

DACxx6xT 具有 2.5V、4PPM/°C 内部基准和 5V TTL I/O 的双路 16 位、14 位、12 位低功耗电压输出 DAC

1 特性

- 相对精度：16 位时为 4 最低有效位 (LSB) 最大积分非线性 (INL)
- 低毛刺脉冲：0.1nV-s
- 双向基准引脚：输入或 2.5V 输出
 - 4ppm/°C 温度漂移（典型值）
- 上电复位至零量程或量程中点
- 低功耗：5V AVDD 时为 4mW
- 宽电源范围：2.7V 至 5.5V
- 带有施密特触发输入的 50MHz 串行外设接口 (SPI)
- LDAC 和 CLR 功能
- 支持轨到轨运行的输出缓冲器
- 与 DAC8562 系列引脚到引脚兼容
- 支持 5V 晶体管晶体管逻辑电路 (TTL) I/O
- 封装：晶圆级小外形无引线 (WSON)-10 (3mm x 3mm)，超薄小外形尺寸 (VSSOP)-10
- 温度范围：-40°C 至 125°C

2 应用

- 便携式仪表
- 可编程逻辑控制器 (PLC) 模拟输出模块
- 双极输出（第 9.2.2 节）
- 闭环伺服器控制
- 压控振荡器调谐
- 数据采集系统
- 可编程增益和偏移调整

3 说明

DAC856xT、DAC816xT 和 DAC756xT 器件分别为 16 位、14 位和 12 位低功耗电压输出双通道数模转换器 (DAC)。这些器件包括一个 2.5V、4ppm/°C 内部基准，从而提供了一个 2.5V 或 5V 的满量程输出电压范围。此内部基准有一个 $\pm 5\text{mV}$ 的初始精度，并且能够在 $V_{\text{REFIN}}/V_{\text{REFOUT}}$ 引脚上提供或吸收高达 20mA 的电流。

这些器件是单片器件，从而提供了出色的线性并大大降低了有害的代码至代码转换时的瞬态电压（毛刺脉冲）。它们使用一个运行时速率高达 50MHz 的多用途 3 线制串口。此接口与标准 SPI™，QSPI™，Microwire，以及数字信号处理器 (DSP) 接口兼容。DACxx62T 器件配有一个上电复位电路，此电路可确保在一个有效代码被写入此器件前，DAC 输出上电并保持零量程，而 DACxx63T 在量程中点上电。这些器件包含一个断电特性，此特性可将 5V 电压时的流耗减少至 550nA（典型值）。此低功耗、内部基准和小封装尺寸使得这些器件非常适合于便携式、电池供电运行类设备。

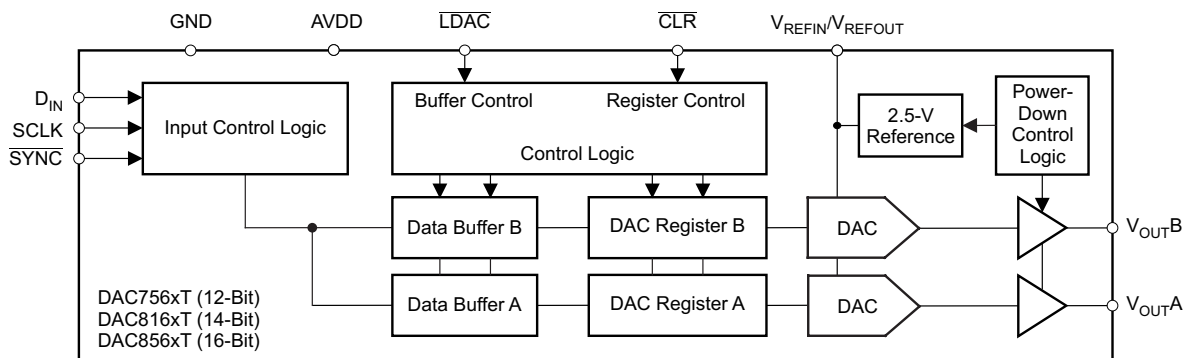
与 DACxx62T 器件一样，DACxx63T 器件之间可互相插接并且功能兼容。整个系列均提供 VSSOP-10 和 WSON-10 封装。

器件信息(1)

| 器件型号 | 封装 | 封装尺寸 (标称值) |
|----------|--------------------------|-----------------|
| DAC8562T | VSSOP (10), WSON (10) | 3.00mm x 3.00mm |
| DAC8162T | | |
| DAC7562T | | |

(1) 要了解所有可用封装，请见数据表末尾的可订购产品附录。

简化框图



目录

| | | | | | |
|----------|--|-----------|-----------|---|-----------|
| 1 | 特性 | 1 | 8.4 | Device Functional Modes | 32 |
| 2 | 应用 | 1 | 8.5 | Programming | 36 |
| 3 | 说明 | 1 | 9 | Application and Implementation | 39 |
| 4 | 修订历史记录 | 2 | 9.1 | Application Information | 39 |
| 5 | Device Comparison Table | 3 | 9.2 | Typical Applications | 41 |
| 6 | Pin Configuration and Functions | 4 | 9.3 | System Examples | 45 |
| 7 | Specifications | 5 | 10 | Power Supply Recommendations | 46 |
| 7.1 | Absolute Maximum Ratings | 5 | 11 | Layout | 46 |
| 7.2 | ESD Ratings | 5 | 11.1 | Layout Guidelines | 46 |
| 7.3 | Recommended Operating Conditions | 5 | 11.2 | Layout Example | 47 |
| 7.4 | Thermal Information | 5 | 12 | 器件和文档支持 | 49 |
| 7.5 | Electrical Characteristics | 6 | 12.1 | 相关链接 | 49 |
| 7.6 | Timing Requirements | 9 | 12.2 | 社区资源 | 49 |
| 7.7 | Typical Characteristics | 10 | 12.3 | Trademarks | 49 |
| 8 | Detailed Description | 28 | 12.4 | Electrostatic Discharge Caution | 49 |
| 8.1 | Overview | 28 | 12.5 | Glossary | 49 |
| 8.2 | Functional Block Diagram | 28 | 13 | 机械、封装和可订购信息 | 49 |
| 8.3 | Feature Description | 28 | | | |

4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

Changes from Original (September 2015) to Revision A

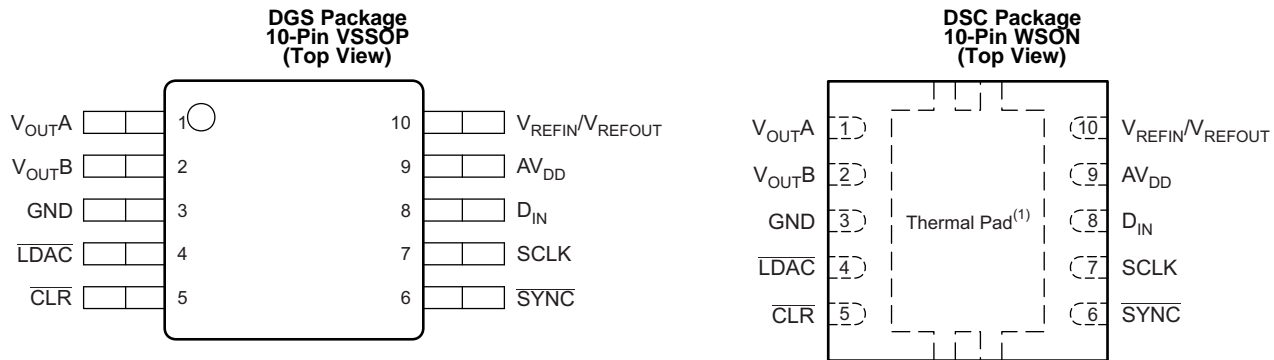
Page

| | | |
|---|-------------------|---|
| • | 从产品预览改为量产数据 | 1 |
|---|-------------------|---|

5 Device Comparison Table

| DEVICE | MAXIMUM RELATIVE ACCURACY (LSB) | MAXIMUM DIFFERENTIAL NONLINEARITY (LSB) | MAXIMUM REFERENCE DRIFT (ppm/°C) | RESET TO |
|----------|---------------------------------|---|----------------------------------|-----------|
| DAC7562T | ±0.75 | ±0.25 | 10 | Zero |
| DAC7563T | | | | Mid-scale |
| DAC8162T | ±3 | ±0.5 | 10 | Zero |
| DAC8163T | | | | Mid-scale |
| DAC8562T | ±12 | ±1 | 10 | Zero |
| DAC8563T | | | | Mid-scale |

6 Pin Configuration and Functions



(1) TI recommends connecting the thermal pad to the ground plane for better thermal dissipation.

Pin Functions

| PIN | | I/O | DESCRIPTION |
|---|-----|-----|--|
| NAME | NO. | | |
| AV _{DD} | 9 | I | Power-supply input, 2.7 V to 5.5 V |
| $\overline{\text{CLR}}$ | 5 | I | Asynchronous clear input. The $\overline{\text{CLR}}$ input is falling-edge sensitive. On activation of $\overline{\text{CLR}}$, zero scale (DACxx62T) or mid-scale (DACxx63T) is loaded to all input and DAC registers. This sets the DAC output voltages accordingly. The device exits clear code mode on the 24 th falling edge of the next write to the device. Activating $\overline{\text{CLR}}$ during a write sequence aborts the write. |
| D _{IN} | 8 | I | Serial data input. Data are clocked into the 24-bit input shift register on each falling edge of the serial clock input. Schmitt-trigger logic input |
| GND | 3 | — | Ground reference point for all circuitry on the device |
| $\overline{\text{LDAC}}$ | 4 | I | In <i>synchronous</i> mode, data update occurs with the falling edge of the 24 th SCLK cycle, which follows a falling edge of SYNC. Such <i>synchronous</i> updates do not require the LDAC, which must be connected to GND permanently or asserted and held low before sending commands to the device. In <i>asynchronous</i> mode, the $\overline{\text{LDAC}}$ pin is used as a negative edge-triggered timing signal for simultaneous DAC updates. Multiple single-channel commands can be written in order to set different channel buffers to desired values and then make a falling edge on the LDAC pin to update the DAC output registers simultaneously. |
| SCLK | 7 | I | Serial clock input. Data can be transferred at rates up to 50 MHz. Schmitt-trigger logic input |
| $\overline{\text{SYNC}}$ | 6 | I | Level-triggered control input (active-low). This input is the frame synchronization signal for the input data. When $\overline{\text{SYNC}}$ goes low, it enables the input shift register, and data are sampled on subsequent falling clock edges. The DAC output updates following the 24 th clock falling edge. If $\overline{\text{SYNC}}$ is taken high before the 23 rd clock edge, the rising edge of SYNC acts as an interrupt, and the write sequence is ignored by the DAC756xT, DAC816xT, and DAC856xT devices. Schmitt-trigger logic input |
| V _{OUTA} | 1 | O | Analog output voltage from DAC-A |
| V _{OUTB} | 2 | O | Analog output voltage from DAC-B |
| V _{REFIN} /V _{REFOUT} | 10 | I/O | Bidirectional voltage reference pin. If internal reference is used, 2.5-V output. |

7 Specifications

7.1 Absolute Maximum Ratings⁽¹⁾

Over operating ambient temperature range (unless otherwise noted).

| | MIN | MAX | UNIT |
|--|------|----------------|------|
| V_{DD} to GND | -0.3 | 6 | V |
| \overline{CLR} , D_{IN} , \overline{LDAC} , \overline{SCLK} and \overline{SYNC} input voltage to GND | -0.3 | $V_{DD} + 0.3$ | V |
| $V_{OUT[A, B]}$ to GND | -0.3 | $V_{DD} + 0.3$ | V |
| V_{REFIN}/V_{REFOUT} to GND | -0.3 | $V_{DD} + 0.3$ | V |
| Operating temperature range | -40 | 125 | °C |
| Junction temperature, T_J | | 150 | °C |
| Storage temperature, T_{stg} | -65 | 150 | °C |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 ESD Ratings

| | | VALUE | UNIT |
|-------------------------------------|--|-------|------|
| $V_{(ESD)}$ Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±1000 | V |
| | Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾ | ±500 | |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

over operating ambient temperature range (unless otherwise noted)

| | | MIN | NOM | MAX | UNIT |
|-------------------------------------|---|-----|-----|----------|------|
| POWER SUPPLY | | | | | |
| Supply voltage | V_{DD} to GND | 2.7 | | 5.5 | V |
| DIGITAL INPUTS | | | | | |
| Digital input voltage | \overline{CLR} , D_{IN} , \overline{LDAC} , \overline{SCLK} and \overline{SYNC} | 0 | | V_{DD} | V |
| REFERENCE INPUT | | | | | |
| V_{REFIN} Reference input voltage | | 0 | | V_{DD} | V |
| TEMPERATURE RANGE | | | | | |
| T_A Operating ambient temperature | | -40 | | 125 | °C |

7.4 Thermal Information

| THERMAL METRIC | | DAC756xT, DAC816xT, DAC856xT | | UNIT |
|----------------------|--|------------------------------|-------------|------|
| | | DSC (WSON) | DGS (VSSOP) | |
| | | 10 PINS | 10 PINS | |
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 62.8 | 173.8 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 44.3 | 48.5 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 26.5 | 79.9 | °C/W |
| Ψ_{JT} | Junction-to-top characterization parameter | 0.4 | 1.7 | °C/W |
| Ψ_{JB} | Junction-to-board characterization parameter | 25.5 | 68.4 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | 46.2 | N/A | °C/W |

7.5 Electrical Characteristics

At $V_{DD} = 2.7\text{ V}$ to 5.5 V and $T_A = -40^\circ\text{C}$ to 125°C (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|--|-----|-------|----------|------------------|
| STATIC PERFORMANCE⁽¹⁾ | | | | | | |
| DAC756xT | Resolution | | 12 | | | Bits |
| | Relative accuracy | Using line passing through codes 32 and 4,064 | | ±0.3 | ±0.75 | LSB |
| | Differential nonlinearity | 12-bit monotonic | | ±0.05 | ±0.25 | |
| DAC816xT | Resolution | | 14 | | | Bits |
| | Relative accuracy | Using line passing through codes 128 and 16,256 | | ±1 | ±3 | LSB |
| | Differential nonlinearity | 14-bit monotonic | | ±0.1 | ±0.5 | |
| DAC856xT | Resolution | | 16 | | | Bits |
| | Relative accuracy | Using line passing through codes 512 and 65,024 | | ±4 | ±12 | LSB |
| | Differential nonlinearity | 16-bit monotonic | | ±0.2 | ±1 | |
| Offset error | | Extrapolated from two-point line ⁽¹⁾ , unloaded | | ±1 | ±4 | mV |
| Offset error drift | | | | ±2 | | μV/°C |
| Full-scale error | | DAC register loaded with all 1s, DAC output unloaded | | ±0.03 | ±0.2 | % FSR |
| Zero-code error | | DAC register loaded with all 0s, DAC output unloaded | | 1 | 4 | mV |
| Zero-code error drift | | | | ±2 | | μV/°C |
| Gain error | | Extrapolated from two-point line ⁽¹⁾ , unloaded | | ±0.01 | ±0.15 | % FSR |
| Gain temperature coefficient | | | | ±1 | | ppm FSR/°C |
| OUTPUT CHARACTERISTICS⁽²⁾ | | | | | | |
| Output voltage range | | | 0 | | V_{DD} | V |
| Output voltage settling time ⁽³⁾ | DACs unloaded | | | 7 | | μs |
| | $R_L = 1\text{ M}\Omega$ | | | 10 | | |
| Slew rate | | Measured between 20%–80% of a full-scale transition | | 0.75 | | V/μs |
| Capacitive load stability | $R_L = \infty$ | | | 1 | | nF |
| | $R_L = 2\text{ k}\Omega$ | | | 3 | | |
| Code-change glitch impulse | | 1-LSB change around major carry | | 0.1 | | nV-s |
| Digital feedthrough | | SCLK toggling, SYNC high | | 0.1 | | nV-s |
| Power-on glitch impulse | | $R_L = 2\text{ k}\Omega$, $C_L = 470\text{ pF}$, $V_{DD} = 5.5\text{ V}$ | | 40 | | mV |
| Channel-to-channel dc crosstalk | Full-scale swing on adjacent channel, External reference | | | 5 | | μV |
| | Full-scale swing on adjacent channel, Internal reference | | | 15 | | |
| DC output impedance | | At mid-scale input | | 5 | | Ω |
| Short-circuit current | | DAC outputs at full-scale, DAC outputs shorted to GND | | 40 | | mA |
| Power-up time, including settling time | | Coming out of power-down mode | | 50 | | μs |
| AC PERFORMANCE⁽²⁾ | | | | | | |
| DAC output noise density | | $T_A = 25^\circ\text{C}$, at mid-scale input, $f_{OUT} = 1\text{ kHz}$ | | 90 | | nV/√Hz |
| DAC output noise | | $T_A = 25^\circ\text{C}$, at mid-scale input, 0.1 Hz to 10 Hz | | 2.6 | | μV _{PP} |
| LOGIC INPUTS⁽²⁾ | | | | | | |
| Input-pin leakage current | | | -1 | ±0.1 | 1 | μA |
| Logic input LOW voltage V_{IL} | | | 0 | | 0.8 | V |
| Logic input HIGH voltage V_{IH} | | | 2.1 | | V_{DD} | V |
| Pin capacitance | | | | | 3 | pF |

(1) 16-bit: codes 512 and 65,024; 14-bit: codes 128 and 16,256; 12-bit: codes 32 and 4,064, All digital inputs kept at same IO levels before and after write to the DAC

(2) Specification based on design or characterization

(3) Transition time between 1 / 4 scale and 3 / 4 scale, including settling to within ±0.024% FSR

Electrical Characteristics (continued)

 At $AV_{DD} = 2.7\text{ V to }5.5\text{ V}$ and $T_A = -40^\circ\text{C to }125^\circ\text{C}$ (unless otherwise noted).

