Burr-Brown Products
from Texas Instruments

# DAC7715


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

## FEATURES

- LOW POWER: 250mW (max)
- UNIPOLAR OR BIPOLAR OPERATION
- SETTLING TIME: 10μs to 0.012%
- 12-BIT LINEARITY AND MONOTONICITY: –40°C to +85°C
- DOUBLE-BUFFERED DATA INPUTS
- SMALL SO-16 PACKAGE

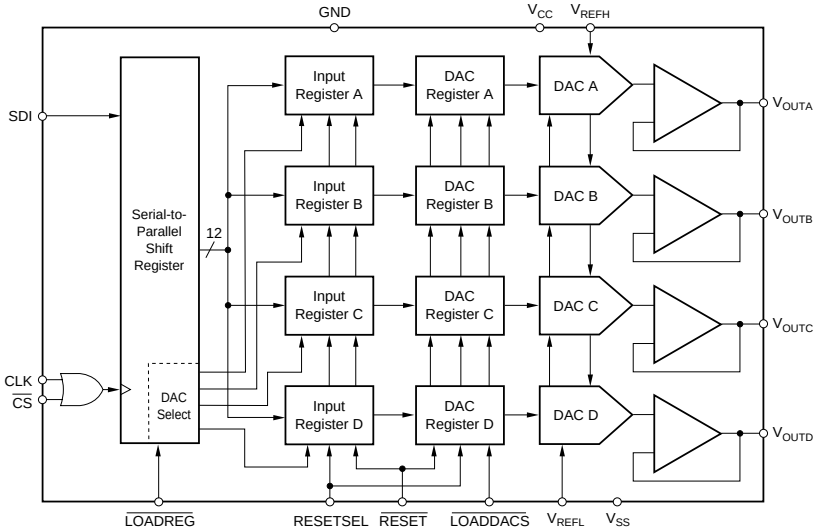
## APPLICATIONS

- PROCESS CONTROL
- ATE PIN ELECTRONICS
- CLOSED-LOOP SERVO-CONTROL
- MOTOR CONTROL
- DATA ACQUISITION SYSTEMS
- DAC-PER-PIN PROGRAMMERS

## DESCRIPTION

The DAC7715 is a quad, serial input, 12-bit, voltage output Digital-to-Analog Converter (DAC) with guaranteed 12-bit monotonic performance over the –40°C to +85°C temperature range. An asynchronous reset clears all registers to either mid-scale ($800_H$) or zero-scale ($000_H$), selectable via the RESETSEL pin. The individual DAC inputs are double buffered to allow for simultaneous update of all DAC outputs. The device can be powered from a single +15V supply or from dual +15V and –15V supplies.

Low power and small size makes the DAC7715 ideal for automatic test equipment, DAC-per-pin programmers, data acquisition systems, and closed-loop servo-control. The device is available in a SO-16 package and is guaranteed over the –40°C to +85°C temperature range.

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SBAS140

# SPECIFICATIONS (Dual Supply)

At $T_A$ = –40°C to +85°C, $V_{CC}$ = +15V, $V_{SS}$ = –15V, $V_{REFH}$ = +10V, $V_{REFL}$ = –10V, unless otherwise noted.

| PARAMETER | CONDITIONS | DAC7715U | | | DAC7715UB | | | UNITS |
|---|---|---|---|---|---|---|---|---|
| | | MIN | TYP | MAX | MIN | TYP | MAX | |
| **ACCURACY** | | | | | | | | |
| Linearity Error | | | | ±2 | | | ±1 | LSB[1] |
| Linearity Matching[2] | | | | ±2 | | | ±1 | LSB |
| Differential Linearity Error | | | | ±1 | | | ±1 | LSB |
| Monotonicity | $T_{MIN}$ to $T_{MAX}$ | 12 | | | * | | | Bits |
| Zero-Scale Error | Code = $000_H$ | | | ±2 | | | * | LSB |
| Zero-Scale Drift | | | 1 | | | * | | ppm/°C |
| Zero-Scale Matching[2] | | | | ±2 | | | ±1 | LSB |
| Full-Scale Error | Code = $FFF_H$ | | | ±2 | | | * | LSB |
| Full-Scale Matching[2] | | | | ±2 | | | ±1 | LSB |
| Power Supply Sensitivity | At Full Scale | | 10 | | | * | | ppm/V |
| **ANALOG OUTPUT** | | | | | | | | |
| Voltage Output[3] | | $V_{REFL}$ | | $V_{REFH}$ | * | | * | V |
| Output Current | | –5 | | +5 | * | | * | mA |
| Load Capacitance | No Oscillation | | 500 | | | * | | pF |
| Short-Circuit Current | | | ±20 | | | * | | mA |
| Short-Circuit Duration | To $V_{SS}$, $V_{CC}$, or GND | | Indefinite | | | * | | |
| **REFERENCE INPUT** | | | | | | | | |
| $V_{REFH}$ Input Range | | $V_{REFL}$ +1.25 | | +10 | * | | * | V |
| $V_{REFL}$ Input Range | | –10 | | $V_{REFH}$ – 1.25 | * | | * | V |
| Ref High Input Current | | –0.5 | | 3.0 | * | | * | mA |
| Ref Low Input Current | | –3.5 | | 0 | * | | * | mA |
| **DYNAMIC PERFORMANCE** | | | | | | | | |
| Settling Time | To ±0.012%, 20V Output Step | | 8 | 10 | | * | * | µs |
| Channel-to-Channel Crosstalk | Full-Scale Step | | 0.25 | | | * | | LSB |
| Digital Feedthrough | | | 2 | | | | * | nV-s |
| Output Noise Voltage | f = 10kHz | | 65 | | | * | | nV/√Hz |
| **DIGITAL INPUT** | | | | | | | | |
| Logic Levels | | | | | | | | |
| $V_{IH}$ | $I_{IH} \leq \pm 10\mu A$ | 3.325 | | | * | | | V |
| $V_{IL}$ | $I_{IL} \leq \pm 10\mu A$ | | | 1.575 | | | * | V |
| Data Format | | | Straight Binary | | | * | | |
| **POWER SUPPLY REQUIREMENTS** | | | | | | | | |
| $V_{CC}$ | | +14.25 | | +15.75 | * | | * | V |
| $V_{SS}$ | | –15.75 | | –14.25 | * | | * | V |
| $I_{CC}$ | | | 6 | 8.5 | | * | * | mA |
| $I_{SS}$ | | –8 | –6 | | * | * | | mA |
| Power Dissipation | | | 180 | 250 | | * | * | mW |
| **TEMPERATURE RANGE** | | | | | | | | |
| Specified Performance | | –40 | | +85 | * | | * | °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.

# SPECIFICATIONS (Single Supply)

At $T_A$ = –40°C to +85°C, $V_{CC}$ = +15V, $V_{SS}$ = GND, $V_{REFH}$ = +10V, $V_{REFL}$ = 0V, unless otherwise noted.

| PARAMETER | CONDITIONS | DAC7715U | | | DAC7715UB | | | UNITS |
|---|---|---|---|---|---|---|---|---|
| | | MIN | TYP | MAX | MIN | TYP | MAX | |
| **ACCURACY** | | | | | | | | |
| Linearity Error[1] | | | | ±2 | | | ±1 | LSB[2] |
| Linearity Matching[3] | | | | ±2 | | | ±1 | LSB |
| Differential Linearity Error | | | | ±1 | | | ±1 | LSB |
| Monotonicity | $T_{MIN}$ to $T_{MAX}$ | 12 | | | * | | | Bits |
| Zero-Scale Error | Code = $004_H$ | | | ±4 | | | * | LSB |
| Zero-Scale Drift | | | 2 | | | * | | ppm/°C |
| Zero-Scale Matching[3] | | | | ±4 | | | ±2 | LSB |
| Full-Scale Error | Code = $FFF_H$ | | | ±4 | | | * | LSB |
| Full-Scale Matching[3] | | | | ±4 | | | ±2 | LSB |
| Power Supply Sensitivity | At Full Scale | | 20 | | | * | | ppm/V |
| **ANALOG OUTPUT** | | | | | | | | |
| Voltage Output[4] | | $V_{REFL}$ | | $V_{REFH}$ | * | | * | V |
| Output Current | | –5 | | +5 | * | | | mA |
| Load Capacitance | No Oscillation | | 500 | | | * | | pF |
| Short-Circuit Current | | | ±20 | | | * | | mA |
| Short-Circuit Duration | To $V_{CC}$ or GND | | Indefinite | | | * | | |
| **REFERENCE INPUT** | | | | | | | | |
| $V_{REFH}$ Input Range | | $V_{REFL}$ +1.25 | | +10 | * | | * | V |
| $V_{REFL}$ Input Range | | 0 | | $V_{REFH}$ – 1.25 | * | | * | V |
| Ref High Input Current | | –0.3 | | 1.5 | * | | * | mA |
| Ref Low Input Current | | –2.0 | | 0 | * | | * | mA |
| **DYNAMIC PERFORMANCE** | | | | | | | | |
| Settling Time[5] | To ±0.012%, 10V Output Step | | 8 | 10 | | * | * | µs |
| Channel-to-Channel Crosstalk | | | 0.25 | | | * | | LSB |
| Digital Feedthrough | | | 2 | | | | * | nV-s |
| Output Noise Voltage | f = 10kHz | | 65 | | | * | | nV/√Hz |
| **DIGITAL INPUT** | | | | | | | | |
| Logic Levels | | | | | | | | |
| $V_{IH}$ | $I_{IH} \leq \pm 10\mu A$ | 3.325 | | | * | | | V |
| $V_{IL}$ | $I_{IL} \leq \pm 10\mu A$ | | | 1.575 | | | * | V |
| Data Format | | | Straight Binary | | | * | | |
| **POWER SUPPLY REQUIREMENTS** | | | | | | | | |
| $V_{CC}$ | | 14.25 | | 15.75 | * | | * | V |
| $I_{CC}$ | | | 3.0 | | | * | * | mA |
| Power Dissipation | | | 45 | | | * | | mW |
| **TEMPERATURE RANGE** | | | | | | | | |
| Specified Performance | | –40 | | +85 | * | | * | °C |

