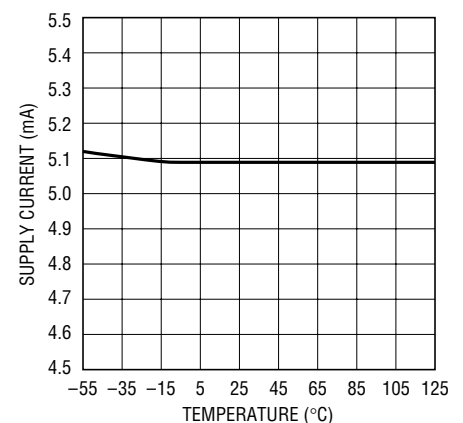
**Minimum Supply Headroom for Full Output Swing vs Load Current**



**Reference Feedthrough**

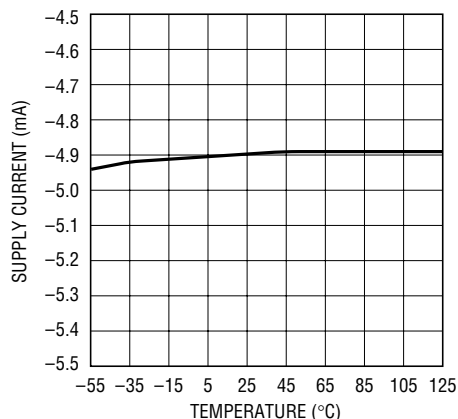


**$AV_{DD}$  Supply Current vs Temperature**



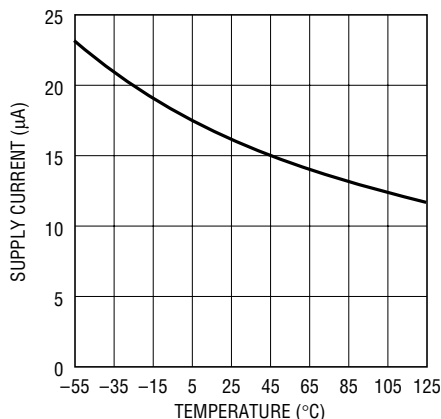
## TYPICAL PERFORMANCE CHARACTERISTICS

**AV<sub>SS</sub> Supply Current vs Temperature**



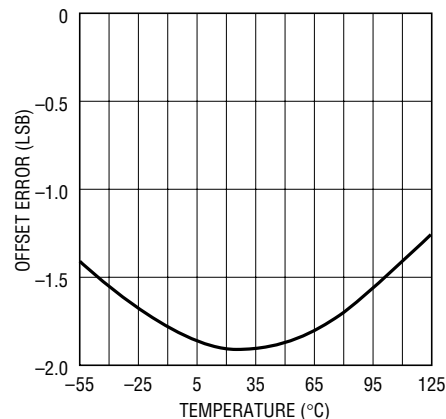
1650 G10

**DV<sub>DD</sub> Supply Current vs Temperature**



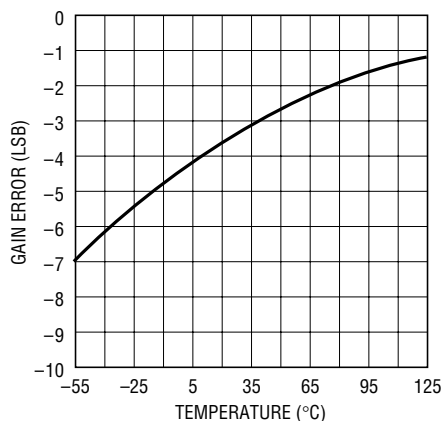
1650 G11

**Offset Error vs Temperature**



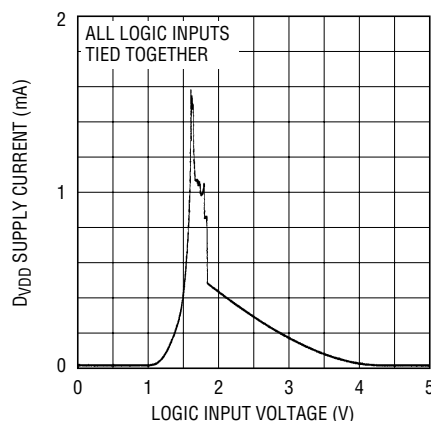
1650 G12

**Gain Error vs Temperature**



1650 G13

**Supply Current vs Logic Input Voltage**



1650 G14

## PIN FUNCTIONS

**V<sub>OUT</sub> (Pin 1):** The DAC Output. The output will swing from REFLO to REFHI in unipolar mode and from (2 • REFLO – REFHI) to REFHI in bipolar mode.