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT | |
|---|--|-------|-----------|-------|------------------------------|----|
| REFERENCE | | | | | | |
| External reference current | External $V_{REF} = 2.5\text{ V}$ (when internal reference is disabled), all channels active using gain = 1 | | 15 | | μA | |
| Reference input impedance | Internal reference disabled, gain = 1 | | 170 | | $\text{k}\Omega$ | |
| | Internal reference disabled, gain = 2 | | 85 | | | |
| REFERENCE OUTPUT | | | | | | |
| Output voltage | $T_A = 25^\circ\text{C}$ | 2.495 | 2.5 | 2.505 | V | |
| Initial accuracy | $T_A = 25^\circ\text{C}$ | -5 | ± 0.1 | 5 | mV | |
| Output-voltage temperature drift | Internal reference output voltage temperature drift is characterized from -40°C to 125°C . | | 4 | 10 | ppm/ $^\circ\text{C}$ | |
| Output-voltage noise | $f = 0.1\text{ Hz to }10\text{ Hz}$ | | 12 | | μV_{PP} | |
| Output-voltage noise density (high-frequency noise) | $T_A = 25^\circ\text{C}$, $f = 1\text{ kHz}$, $C_L = 0\text{ }\mu\text{F}$ | | 250 | | $\text{nV}/\sqrt{\text{Hz}}$ | |
| | $T_A = 25^\circ\text{C}$, $f = 1\text{ MHz}$, $C_L = 0\text{ }\mu\text{F}$ | | 30 | | | |
| | $T_A = 25^\circ\text{C}$, $f = 1\text{ MHz}$, $C_L = 4.7\text{ }\mu\text{F}$ | | 10 | | | |
| Load regulation, sourcing ⁽⁴⁾ | $T_A = 25^\circ\text{C}$ | | 20 | | $\mu\text{V}/\text{mA}$ | |
| Load regulation, sinking ⁽⁴⁾ | $T_A = 25^\circ\text{C}$ | | 185 | | $\mu\text{V}/\text{mA}$ | |
| Output-current load capability ⁽²⁾ | | | ± 20 | | mA | |
| Line regulation | $T_A = 25^\circ\text{C}$ | | 50 | | $\mu\text{V}/\text{V}$ | |
| Long-term stability or drift (aging) ⁽⁴⁾ | $T_A = 25^\circ\text{C}$, time = 0 to 1900 hours | | 100 | | ppm | |
| Thermal hysteresis ⁽⁴⁾ | First cycle | | 200 | | ppm | |
| | Additional cycles | | 50 | | | |
| POWER REQUIREMENTS⁽⁵⁾ | | | | | | |
| Power supply current (I_{DD}) | $AV_{DD} = 3.6\text{ V to }5.5\text{ V}$, normal mode, internal reference off, Digital inputs at VDD or GND | | 0.25 | 0.5 | mA | |
| | $AV_{DD} = 3.6\text{ V to }5.5\text{ V}$, normal mode, internal reference off, Digital inputs at TTL level | | | 4 | | |
| | $AV_{DD} = 3.6\text{ V to }5.5\text{ V}$, normal mode, internal reference on, Digital inputs at VDD or GND | | 0.9 | 1.6 | | |
| | $AV_{DD} = 3.6\text{ V to }5.5\text{ V}$, normal mode, internal reference on, Digital inputs at TTL level | | | 5 | | |
| | $AV_{DD} = 3.6\text{ V to }5.5\text{ V}$, power-down modes, Digital inputs at VDD or GND | | 0.55 | 4 | μA | |
| | $AV_{DD} = 2.7\text{ V to }3.6\text{ V}$, normal mode, internal reference off, Digital inputs at VDD or GND | | | 0.2 | 0.4 | mA |
| | $AV_{DD} = 2.7\text{ V to }3.6\text{ V}$, normal mode, internal reference off, Digital inputs at TTL level | | | | 0.8 | |
| | $AV_{DD} = 2.7\text{ V to }3.6\text{ V}$, normal mode, internal reference on, Digital inputs at VDD or GND | | 0.73 | 1.4 | | |
| | $AV_{DD} = 2.7\text{ V to }3.6\text{ V}$, normal mode, internal reference on, Digital inputs at TTL level | | | | 1.8 | |
| | $AV_{DD} = 2.7\text{ V to }3.6\text{ V}$, power-down modes, Digital inputs at VDD or GND | | 0.35 | 3 | μA | |

 (4) See the [Application Information](#) section of this data sheet.

(5) Input code = mid-scale, no load

Electrical Characteristics (continued)

At $V_{DD} = 2.7\text{ V to }5.5\text{ V}$ and $T_A = -40^\circ\text{C to }125^\circ\text{C}$ (unless otherwise noted).

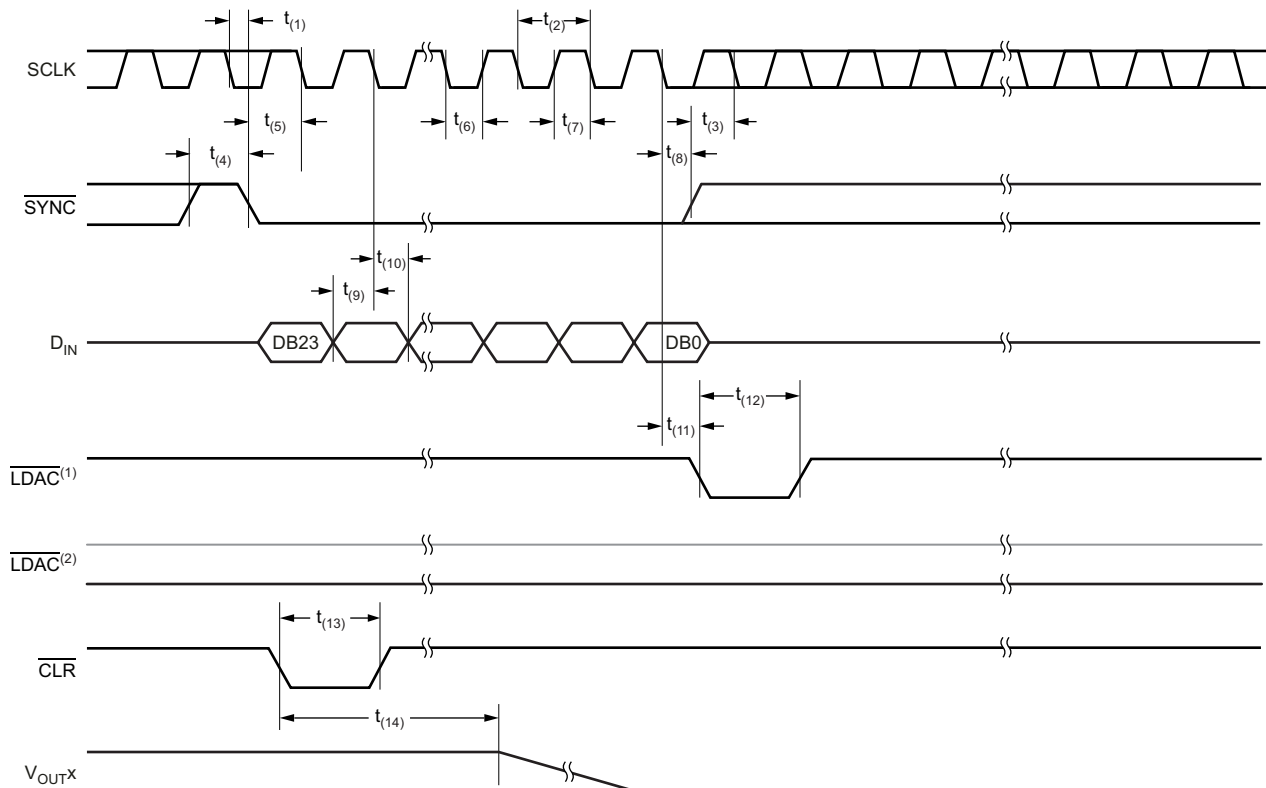
| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-------------------|---|-----|------|------|---------------|
| Power dissipation | $V_{DD} = 3.6\text{ V to }5.5\text{ V}$, normal mode, internal reference off, Digital inputs at VDD or GND | | 0.9 | 2.75 | mW |
| | $V_{DD} = 3.6\text{ V to }5.5\text{ V}$, normal mode, internal reference on, Digital inputs at VDD or GND | | 3.2 | 8.8 | |
| | $V_{DD} = 3.6\text{ V to }5.5\text{ V}$, power-down modes, Digital inputs at VDD or GND | | 2 | 22 | μW |
| | $V_{DD} = 2.7\text{ V to }3.6\text{ V}$, normal mode, internal reference off, Digital inputs at VDD or GND | | 0.54 | 1.44 | mW |
| | $V_{DD} = 2.7\text{ V to }3.6\text{ V}$, normal mode, internal reference on, Digital inputs at VDD or GND | | 1.97 | 5 | |
| | $V_{DD} = 2.7\text{ V to }3.6\text{ V}$, power-down modes, Digital inputs at VDD or GND | | 0.95 | 10.8 | μW |

7.6 Timing Requirements⁽¹⁾⁽²⁾

At $AV_{DD} = 2.7\text{ V}$ to 5.5 V , external $V_{REFIN} = 2.5\text{ V}$ to 5.5 V , and over -40°C to 125°C (unless otherwise noted). See [Figure 1](#).

| | | DAC756xT, DAC816xT, DAC856xT | | | UNIT |
|--------------|--|---------------------------------|-----|-----|------|
| | | MIN | TYP | MAX | |
| $f_{(SCLK)}$ | Serial clock frequency | | | 50 | MHz |
| $t_{(1)}$ | SCLK falling edge to \overline{SYNC} falling edge (for successful write operation) | 10 | | | ns |
| $t_{(2)}$ | SCLK cycle time | 20 | | | ns |
| $t_{(3)}$ | \overline{SYNC} rising edge to 23 rd SCLK falling edge (for successful \overline{SYNC} interrupt) | 13 | | | ns |
| $t_{(4)}$ | Minimum \overline{SYNC} HIGH time | 15 | | | ns |
| $t_{(5)}$ | \overline{SYNC} to SCLK falling edge setup time | 13 | | | ns |
| $t_{(6)}$ | SCLK LOW time | 8 | | | ns |
| $t_{(7)}$ | SCLK HIGH time | 8 | | | ns |
| $t_{(8)}$ | SCLK falling edge to \overline{SYNC} rising edge | 10 | | | ns |
| $t_{(9)}$ | Data setup time | 6 | | | ns |
| $t_{(10)}$ | Data hold time | 6 | | | ns |
| $t_{(11)}$ | SCLK falling edge to \overline{LDAC} falling edge for asynchronous LDAC update mode | 5 | | | ns |
| $t_{(12)}$ | \overline{LDAC} pulse duration, LOW time | 10 | | | ns |
| $t_{(13)}$ | \overline{CLR} pulse duration, LOW time | 80 | | | ns |
| $t_{(14)}$ | \overline{CLR} falling edge to start of V_{OUTX} transition | | | 100 | ns |

- (1) All input signals are specified with $t_r = t_f = 1\text{ ns/V}$ (10% to 90% of AV_{DD}) and timed from a voltage level of $(V_{IL} + V_{IH}) / 2$.
 (2) See the *Serial Write Operation* timing diagram ([Figure 1](#)).



- (1) Asynchronous \overline{LDAC} update mode. For more information, see the [LDAC Functionality](#) section.
 (2) Synchronous \overline{LDAC} update mode; \overline{LDAC} remains low. For more information, see the [LDAC Functionality](#) section.

Figure 1. Timing Diagram, Serial Write Operation

7.7 Typical Characteristics

Table 1. Typical Characteristics: Internal Reference Performance

| MEASUREMENT | POWER-SUPPLY VOLTAGE | FIGURE NUMBER |
|--|----------------------|---------------|
| Internal Reference Voltage vs Temperature | 5.5 V | Figure 2 |
| Internal Reference Voltage Temperature Drift Histogram | | Figure 3 |
| Internal Reference Voltage vs Load Current | | Figure 4 |
| Internal Reference Voltage vs Time | | Figure 5 |
| Internal Reference Noise Density vs Frequency | | Figure 6 |
| Internal Reference Voltage vs Supply Voltage | 2.7 V–5.5 V | Figure 7 |

Table 2. Typical Characteristics: DAC Static Performance

| MEASUREMENT | POWER-SUPPLY VOLTAGE | FIGURE NUMBER | |
|--|----------------------|---------------|-----------|
| FULL-SCALE, GAIN, OFFSET AND ZERO-CODE ERRORS | | | |
| Full-Scale Error vs Temperature | 5.5 V | Figure 16 | |
| Gain Error vs Temperature | | Figure 17 | |
| Offset Error vs Temperature | | Figure 18 | |
| Zero-Code Error vs Temperature | | Figure 19 | |
| Full-Scale Error vs Temperature | 2.7 V | Figure 63 | |
| Gain Error vs Temperature | | Figure 64 | |
| Offset Error vs Temperature | | Figure 65 | |
| Zero-Code Error vs Temperature | | Figure 66 | |
| LOAD REGULATION | | | |
| DAC Output Voltage vs Load Current | 5.5 V | Figure 30 | |
| | 2.7 V | Figure 74 | |
| DIFFERENTIAL NONLINEARITY ERROR | | | |
| Differential Linearity Error vs Digital Input Code | T = –40°C | Figure 9 | |
| | T = 25°C | Figure 11 | |
| | T = 125°C | Figure 13 | |
| Differential Linearity Error vs Temperature | 5.5 V | Figure 15 | |
| Differential Linearity Error vs Digital Input Code | | T = –40°C | Figure 56 |
| | | T = 25°C | Figure 58 |
| | | T = 125°C | Figure 60 |
| Differential Linearity Error vs Temperature | 2.7 V | Figure 62 | |
| INTEGRAL NONLINEARITY ERROR (RELATIVE ACCURACY) | | | |
| Linearity Error vs Digital Input Code | T = –40°C | Figure 8 | |
| | T = 25°C | Figure 10 | |
| | T = 125°C | Figure 12 | |
| Linearity Error vs Temperature | 5.5 V | Figure 14 | |
| Linearity Error vs Digital Input Code | | T = –40°C | Figure 55 |
| | | T = 25°C | Figure 57 |
| | | T = 125°C | Figure 59 |
| Linearity Error vs Temperature | 2.7 V | Figure 61 | |

