



Burr-Brown Products  
from Texas Instruments

DAC7714



## Quad, Serial Input, 12-Bit, Voltage Output DIGITAL-TO-ANALOG CONVERTER

### FEATURES

- **LOW POWER:** 250mW (max)
- **UNIPOLAR OR BIPOLAR OPERATION**
- **SETTLING TIME:** 10 $\mu$ s to 0.012%
- **12-BIT LINEARITY AND MONOTONICITY:**  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$
- **USER SELECTABLE RESET TO MID-SCALE OR ZERO-SCALE**
- **SECOND-SOURCE** for DAC8420
- **SMALL SO-16 PACKAGE**

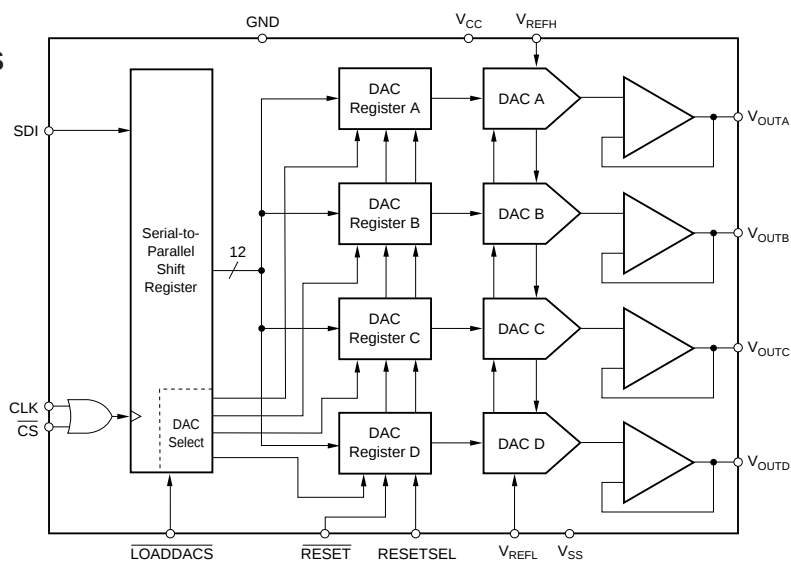
### APPLICATIONS

- **ATE PIN ELECTRONICS**
- **PROCESS CONTROL**
- **CLOSED-LOOP SERVO-CONTROL**
- **MOTOR CONTROL**
- **DATA ACQUISITION SYSTEMS**

### DESCRIPTION

The DAC7714 is a quad, serial input, 12-bit, voltage output Digital-to-Analog Converter (DAC) with guaranteed 12-bit monotonic performance over the  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  temperature range. An asynchronous reset clears all registers to either mid-scale ( $800_{\text{H}}$ ) or zero-scale ( $000_{\text{H}}$ ), selectable via the RESETSEL pin. The device can be powered from a single  $+15\text{V}$  supply or from dual  $+15\text{V}$  and  $-15\text{V}$  supplies.

Low power and small size makes the DAC7714 ideal for process control, data acquisition systems, and closed-loop servo-control. The device is available in a SO-16 package, and is guaranteed over the  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  temperature range.



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<http://www.burr-brown.com/>



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# SPECIFICATIONS (Dual Supply)

At  $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{CC} = +15\text{V}$ ,  $V_{SS} = -15\text{V}$ ,  $V_{REFH} = +10\text{V}$ ,  $V_{REFL} = -10\text{V}$ , unless otherwise noted.

| PARAMETER                          | CONDITIONS                                                             | DAC7714U                                 |                               |                   | DAC7714UB |     |         | UNITS                   |
|------------------------------------|------------------------------------------------------------------------|------------------------------------------|-------------------------------|-------------------|-----------|-----|---------|-------------------------|
|                                    |                                                                        | MIN                                      | TYP                           | MAX               | MIN       | TYP | MAX     |                         |
| <b>ACCURACY</b>                    |                                                                        |                                          |                               |                   |           |     |         |                         |
| Linearity Error                    | $T_{MIN}$ to $T_{MAX}$<br>Code = 000 <sub>H</sub>                      | 12                                       | 1                             | $\pm 2$           | *         | *   | $\pm 1$ | LSB <sup>(1)</sup>      |
| Linearity Matching <sup>(2)</sup>  |                                                                        |                                          |                               | $\pm 2$           |           |     | $\pm 1$ | LSB                     |
| Differential Linearity Error       |                                                                        |                                          |                               | $\pm 1$           |           |     | $\pm 1$ | LSB                     |
| Monotonicity                       |                                                                        |                                          |                               |                   |           |     |         | Bits                    |
| Zero-Scale Error                   |                                                                        |                                          |                               | $\pm 2$           |           |     | *       | LSB                     |
| Zero-Scale Drift                   | Code = FFF <sub>H</sub>                                                |                                          |                               | $\pm 2$           |           | *   | $\pm 1$ | ppm/ $^{\circ}\text{C}$ |
| Zero-Scale Matching <sup>(2)</sup> |                                                                        |                                          |                               | $\pm 2$           |           |     | *       | LSB                     |
| Full-Scale Error                   |                                                                        |                                          |                               | $\pm 2$           |           |     | $\pm 1$ | LSB                     |
| Full-Scale Matching <sup>(2)</sup> | At Full Scale                                                          |                                          | 10                            | $\pm 2$           |           | *   | $\pm 1$ | LSB                     |
| Power Supply Sensitivity           |                                                                        |                                          |                               |                   |           |     |         | ppm/V                   |
| <b>ANALOG OUTPUT</b>               |                                                                        |                                          |                               |                   |           |     |         |                         |
| Voltage Output <sup>(3)</sup>      | No Oscillation<br><br>To $V_{SS}$ , $V_{CC}$ , or GND                  | $V_{REFL}$<br>-5                         | 500<br>$\pm 20$<br>Indefinite | $V_{REFH}$<br>+5  | *         |     | *       | V                       |
| Output Current                     |                                                                        |                                          |                               |                   | *         |     | *       | mA                      |
| Load Capacitance                   |                                                                        |                                          |                               |                   |           | *   |         | pF                      |
| Short-Circuit Current              |                                                                        |                                          |                               |                   |           | *   |         | mA                      |
| Short-Circuit Duration             |                                                                        |                                          |                               |                   |           | *   |         |                         |
| <b>REFERENCE INPUT</b>             |                                                                        |                                          |                               |                   |           |     |         |                         |
| $V_{REFH}$ Input Range             |                                                                        | $V_{REFL} + 1.25$<br>-10<br>-0.5<br>-3.5 |                               | +10               | *         |     | *       | V                       |
| $V_{REFL}$ Input Range             |                                                                        |                                          |                               | $V_{REFH} - 1.25$ | *         |     | *       | V                       |
| Ref High Input Current             |                                                                        |                                          |                               | 3.0               | *         |     | *       | mA                      |
| Ref Low Input Current              |                                                                        |                                          |                               | 0                 | *         |     | *       | mA                      |
| <b>DYNAMIC PERFORMANCE</b>         |                                                                        |                                          |                               |                   |           |     |         |                         |
| Settling Time                      | To $\pm 0.012\%$ , 20V Output Step<br>Full-Scale Step<br><br>f = 10kHz |                                          | 8<br>0.25<br>2<br>65          | 10                |           | *   | *       | $\mu\text{s}$           |
| Channel-to-Channel Crosstalk       |                                                                        |                                          |                               |                   |           | *   | *       | LSB                     |
| Digital Feedthrough                |                                                                        |                                          |                               |                   |           |     | *       | nV-s                    |
| Output Noise Voltage               |                                                                        |                                          |                               |                   |           | *   |         | nV/ $\sqrt{\text{Hz}}$  |
| <b>DIGITAL INPUT</b>               |                                                                        |                                          |                               |                   |           |     |         |                         |
| Logic Levels                       | $I_{IH} \leq \pm 10\mu\text{A}$<br>$I_{IL} \leq \pm 10\mu\text{A}$     | 3.325                                    |                               |                   | *         |     | *       | V                       |
| $V_{IH}$                           |                                                                        |                                          |                               |                   |           |     |         | V                       |
| $V_{IL}$                           |                                                                        |                                          |                               | 1.575             |           |     |         | V                       |
| Data Format                        |                                                                        |                                          |                               | Straight Binary   |           |     |         |                         |
| <b>POWER SUPPLY REQUIREMENTS</b>   |                                                                        |                                          |                               |                   |           |     |         |                         |
| $V_{CC}$                           |                                                                        | +14.25<br>-15.75                         | 6<br>-6<br>180                | +15.75            | *         |     | *       | V                       |
| $V_{SS}$                           |                                                                        |                                          |                               | -14.25            | *         |     | *       | V                       |
| $I_{CC}$                           |                                                                        |                                          |                               | 8.5               |           | *   | *       | mA                      |
| $I_{SS}$                           |                                                                        |                                          |                               |                   | *         | *   | *       | mA                      |
| Power Dissipation                  |                                                                        |                                          |                               | 250               |           | *   | *       | mW                      |
|                                    |                                                                        |                                          |                               |                   |           |     |         |                         |
| <b>TEMPERATURE RANGE</b>           |                                                                        |                                          |                               |                   |           |     |         |                         |
| Specified Performance              |                                                                        | -40                                      |                               | +85               | *         |     | *       | $^{\circ}\text{C}$      |

NOTES: (1) LSB means Least Significant Bit; if  $V_{REFH}$  equals +10V and  $V_{REFL}$  equals -10V, then one LSB equals 4.88mV. (2) All DAC outputs will match within the specified error band. (3) Ideal output voltage does not take into account zero or full-scale error.