**V<sub>RST</sub> (Pin 2):** The user-defined voltage to which the output gets reset when CLR is active, when any of the supplies drop below 2.5V or when the part powers-up. The output will stay at this voltage until a new code is loaded into the DAC register.

**DV<sub>DD</sub> (Pin 3):** The Digital Positive Supply Input.  $4.75\text{V} \leq \text{DV}_{\text{DD}} \leq 5.25\text{V}$ .

**DGND (Pin 4):** Digital Ground.

**D<sub>IN</sub> (Pin 5):** The TTL Level Input for the Serial Interface Data. Data on the D<sub>IN</sub> pin is latched into the shift register on the rising edge of the serial clock. Data is loaded as one 16-bit word, MSB first.

**D<sub>OUT</sub> (Pin 6):** The output of the shift register that becomes valid on the rising edge of the serial clock.

**CLK (Pin 7):** The TTL Level Input for the Serial Interface Clock.

## PIN FUNCTIONS

**CS/LD (Pin 8):** The TTL Level Input for the Serial Interface Enable and Load Control. When CS/LD is low, the CLK signal is enabled so the data can be clocked in. When CS/LD is pulled high, data is loaded from the shift register into the DAC register, updating the DAC output.

**CLR (Pin 9):** The DAC is cleared to  $V_{RST}$  when this pin is pulled low. It should be logic high for normal operation.

**RSTOUT (Pin 10):** The logic output pin that goes active when any of the supplies drop below 2.5V. This pin is active low.

**REFHI (Pin 11):** The Reference Input Pin. The DAC is capable of 4-quadrant multiplying; this pin can swing from 4.5V to -4V.

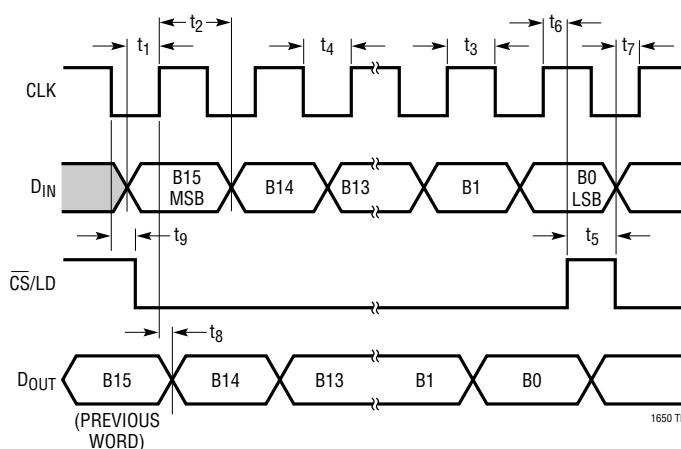
**REFLO F/REFLO S (Pins 12, 13):** The Force and Sense Pin for the Lower Reference Input. This should nominally be tied to ground. This pin can swing from -1V to 1V.

**AV<sub>SS</sub> (Pin 14):** The Analog Negative Supply Input.  $-5.25V \leq AV_{SS} \leq -4.75V$ . Requires a bypass capacitor to ground.

**AV<sub>DD</sub> (Pin 15):** The Analog Positive Supply Input.  $4.75V \leq AV_{DD} \leq 5.25V$ . Requires a bypass capacitor to ground.

**UNI/BIP (Pin 16):** The Unipolar/Bipolar Selection Pin. For unipolar operation, tie this pin to  $V_{OUT}$  and for bipolar operation, tie this pin the REFHI.

## TIMING DIAGRAM



## DEFINITIONS

### Resolution (n)

Resolution is defined as the number of digital input bits, n. It defines the number of DAC output states ( $2^n$ ) that divide the full-scale range. The resolution does not imply linearity.