Table 2. Typical Characteristics: DAC Static Performance (continued)

| MEASUREMENT | | POWER-SUPPLY VOLTAGE | FIGURE NUMBER | |
|--|--------------------|---------------------------|---------------------------|---------------------------|
| POWER-DOWN CURRENT | | | | |
| Power-Down Current vs Temperature | | 5.5 V | Figure 28 | |
| Power-Down Current vs Power-Supply Voltage | | 2.7 V – 5.5 V | Figure 29 | |
| Power-Down Current vs Temperature | | 2.7 V | Figure 73 | |
| POWER-SUPPLY CURRENT | | | | |
| Power-Supply Current vs Temperature | External V_{REF} | 5.5 V | Figure 20 | |
| | Internal V_{REF} | | Figure 21 | |
| Power-Supply Current vs Digital Input Code | External V_{REF} | | Figure 22 | |
| | Internal V_{REF} | | Figure 23 | |
| Power-Supply Current Histogram | External V_{REF} | | Figure 24 | |
| | Internal V_{REF} | | Figure 25 | |
| Power-Supply Current vs Power-Supply Voltage | External V_{REF} | | 2.7 V – 5.5 V | Figure 26 |
| | Internal V_{REF} | | | Figure 27 |
| Power-Supply Current vs Temperature | External V_{REF} | | 3.6 V | Figure 49 |
| | Internal V_{REF} | | | Figure 50 |
| Power-Supply Current vs Digital Input Code | External V_{REF} | Figure 51 | | |
| | Internal V_{REF} | Figure 52 | | |
| Power-Supply Current Histogram | External V_{REF} | Figure 53 | | |
| | Internal V_{REF} | Figure 54 | | |
| Power-Supply Current vs Temperature | External V_{REF} | 2.7 V | | Figure 67 |
| | Internal V_{REF} | | | Figure 68 |
| Power-Supply Current vs Digital Input Code | External V_{REF} | | | Figure 69 |
| | Internal V_{REF} | | | Figure 70 |
| Power-Supply Current Histogram | External V_{REF} | | Figure 71 | |
| | Internal V_{REF} | | Figure 72 | |

Table 3. Typical Characteristics: DAC Dynamic Performance

| MEASUREMENT | | POWER-SUPPLY VOLTAGE | FIGURE NUMBER |
|-------------------------------------|-----------------------------------|----------------------|---------------------------|
| CHANNEL-TO-CHANNEL CROSSTALK | | | |
| Channel-to-Channel Crosstalk | 5-V Rising Edge | 5.5 V | Figure 43 |
| | 5-V Falling Edge | | Figure 44 |
| CLOCK FEEDTHROUGH | | | |
| Clock Feedthrough | 500 kHz, Midscale | 5.5 V | Figure 48 |
| | | 2.7 V | Figure 87 |
| GLITCH IMPULSE | | | |
| Glitch Impulse, 1-LSB Step | Rising Edge, Code 7FFFh to 8000h | 5.5 V | Figure 37 |
| | Falling Edge, Code 8000h to 7FFFh | | Figure 38 |
| Glitch Impulse, 4-LSB Step | Rising Edge, Code 7FFCh to 8000h | | Figure 39 |
| | Falling Edge, Code 8000h to 7FFCh | | Figure 40 |
| Glitch Impulse, 16-LSB Step | Rising Edge, Code 7FF0h to 8000h | | Figure 41 |
| | Falling Edge, Code 8000h to 7FF0h | | Figure 42 |

Table 3. Typical Characteristics: DAC Dynamic Performance (continued)

| MEASUREMENT | | POWER-SUPPLY VOLTAGE | FIGURE NUMBER |
|---------------------------------------|-----------------------------------|----------------------|---------------------------|
| Glitch Impulse, 1-LSB Step | Rising Edge, Code 7FFFh to 8000h | 2.7 V | Figure 79 |
| | Falling Edge, Code 8000h to 7FFFh | | Figure 80 |
| Glitch Impulse, 4-LSB Step | Rising Edge, Code 7FFCh to 8000h | | Figure 81 |
| | Falling Edge, Code 8000h to 7FFCh | | Figure 82 |
| Glitch Impulse, 16-LSB Step | Rising Edge, Code 7FF0h to 8000h | | Figure 83 |
| | Falling Edge, Code 8000h to 7FF0h | | Figure 84 |
| NOISE | | | |
| DAC Output Noise Density vs Frequency | External V_{REF} | 5.5 V | Figure 45 |
| | Internal V_{REF} | | Figure 46 |
| DAC Output Noise 0.1 Hz to 10 Hz | External V_{REF} | | Figure 47 |
| POWER-ON GLITCH | | | |
| Power-On Glitch | Reset to Zero Scale | 5.5 V | Figure 35 |
| | Reset to Midscale | | Figure 36 |
| | Reset to Zero Scale | 2.7 V | Figure 85 |
| | Reset to Midscale | | Figure 86 |
| SETTLING TIME | | | |
| Full-Scale Settling Time | Rising Edge, Code 0h to FFFFh | 5.5 V | Figure 31 |
| | Falling Edge, Code FFFFh to 0h | | Figure 32 |
| Half-Scale Settling Time | Rising Edge, Code 4000h to C000h | | Figure 33 |
| | Falling Edge, Code C000h to 4000h | | Figure 34 |
| Full-Scale Settling Time | Rising Edge, Code 0h to FFFFh | 2.7 V | Figure 75 |
| | Falling Edge, Code FFFFh to 0h | | Figure 76 |
| Half-Scale Settling Time | Rising Edge, Code 4000h to C000h | | Figure 77 |
| | Falling Edge, Code C000h to 4000h | | Figure 78 |

7.7.1 Typical Characteristics: Internal Reference

At $T_A = 25^\circ\text{C}$, $AV_{DD} = 5.5\text{ V}$, gain = 2, and V_{REFOUT} unloaded, unless otherwise noted.

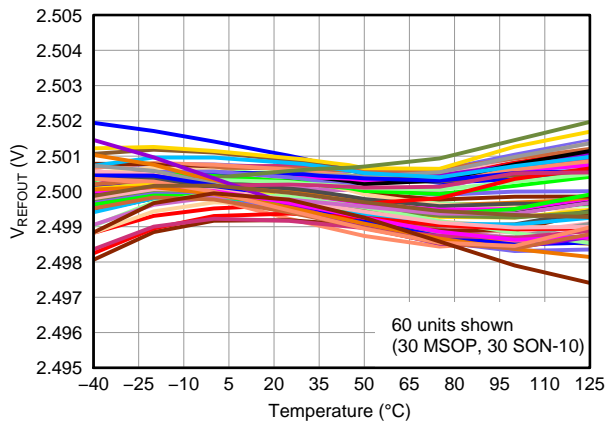


Figure 2. Internal Reference Voltage vs Temperature

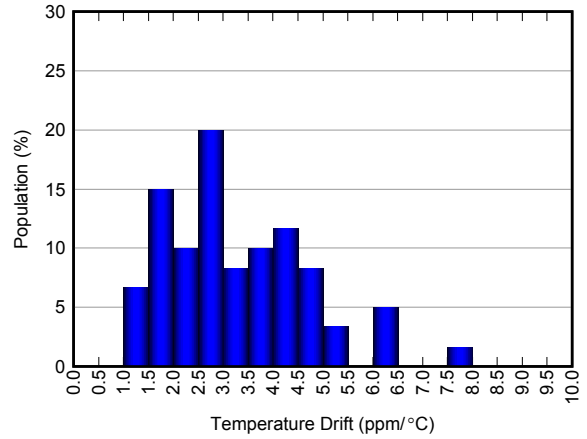


Figure 3. Internal Reference Voltage, Temperature Drift Histogram

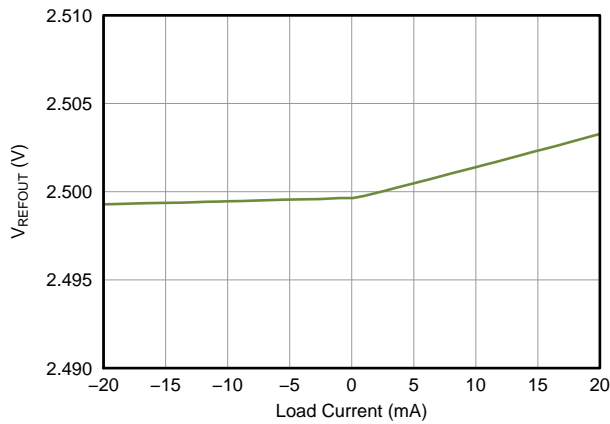


Figure 4. Internal Reference Voltage vs Load Current

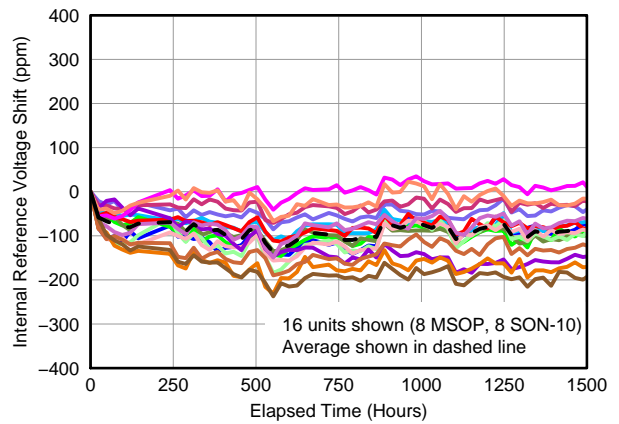


Figure 5. Internal Reference Voltage vs Time

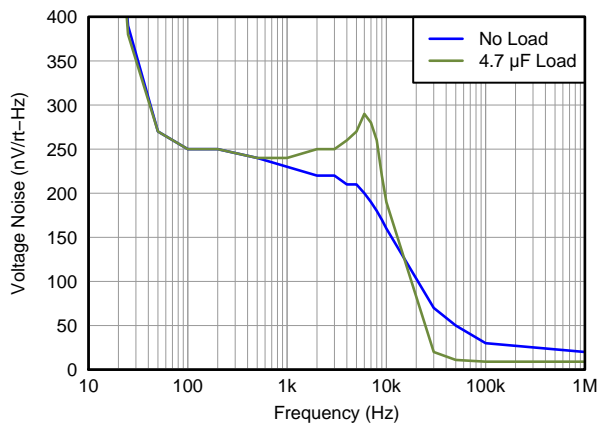


Figure 6. Internal Reference Noise Density vs Frequency

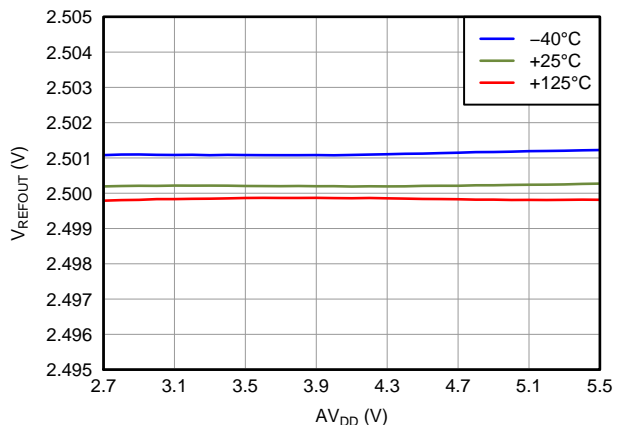


Figure 7. Internal Reference Voltage vs Supply Voltage

7.7.2 Typical Characteristics: DAC at $V_{DD} = 5.5\text{ V}$

At $T_A = 25^\circ\text{C}$, 5-V external reference used, gain = 1 and DAC output not loaded, unless otherwise noted.

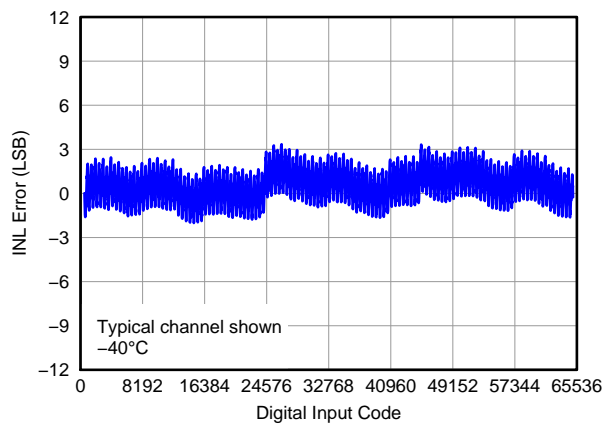


Figure 8. Linearity Error vs Digital Input Code (-40°C)

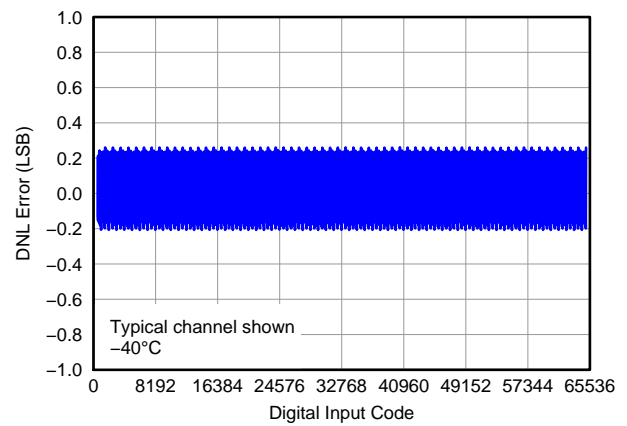


Figure 9. Differential Linearity Error vs Digital Input Code (-40°C)

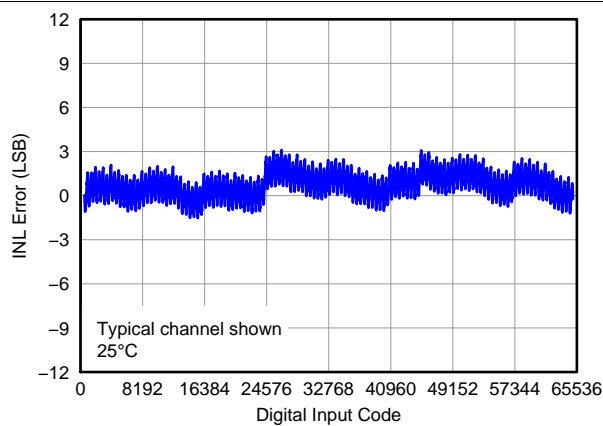


Figure 10. Linearity Error vs Digital Input Code (25°C)

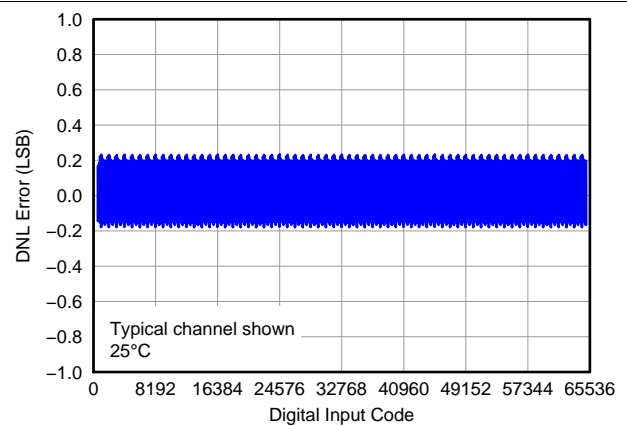


Figure 11. Differential Linearity Error vs Digital Input Code (25°C)

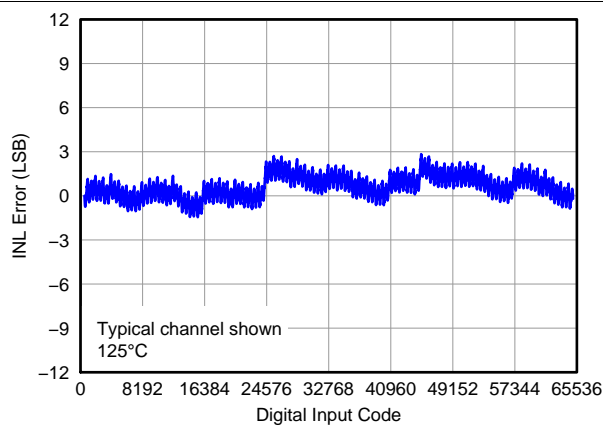


Figure 12. Linearity Error vs Digital Input Code (125°C)

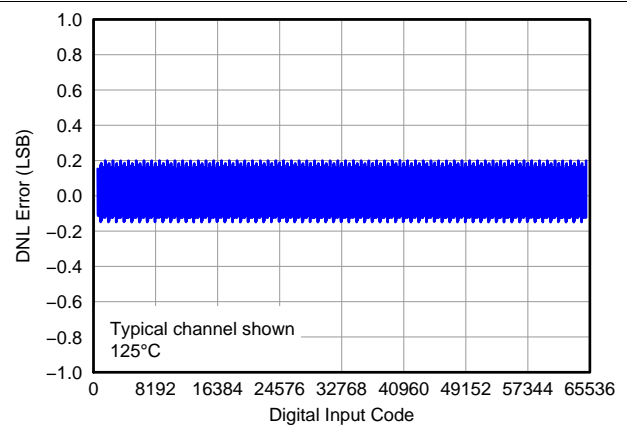


Figure 13. Differential Linearity Error vs Digital Input Code (125°C)

Typical Characteristics: DAC at AV_{DD} = 5.5 V (continued)

At T_A = 25°C, 5-V external reference used, gain = 1 and DAC output not loaded, unless otherwise noted.