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# SPECIFICATIONS (Single Supply)

At  $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{CC} = +15\text{V}$ ,  $V_{SS} = \text{GND}$ ,  $V_{REFH} = +10\text{V}$ ,  $V_{REFL} = 0\text{V}$ , unless otherwise noted.

| PARAMETER                          | CONDITIONS                                                      | DAC7714U                                     |                          |                          | DAC7714UB |     |     | UNITS              |
|------------------------------------|-----------------------------------------------------------------|----------------------------------------------|--------------------------|--------------------------|-----------|-----|-----|--------------------|
|                                    |                                                                 | MIN                                          | TYP                      | MAX                      | MIN       | TYP | MAX |                    |
| ACCURACY                           |                                                                 |                                              |                          |                          |           |     |     |                    |
| Linearity Error <sup>(1)</sup>     | T <sub>MIN</sub> to T <sub>MAX</sub><br>Code = 004 <sub>H</sub> | 12                                           | 2                        | ±2                       | *         | *   | ±1  | LSB <sup>(2)</sup> |
| Linearity Matching <sup>(3)</sup>  |                                                                 |                                              |                          | ±2                       |           |     | ±1  | LSB                |
| Differential Linearity Error       |                                                                 |                                              |                          | ±1                       |           |     | ±1  | LSB                |
| Monotonicity                       |                                                                 |                                              |                          |                          |           |     |     | Bits               |
| Zero-Scale Error                   |                                                                 |                                              |                          | ±4                       |           |     | *   | LSB                |
| Zero-Scale Drift                   | Code = FFF <sub>H</sub>                                         |                                              | 2                        | ±4                       |           | *   | ±2  | ppm/°C             |
| Zero-Scale Matching <sup>(3)</sup> |                                                                 |                                              |                          | ±4                       |           |     | *   | LSB                |
| Full-Scale Error                   |                                                                 |                                              |                          | ±4                       |           |     | ±2  | LSB                |
| Full-Scale Matching <sup>(3)</sup> | At Full Scale                                                   |                                              | 20                       | ±4                       |           | *   | ±2  | LSB                |
| Power Supply Sensitivity           |                                                                 |                                              |                          |                          |           |     |     | ppm/V              |
| ANALOG OUTPUT                      |                                                                 |                                              |                          |                          |           |     |     |                    |
| Voltage Output <sup>(4)</sup>      | No Oscillation<br><br>To V <sub>CC</sub> or GND                 | V <sub>REFL</sub><br>−5                      | 500<br>±20<br>Indefinite | V <sub>REFH</sub><br>+5  | *         | *   | *   | V                  |
| Output Current                     |                                                                 |                                              |                          | mA                       |           |     |     |                    |
| Load Capacitance                   |                                                                 |                                              |                          | pF                       |           |     |     |                    |
| Short-Circuit Current              |                                                                 |                                              |                          | mA                       |           |     |     |                    |
| Short-Circuit Duration             |                                                                 |                                              |                          |                          |           |     |     |                    |
| REFERENCE INPUT                    |                                                                 |                                              |                          |                          |           |     |     |                    |
| V <sub>REFH</sub> Input Range      |                                                                 | V <sub>REFL</sub> +1.25<br>0<br>−0.3<br>−2.0 |                          | +10                      | *         |     | *   | V                  |
| V <sub>REFL</sub> Input Range      |                                                                 |                                              |                          | V <sub>REFH</sub> − 1.25 |           |     | *   | V                  |
| Ref High Input Current             |                                                                 |                                              |                          | 1.5                      |           |     | *   | mA                 |
| Ref Low Input Current              |                                                                 |                                              |                          | 0                        |           |     | *   | mA                 |
| DYNAMIC PERFORMANCE                |                                                                 |                                              |                          |                          |           |     |     |                    |
| Settling Time <sup>(5)</sup>       | To ±0.012%, 10V Output Step                                     |                                              | 8<br>0.25<br>2<br>65     | 10                       |           | *   | *   | μs                 |
| Channel-to-Channel Crosstalk       |                                                                 |                                              |                          |                          |           |     |     | LSB                |
| Digital Feedthrough                | f = 10kHz                                                       |                                              |                          |                          |           | *   | *   | nV-s               |
| Output Noise Voltage               |                                                                 |                                              |                          |                          |           |     |     | nV/√Hz             |
| DIGITAL INPUT/OUTPUT               |                                                                 |                                              |                          |                          |           |     |     |                    |
| Logic Levels                       | I <sub>IH</sub> ≤ ±10μA<br>I <sub>IL</sub> ≤ ±10μA              | 3.325                                        |                          | 1.575                    | *         |     | *   | V                  |
| V <sub>IH</sub>                    |                                                                 |                                              |                          |                          |           |     |     | V                  |
| V <sub>IL</sub>                    |                                                                 |                                              |                          |                          |           |     |     | V                  |
| Data Format                        | Straight Binary                                                 |                                              |                          |                          |           | *   |     |                    |
| POWER SUPPLY REQUIREMENTS          |                                                                 |                                              |                          |                          |           |     |     |                    |
| V <sub>CC</sub>                    |                                                                 | 14.25                                        | 3.0<br>45                | 15.75                    | *         | *   | *   | V                  |
| I <sub>CC</sub>                    |                                                                 |                                              |                          |                          |           |     |     | mA                 |
| Power Dissipation                  |                                                                 |                                              |                          |                          |           |     |     | mW                 |
| TEMPERATURE RANGE                  |                                                                 |                                              |                          |                          |           |     |     |                    |
| Specified Performance              |                                                                 | −40                                          |                          | +85                      | *         |     | *   | °C                 |

NOTES: (1) If  $V_{SS} = 0\text{V}$ , specification applies at code 004<sub>H</sub> and above. (2) LSB means Least Significant Bit; if  $V_{REFH}$  equals +10V and  $V_{REFL}$  equals 0V, then one LSB equals 2.44mV. (3) All DAC outputs will match within the specified error band. (4) Ideal output voltage does not take into account zero or full-scale error. (5) Full-scale positive 10V step and negative step from code FFF<sub>H</sub> to 020<sub>H</sub>.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

|                                             |                 |
|---------------------------------------------|-----------------|
| $V_{CC}$ to $V_{SS}$ .....                  | -0.3V to +32V   |
| $V_{CC}$ to GND .....                       | -0.3V to +16V   |
| $V_{SS}$ to GND .....                       | +0.3V to -16V   |
| $V_{REFH}$ to GND .....                     | -9V to +11V     |
| $V_{REFL}$ to GND ( $V_{SS} = -15V$ ) ..... | -11V to +9V     |
| $V_{REFL}$ to GND ( $V_{SS} = 0V$ ) .....   | -0.3V to +9V    |
| $V_{REFH}$ to $V_{REFL}$ .....              | -1V to +22V     |
| Digital Input Voltage to GND .....          | -0.3V to 5.8V   |
| Digital Output Voltage to GND .....         | -0.3V to 5.8V   |
| Maximum Junction Temperature .....          | +150°C          |
| Operating Temperature Range .....           | -40°C to +85°C  |
| Storage Temperature Range .....             | -65°C to +150°C |
| Lead Temperature (soldering, 10s) .....     | +300°C          |

NOTE: (1) Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability.



## ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

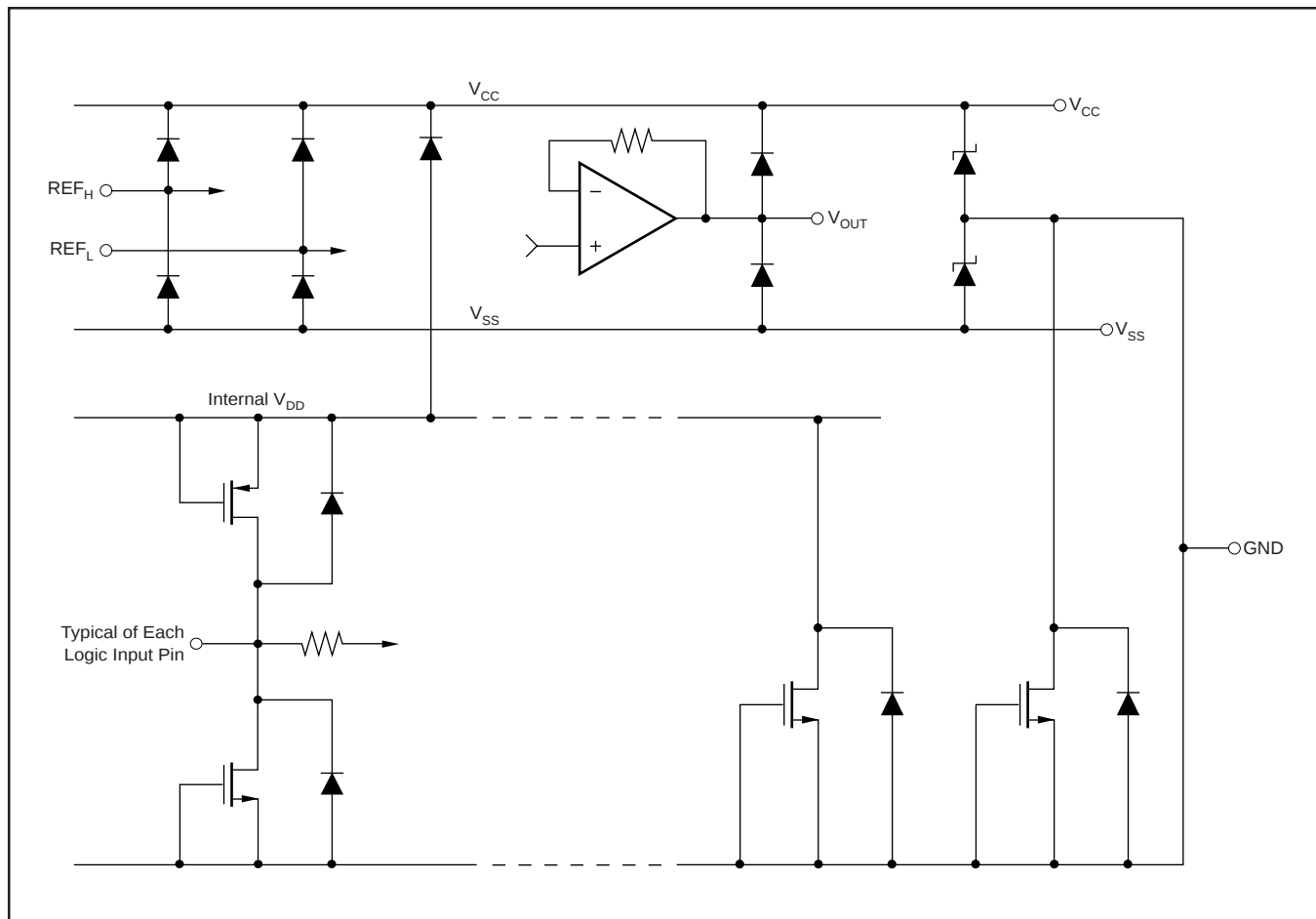
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION

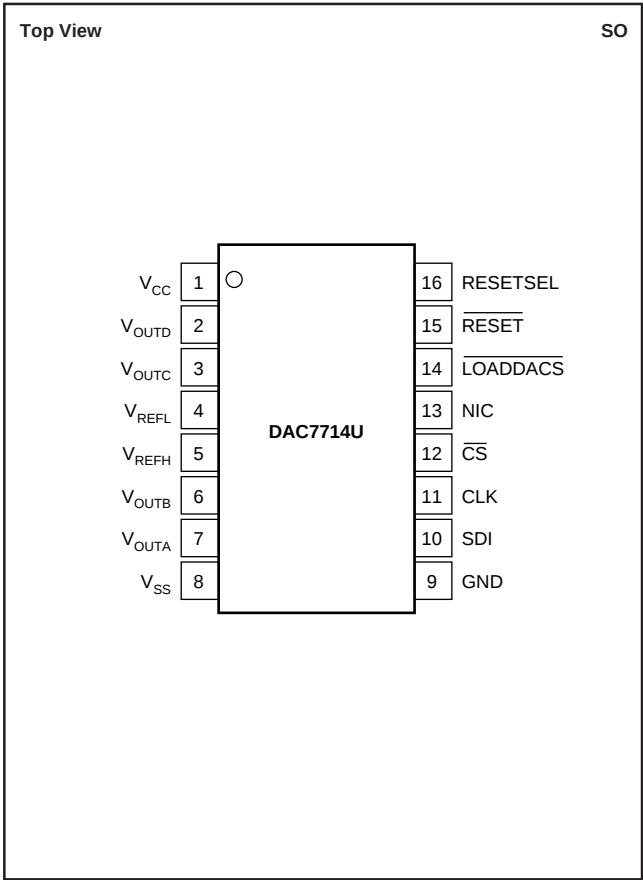
| PRODUCT        | MAXIMUM LINEARITY ERROR (LSB) | MAXIMUM DIFFERENTIAL LINEARITY (LSB) | PACKAGE    | PACKAGE DRAWING NUMBER | SPECIFICATION TEMPERATURE RANGE | ORDERING NUMBER <sup>(1)</sup> | TRANSPORT MEDIA        |
|----------------|-------------------------------|--------------------------------------|------------|------------------------|---------------------------------|--------------------------------|------------------------|
| DAC7714U<br>"  | ±2<br>"                       | ±1<br>"                              | SO-16<br>" | 211<br>"               | -40°C to +85°C<br>"             | DAC7714U<br>DAC7714U/1K        | Rails<br>Tape and Reel |
| DAC7714UB<br>" | ±1<br>"                       | ±1<br>"                              | SO-16<br>" | 211<br>"               | -40°C to +85°C<br>"             | DAC7714UB<br>DAC7714UB/1K      | Rails<br>Tape and Reel |

NOTE: (1) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /1K indicates 1000 devices per reel). Ordering 1000 pieces of "DAC7714UB/1K" will get a single 1000-piece Tape and Reel.