### Full-Scale Voltage ( $V_{FS}$ )

This is the output of the DAC when all bits are set to 1. The output will swing from REFLO to REFHI in unipolar mode and from ( $2 \cdot \text{REFLO} - \text{REFHI}$ ) to REFHI when in bipolar mode.

### Voltage Offset Error ( $V_{OS}$ )

This is the voltage at the output when the DAC is loaded with all zeros.

### Least Significant Bit (LSB)

One LSB is the ideal voltage difference between two successive codes.

$$\text{LSB} = (V_{FS} - V_{OS}) / (2^n - 1) = (V_{FS} - V_{OS}) / 65535$$

### Integral Nonlinearity (INL)

Endpoint INL is the maximum deviation from a straight line passing through the endpoints of the DAC transfer curve. It is measured after adjusting out gain and offset error for the DAC.

### Differential Nonlinearity (DNL)

DNL is the difference between the measured change and the ideal 1LSB change between any two adjacent codes. The DNL error between any two codes is calculated as follows:

$$\text{DNL} = (\Delta V_{OUT} - \text{LSB}) / \text{LSB}$$

$\Delta V_{OUT}$  = The measured voltage difference between two adjacent codes.

### Gain Error (GE)

Gain error is the difference between the full-scale output of a DAC from its ideal full-scale value after offset error has been adjusted for.

### Bipolar Zero Error

When configured for bipolar output and with REFLO tied to 0V, the LTC1650 output should be 0V with (100...00) loaded in. Any deviation from 0V at this code is called bipolar zero error.

### Bipolar Negative Full-Scale Error

This is the offset error of the LTC1650 in bipolar mode.

## OPERATION

### Serial Interface

The data on the  $D_{IN}$  input is loaded into the shift register on the rising edge of the clock. Data is loaded as one 16-bit word, MSB first. The DAC register loads the data from the shift register when  $\overline{CS}/LD$  is pulled high. The clock is disabled internally when  $\overline{CS}/LD$  is high. Note: CLK must be low before  $\overline{CS}/LD$  is pulled low to avoid an extra internal clock pulse.

The buffered output of the 16-bit shift register is available on the  $D_{OUT}$  pin which swings from DGND to  $DV_{DD}$ .

Multiple LTC1650s may be daisy-chained together by connecting the  $D_{OUT}$  pin to the  $D_{IN}$  pin of the next chip while the clock and  $\overline{CS}/LD$  signals remain common to all chips in the daisy chain. The serial data is clocked to all of the chips, then the  $\overline{CS}/LD$  signal is pulled high to update all of them simultaneously.

When  $\overline{CLR}$  is pulled low or when the part powers up, the output connects through an internal pass gate to  $V_{RST}$  and will go to whatever voltage is on  $V_{RST}$ . When any of three supplies ( $DV_{DD}$ ,  $AV_{DD}$ ,  $|AV_{SS}|$ ) goes below 2.5V, the  $\overline{RSTOUT}$  pin goes low and stays low as long as the supply is below 2.5V. The power-on reset is also activated when one of the supplies drops below 2.5V and the output is then connected to  $V_{RST}$ . The output connects to  $V_{RST}$  when any of three conditions occur:  $\overline{CLR}$  goes low, the part powers up or one of the supplies drops below 2.5V. This

condition exists as long as  $\overline{CS}/LD$  is low. As soon as  $\overline{CS}/LD$  goes high, the DAC register is loaded with the data in the shift register and the output will settle to its new value.