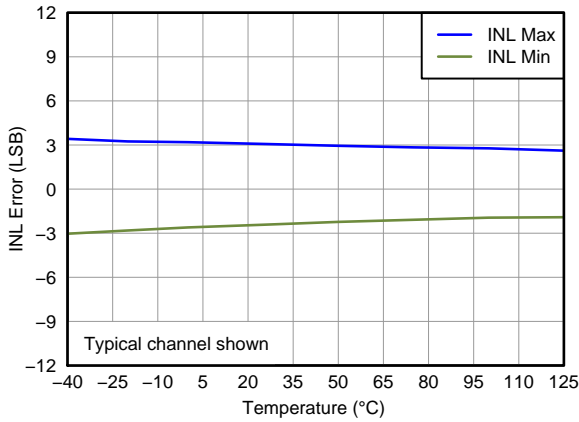


Figure 14. Linearity Error vs Temperature

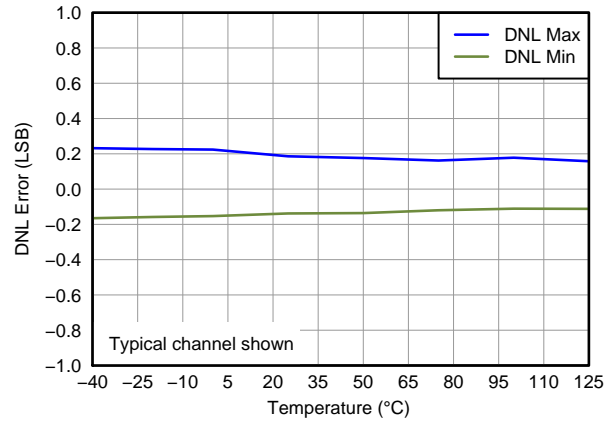


Figure 15. Differential Linearity Error vs Temperature

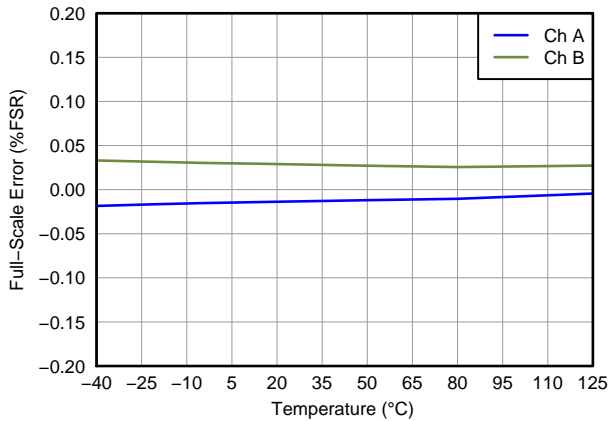


Figure 16. Full-Scale Error vs Temperature

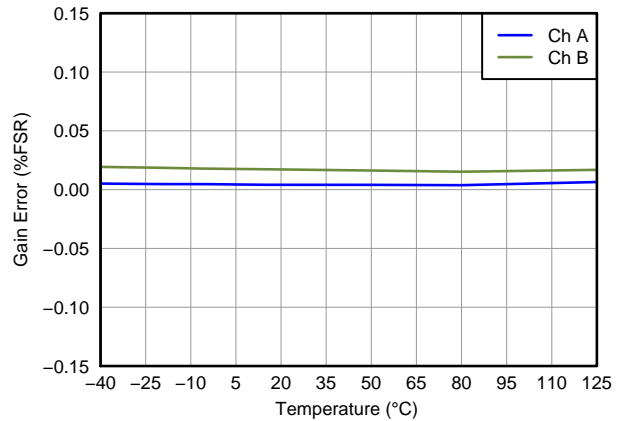


Figure 17. Gain Error vs Temperature

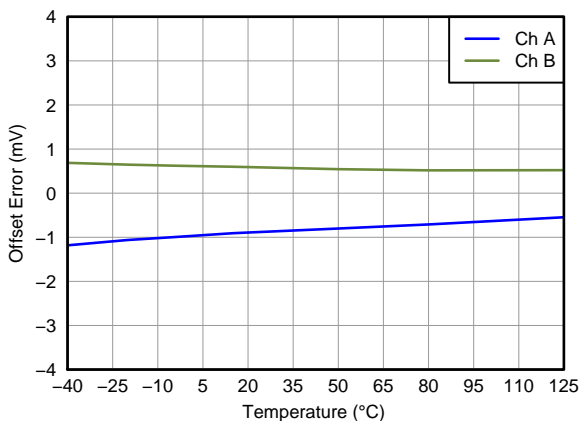


Figure 18. Offset Error vs Temperature

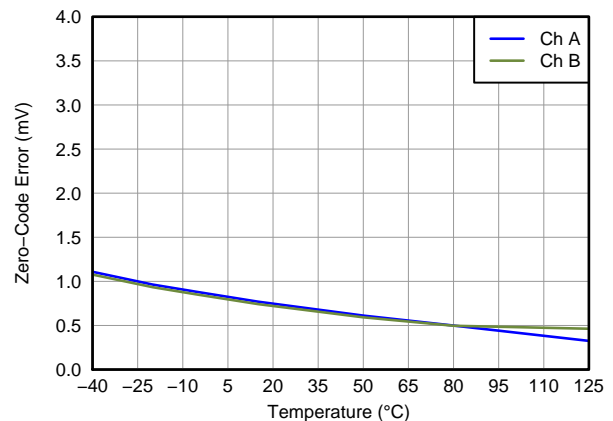


Figure 19. Zero-Code Error vs Temperature

Typical Characteristics: DAC at $V_{DD} = 5.5\text{ V}$ (continued)

At $T_A = 25^\circ\text{C}$, 5-V external reference used, gain = 1 and DAC output not loaded, unless otherwise noted.

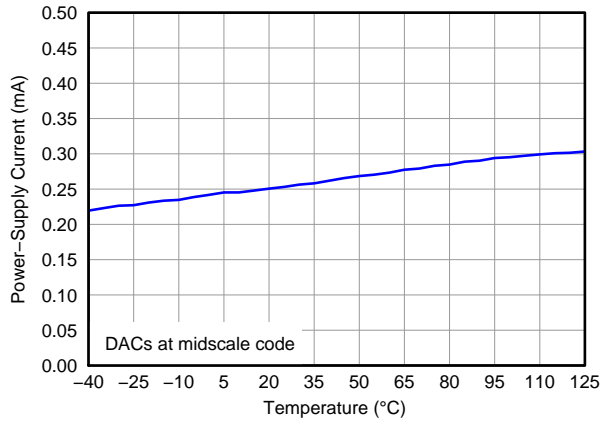


Figure 20. Power-Supply Current vs Temperature

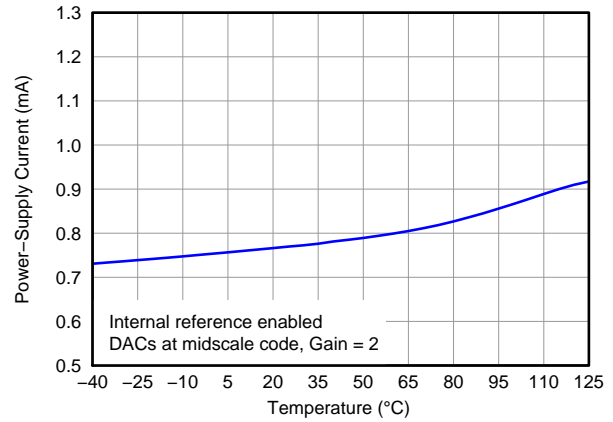


Figure 21. Power-Supply Current vs Temperature

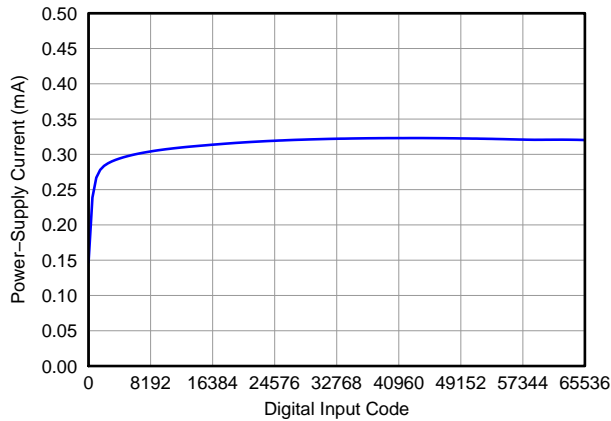


Figure 22. Power-Supply Current vs Digital Input Code

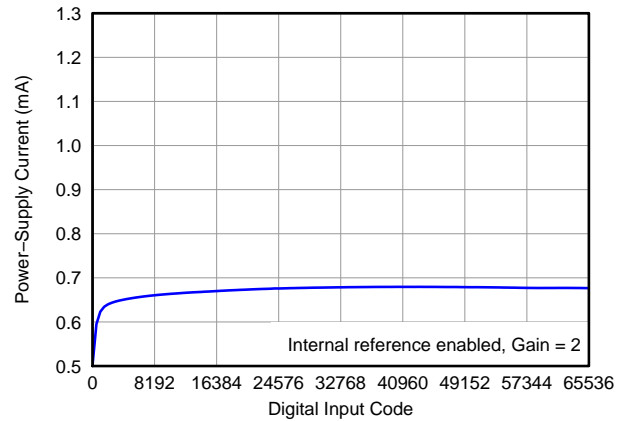


Figure 23. Power-Supply Current vs Digital Input Code

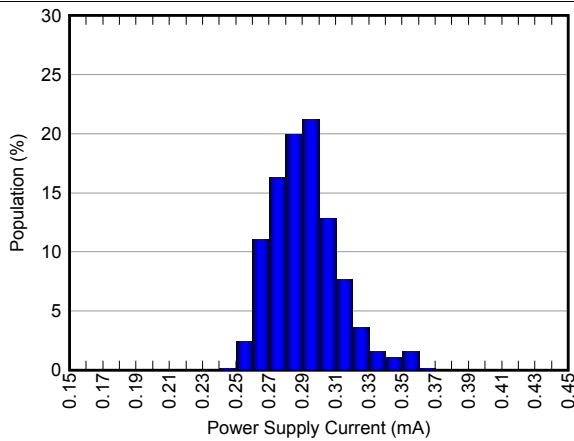


Figure 24. Power-Supply Current Histogram

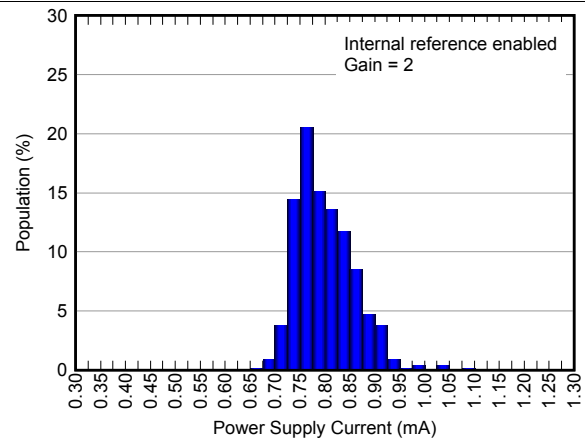


Figure 25. Power-Supply Current Histogram

Typical Characteristics: DAC at AV_{DD} = 5.5 V (continued)

At T_A = 25°C, 5-V external reference used, gain = 1 and DAC output not loaded, unless otherwise noted.

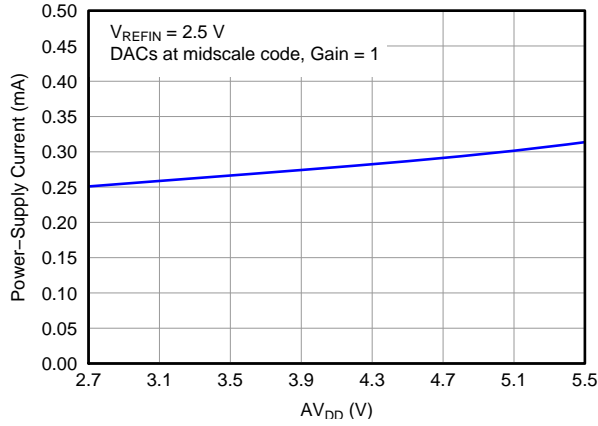


Figure 26. Power-Supply Current vs Power-Supply Voltage

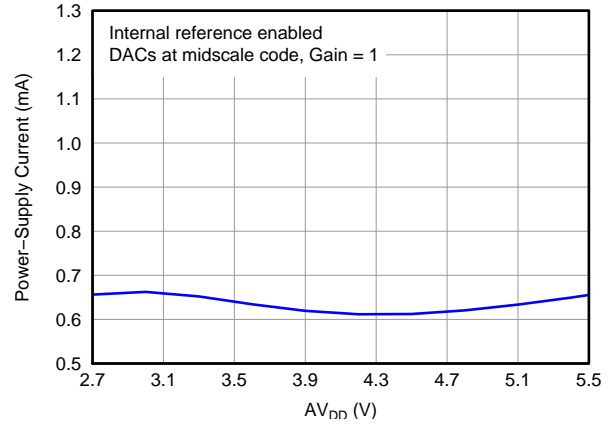


Figure 27. Power-Supply Current vs Power-Supply Voltage

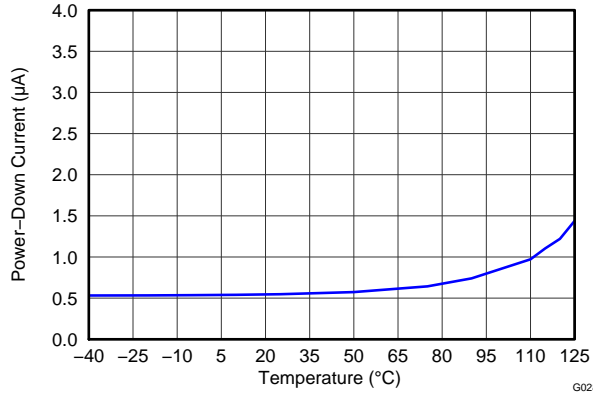


Figure 28. Power-Down Current vs Temperature

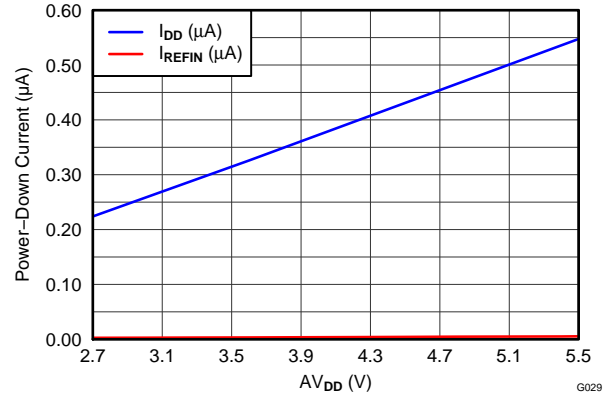


Figure 29. Power-Down Current vs Power-Supply Voltage

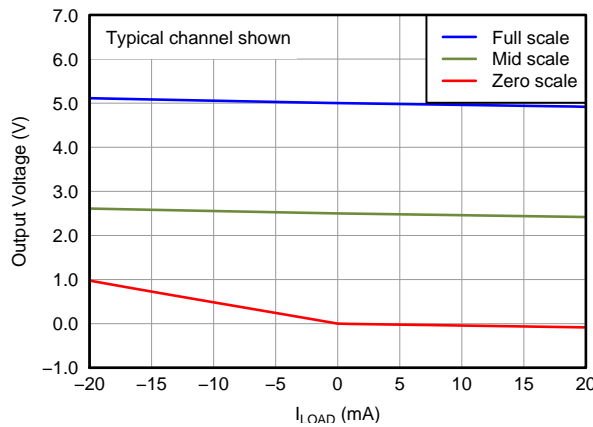


Figure 30. DAC Output Voltage vs Load Current

Typical Characteristics: DAC at $V_{DD} = 5.5\text{ V}$ (continued)

At $T_A = 25^\circ\text{C}$, 5-V external reference used, gain = 1 and DAC output not loaded, unless otherwise noted.