## ESD PROTECTION CIRCUITS



PIN CONFIGURATION—U Package



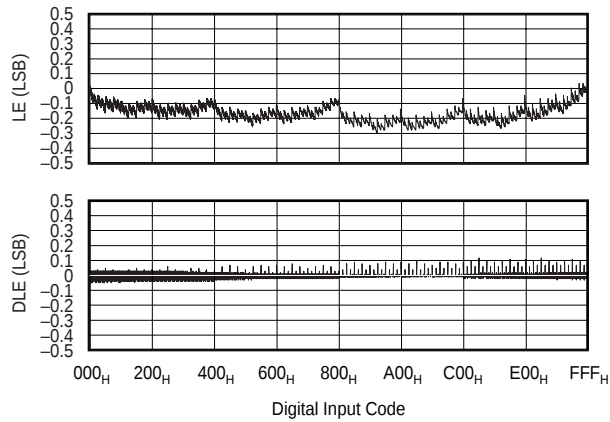
PIN DESCRIPTIONS—U Package

| PIN | LABEL                        | DESCRIPTION                                                                                                                                                                                                                |
|-----|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | V <sub>CC</sub>              | Positive Analog Supply Voltage, +15V nominal.                                                                                                                                                                              |
| 2   | V <sub>OUTD</sub>            | DAC D Voltage Output                                                                                                                                                                                                       |
| 3   | V <sub>OUTC</sub>            | DAC C Voltage Output                                                                                                                                                                                                       |
| 4   | V <sub>REFL</sub>            | Reference Input Voltage Low. Sets minimum output voltage for all DACs.                                                                                                                                                     |
| 5   | V <sub>REFH</sub>            | Reference Input Voltage High. Sets maximum output voltage for all DACs.                                                                                                                                                    |
| 6   | V <sub>OUTB</sub>            | DAC B Voltage Output                                                                                                                                                                                                       |
| 7   | V <sub>OUTA</sub>            | DAC A Voltage Output                                                                                                                                                                                                       |
| 8   | V <sub>SS</sub>              | Negative Analog Supply Voltage, 0V or –15V nominal.                                                                                                                                                                        |
| 9   | GND                          | Ground                                                                                                                                                                                                                     |
| 10  | SDI                          | Serial Data Input                                                                                                                                                                                                          |
| 11  | CLK                          | Serial Data Clock                                                                                                                                                                                                          |
| 12  | $\overline{\text{CS}}$       | Chip Select Input                                                                                                                                                                                                          |
| 13  | NIC                          | Not Internally Connected                                                                                                                                                                                                   |
| 14  | $\overline{\text{LOADDACS}}$ | The selected DAC register becomes transparent when $\overline{\text{LOADDACS}}$ is LOW. It is in the latched state when $\overline{\text{LOADDACS}}$ is HIGH.                                                              |
| 15  | $\overline{\text{RESET}}$    | Asynchronous Reset Input. Sets all DAC registers to either zero-scale (000 <sub>H</sub> ) or mid-scale (800 <sub>H</sub> ) when LOW. RESETSEL determines which code is active.                                             |
| 16  | RESETSEL                     | When LOW, a LOW on $\overline{\text{RESET}}$ will cause all DAC registers to be set to code 000 <sub>H</sub> . When RESETSEL is HIGH, a LOW on $\overline{\text{RESET}}$ will set the registers to code 800 <sub>H</sub> . |

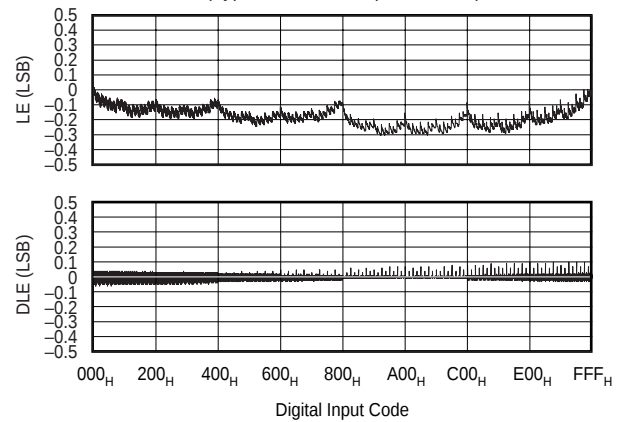
# TYPICAL PERFORMANCE CURVES: $V_{SS} = 0V$

At  $T_A = +25^\circ C$ ,  $V_{CC} = +15V$ ,  $V_{SS} = 0V$ ,  $V_{REFH} = +10V$ ,  $V_{REFL} = 0V$ , representative unit, unless otherwise specified.

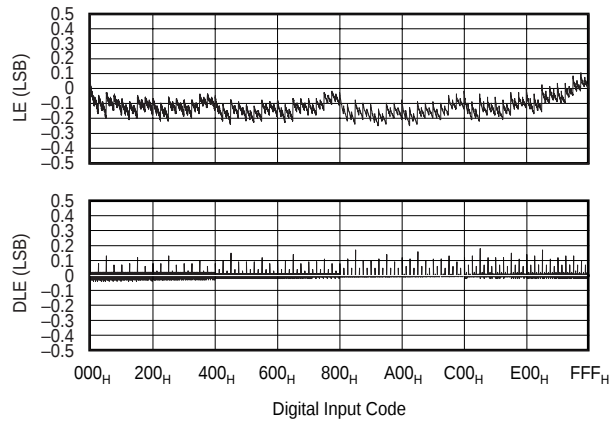
LINEARITY ERROR AND  
DIFFERENTIAL LINEARITY ERROR vs CODE  
**Single Channel  $25^\circ C$**   
(Typical of Each Output Channel)



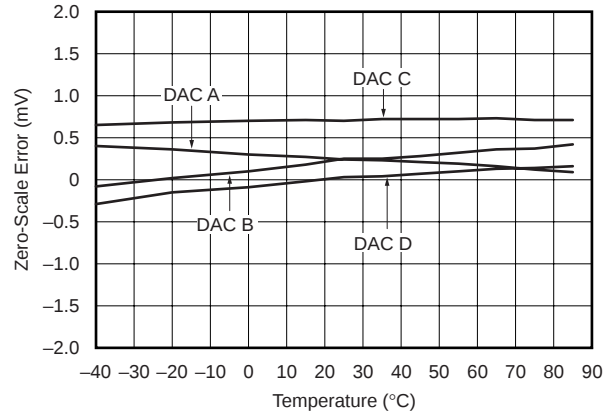
LINEARITY ERROR AND  
DIFFERENTIAL LINEARITY ERROR vs CODE  
**Single Channel  $85^\circ C$**   
(Typical of Each Output Channel)



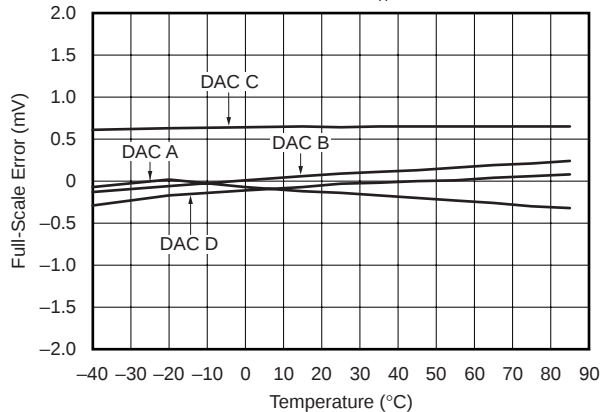
LINEARITY ERROR AND  
DIFFERENTIAL LINEARITY ERROR vs CODE  
**Single Channel  $-40^\circ C$**   
(Typical of Each Output Channel)



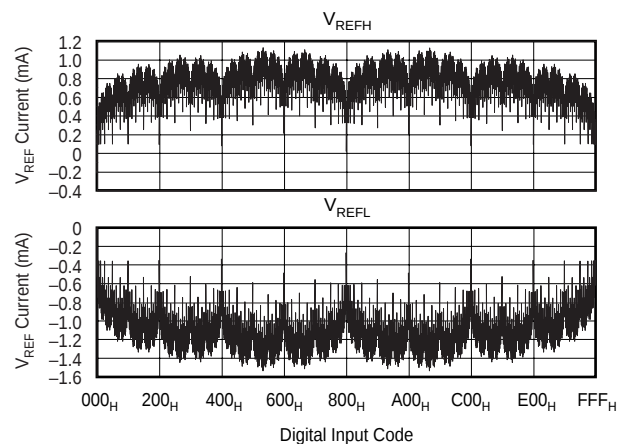
ZERO-SCALE ERROR vs TEMPERATURE  
(Code 004<sub>H</sub>)



FULL-SCALE ERROR vs TEMPERATURE  
(Code FFF<sub>H</sub>)