NOTES: (1) If $V_{SS}$ = 0V, specification applies at code $004_H$ 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 $FFF_H$ to $020_H$.

## ABSOLUTE MAXIMUM RATINGS[1]

| | |
|---|---|
| $V_{CC}$ to $V_{SS}$ | –0.3V to +32V |
| $V_{CC}$ to GND | –0.3V to +16V |
| $V_{SS}$ to GND | +0.3V to –16V |
| $V_{REF}H$ to GND | –9V to +11V |
| $V_{REF}L$ to GND ($V_{SS}$ = –15V) | –11V to +9V |
| $V_{REF}L$ 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.

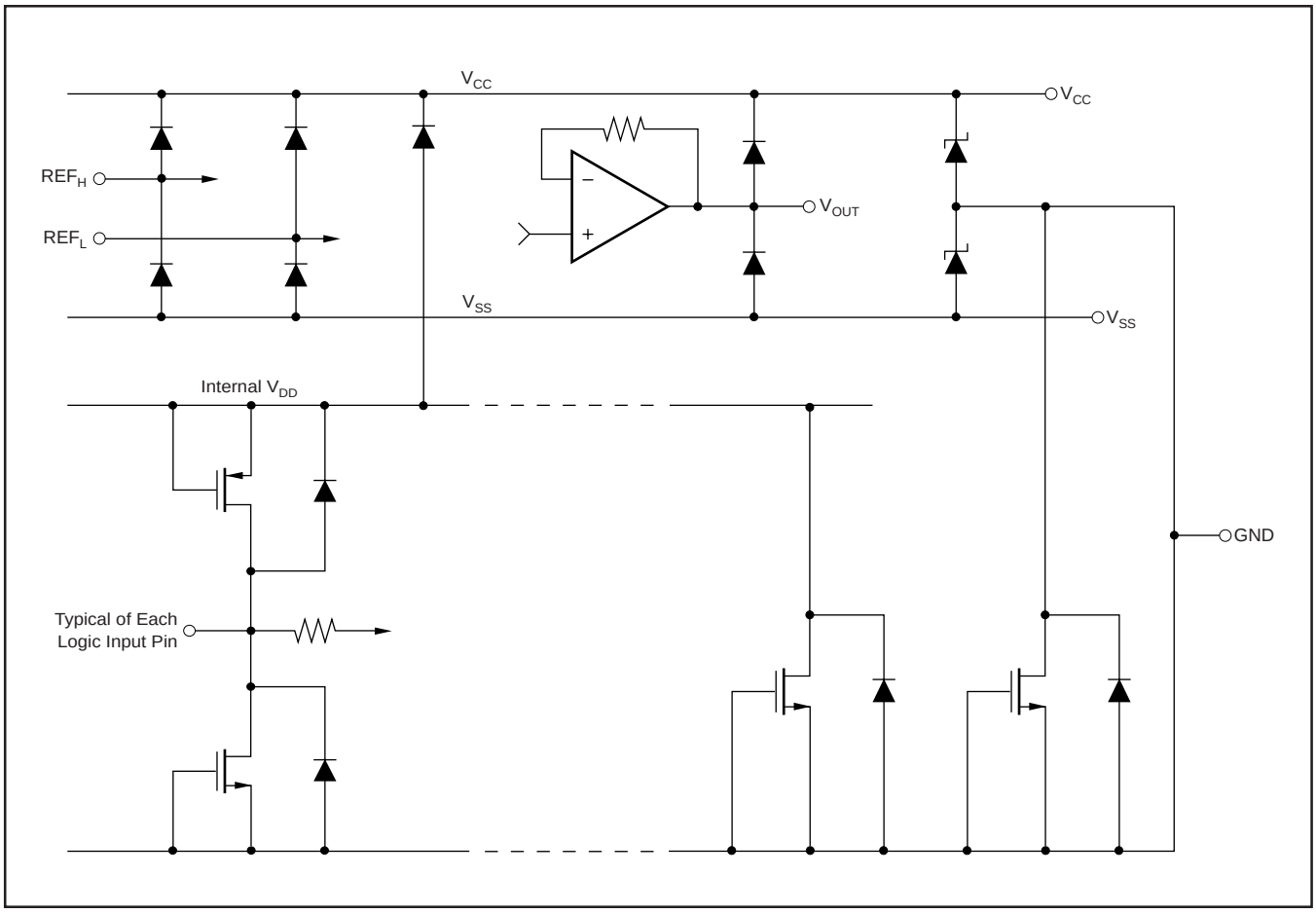
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION

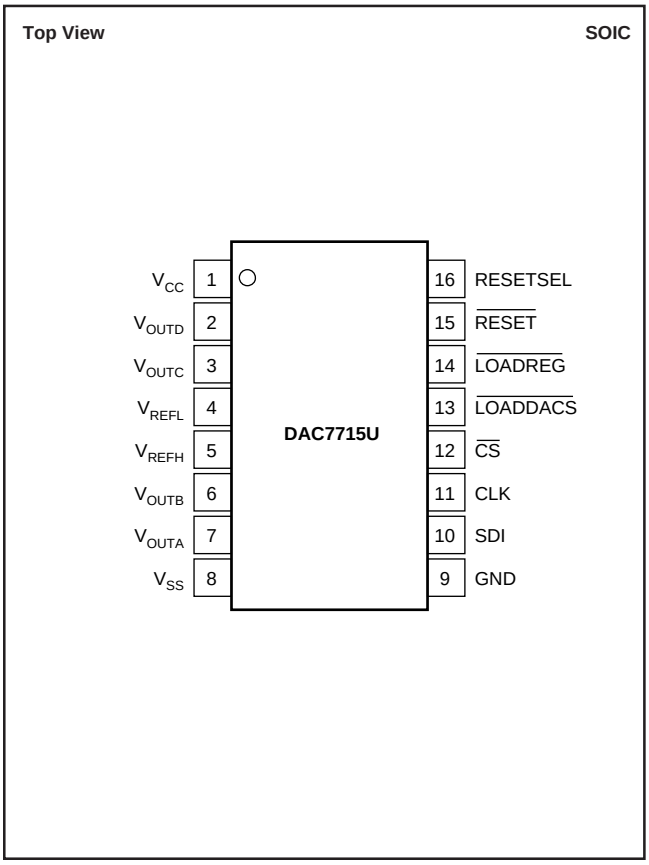
| PRODUCT | MAXIMUM LINEARITY ERROR (LSB) | MAXIMUM DIFFERENTIAL LINEARITY (LSB) | PACKAGE | PACKAGE DRAWING NUMBER | SPECIFICATION TEMPERATURE RANGE | ORDERING NUMBER[1] | TRANSPORT MEDIA |
|---|---|---|---|---|---|---|---|
| DAC7715U | ±2 | ±1 | SOIC-16 | 211 | –40°C to +85°C | DAC7715U | Rails |
| " | " | " | " | " | " | DAC7715U/1K | Tape and Reel |
| DAC7715UB | ±1 | ±1 | SOIC-16 | 211 | –40°C to +85°C | DAC7715UB | Rails |
| " | " | " | " | " | " | DAC7715UB/1K | 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 "DAC7715UB/1K" will get a single 1000-piece Tape and Reel.