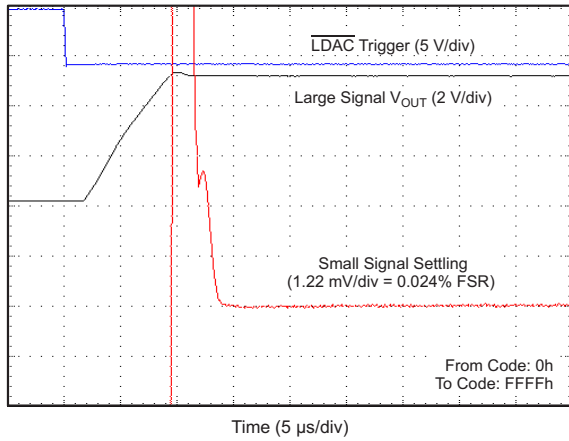


Figure 31. Full-Scale Settling Time, Rising Edge

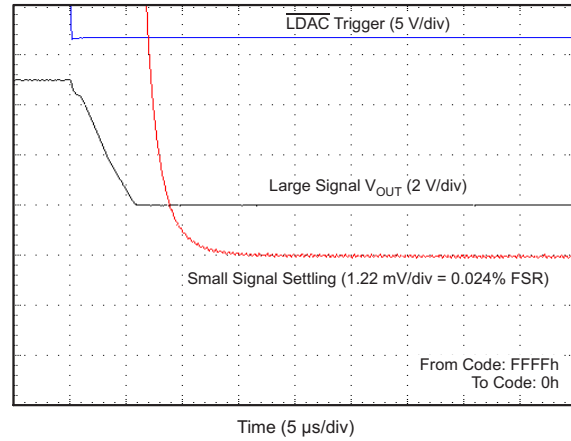


Figure 32. Full-Scale Settling Time, Falling Edge

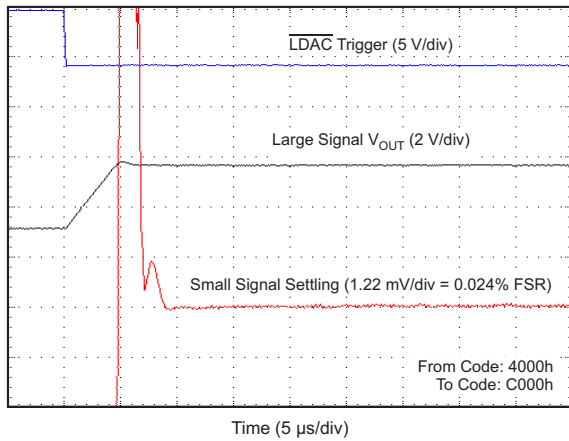


Figure 33. Half-Scale Settling Time, Rising Edge

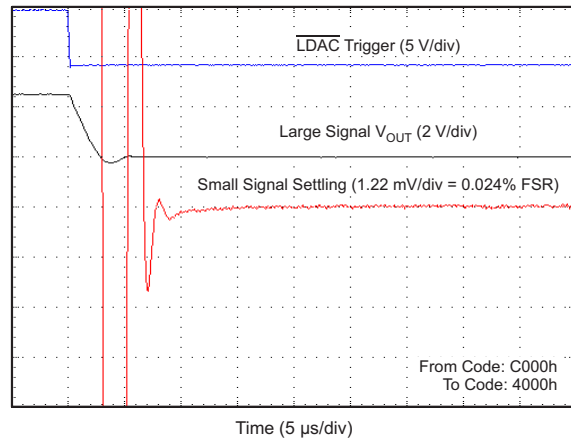


Figure 34. Half-Scale Settling Time, Falling Edge

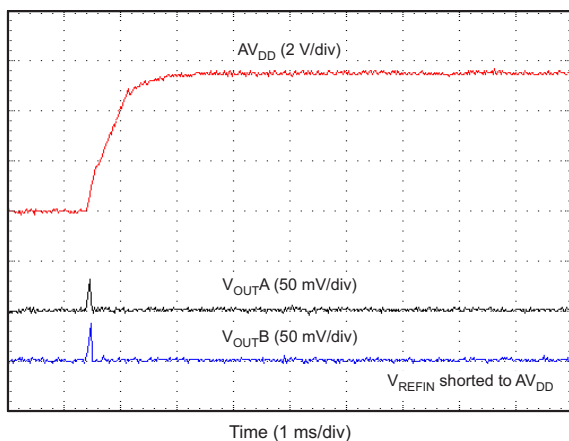


Figure 35. Power-On Glitch, Reset to Zero Scale

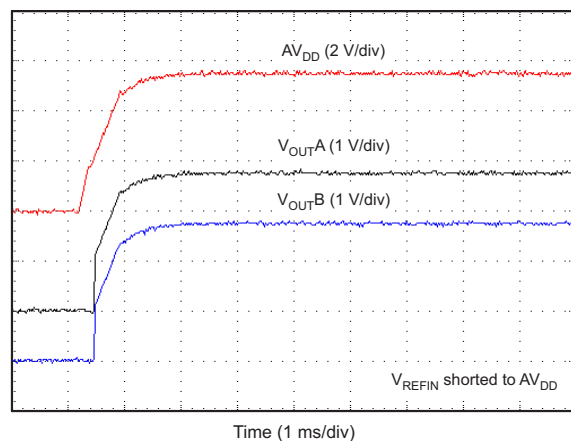


Figure 36. Power-On Glitch, Reset to Midscale

Typical Characteristics: DAC at $AV_{DD} = 5.5\text{ V}$ (continued)

At $T_A = 25^\circ\text{C}$, 5-V external reference used, gain = 1 and DAC output not loaded, unless otherwise noted.

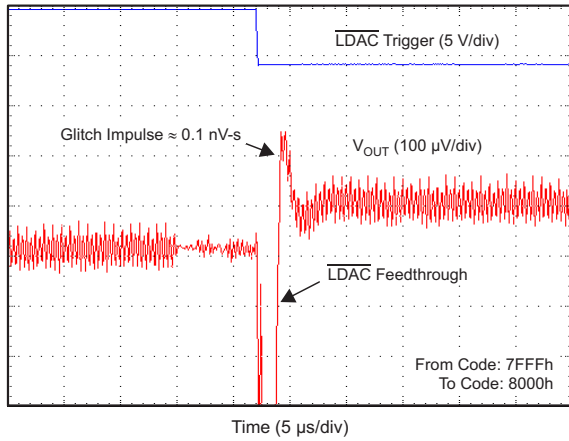


Figure 37. Glitch Impulse, Rising Edge, 1-LSB Step

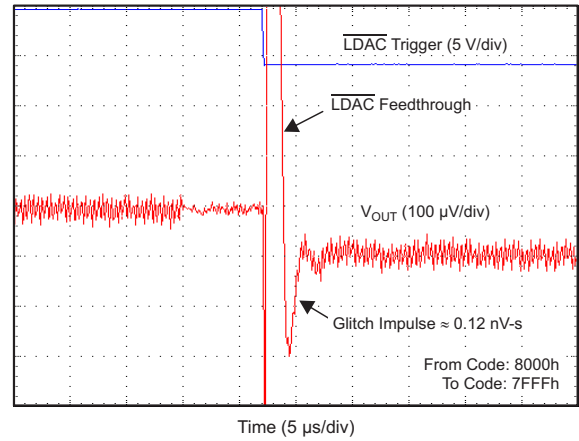


Figure 38. Glitch Impulse, Falling Edge, 1-LSB Step

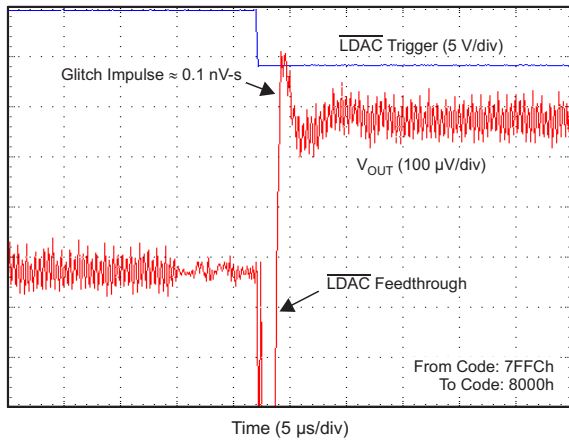


Figure 39. Glitch Impulse, Rising Edge, 4-LSB Step

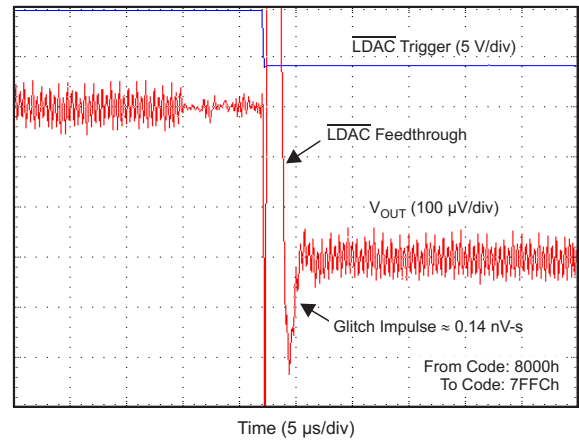


Figure 40. Glitch Impulse, Falling Edge, 4-LSB Step

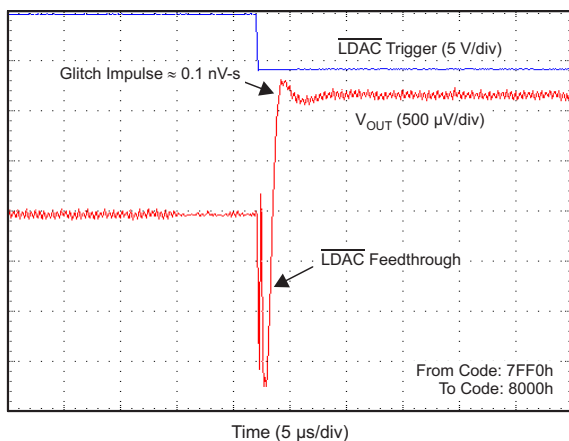


Figure 41. Glitch Impulse, Rising Edge, 16-LSB Step

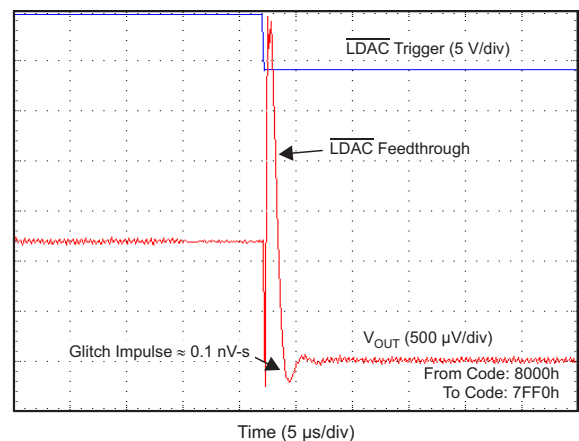


Figure 42. Glitch Impulse, Falling Edge, 16-LSB Step

Typical Characteristics: DAC at $V_{DD} = 5.5\text{ V}$ (continued)

At $T_A = 25^\circ\text{C}$, 5-V external reference used, gain = 1 and DAC output not loaded, unless otherwise noted.

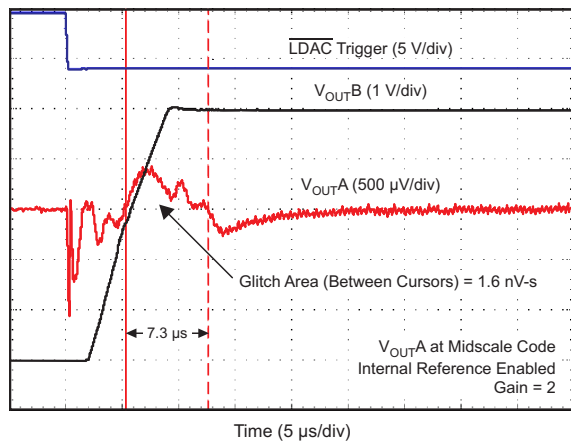


Figure 43. Channel-to-Channel Crosstalk, 5-V Rising Edge

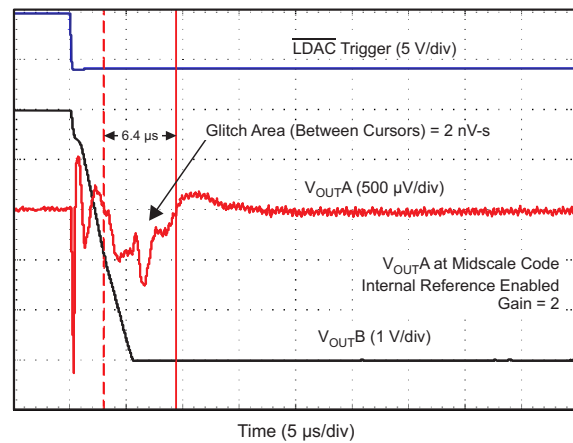


Figure 44. Channel-to-Channel Crosstalk, 5-V Falling Edge

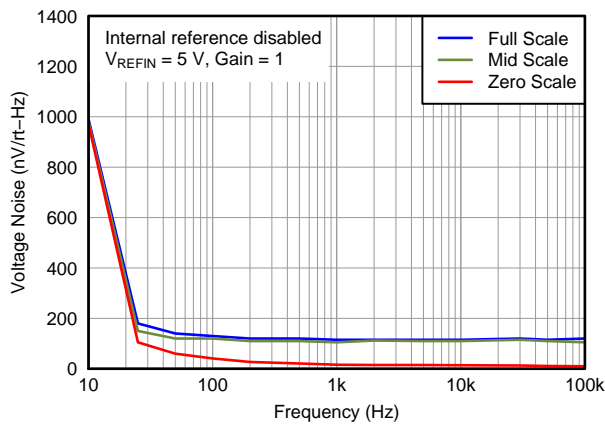


Figure 45. DAC Output Noise Density vs Frequency

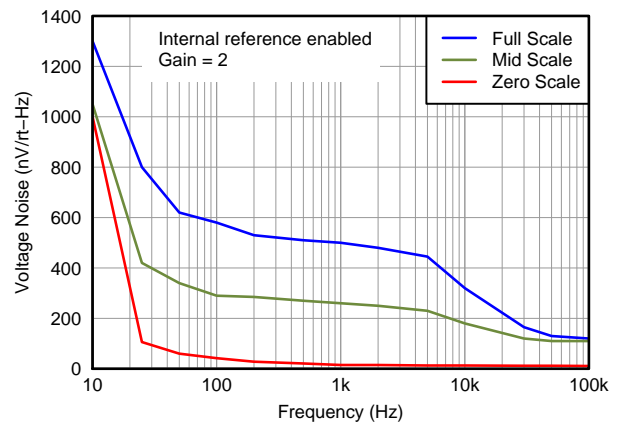


Figure 46. DAC Output Noise Density vs Frequency

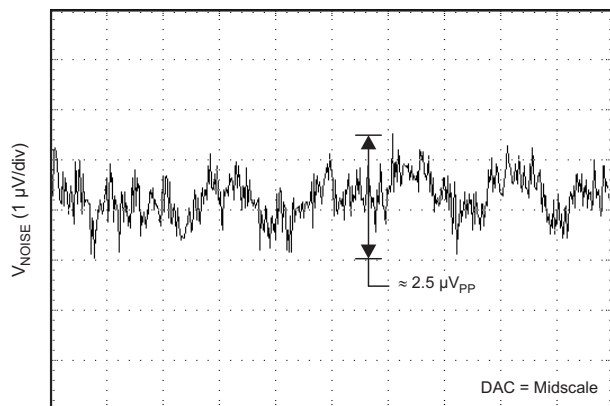


Figure 47. DAC Output Noise, 0.1 Hz to 10 Hz

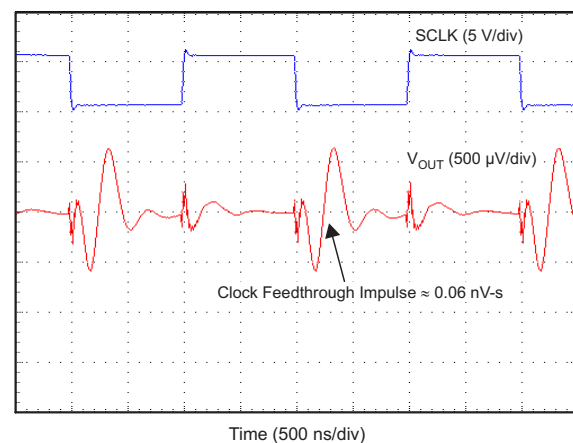


Figure 48. Clock Feedthrough, 500 kHz, Midscale

7.7.3 Typical Characteristics: DAC at $AV_{DD} = 3.6\text{ V}$

At $T_A = 25^\circ\text{C}$, 3.3-V external reference used, gain = 1 and DAC output not loaded, unless otherwise noted.