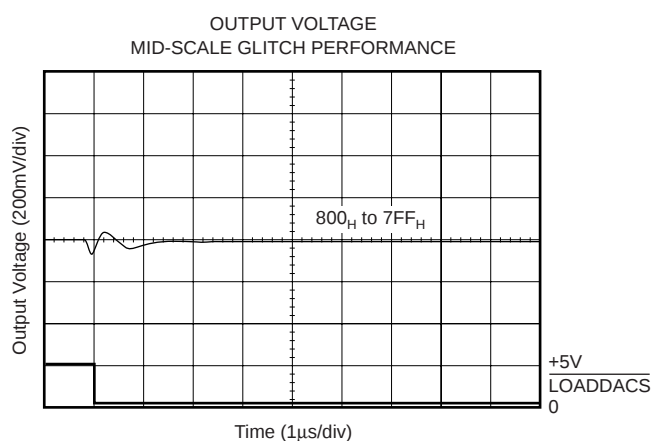
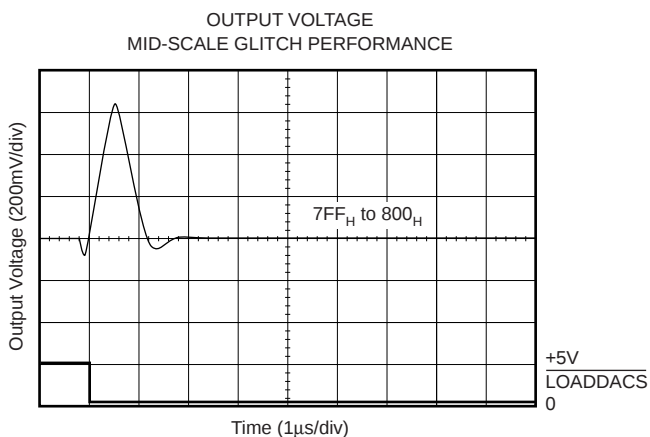
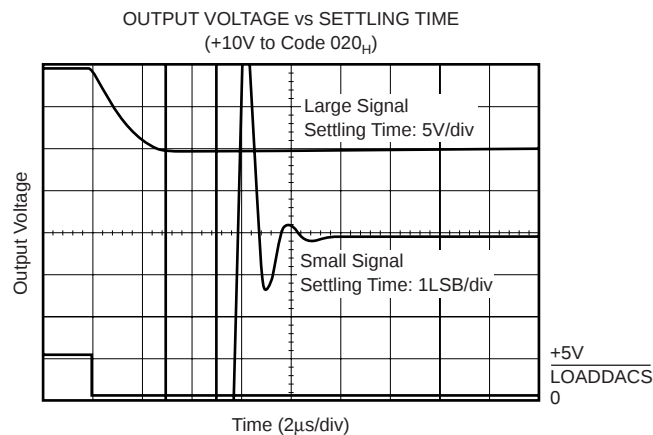
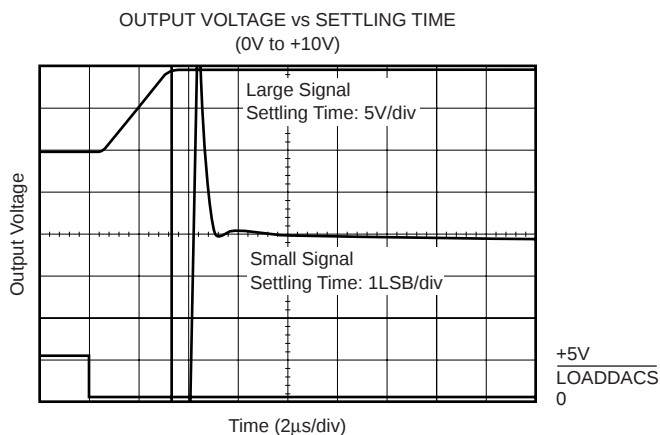
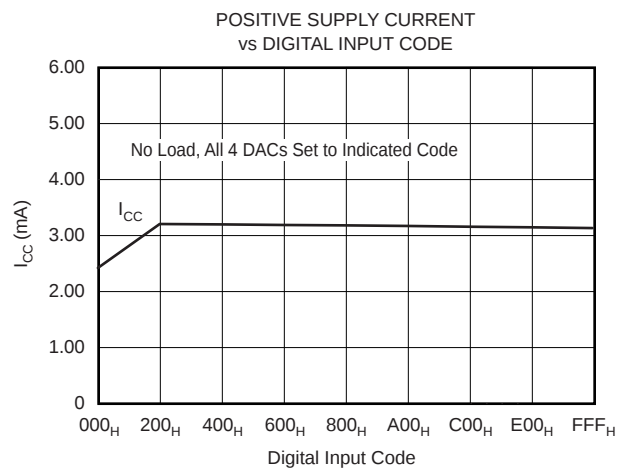
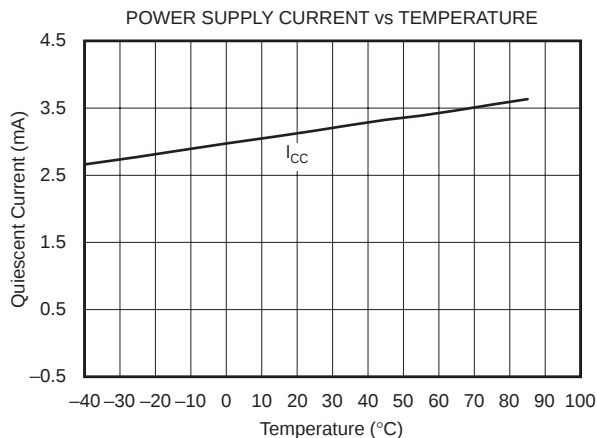


CURRENT vs CODE  
All DACs Set to Indicated Code



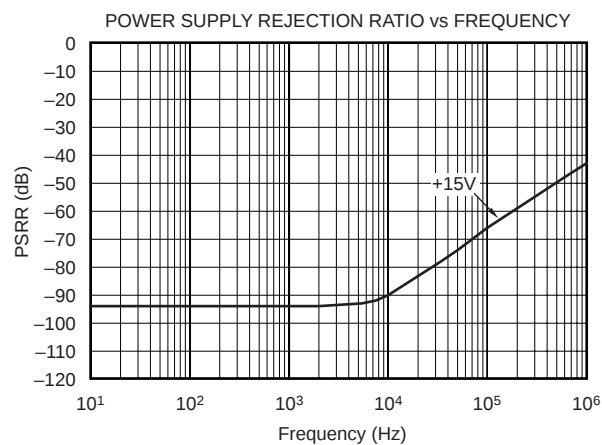
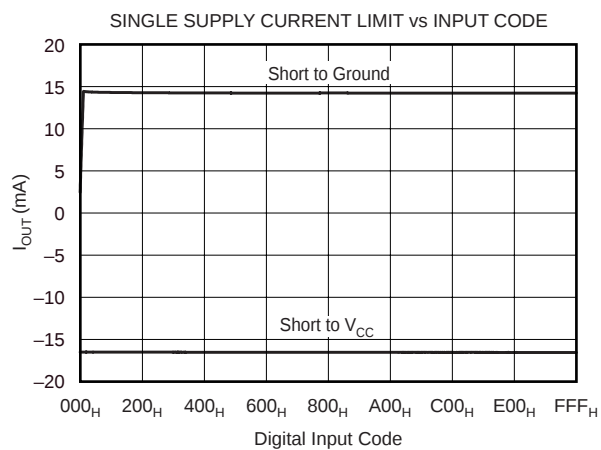
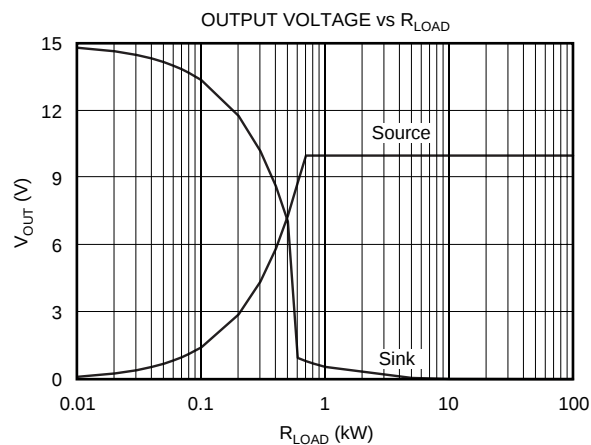
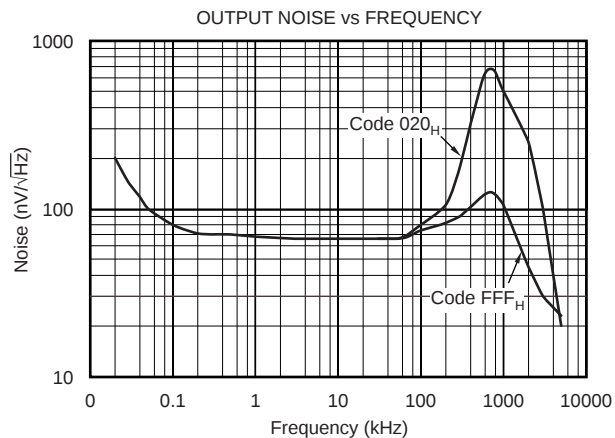
# TYPICAL PERFORMANCE CURVES: $V_{SS} = 0V$ (Cont.)

At  $T_A = +25^\circ C$ ,  $V_{CC} = +15V$ ,  $V_{SS} = 0V$ ,  $V_{REFH} = +10V$ ,  $V_{REFL} = 0V$ , representative unit, unless otherwise specified.