## ESD PROTECTION CIRCUITS



## PIN CONFIGURATION—U Package



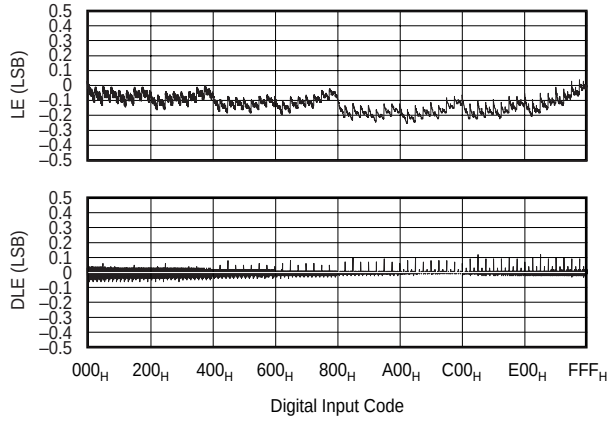

## PIN DESCRIPTIONS—U Package

| PIN | LABEL | DESCRIPTION |
|---|---|---|
| 1 | $V_{CC}$ | Positive Supply Voltage, +15V nominal. |
| 2 | $V_{OUTD}$ | DAC D Voltage Output |
| 3 | $V_{OUTC}$ | DAC C Voltage Output |
| 4 | $V_{REFL}$ | Reference Input Voltage Low. Sets minimum output voltage for all DACs. |
| 5 | $V_{REFH}$ | Reference Input Voltage High. Sets maximum output voltage for all DACs. |
| 6 | $V_{OUTB}$ | DAC B Voltage Output |
| 7 | $V_{OUTA}$ | DAC A Voltage Output |
| 8 | $V_{SS}$ | Negative 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 | $\overline{\text{LOADDACS}}$ | All DAC registers become transparent when $\overline{\text{LOADDACS}}$ is LOW. They are in the latched state when $\overline{\text{LOADDACS}}$ is HIGH. |
| 14 | $\overline{\text{LOADREG}}$ | The selected input register becomes transparent when $\overline{\text{LOADREG}}$ is LOW. It is in the latched state when $\overline{\text{LOADREG}}$ is HIGH. |
| 15 | $\overline{\text{RESET}}$ | Asynchronous Reset Input. Sets DAC and input registers to either zero-scale ($000_H$) or mid-scale ($800_H$) when LOW. RESETSEL determines which code is active. |
| 16 | RESETSEL | When LOW, a LOW on $\overline{\text{RESET}}$ will cause the DAC and input registers to be set to code $000_H$. When RESETSEL is HIGH, a LOW on $\overline{\text{RESET}}$ will set the registers to code $800_H$. |

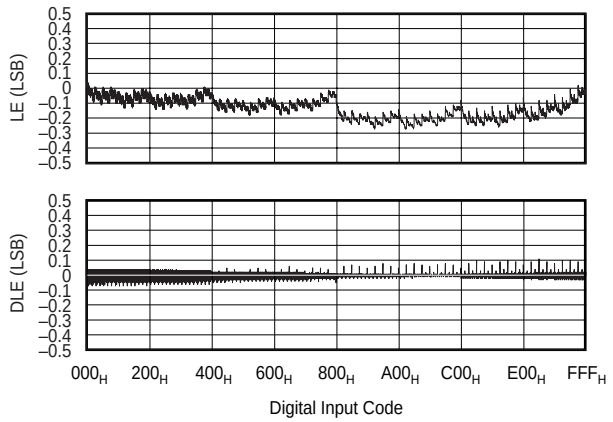
# TYPICAL PERFORMANCE CURVES: $V_{SS}$ = 0V

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

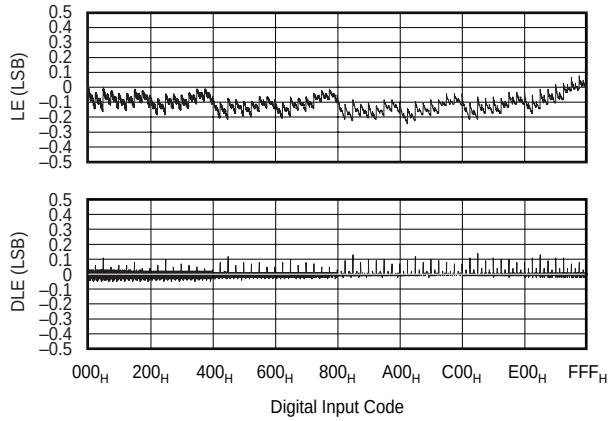
LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
**Single Channel 25°C**
(Typical of Each Output Channel)



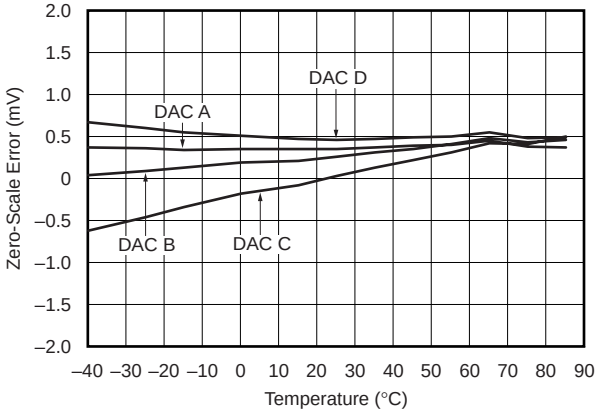

LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
**Single Channel 85°C**
(Typical of Each Output Channel)



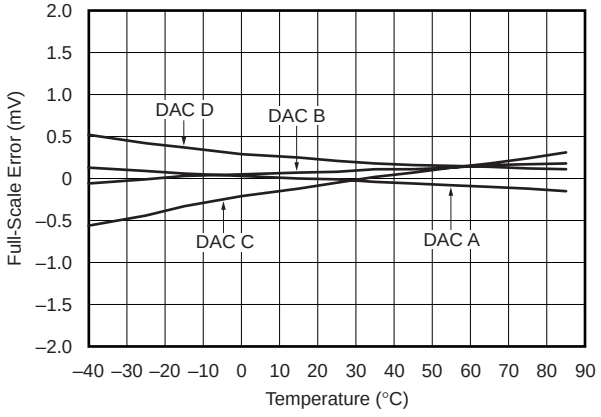

LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
**Single Channel –40°C**
(Typical of Each Output Channel)



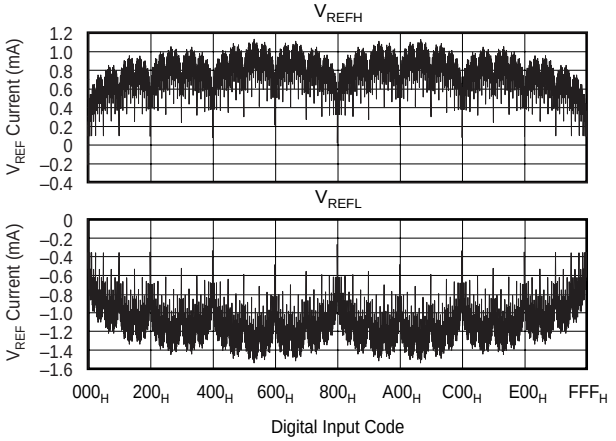

ZERO-SCALE ERROR vs TEMPERATURE
(Code $004_H$)




FULL-SCALE ERROR vs TEMPERATURE
(Code $FFF_H$)



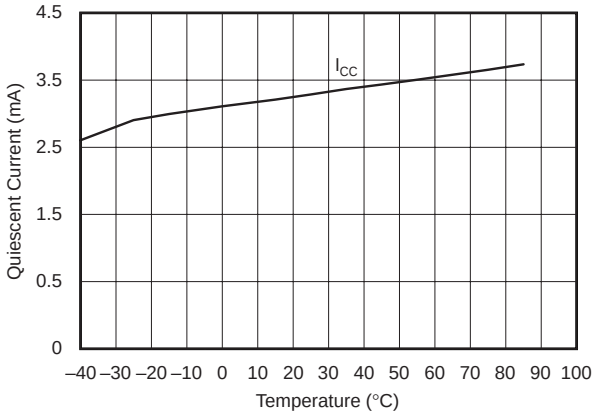

CURRENT vs CODE
All DACs Set to Indicated Code



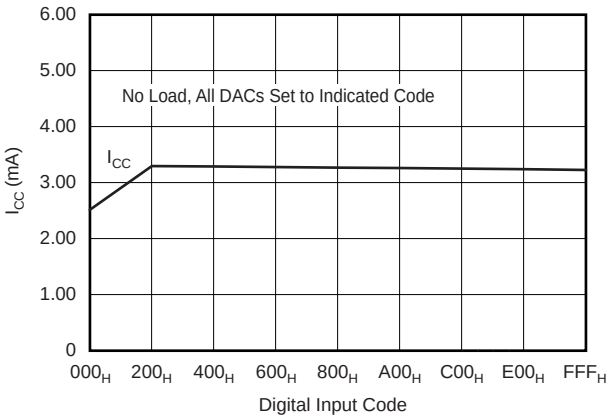
# TYPICAL PERFORMANCE CURVES: $V_{SS}$ = 0V (Cont.)