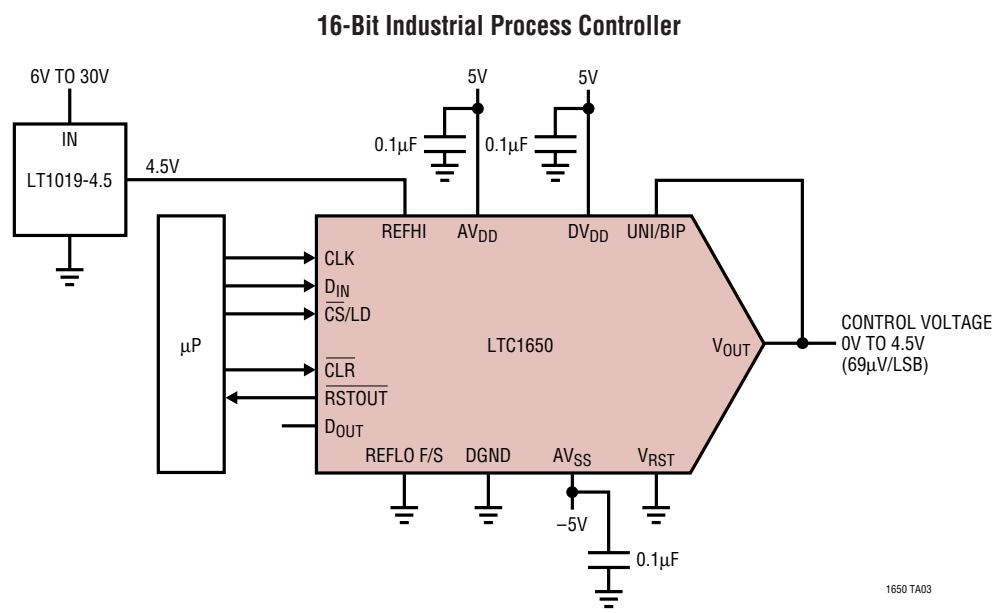
### Voltage Output

The LTC1650 rail-to-rail buffered output can source or sink 5mA over the entire operating temperature range. The output is specified to swing up to  $\pm 4.5V$  on  $\pm 4.75V$  supplies with  $V_{OUT}$  unloaded. (For typical output swing at various load currents, refer to the typical curve "Minimum Supply Headroom for Full Output Swing vs Load Current.") The buffer amplifier can drive 1000pF without going into oscillation. The LTC1650 has a deglitched voltage output. The midscale glitch is less than 2nV-s. The digital feedthrough is about 0.05nV-s.

### Output Ranges

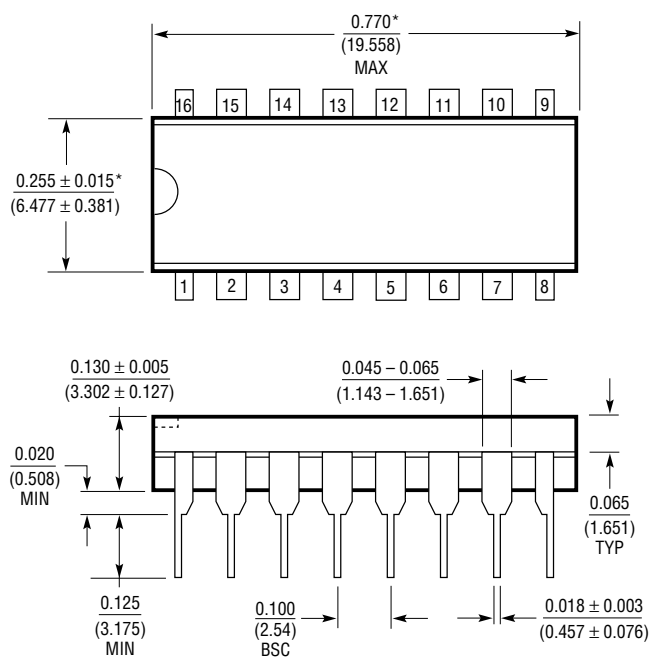
The LTC1650 is capable of unipolar or bipolar output swing. When the UNI/BIP pin is connected to  $V_{OUT}$  the part is configured for unipolar operation and the output will swing from REFLO to REFHI. When UNI/BIP is connected to REFHI the part is configured in bipolar mode and the output will swing from  $(2 \bullet \text{REFLO} - \text{REFHI})$  to REFHI and will be at REFLO at midscale. With REFLO = 0V the output swing is  $\pm \text{REFHI}$  in bipolar mode and 0V to REFHI in unipolar mode.