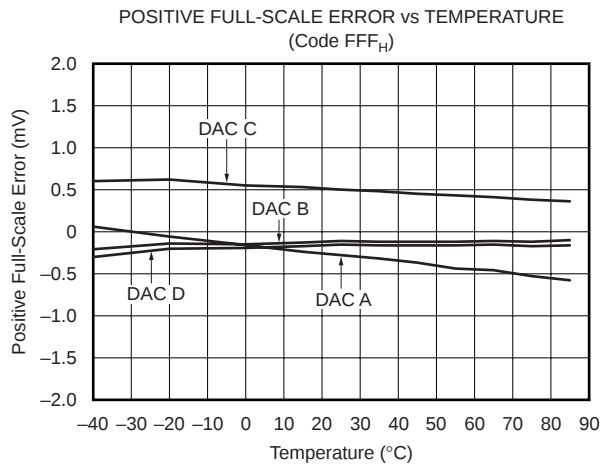
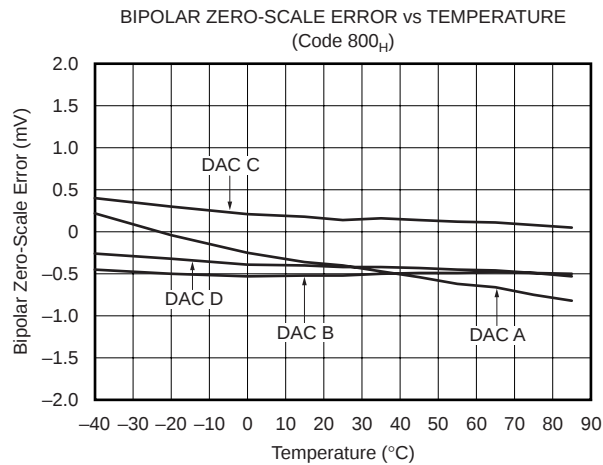
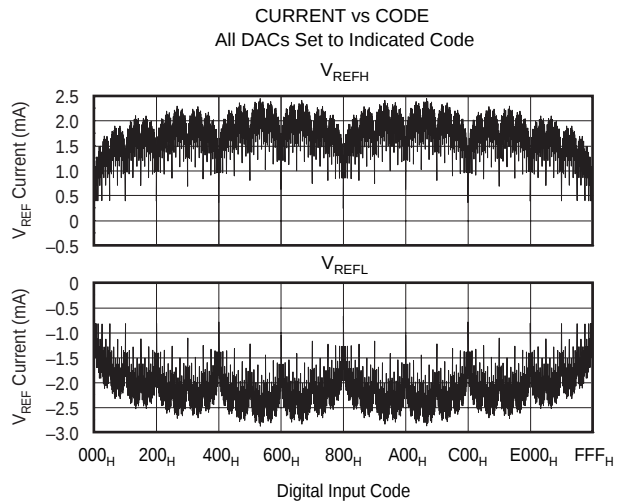
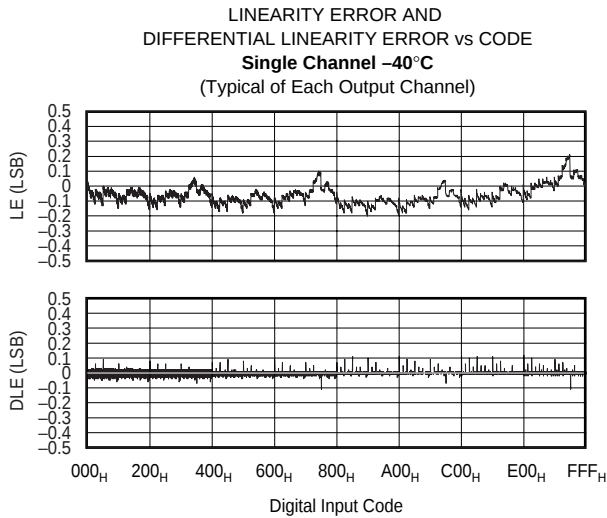
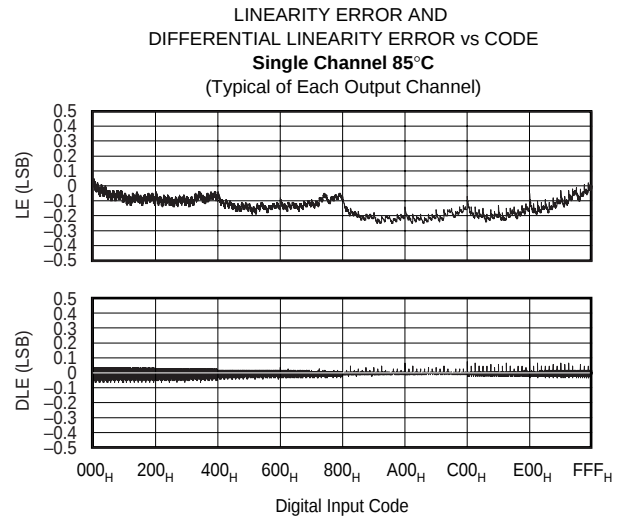
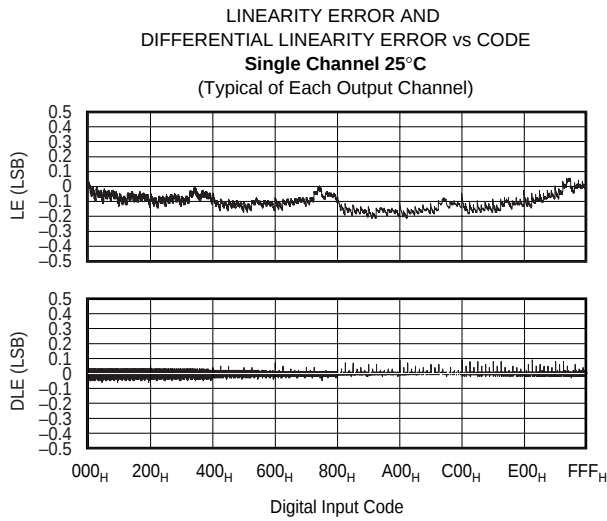
# TYPICAL PERFORMANCE CURVES: $V_{SS} = 0V$ (Cont.)

At  $T_A = +25^\circ C$ ,  $V_{CC} = +15V$ ,  $V_{SS} = 0V$ ,  $V_{REFH} = +10V$ ,  $V_{REFL} = 0V$ , representative unit, unless otherwise specified.



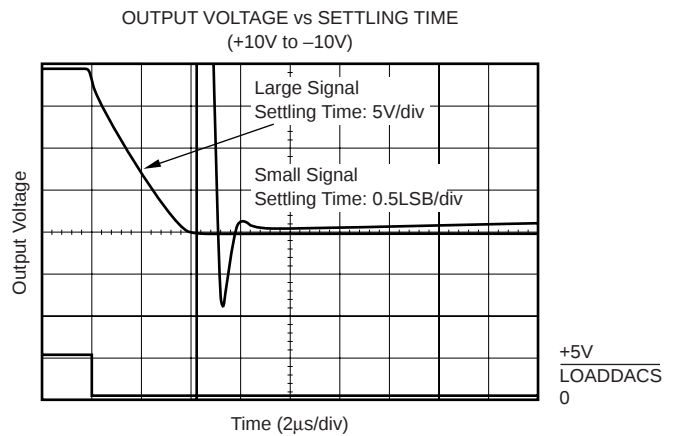
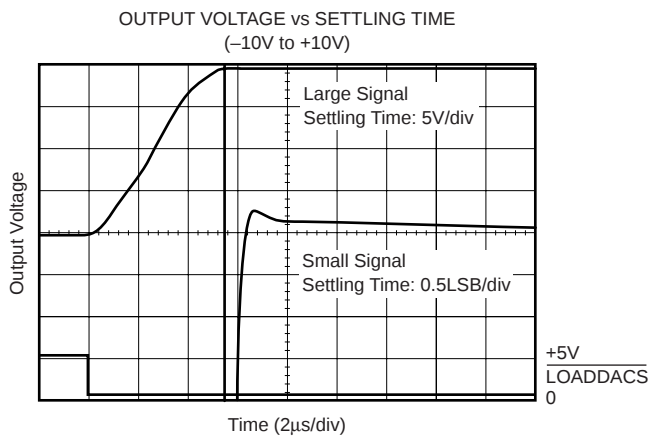
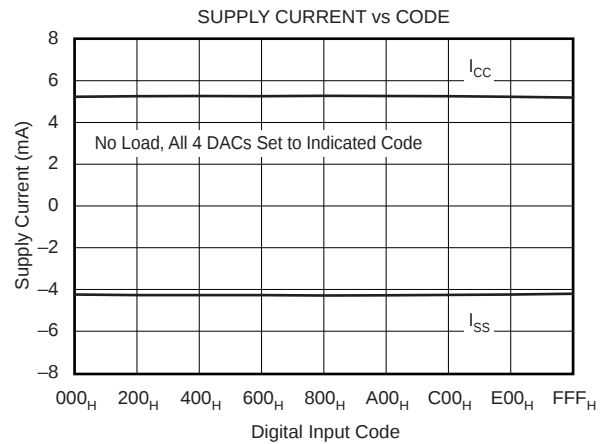
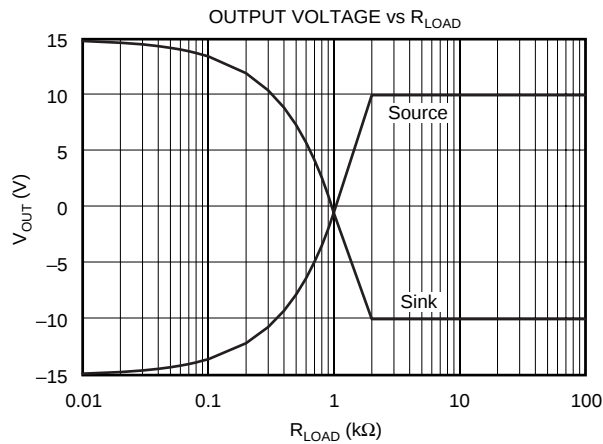
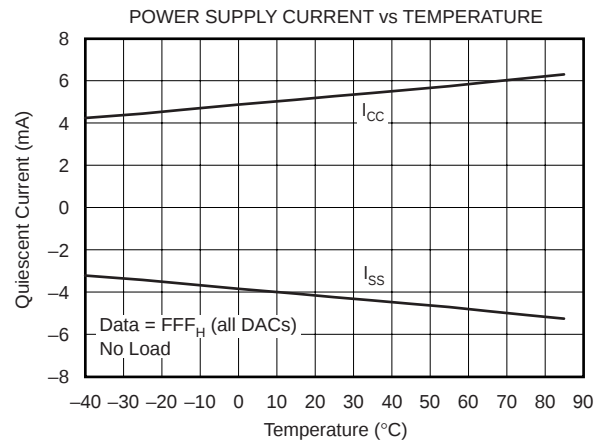
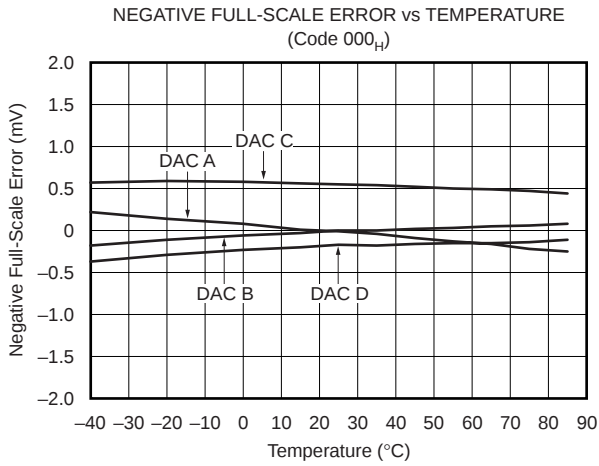
# TYPICAL PERFORMANCE CURVES: $V_{SS} = -15V$

At  $T_A = +25^\circ C$ ,  $V_{CC} = +15V$ ,  $V_{SS} = -15V$ ,  $V_{REFH} = +10V$ ,  $V_{REFL} = -10V$ , representative unit, unless otherwise specified.