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

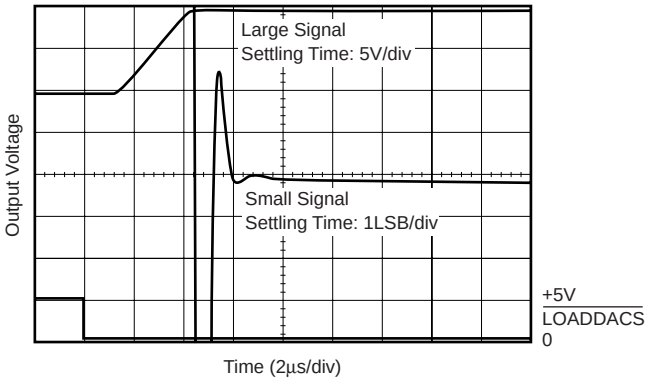
POWER SUPPLY CURRENT vs TEMPERATURE



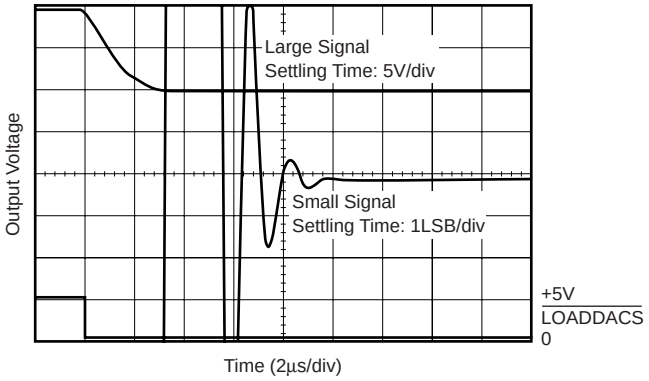

POSITIVE SUPPLY CURRENT vs DIGITAL INPUT CODE



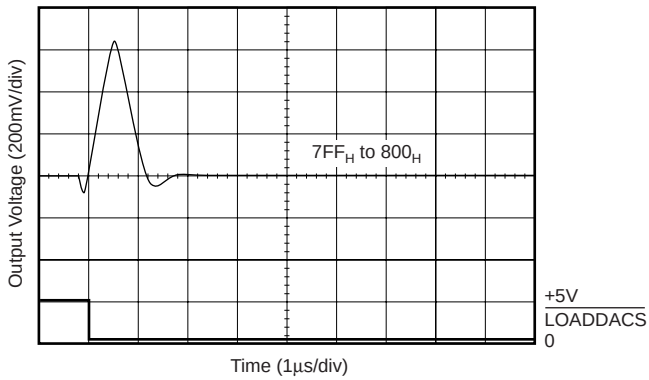

OUTPUT VOLTAGE vs SETTLING TIME (0V to +10V)



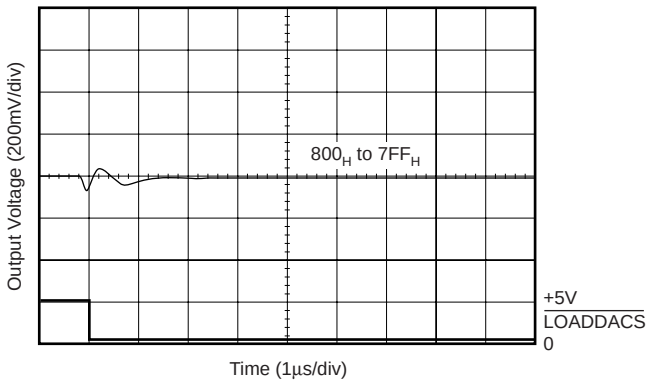

OUTPUT VOLTAGE vs SETTLING TIME (+10V to Code $020_H$)




OUTPUT VOLTAGE MID-SCALE GLITCH PERFORMANCE



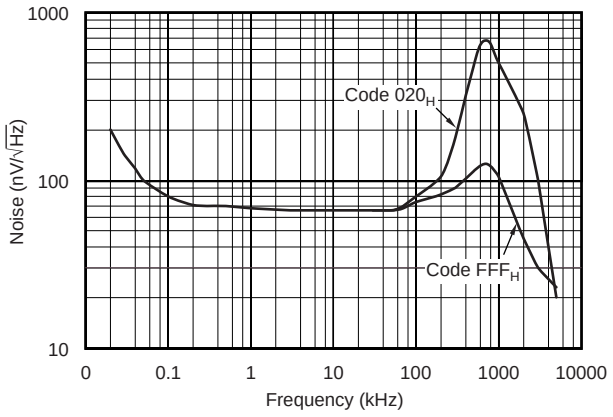

OUTPUT VOLTAGE MID-SCALE GLITCH PERFORMANCE



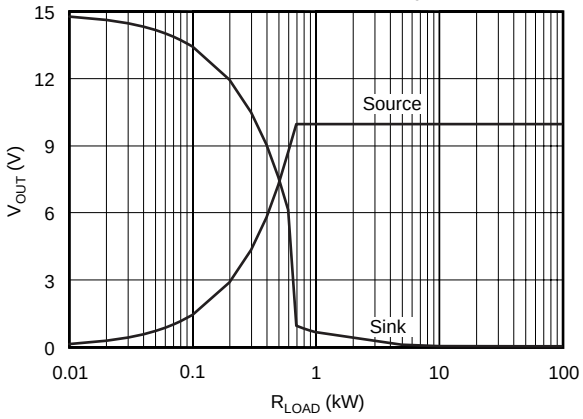
# TYPICAL PERFORMANCE CURVES: $V_{SS}$ = 0V (Cont.)