TYPICAL APPLICATION



## PACKAGE DESCRIPTION

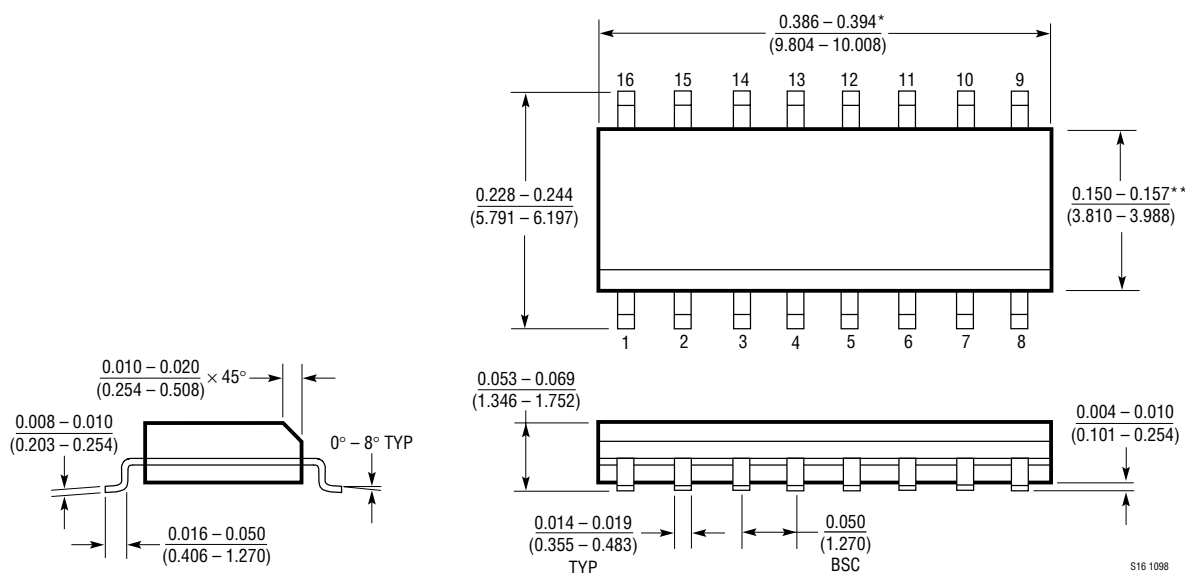
### N Package 16-Lead PDIP (Narrow .300 Inch) (Reference LTC DWG # 05-08-1510)



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

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### S Package 16-Lead Plastic Small Outline (Narrow .150 Inch) (Reference LTC DWG # 05-08-1610)



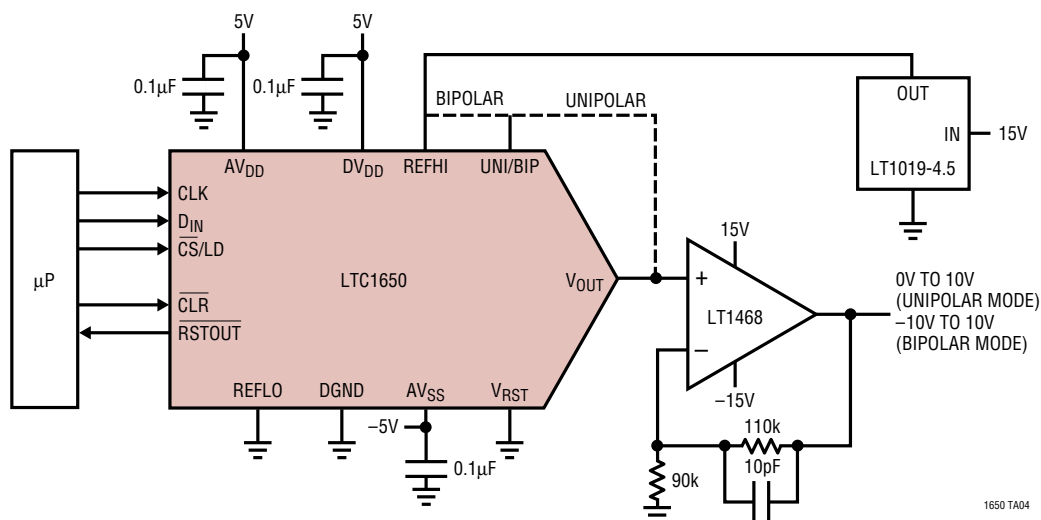
\*DIMENSION DOES NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.006\* (0.152mm) PER SIDE