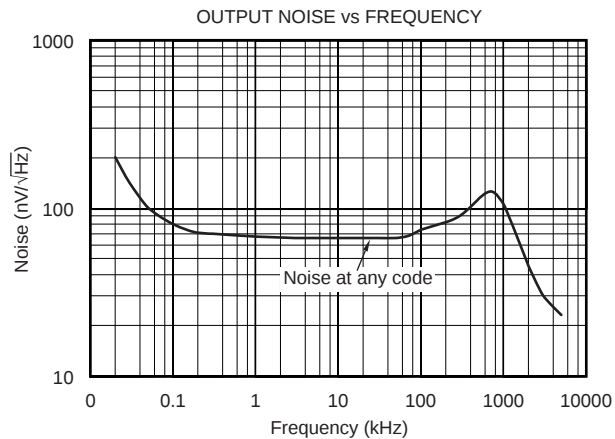
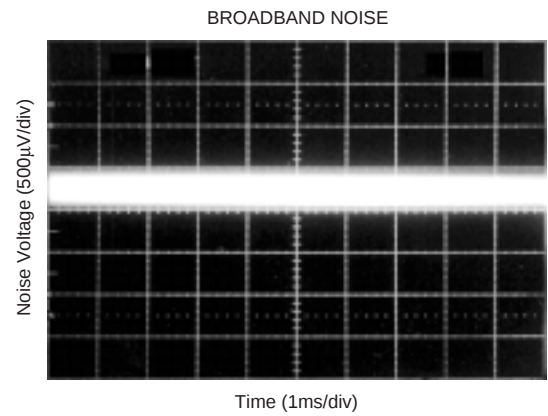
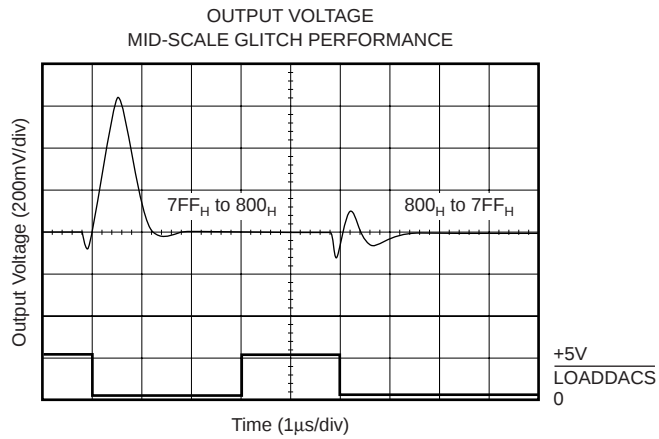
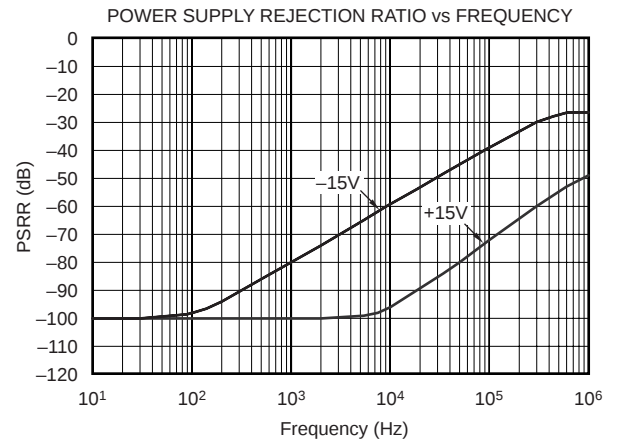
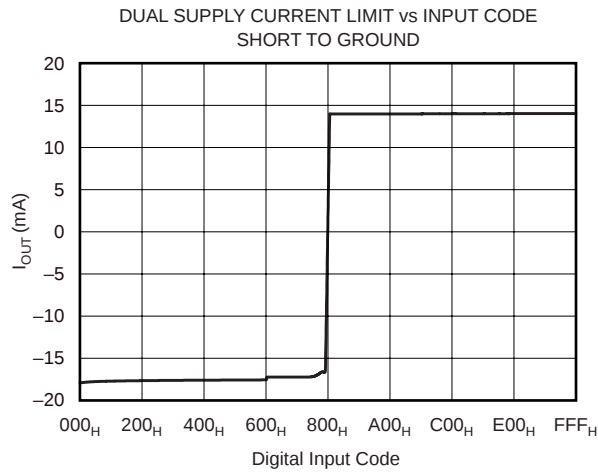
# TYPICAL PERFORMANCE CURVES: $V_{SS} = -15V$ (Cont.)

At  $T_A = +25^\circ C$ ,  $V_{CC} = +15V$ ,  $V_{SS} = -15V$ ,  $V_{REFH} = +10V$ ,  $V_{REFL} = -10V$ , representative unit, unless otherwise specified.



# TYPICAL PERFORMANCE CURVES: $V_{SS} = -15V$ (Cont.)

At  $T_A = +25^\circ C$ ,  $V_{CC} = +15V$ ,  $V_{SS} = -15V$ ,  $V_{REFH} = +10V$ ,  $V_{REFL} = -10V$ , representative unit, unless otherwise specified.



# THEORY OF OPERATION

The DAC7714 is a quad, serial input, 12-bit, voltage output DAC. The architecture is a classic R-2R ladder configuration followed by an operational amplifier that serves as a buffer. Each DAC has its own R-2R ladder network and output op amp, but all share the reference voltage inputs, as shown in Figure 1. The minimum voltage output (“zero-scale”) and maximum voltage output (“full-scale”) are set by external voltage references ( $V_{REFL}$  and  $V_{REFH}$ , respectively). The digital input is a 16-bit serial word that contains the 12-bit DAC code and a 2-bit address code that selects one of the four DACs (the two remaining bits are unused). The converter can be powered from a single +15V supply or a dual  $\pm 15V$  supply. Each device offers a reset function which immediately sets all DAC output voltages and internal registers to either zero-scale (code 000<sub>H</sub>) or mid-scale (code 800<sub>H</sub>). The reset code is selected by the state of the RESETSEL pin (LOW = 000<sub>H</sub>, HIGH = 800<sub>H</sub>). Figures 2 and 3 show the basic operation of the DAC7714.

## ANALOG OUTPUTS

When  $V_{SS} = -15V$  (dual supply operation), the output amplifier can swing to within 4V of the supply rails, over the  $-40^{\circ}C$  to  $+85^{\circ}C$  temperature range. With  $V_{SS} = 0V$  (single-supply operation), the output can swing to ground. Note that the settling time of the output op amp will be longer with voltages very near ground. Care must also be taken when measuring the zero-scale error when  $V_{SS} = 0V$ . If the output amplifier has a negative offset, the output voltage may not change for the first few digital input codes (000<sub>H</sub>, 001<sub>H</sub>, 002<sub>H</sub>, etc.) since the output voltage cannot swing below ground.

At the negative offset limit of  $-4LSB$  ( $-9.76mV$ ), for the single-supply case, the first specified output starts at code 004<sub>H</sub>.

## REFERENCE INPUTS

The reference inputs,  $V_{REFL}$  and  $V_{REFH}$ , can be any voltage between  $V_{SS} + 4V$  and  $V_{CC} - 4V$  provided that  $V_{REFH}$  is at least 1.25V greater than  $V_{REFL}$ . The minimum output of each D/A is equal to  $V_{REFL} - 1LSB$  plus a small offset voltage (essentially, the offset of the output op amp). The maximum output is equal to  $V_{REFH}$  plus a similar offset voltage. Note that  $V_{SS}$  (the negative power supply) must either be connected to ground or must be in the range of  $-14.75V$  to  $-15.75V$ . The voltage on  $V_{SS}$  sets several bias points within the converter. If  $V_{SS}$  is not in one of these two configurations, the bias values may be in error and proper operation of the device is not guaranteed.

The current into the reference inputs depends on the DAC output voltages and can vary from a few microamps to approximately 3mA. The reference input appears as a varying load to the reference. If the reference can sink or source the required current, a reference buffer is not required. See “Reference Current vs Code” in the Typical Performance Curves.

The analog supplies must come up before the reference power supplies, if they are separate. If the power supplies for the references come up first, then the  $V_{CC}$  and  $V_{SS}$  supplies will be powered from the reference via the ESD protection diodes (see page 4).

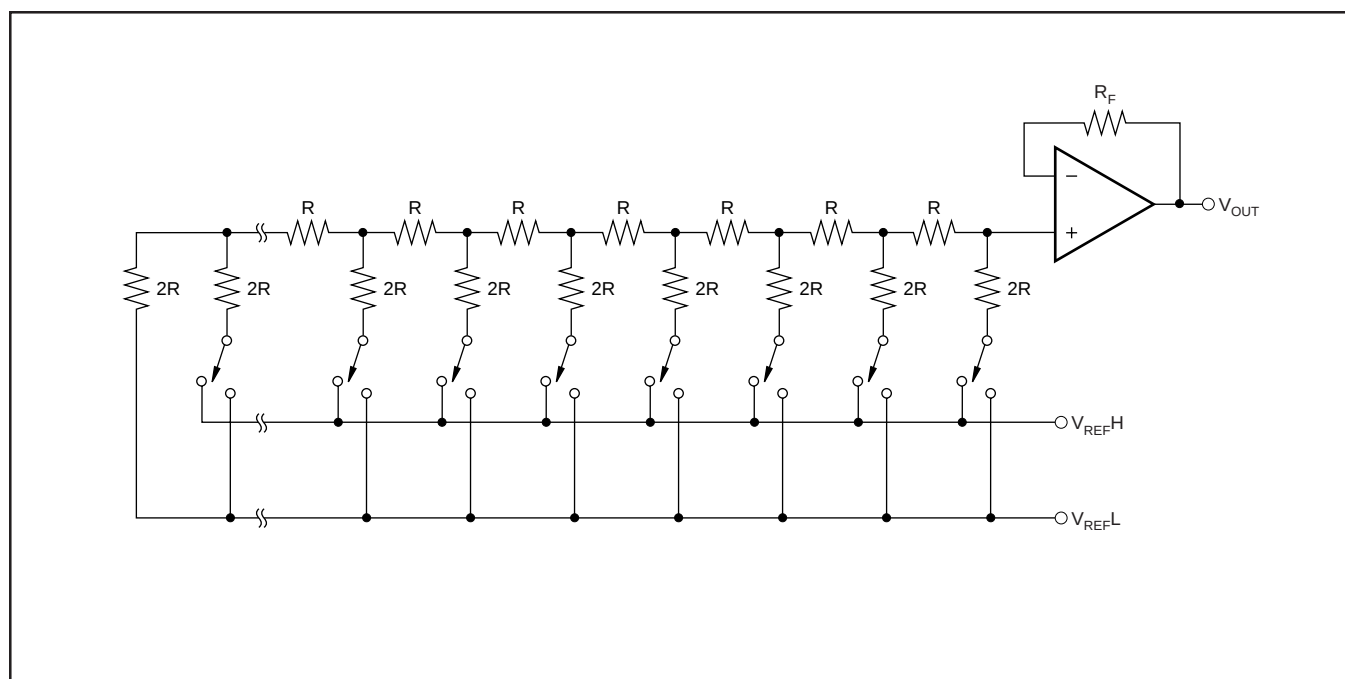


FIGURE 1. DAC7714 Architecture.

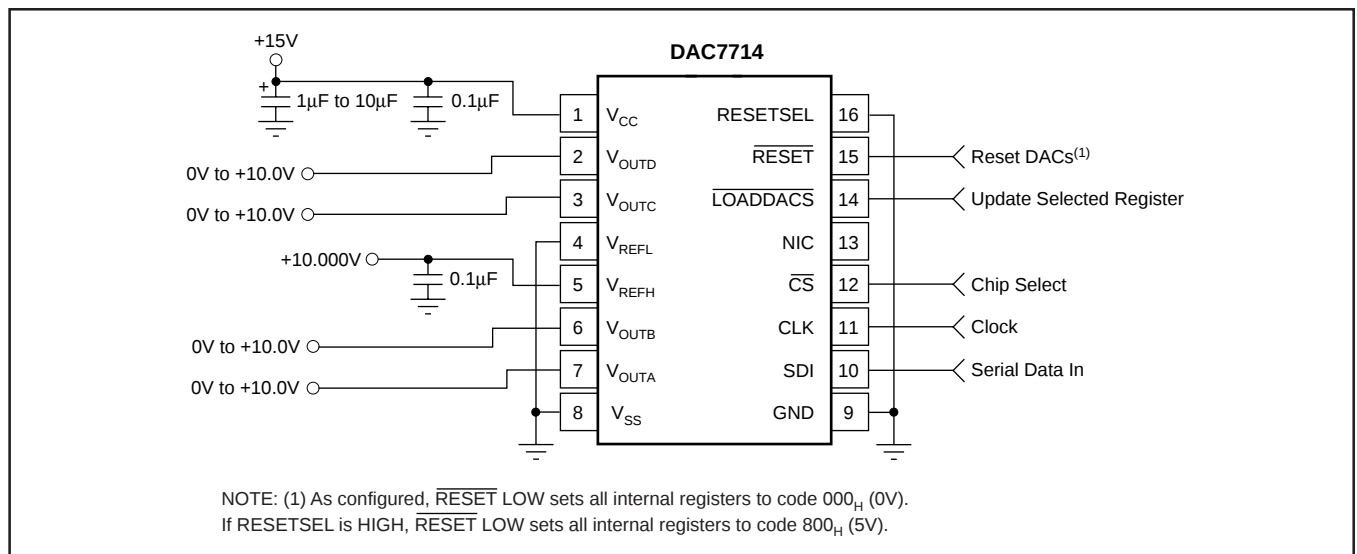


FIGURE 2. Basic Single-Supply Operation of the DAC7714.