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

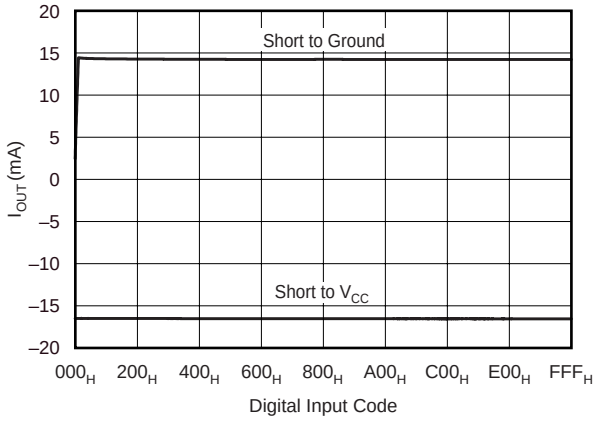
OUTPUT NOISE vs FREQUENCY



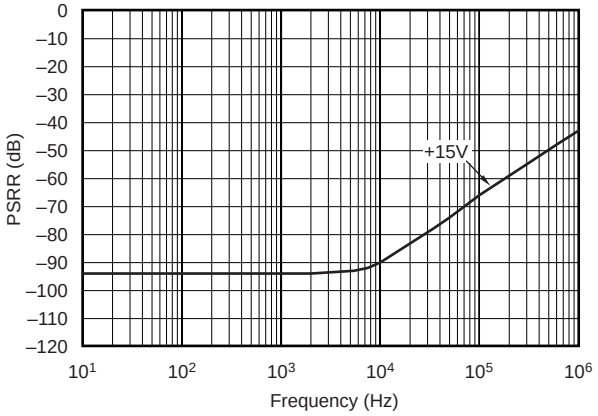

OUTPUT VOLTAGE vs $R_{LOAD}$




SINGLE SUPPLY CURRENT LIMIT vs INPUT CODE



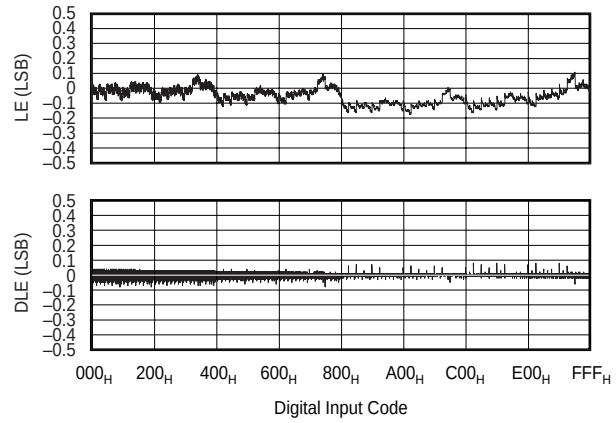

POWER SUPPLY REJECTION RATIO vs FREQUENCY



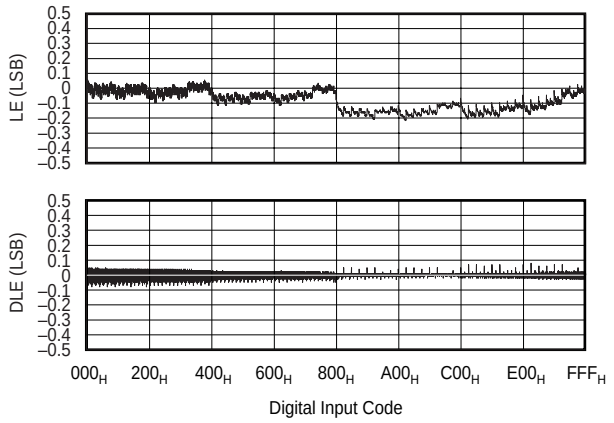
# TYPICAL PERFORMANCE CURVES: $V_{SS}$ = –15V

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

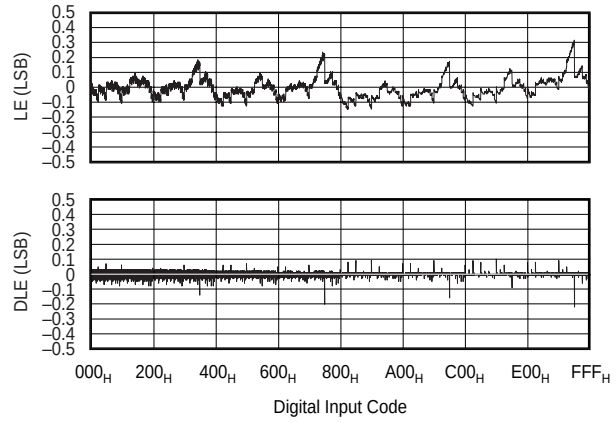
LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
**Single Channel 25°C**
(Typical of Each Output Channel)



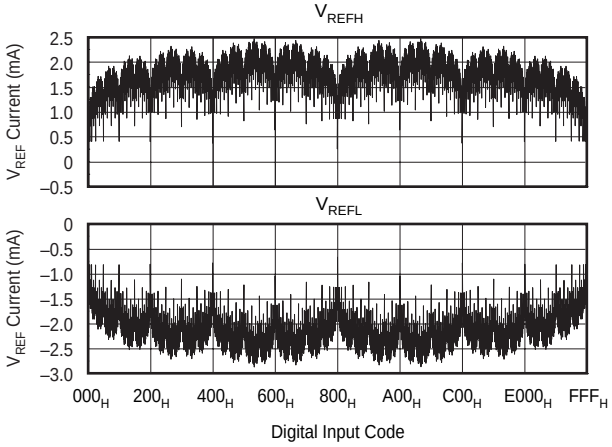

LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
**Single Channel 85°C**
(Typical of Each Output Channel)



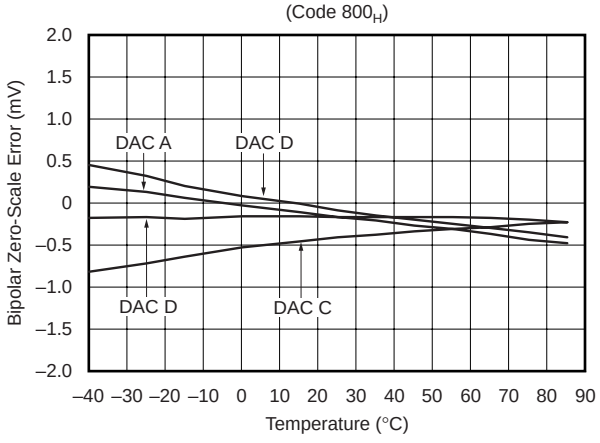

LINEARITY ERROR AND
DIFFERENTIAL LINEARITY ERROR vs CODE
**Single Channel –40°C**
(Typical of Each Output Channel)



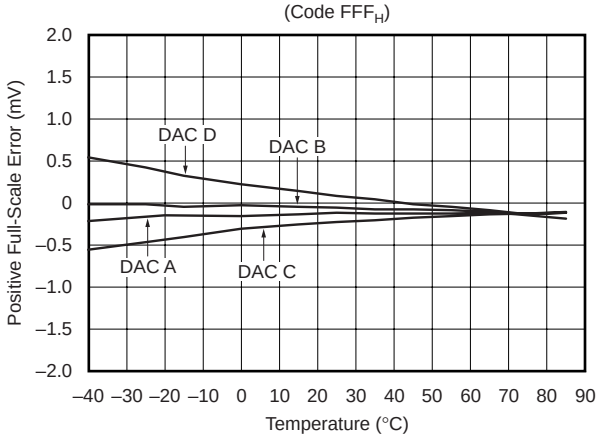

CURRENT vs CODE
All DACs Set to Indicated Code




BIPOLAR ZERO-SCALE ERROR vs TEMPERATURE
(Code $800_H$)



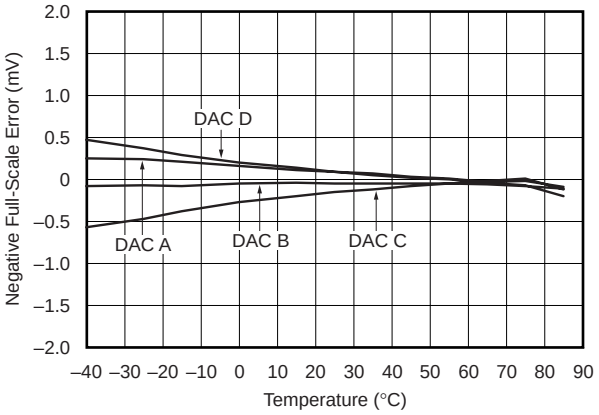

POSITIVE FULL-SCALE ERROR vs TEMPERATURE
(Code $FFF_H$)



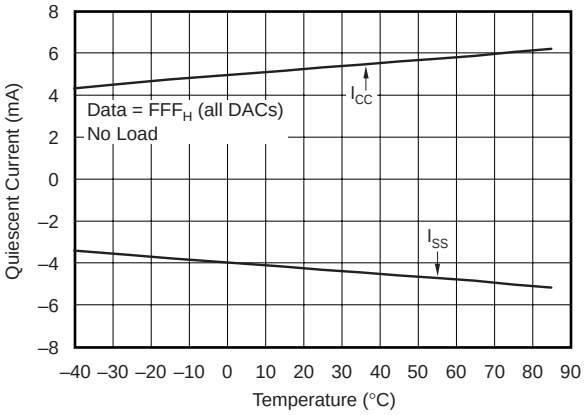
# TYPICAL PERFORMANCE CURVES: $V_{SS}$ = –15V (Cont.)

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

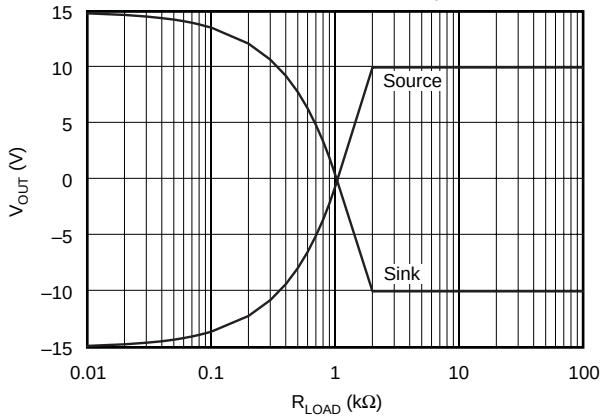
NEGATIVE FULL-SCALE ERROR vs TEMPERATURE
(Code $000_H$)