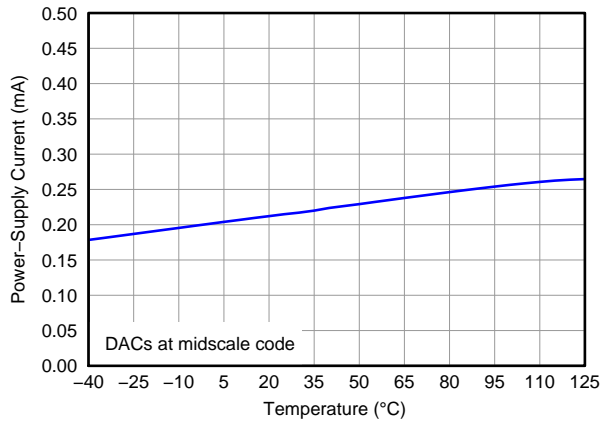


Figure 49. Power-Supply Current vs Temperature

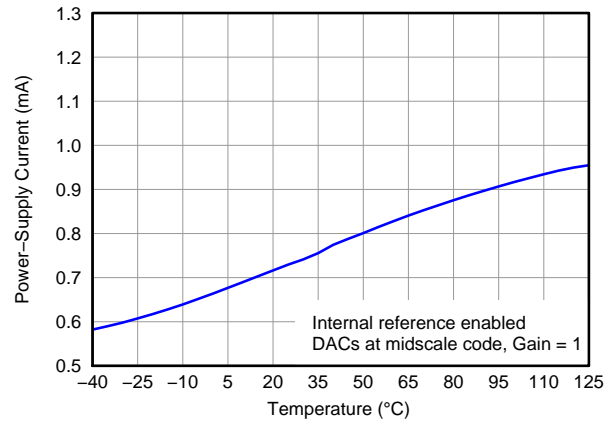


Figure 50. Power-Supply Current vs Temperature

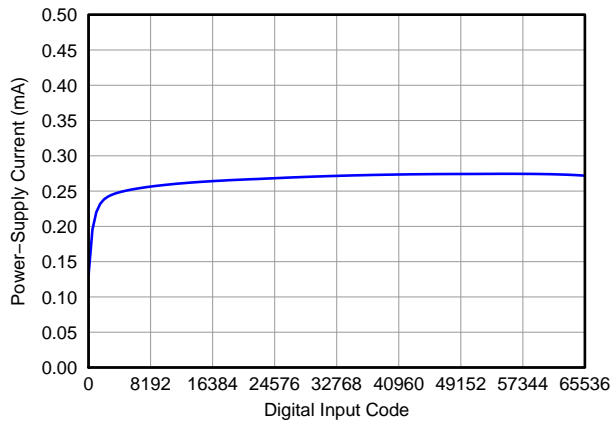


Figure 51. Power-Supply Current vs Digital Input Code

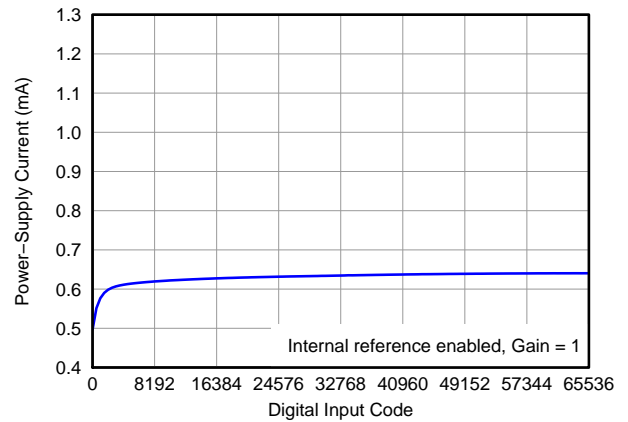


Figure 52. Power-Supply Current vs Digital Input Code

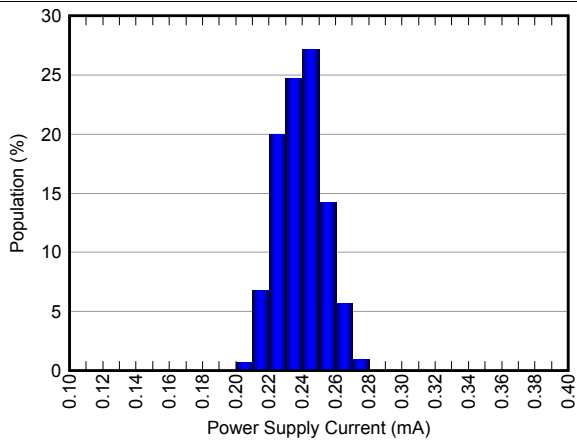


Figure 53. Power-Supply Current Histogram

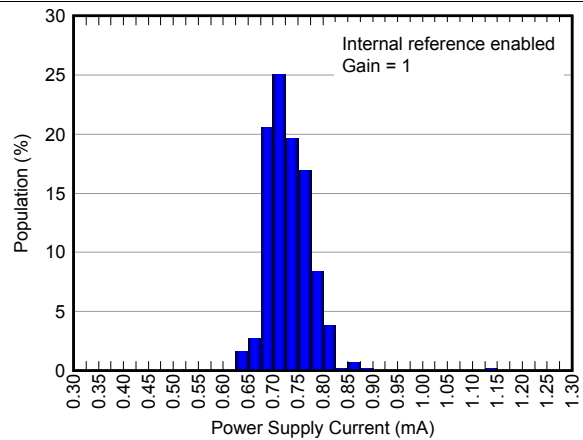


Figure 54. Power-Supply Current Histogram

7.7.4 Typical Characteristics: DAC at $AV_{DD} = 2.7\text{ V}$

At $T_A = 25^\circ\text{C}$, 2.5-V external reference used, gain = 1, and DAC output not loaded, unless otherwise noted.

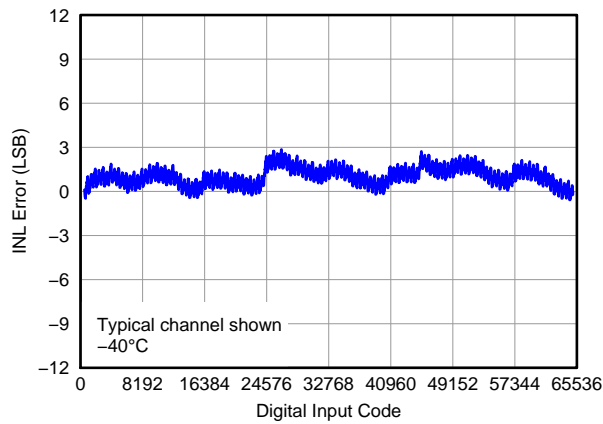


Figure 55. Linearity Error vs Digital Input Code (-40°C)

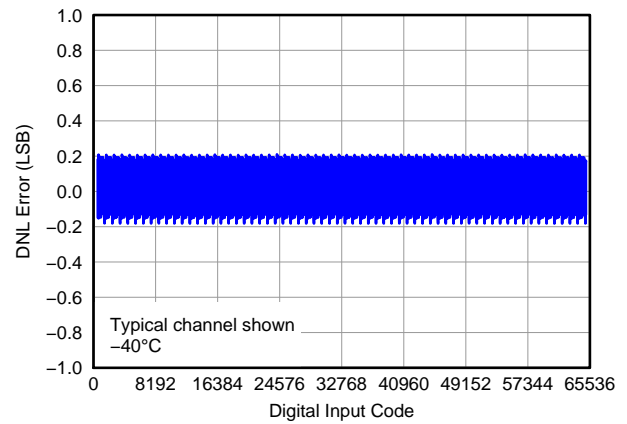


Figure 56. Differential Linearity Error vs Digital Input Code (-40°C)

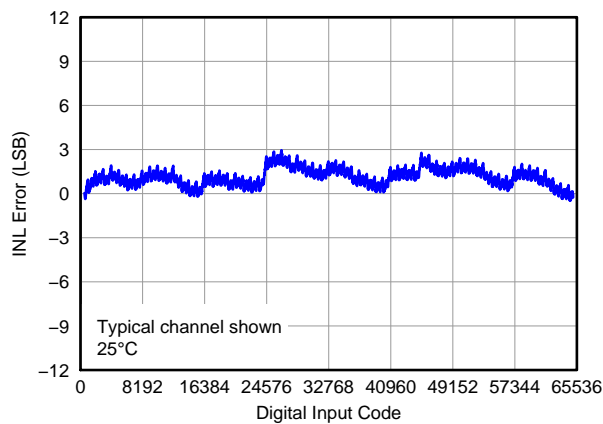


Figure 57. Linearity Error vs Digital Input Code (25°C)

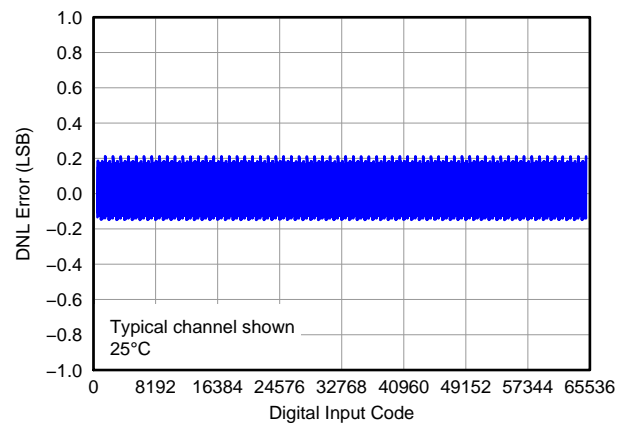


Figure 58. Differential Linearity Error vs Digital Input Code (25°C)

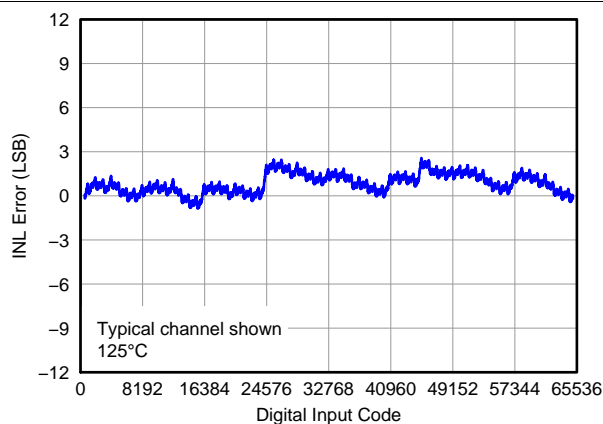


Figure 59. Linearity Error vs Digital Input Code (125°C)

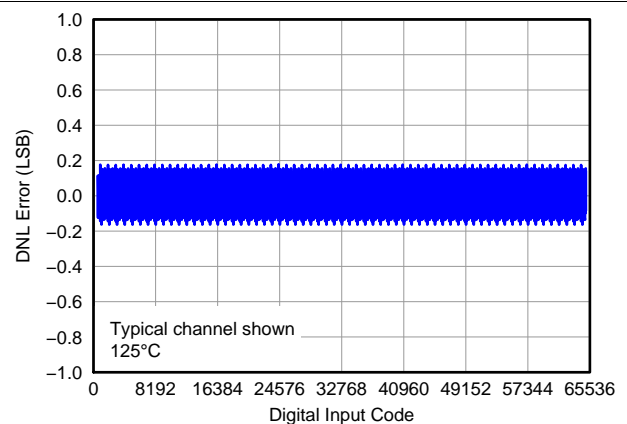
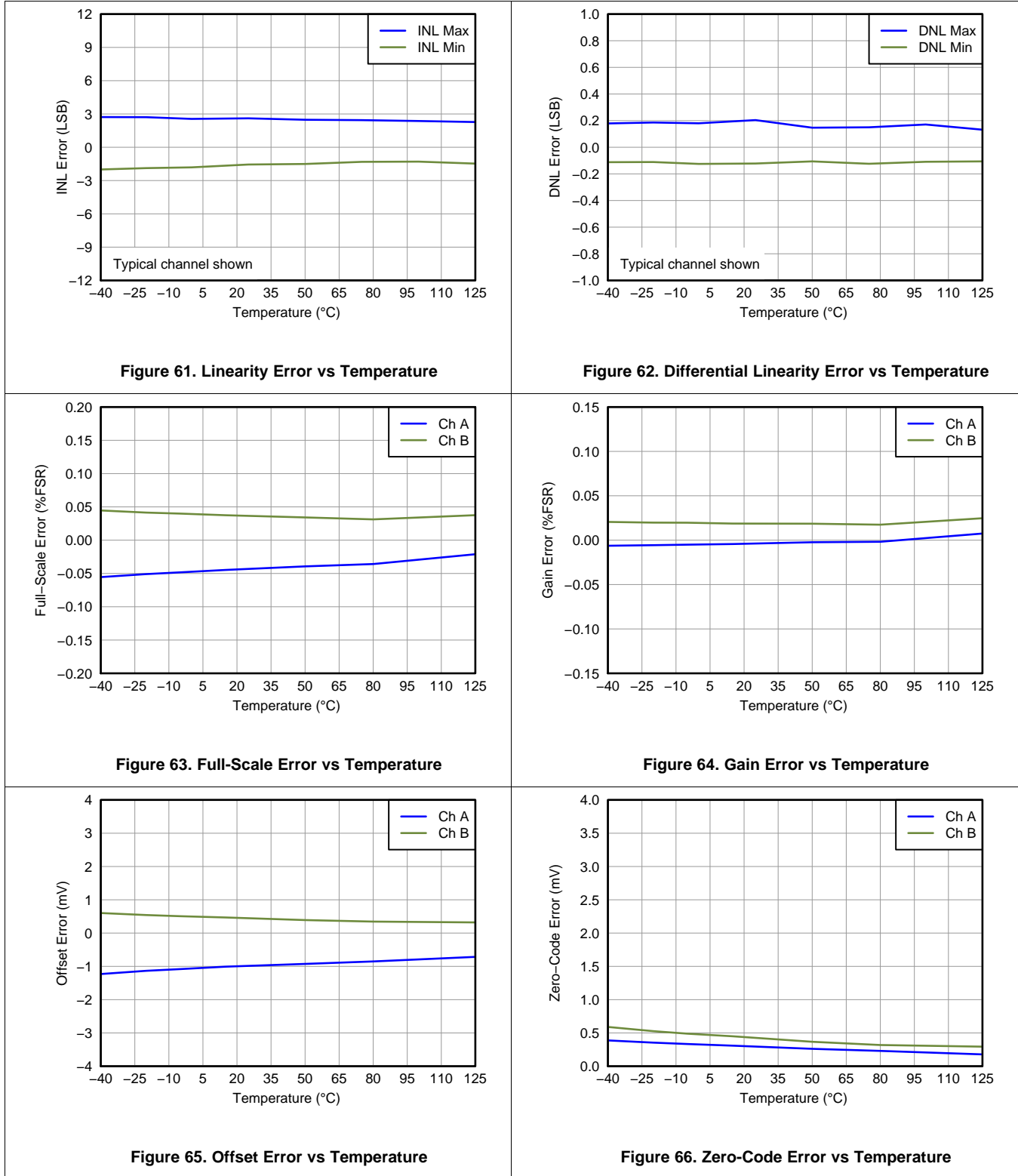


Figure 60. Differential Linearity Error vs Digital Input Code (125°C)

Typical Characteristics: DAC at $AV_{DD} = 2.7\text{ V}$ (continued)

At $T_A = 25^\circ\text{C}$, 2.5-V external reference used, gain = 1, and DAC output not loaded, unless otherwise noted.