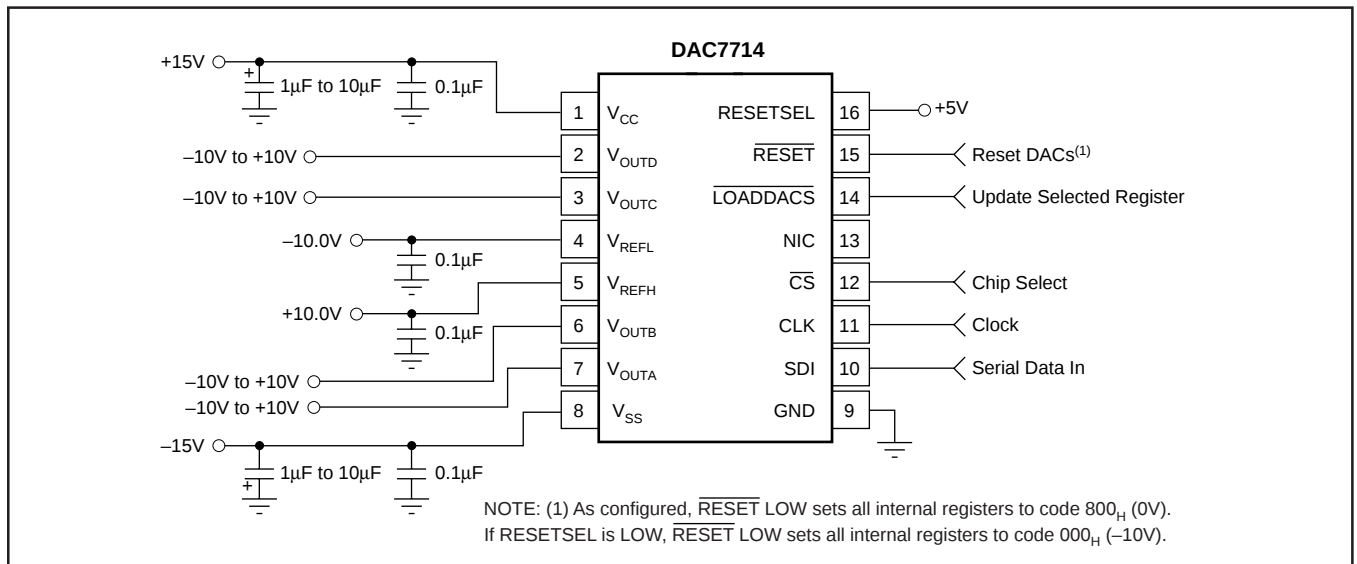


FIGURE 3. Basic Dual-Supply Operation of the DAC7714.

## DIGITAL INTERFACE

Figure 4 and Table I provide the basic timing for the DAC7714. The interface consists of a serial clock (CLK), serial data (SDI), and a load DAC signal ( $\overline{\text{LOADDACS}}$ ). In addition, a chip select ( $\overline{\text{CS}}$ ) input is available to enable serial communication when there are multiple serial devices. An asynchronous reset input ( $\overline{\text{RESET}}$ ) is provided to simplify start-up conditions, periodic resets, or emergency resets to a known state.

The DAC code and address are provided via a 16-bit serial interface (see Figure 4). The first two bits select the DAC register that will be updated when  $\overline{\text{LOADDACS}}$  goes LOW (see Table II). The next two bits are not used. The last 12 bits is the DAC code which is provided, most significant bit first.

Note that  $\overline{\text{CS}}$  and CLK are combined with an OR gate and the output controls the serial-to-parallel shift register internal to the DAC7714 (see the block diagram on the front of this data sheet). These two inputs are completely interchangeable. In addition, care must be taken with the state of CLK when  $\overline{\text{CS}}$  rises at the end of a serial transfer. If CLK is LOW when  $\overline{\text{CS}}$  rises, the OR gate will provide a rising edge to the shift register, shifting the internal data one additional bit. The result will be incorrect data and possible selection of the wrong DAC.

If both  $\overline{\text{CS}}$  and CLK are used, then  $\overline{\text{CS}}$  should rise only when CLK is HIGH. If not, then either  $\overline{\text{CS}}$  or CLK can be used to operate the shift register. See Table III for more information.

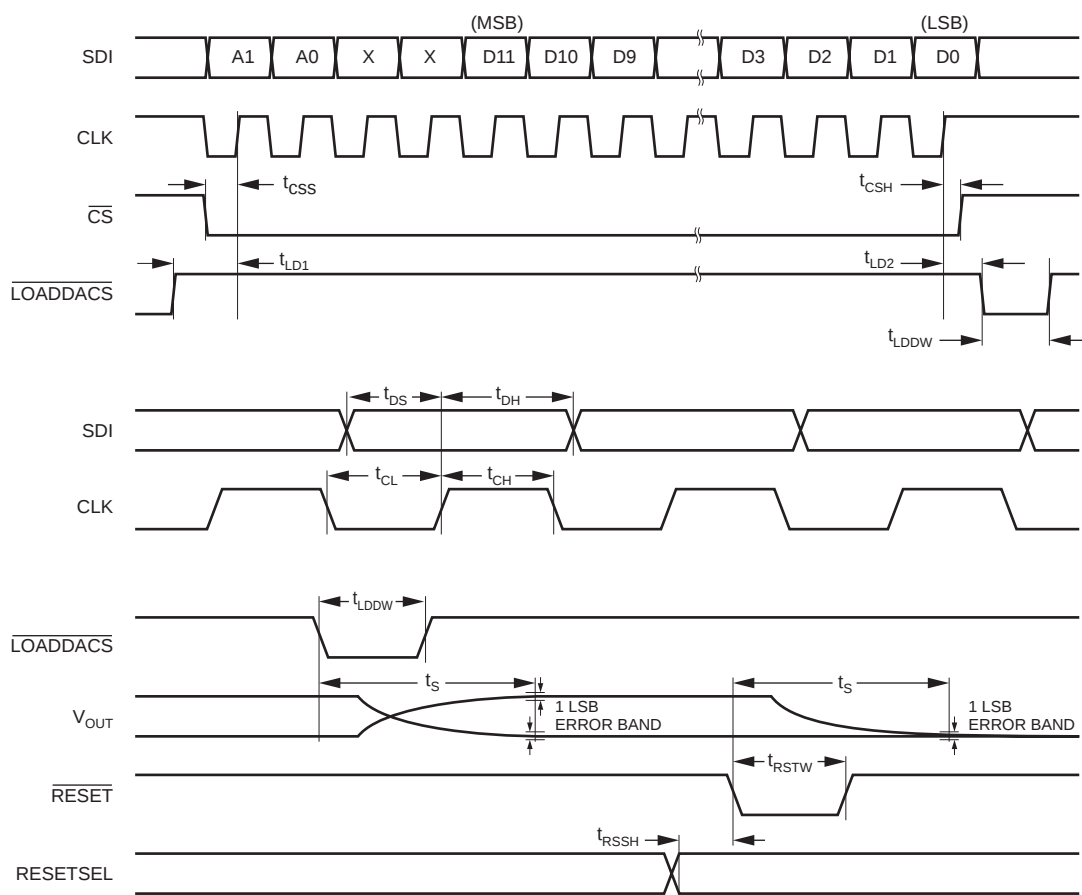


FIGURE 4. DAC7714 Timing.

| SYMBOL     | DESCRIPTION                              | MIN | TYP | MAX | UNITS   |
|------------|------------------------------------------|-----|-----|-----|---------|
| $t_{DS}$   | Data Valid to CLK Rising                 | 25  |     |     | ns      |
| $t_{DH}$   | Data Held Valid after CLK Rises          | 20  |     |     | ns      |
| $t_{CH}$   | CLK HIGH                                 | 30  |     |     | ns      |
| $t_{CL}$   | CLK LOW                                  | 50  |     |     | ns      |
| $t_{CSS}$  | $\overline{CS}$ LOW to CLK Rising        | 55  |     |     | ns      |
| $t_{CSH}$  | CLK HIGH to $\overline{CS}$ Rising       | 15  |     |     | ns      |
| $t_{LD1}$  | LOADDACS HIGH to CLK Rising              | 40  |     |     | ns      |
| $t_{LD2}$  | CLK Rising to $\overline{LOADDACS}$ LOW  | 15  |     |     | ns      |
| $t_{LDDW}$ | $\overline{LOADDACS}$ LOW Time           | 45  |     |     | ns      |
| $t_{RSSH}$ | RESETSEL Valid to $\overline{RESET}$ LOW | 25  |     |     | ns      |
| $t_{RSTW}$ | $\overline{RESET}$ LOW Time              | 70  |     |     | ns      |
| $t_S$      | Settling Time                            | 10  |     |     | $\mu$ s |

TABLE I. Timing Specifications ( $T_A = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ ).

| A1               | A0 | $\overline{LOADDACS}$ | $\overline{RESET}$ | SELECTED DAC REGISTER | STATE OF SELECTED DAC REGISTER |
|------------------|----|-----------------------|--------------------|-----------------------|--------------------------------|
| L <sup>(1)</sup> | L  | L                     | H <sup>(2)</sup>   | A                     | Transparent                    |
| L                | H  | L                     | H                  | B                     | Transparent                    |
| H                | L  | L                     | H                  | C                     | Transparent                    |
| H                | H  | L                     | H                  | D                     | Transparent                    |
| X <sup>(3)</sup> | X  | H                     | H                  | NONE                  | (All Latched)                  |
| X                | X  | X                     | L                  | ALL                   | Reset <sup>(4)</sup>           |

NOTES: (1) L = Logic LOW. (2) H = Logic HIGH. (3) X = Don't Care. (4) Resets to either 000H or 800H, per the RESETSEL state (LOW = 000H, HIGH = 800H). When RESET rises, all registers that are in their latched state retain the reset value.

TABLE II. Control Logic Truth Table.

| $\overline{\text{CS}}^{(1)}$ | $\text{CLK}^{(1)}$ | $\overline{\text{LOADDACS}}$ | $\overline{\text{RESET}}$ | SERIAL SHIFT REGISTER |
|------------------------------|--------------------|------------------------------|---------------------------|-----------------------|
| H <sup>(2)</sup>             | X <sup>(3)</sup>   | H                            | H                         | No Change             |
| L <sup>(4)</sup>             | L                  | H                            | H                         | No Change             |
| L                            | ↑ <sup>(5)</sup>   | H                            | H                         | Advanced One Bit      |
| ↑                            | L                  | H                            | H                         | Advanced One Bit      |
| H <sup>(6)</sup>             | X                  | L <sup>(7)</sup>             | H                         | No Change             |
| H <sup>(6)</sup>             | X                  | H                            | L <sup>(8)</sup>          | No Change             |

NOTES: (1)  $\overline{\text{CS}}$  and CLK are interchangeable. (2) H = Logic HIGH. (3) X = Don't Care. (4) L = Logic LOW (5) = Positive Logic Transition. (6) A HIGH value is suggested in order to avoid a "false clock" from advancing the shift register and changing the shift register. (7) If data is clocked into the serial register while  $\overline{\text{LOADDACS}}$  is LOW, the selected DAC register will change as the shift register bits "flow" through A1 and A0. This will corrupt the data in each DAC register that has been erroneously selected. (8)  $\overline{\text{RESET}}$  LOW causes no change in the contents of the serial shift register.