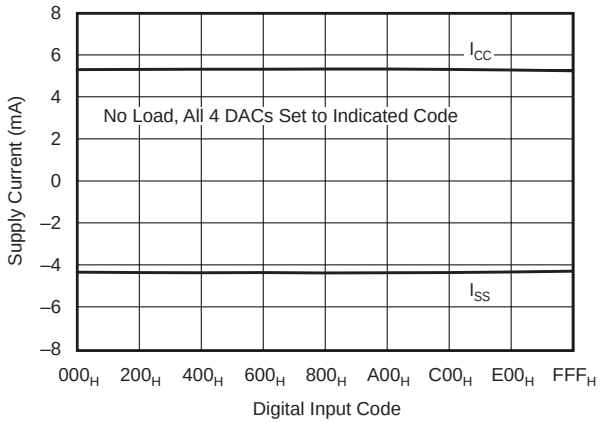

POWER SUPPLY CURRENT vs TEMPERATURE



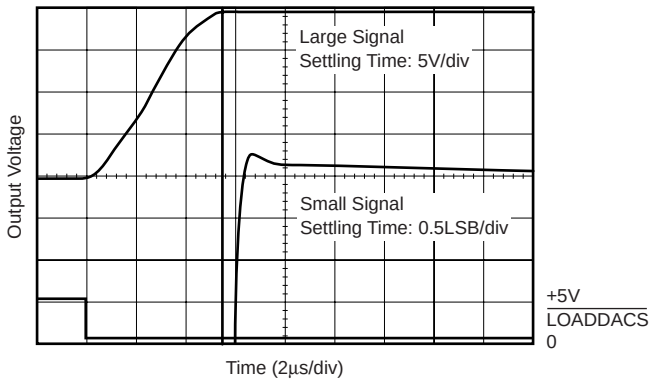

OUTPUT VOLTAGE vs $R_{LOAD}$



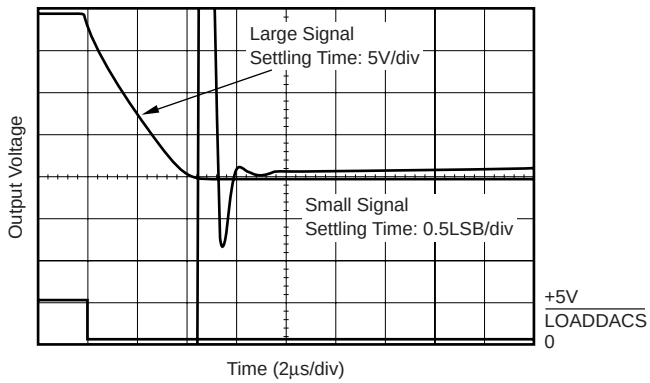

SUPPLY CURRENT vs CODE




OUTPUT VOLTAGE vs SETTLING TIME
(–10V to +10V)



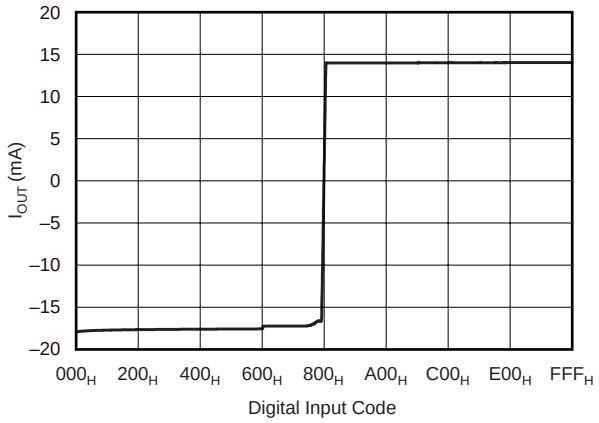

OUTPUT VOLTAGE vs SETTLING TIME
(+10V to –10V)



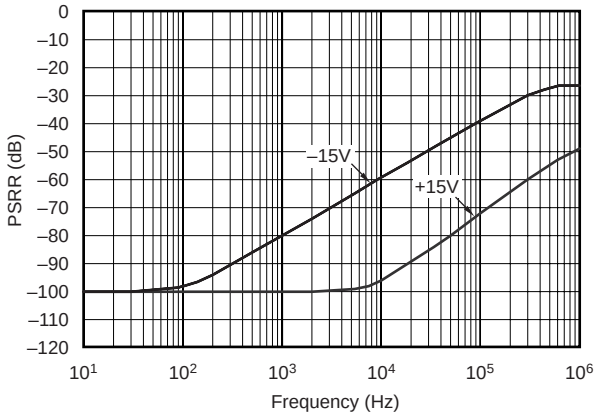
# TYPICAL PERFORMANCE CURVES: $V_{SS}$ = –15V (Cont.)

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

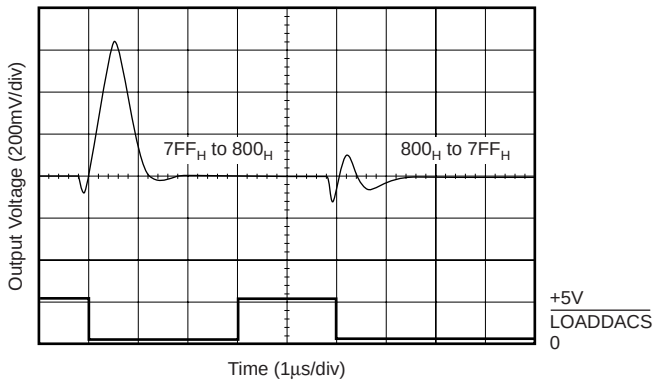
DUAL SUPPLY CURRENT LIMIT vs INPUT CODE
SHORT TO GROUND



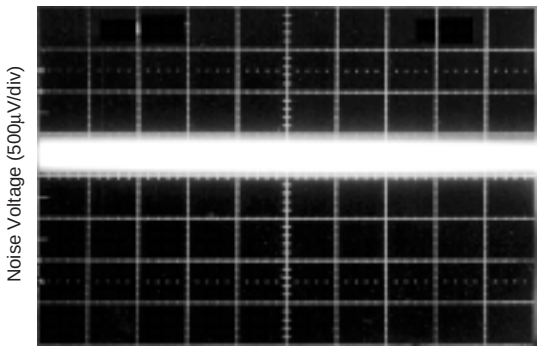

POWER SUPPLY REJECTION RATIO vs FREQUENCY



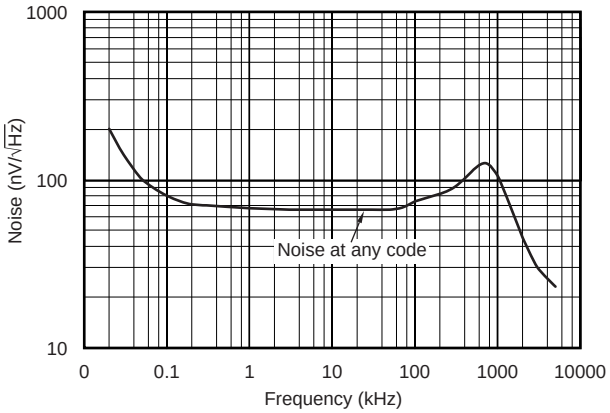

OUTPUT VOLTAGE
MID-SCALE GLITCH PERFORMANCE




BROADBAND NOISE




OUTPUT NOISE vs FREQUENCY



# THEORY OF OPERATION

The DAC7715 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, as shown in Figure 1. Each DAC has its own R-2R ladder network and output op amp, but all share the reference voltage inputs. 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 ±15V supply. Each device offers a reset function which immediately sets all DAC output voltages and internal registers to either zero-scale (code $000_H$) or mid-scale (code $800_H$). The reset code is selected by the state of the RESETSEL pin (LOW = $000_H$, HIGH = $800_H$). See Figures 2 and 3 for the basic operation of the DAC7715.

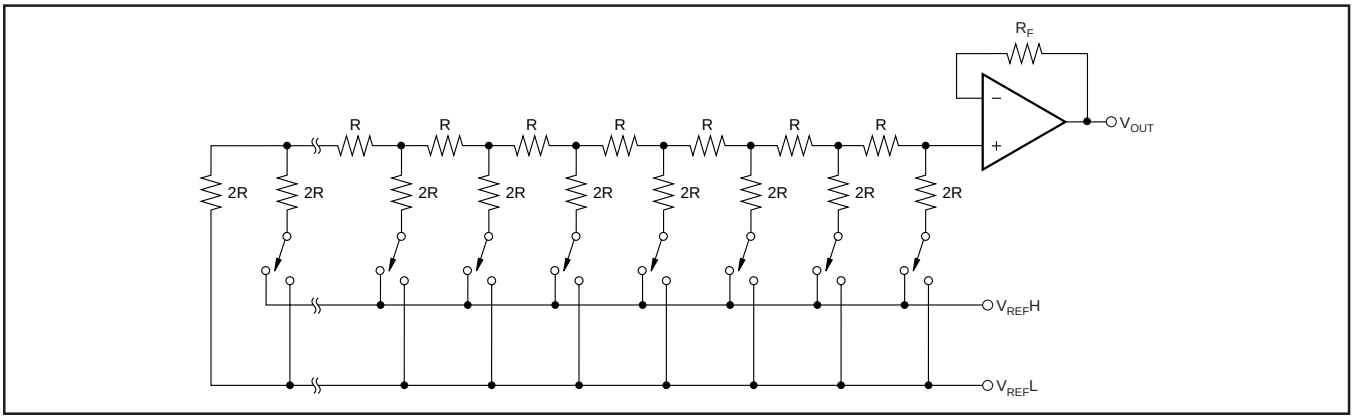



FIGURE 1. DAC7715 Architecture.