Typical Characteristics: DAC at $V_{DD} = 2.7\text{ V}$ (continued)

At $T_A = 25^\circ\text{C}$, 2.5-V external reference used, gain = 1, and DAC output not loaded, unless otherwise noted.

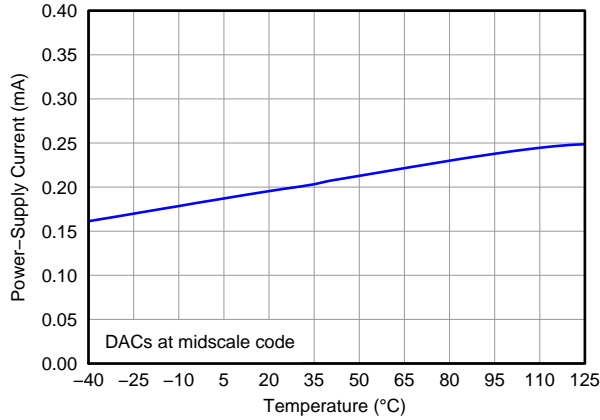


Figure 67. Power-Supply Current vs Temperature

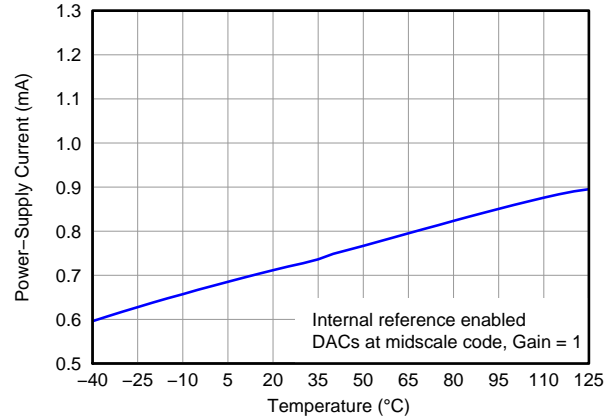


Figure 68. Power-Supply Current vs Temperature

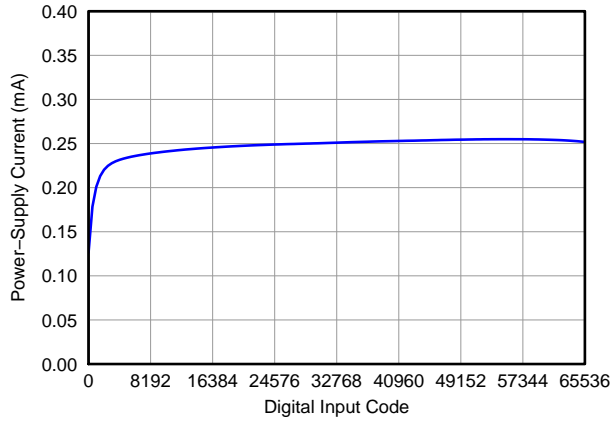


Figure 69. Power-Supply Current vs Digital Input Code

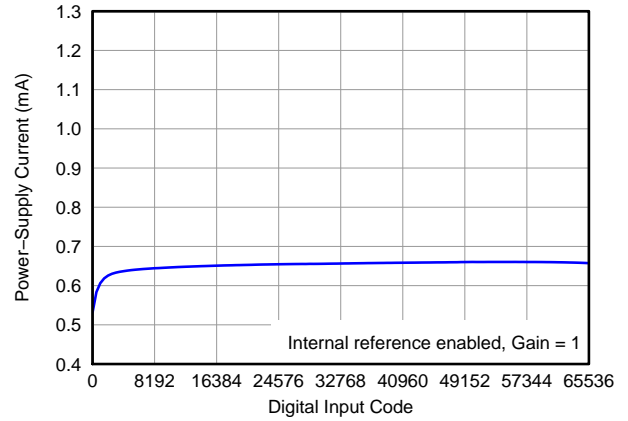


Figure 70. Power-Supply Current vs Digital Input Code

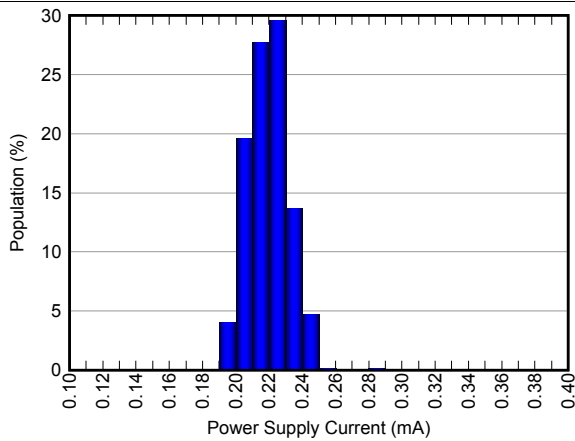


Figure 71. Power-Supply Current Histogram

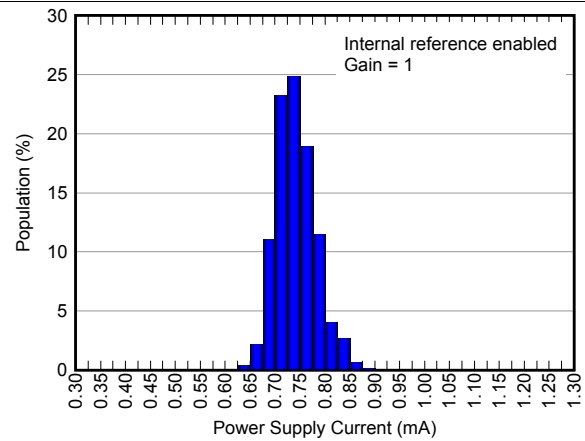


Figure 72. Power-Supply Current Histogram

Typical Characteristics: DAC at AV_{DD} = 2.7 V (continued)

At T_A = 25°C, 2.5-V external reference used, gain = 1, and DAC output not loaded, unless otherwise noted.

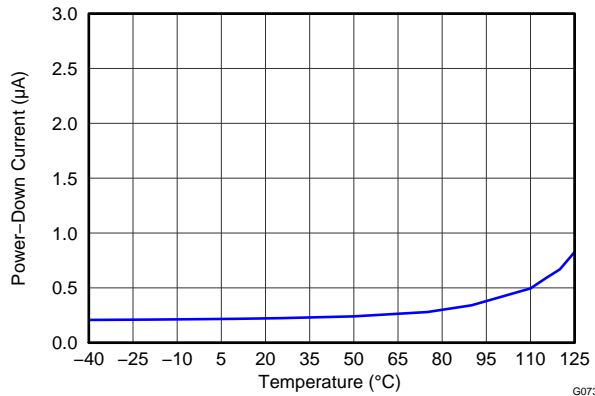


Figure 73. Power-Down Current vs Temperature

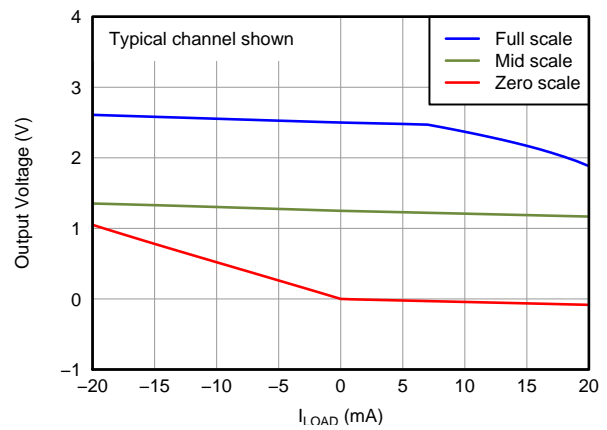


Figure 74. DAC Output Voltage vs Load Current

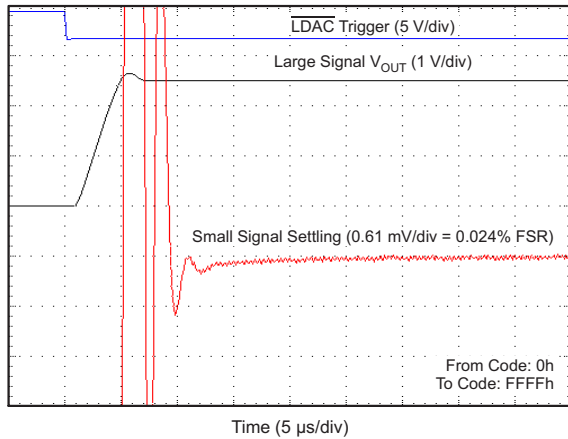


Figure 75. Full-Scale Settling Time, Rising Edge

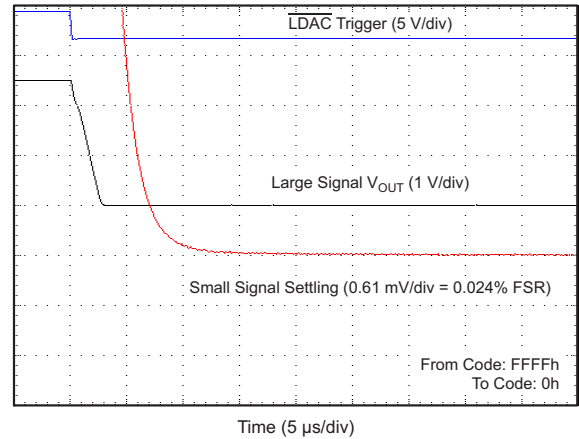


Figure 76. Full-Scale Settling Time, Falling Edge

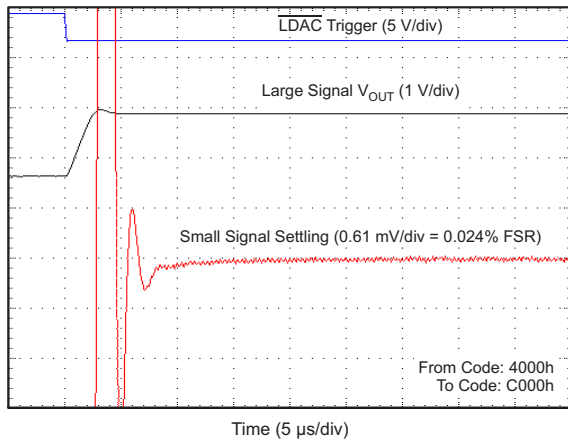


Figure 77. Half-Scale Settling Time, Rising Edge

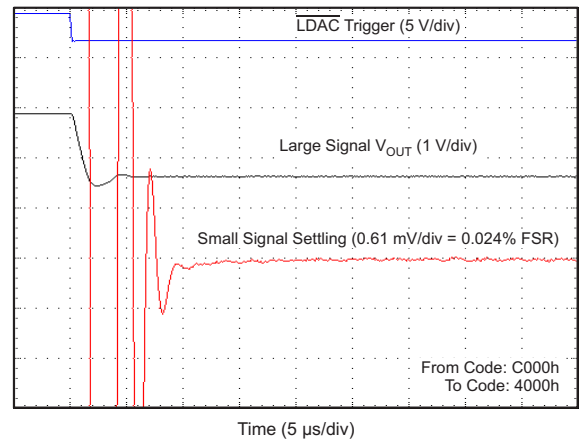


Figure 78. Half-Scale Settling Time, Falling Edge

Typical Characteristics: DAC at $V_{DD} = 2.7\text{ V}$ (continued)

At $T_A = 25^\circ\text{C}$, 2.5-V external reference used, gain = 1, and DAC output not loaded, unless otherwise noted.

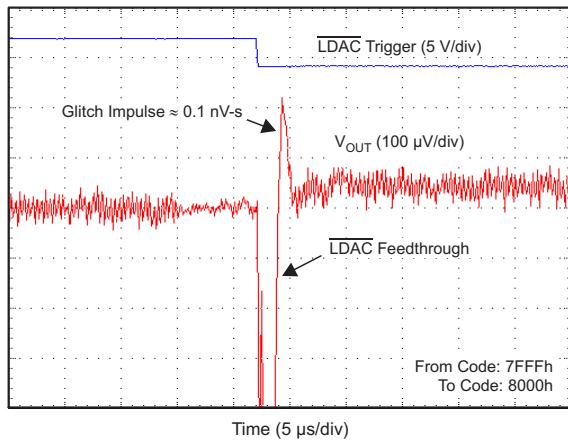


Figure 79. Glitch Impulse, Rising Edge, 1-LSB Step

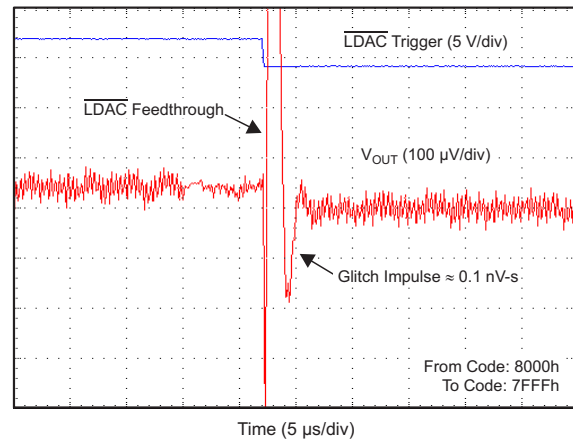


Figure 80. Glitch Impulse, Falling Edge, 1-LSB Step

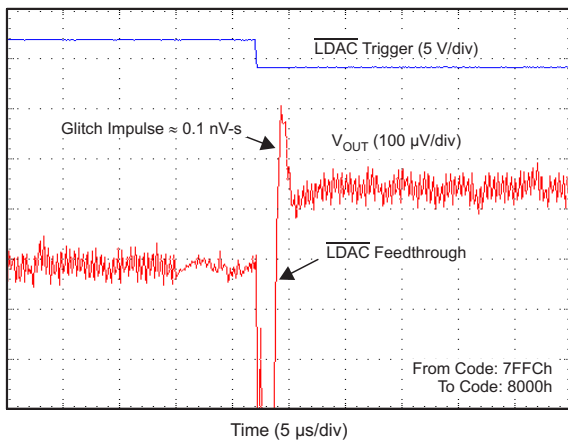


Figure 81. Glitch Impulse, Rising Edge, 4-LSB Step



Figure 82. Glitch Impulse, Falling Edge, 4-LSB Step

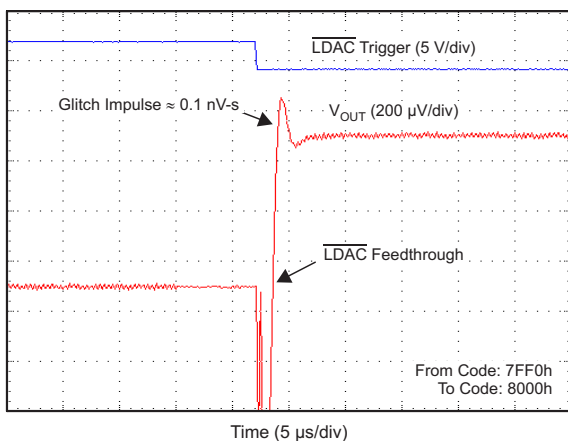


Figure 83. Glitch Impulse, Rising Edge, 16-LSB Step

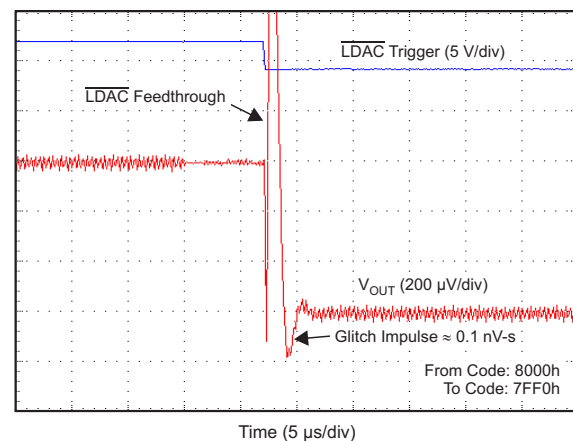


Figure 84. Glitch Impulse, Falling Edge, 16-LSB Step

Typical Characteristics: DAC at $AV_{DD} = 2.7\text{ V}$ (continued)

At $T_A = 25^\circ\text{C}$, 2.5-V external reference used, gain = 1, and DAC output not loaded, unless otherwise noted.