TABLE III. Serial Shift Register Truth Table.

### Digital Input Coding

The DAC7714 input data is in Straight Binary format. The output voltage is given by the following equation:

$$V_{\text{OUT}} = V_{\text{REFL}} + \frac{(V_{\text{REFH}} - V_{\text{REFL}}) \cdot N}{4096}$$

where N is the digital input code (in decimal). This equation does not include the effects of offset (zero-scale) or gain (full-scale) errors.

## LAYOUT

A precision analog component requires careful layout, adequate bypassing, and clean, well-regulated power supplies. As the DAC7714 offers single-supply operation, it will often be used in close proximity with digital logic, microcontrollers, microprocessors, and digital signal processors. The more digital logic present in the design and the higher the switching speed, the more difficult it will be to achieve good performance from the converter.

Because the DAC7714 has a single ground pin, all return currents, including digital and analog return currents, must flow through the GND pin. Ideally, GND would be connected directly to an analog ground plane. This plane would be separate from the ground connection for the digital components until they were connected at the power entry point of the system.

The power applied to  $V_{\text{CC}}$  (as well as  $V_{\text{SS}}$ , if not grounded) should be well regulated and low noise. Switching power supplies and DC/DC converters will often have high-frequency glitches or spikes riding on the output voltage. In addition, digital components can create similar high-frequency spikes as their internal logic switches states. This noise can easily couple into the DAC output voltage through various paths between the power connections and analog output.

## PACKAGING INFORMATION

| Orderable part number        | Status<br>(1) | Material type<br>(2) | Package   Pins | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">DAC7714U</a>     | Active        | Production           | SOIC (DW)   16 | 40   TUBE             | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | DAC7714U            |
| DAC7714U.A                   | Active        | Production           | SOIC (DW)   16 | 40   TUBE             | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | DAC7714U            |
| <a href="#">DAC7714U/1K</a>  | Active        | Production           | SOIC (DW)   16 | 1000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | DAC7714U            |
| DAC7714U/1K.A                | Active        | Production           | SOIC (DW)   16 | 1000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | DAC7714U            |
| <a href="#">DAC7714UB</a>    | Active        | Production           | SOIC (DW)   16 | 40   TUBE             | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | DAC7714U<br>B       |
| DAC7714UB.A                  | Active        | Production           | SOIC (DW)   16 | 40   TUBE             | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | DAC7714U<br>B       |
| <a href="#">DAC7714UB/1K</a> | Active        | Production           | SOIC (DW)   16 | 1000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | DAC7714U<br>B       |
| DAC7714UB/1K.A               | Active        | Production           | SOIC (DW)   16 | 1000   LARGE T&R      | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | DAC7714U<br>B       |
| DAC7714UBG4                  | Active        | Production           | SOIC (DW)   16 | 40   TUBE             | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | DAC7714U<br>B       |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

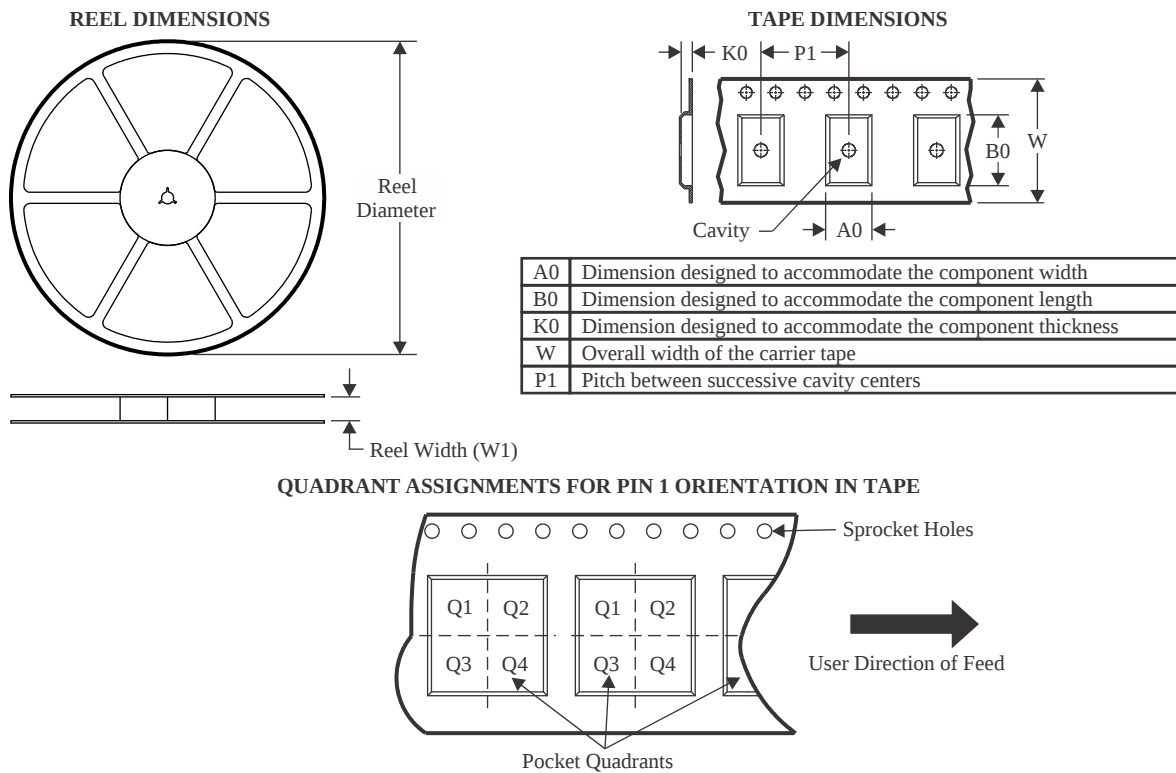
<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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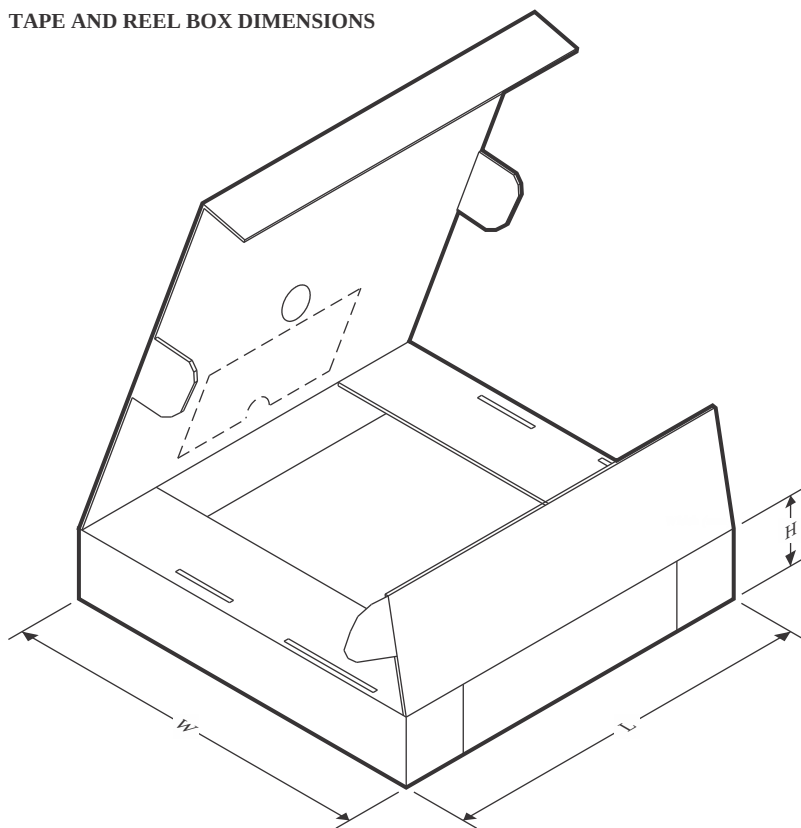
## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| DAC7714U/1K  | SOIC         | DW              | 16   | 1000 | 330.0              | 16.4               | 10.75   | 10.7    | 2.7     | 12.0    | 16.0   | Q1            |
| DAC7714UB/1K | SOIC         | DW              | 16   | 1000 | 330.0              | 16.4               | 10.75   | 10.7    | 2.7     | 12.0    | 16.0   | Q1            |

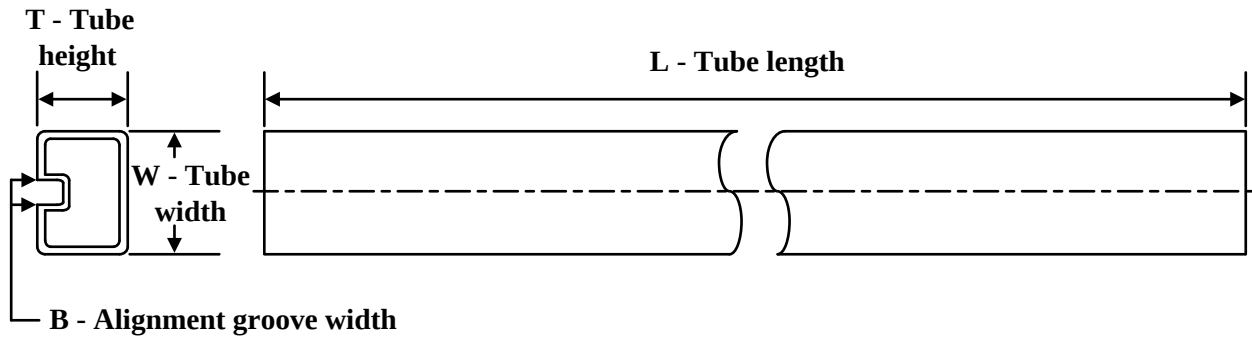
## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| DAC7714U/1K  | SOIC         | DW              | 16   | 1000 | 350.0       | 350.0      | 43.0        |
| DAC7714UB/1K | SOIC         | DW              | 16   | 1000 | 350.0       | 350.0      | 43.0        |

## TUBE



\*All dimensions are nominal

| Device      | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|-------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| DAC7714U    | DW           | SOIC         | 16   | 40  | 506.98 | 12.7   | 4826   | 6.6    |
| DAC7714U.A  | DW           | SOIC         | 16   | 40  | 506.98 | 12.7   | 4826   | 6.6    |
| DAC7714UB   | DW           | SOIC         | 16   | 40  | 506.98 | 12.7   | 4826   | 6.6    |
| DAC7714UB.A | DW           | SOIC         | 16   | 40  | 506.98 | 12.7   | 4826   | 6.6    |
| DAC7714UBG4 | DW           | SOIC         | 16   | 40  | 506.98 | 12.7   | 4826   | 6.6    |

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