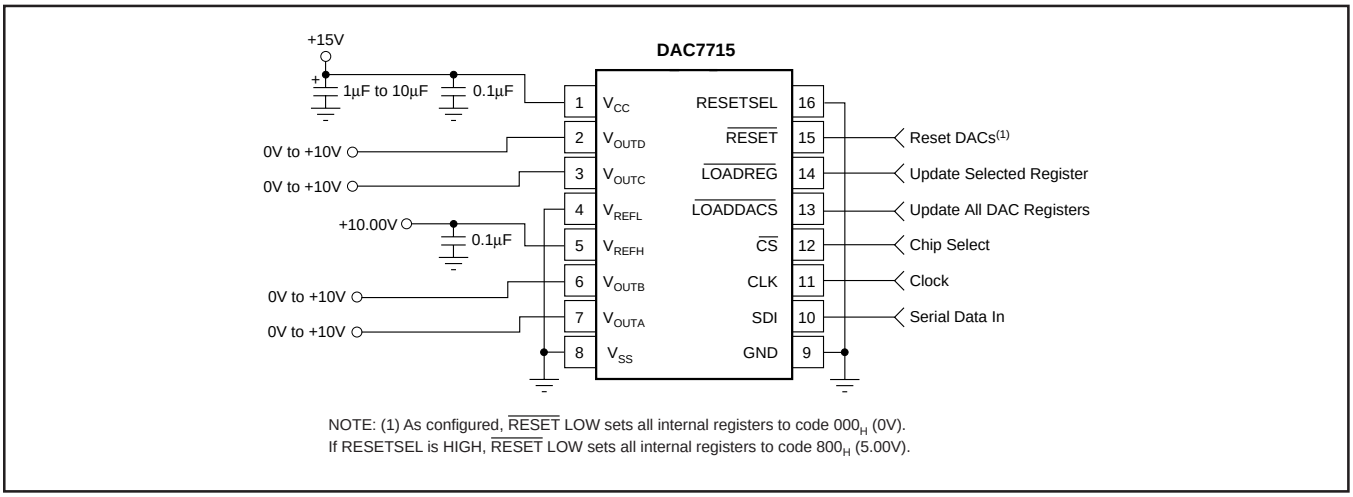



FIGURE 2. Basic Single-Supply Operation of the DAC7715.

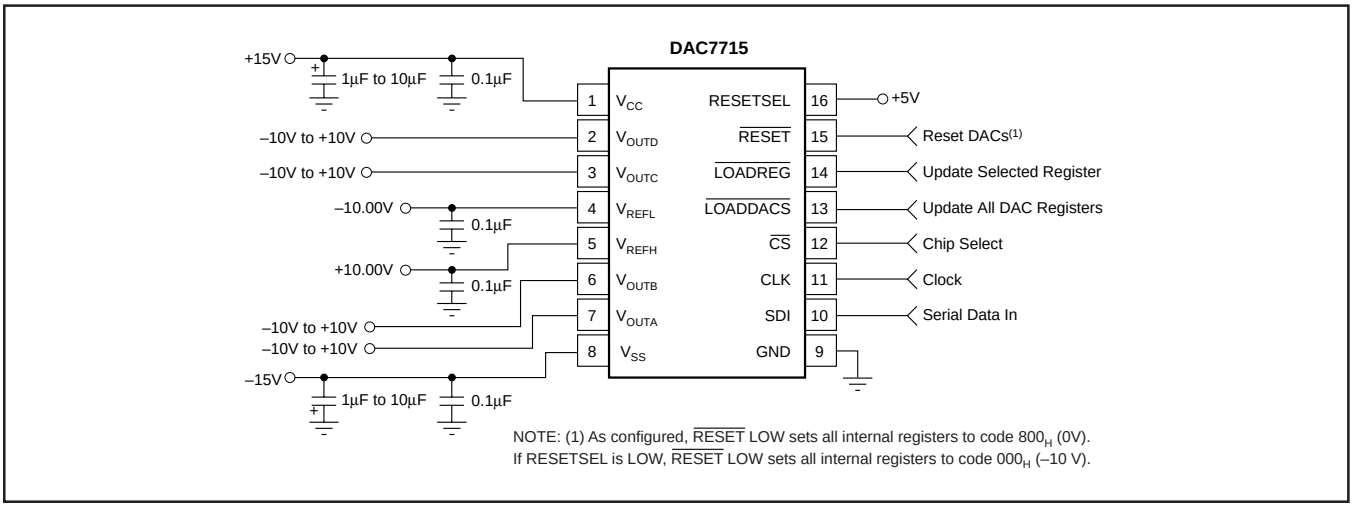



FIGURE 3. Basic Dual-Supply Operation of the DAC7715.

## ANALOG OUTPUTS

When $V_{SS}$ = –15V (dual supply operation), the output amplifier can swing to within 4V of the supply rails, over the –40°C to +85°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. Also, care must 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 ($000_H$, $001_H$, $002_H$, 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 $004_H$.

## 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 DAC 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 be in the range of –14.75V to –15.25V. 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).

## DIGITAL INTERFACE

Figure 4 and Table I provide the basic timing for the DAC7715. The interface consists of a serial clock (CLK), serial data (SDI), a load register signal ($\overline{\text{LOADREG}}$), and a

| 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 |
| $t_{CSS}$ | $\overline{\text{CS}}$ LOW to CLK Rising | 55 | | | ns |
| $t_{CSH}$ | CLK HIGH to $\overline{\text{CS}}$ Rising | 15 | | | ns |
| $t_{LD1}$ | $\overline{\text{LOADREG}}$ HIGH to CLK Rising | 40 | | | ns |
| $t_{LD2}$ | CLK Rising to $\overline{\text{LOADREG}}$ LOW | 15 | | | ns |
| $t_{LDRW}$ | $\overline{\text{LOADREG}}$ LOW Time | 45 | | | ns |
| $t_{LDDW}$ | $\overline{\text{LOADDACS}}$ LOW Time | 45 | | | ns |
| $t_{RSSH}$ | RESETSEL Valid to $\overline{\text{RESET}}$ LOW | 25 | | | ns |
| $t_{RSTW}$ | RESET LOW Time | 70 | | | ns |
| $t_S$ | Settling Time | 10 | | | µs |

TABLE I. Timing Specifications ($T_A$ = –40°C to +85°C).