\*\*DIMENSION DOES NOT INCLUDE INTERLEAD FLASH. INTERLEAD FLASH SHALL NOT EXCEED 0.010\* (0.254mm) PER SIDE

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## TYPICAL APPLICATION

### A $\pm 10\text{V}$ Bipolar Output 16-Bit DAC



## RELATED PARTS

| PART NUMBER                 | DESCRIPTION                                                                                                                                | COMMENTS                                                                                                                                                                                        |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DACs</b>                 |                                                                                                                                            |                                                                                                                                                                                                 |
| LTC1257                     | Single 12-Bit $V_{OUT}$ DAC, Full Scale: 2.048V, $V_{CC}$ : 4.75V to 15.75V, Reference Can Be Overdriven Up to 12V, i.e., $FS_{MAX} = 12V$ | 5V to 15V Single Supply, Complete $V_{OUT}$ DAC in SO-8 Package                                                                                                                                 |
| LTC1446/LTC1446L            | Dual 12-Bit $V_{OUT}$ DACs in SO-8 Package                                                                                                 | LTC1446: $V_{CC} = 4.5V$ to 5.5V, $V_{OUT} = 0V$ to 4.095V<br>LTC1446L: $V_{CC} = 2.7V$ to 5.5V, $V_{OUT} = 0V$ to 2.5V                                                                         |
| LTC1448                     | Dual 12-Bit $V_{OUT}$ DAC, $V_{CC}$ : 2.7V to 5.5V                                                                                         | Output Swings from GND to REF. REF Input Can Be Tied to $V_{CC}$                                                                                                                                |
| LTC1450/LTC1450L            | Single 12-Bit $V_{OUT}$ DACs with Parallel Interface                                                                                       | LTC1450: $V_{CC} = 4.5V$ to 5.5V, $V_{OUT} = 0V$ to 4.095V<br>LTC1450L: $V_{CC} = 2.7V$ to 5.5V, $V_{OUT} = 0V$ to 2.5V                                                                         |
| LTC1451/LTC1452/<br>LTC1453 | Single 12-Bit $V_{OUT}$ DACs with Serial Interface                                                                                         | LTC1451: $V_{CC} = 4.5V$ to 5.5V, $V_{OUT} = 0V$ to 4.095V<br>LTC1452: $V_{CC} = 2.7V$ to 5.5V, $V_{OUT} = 0V$ to $2 \cdot V_{REF}$<br>LTC1453: $V_{CC} = 2.7V$ to 5.5V, $V_{OUT} = 0V$ to 2.5V |
| LTC1456                     | Single Rail-to-Rail Output 12-Bit DAC with Clear Pin, Full Scale: 4.095V, $V_{CC}$ : 4.5V to 5.5V                                          | Low Power, Complete $V_{OUT}$ DAC in SO-8 Package with Clear Pin                                                                                                                                |
| LTC1458/LTC1458L            | Quad 12 Bit Rail-to-Rail Output DACs with Added Functionality                                                                              | LTC1458: $V_{CC} = 4.5V$ to 5.5V, $V_{OUT} = 0V$ to 4.095V<br>LTC1458L: $V_{CC} = 2.7V$ to 5.5V, $V_{OUT} = 0V$ to 2.5V                                                                         |
| LTC1595/LTC1596             | 16-Bit Serial I/O Multiplying $I_{OUT}$ DACs                                                                                               | $\pm 1LSB$ Max INL/DNL, Low Glitch, SO-8 Package (LTC1595), Clear Pin (LTC1596)                                                                                                                 |
| LTC1659                     | Single Rail-to-Rail 12-Bit $V_{OUT}$ DAC in MSOP-8 Package, $V_{CC}$ : 2.7V TO 5.5V                                                        | Low Power Multiplying $V_{OUT}$ DAC in MSOP-8 Package. Output Swings from GND to REF. REF Input Can Be Tied to $V_{CC}$                                                                         |
| <b>References</b>           |                                                                                                                                            |                                                                                                                                                                                                 |
| LT1019                      | Precision Voltage Reference                                                                                                                | Ultralow Drift 5ppm/ $^{\circ}C$ , Initial Accuracy: 0.05%                                                                                                                                      |
| LT1634                      | Micropower Precision Reference                                                                                                             | Low Drift 10ppm/ $^{\circ}C$ , Initial Accuracy: 0.05%                                                                                                                                          |