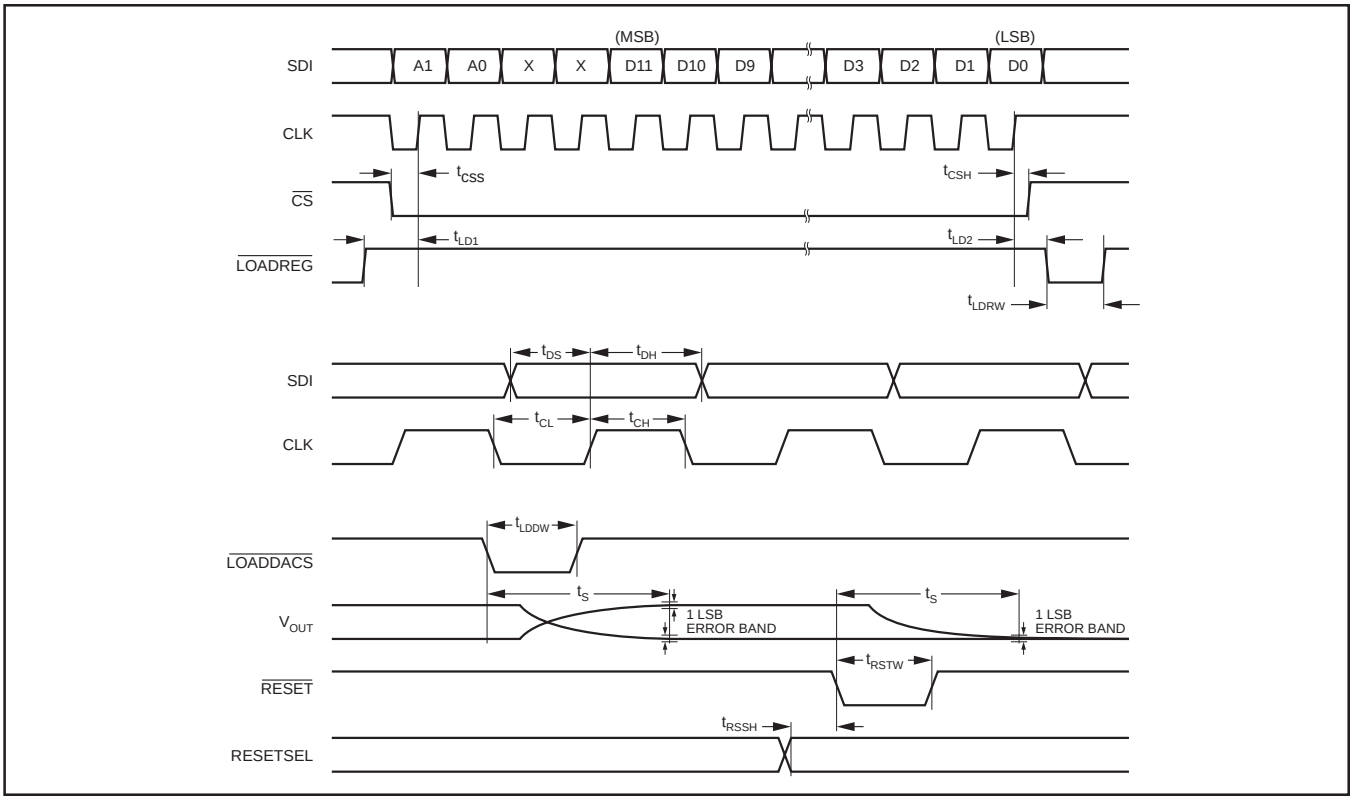



FIGURE 4. DAC7715 Timing.

| A1 | A0 | $\overline{\text{LOADREG}}$ | $\overline{\text{LOADDACS}}$ | $\overline{\text{RESET}}$ | SELECTED INPUT REGISTER | STATE OF SELECTED INPUT REGISTER | STATE OF ALL DAC REGISTERS |
|---|---|---|---|---|---|---|---|
| L[1] | L | L | H[2] | H | A | Transparent | Latched |
| L | H | L | H | H | B | Transparent | Latched |
| H | L | L | H | H | C | Transparent | Latched |
| H | H | L | H | H | D | Transparent | Latched |
| X[3] | X | H | L | H | NONE | (All Latched) | Transparent |
| X | X | H | H | H | NONE | (All Latched) | Latched |
| X | X | X | X | L | ALL | Reset[4] | Reset[4] |

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

TABLE II. Control Logic Truth Table.

| $\overline{\text{CS}}$[1] | CLK[1] | $\overline{\text{LOADREG}}$ | $\overline{\text{RESET}}$ | SERIAL SHIFT REGISTER |
|---|---|---|---|---|
| H[2] | X[3] | H | H | No Change |
| L[4] | L | H | H | No Change |
| L | ↑[5] | H | H | Advanced One Bit |
| ↑ | L | H | H | Advanced One Bit |
| H[6] | X | L[7] | H | No Change |
| H[6] | X | H | L[8] | 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 $\overline{\text{LOADREG}}$ is LOW, the selected input register will change as the shift register bits "flow" through A1 and A0. This will corrupt the data in each input 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.

"load all DAC registers" 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 as shown in Figure 4. The first two bits select the input register that will be updated when LOADREG goes LOW, as shown in Table II. The next two bits are not used. The last 12 bits are 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 DAC7715 (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 input register.

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.

The digital data into the DAC7715 is double-buffered. This allows new data to be entered for each DAC without disturbing the analog outputs. When the new settings have been entered into the device, all of the DAC outputs can be updated simultaneously. The transfer from the input registers to the DAC registers is accomplished with a HIGH to LOW transition on the $\overline{\text{LOADDACS}}$ input.

Because the DAC registers become transparent when $\overline{\text{LOADDACS}}$ is LOW, it is possible to keep this pin LOW and update each DAC via $\overline{\text{LOADREG}}$. However, as each new data word is entered into the device, the corresponding output will update immediately when $\overline{\text{LOADREG}}$ is taken LOW.

### Digital Input Coding

The DAC7715 input data is in Straight Binary format. The output voltage is given by the following equation:

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

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 DAC7715 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 DAC7715 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 $V_{DD}$ (as well as $V_{SS}$, 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 Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DAC7715U | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | DAC7715U | Samples |
| DAC7715U/1K | ACTIVE | SOIC | DW | 16 | 1000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | DAC7715U | Samples |
| DAC7715UB | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | DAC7715U B | Samples |
| DAC7715UB/1K | ACTIVE | SOIC | DW | 16 | 1000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | DAC7715U B | Samples |

(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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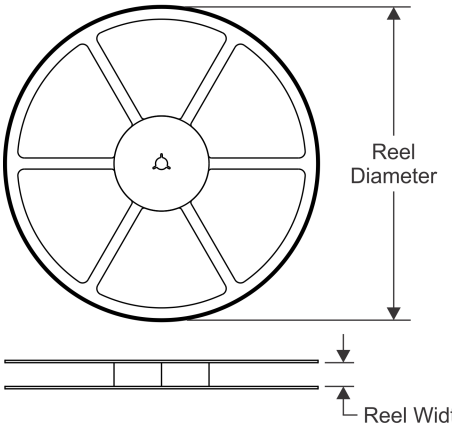
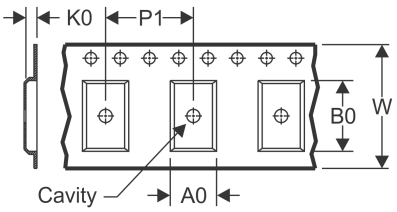
**REEL DIMENSIONS**

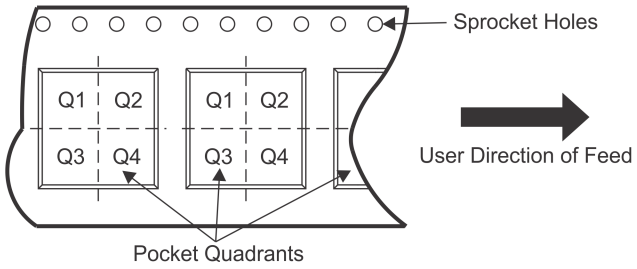



**TAPE DIMENSIONS**




| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

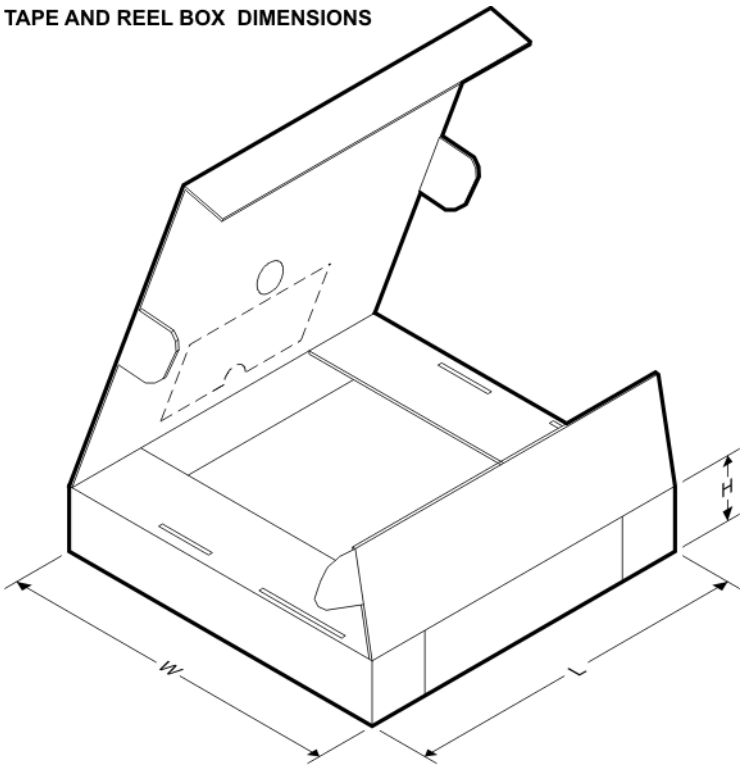
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DAC7715U/1K | SOIC | DW | 16 | 1000 | 330.0 | 16.4 | 10.75 | 10.7 | 2.7 | 12.0 | 16.0 | Q1 |
| DAC7715UB/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) |
|---|---|---|---|---|---|---|---|
| DAC7715U/1K | SOIC | DW | 16 | 1000 | 367.0 | 367.0 | 38.0 |
| DAC7715UB/1K | SOIC | DW | 16 | 1000 | 367.0 | 367.0 | 38.0 |

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