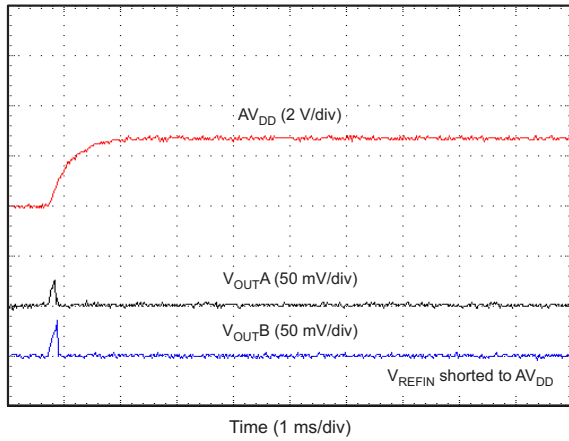


Figure 85. Power-On Glitch, Reset to Zero Scale

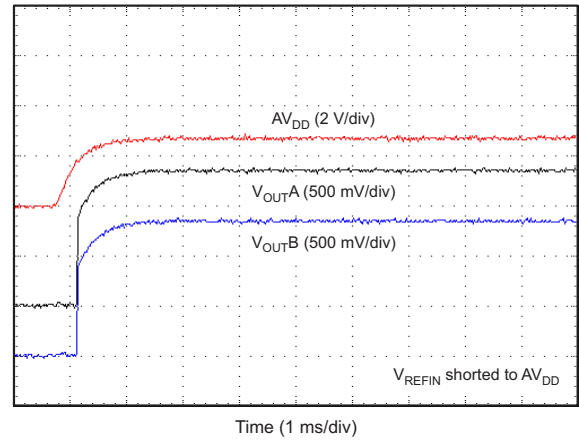


Figure 86. Power-On Glitch, Reset to Midscale

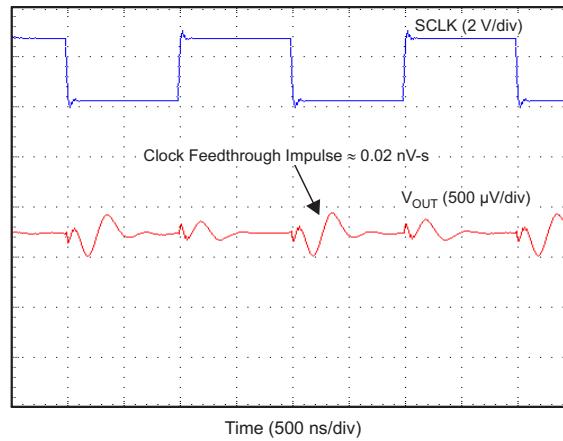


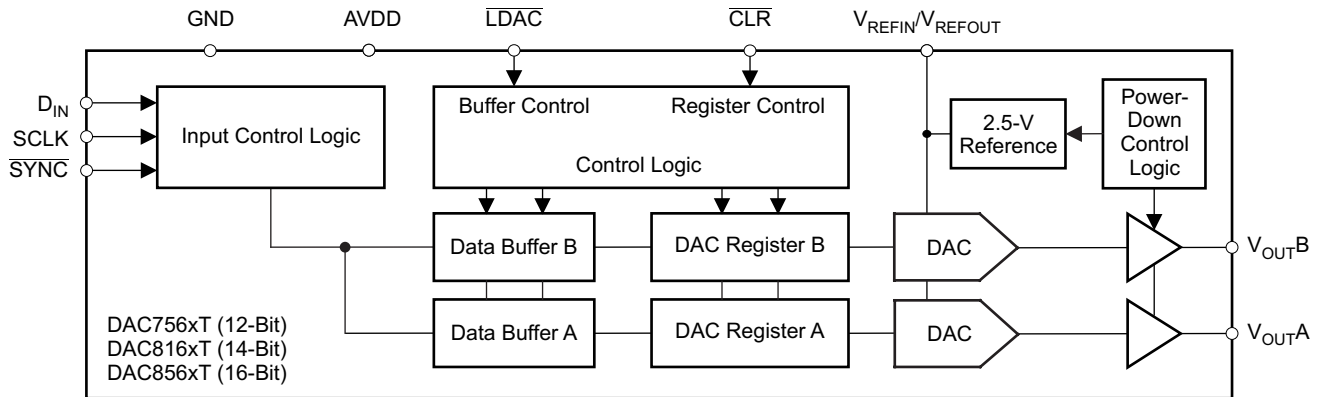
Figure 87. Clock Feedthrough, 500 kHz, Midscale

8 Detailed Description

8.1 Overview

The DAC756xT, DAC816xT, and DAC856xT devices are low-power, voltage-output, dual-channel, 16-, 14-, and 12-bit digital-to-analog converters (DACs), respectively. These devices include a 2.5-V, 4-ppm/°C internal reference, giving a full-scale output voltage range of 2.5 V or 5 V. The internal reference has an initial accuracy of ±5 mV and can source or sink up to 20 mA at the V_{REFIN}/V_{REFOUT} pin.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Digital-to-Analog Converter (DAC)

The DAC756xT, DAC816xT, and DAC856xT architecture consists of two string DACs, each followed by an output buffer amplifier. The devices include an internal 2.5-V reference with 4-ppm/°C temperature drift performance. Figure 88 shows a principal block diagram of the DAC architecture.

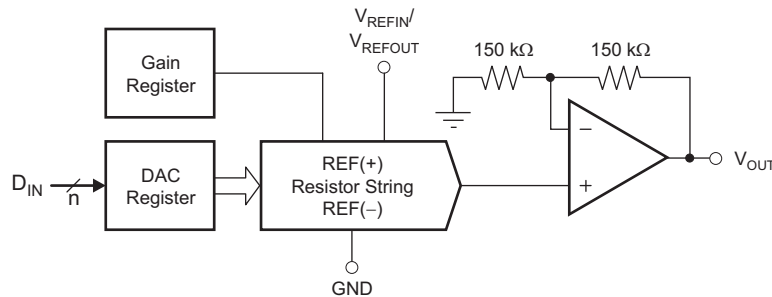


Figure 88. DAC Architecture

The input coding to the DAC756xT, DAC816xT, and DAC856xT devices is straight binary, so the ideal output voltage is given by Equation 1:

$$V_{OUT} = \left(\frac{D_{IN}}{2^n} \right) \times V_{REF} \times \text{Gain} \quad (1)$$

where:

n = resolution in bits; either 12 (DAC756xT), 14 (DAC816xT) or 16 (DAC856xT)

D_{IN} = decimal equivalent of the binary code that is loaded to the DAC register. D_{IN} ranges from 0 to $2^n - 1$.
 V_{REF} = DAC reference voltage; either V_{REFOUT} from the internal 2.5-V reference or V_{REFIN} from an external reference.

Gain = 1 by default when internal reference is disabled (using external reference), and gain = 2 by default when using internal reference. Gain can also be manually set to either 1 or 2 using the gain register. See the [Gain Function](#) section for more information.

Feature Description (continued)

8.3.1.1 Resistor String

The resistor string section is shown in [Figure 89](#). It is simply a string of resistors, each of value R . The code loaded into the DAC register determines at which node on the string the voltage is tapped off to be fed into the output amplifier by closing one of the switches connecting the string to the amplifier. The resistor string architecture results in monotonicity. The R_{DIVIDER} switch is controlled by the gain registers (see the [Gain Function](#) section). Because the output amplifier has a gain of 2, R_{DIVIDER} is not shorted when the DAC-n gain is set to 1 (default if internal reference is disabled), and is shorted when the DAC-n gain is set to 2 (default if internal reference is enabled).

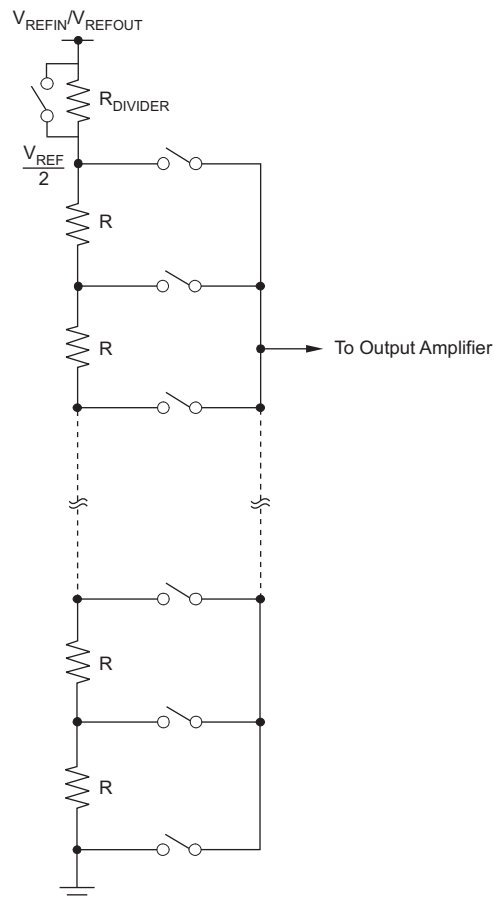


Figure 89. Resistor String

8.3.1.2 Output Amplifier

The output buffer amplifier is capable of generating rail-to-rail voltages on its output, giving a maximum output range of 0 V to AV_{DD} . It is capable of driving a load of 2 k Ω in parallel with 3 nF to GND. The typical slew rate is 0.75 V/ μs , with a typical full-scale settling time of 14 μs as shown in [Figure 31](#), [Figure 32](#), [Figure 75](#) and [Figure 76](#).

Feature Description (continued)

8.3.2 Internal Reference

The DAC756xT, DAC816xT, and DAC856xT devices include a 2.5-V internal reference that is disabled by default. The internal reference is externally available at the V_{REFIN}/V_{REFOUT} pin. The internal reference output voltage is 2.5 V and can sink and source up to 20 mA.

A minimum 150-nF capacitor is recommended between the reference output and GND for noise filtering.

The internal reference of the DAC756xT, DAC816xT, and DAC856xT devices is a bipolar transistor-based precision band-gap voltage reference. Figure 90 shows the basic band-gap topology. Transistors Q_1 and Q_2 are biased such that the current density of Q_1 is greater than that of Q_2 . The difference of the two base-emitter voltages ($V_{BE1} - V_{BE2}$) has a positive temperature coefficient and is forced across resistor R_1 . This voltage is amplified and added to the base-emitter voltage of Q_2 , which has a negative temperature coefficient. The resulting output voltage is virtually independent of temperature. The short-circuit current is limited by design to approximately 100 mA.

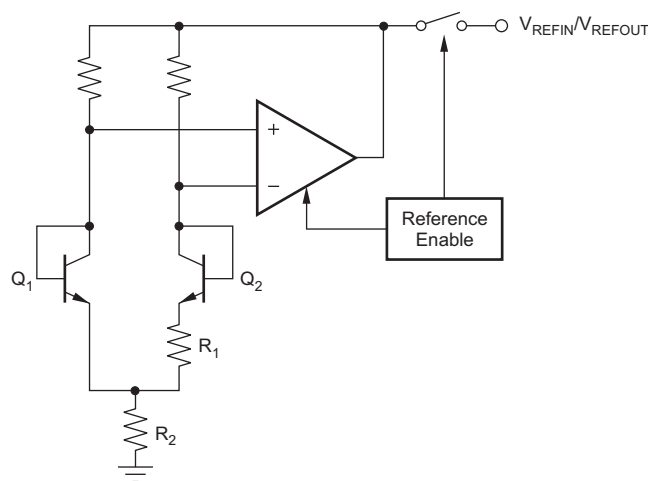


Figure 90. Band-Gap Reference Simplified Schematic

8.3.3 Power-On Reset

8.3.3.1 Power-On Reset to Zero-Scale

The DAC7562T, DAC8162T, and DAC8562T devices contain a power-on-reset circuit that controls the output voltage during power up. All device registers are reset as shown in Table 4. At power up, all DAC registers are filled with zeros and the output voltages of all DAC channels are set to zero volts. Each DAC channel remains that way until a valid load command is written to it. The power-on reset is useful in applications where it is important to know the state of the output of each DAC while the device is in the process of powering up. No device pin should be brought high before applying power to the device. The internal reference is disabled by default and remains that way until a valid reference-change command is executed.

8.3.3.2 Power-On Reset to Mid-Scale

The DAC7563T, DAC8163T, and DAC8563T devices contain a power-on reset circuit that controls the output voltage during power up. At power up, all DAC registers are reset to mid-scale code and the output voltages of all DAC channels are set to $V_{REFIN} / 2$ volts. Each DAC channel remains that way until a valid load command is written to it. The power-on reset is useful in applications where it is important to know the state of the output of each DAC while the device is in the process of powering up. No device pin should be brought high before applying power to the device. The internal reference is powered off or down by default and remains that way until a valid reference-change command is executed. If using an external reference, it is acceptable to power on the V_{REFIN} pin either at the same time as or after applying AV_{DD} .

Table 4. DACxx62T and DACxx63T Power-On Reset Values

| REGISTER | DEFAULT SETTING | |
|-----------------------------|------------------------------------|------------|
| DAC and input registers | DACxx62T | Zero-scale |
| | DACxx63T | Mid-scale |
| LDAC registers | LDAC pin enabled for both channels | |
| Power-down registers | DACs powered up | |
| Internal reference register | Internal reference disabled | |
| Gain registers | Gain = 1 for both channels | |

8.3.3.3 Power-On Reset (POR) Levels

When the device powers up, a POR circuit sets the device in default mode as shown in Table 4. The POR circuit requires specific AV_{DD} levels, as indicated in Figure 91, to ensure discharging of internal capacitors and to reset the device on power up. In order to ensure a power-on reset, AV_{DD} must be below 0.7 V for at least 1 ms. When AV_{DD} drops below 2.2 V but remains above 0.7 V (shown as the undefined region), the device may or may not reset under all specified temperature and power-supply conditions. In this case, TI recommends a power-on reset. When AV_{DD} remains above 2.2 V, a power-on reset does not occur.

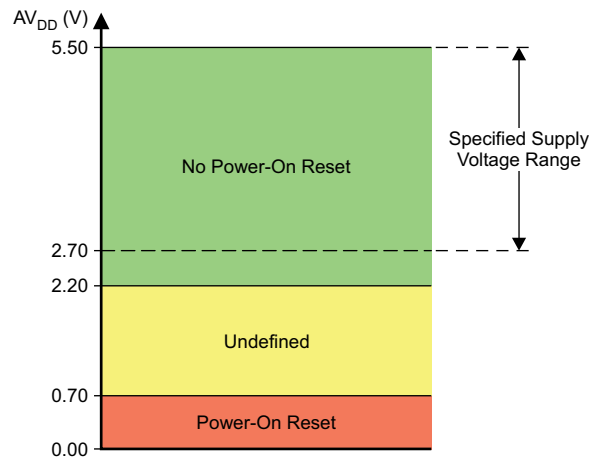


Figure 91. Relevant Voltage Levels for POR Circuit

8.4 Device Functional Modes

8.4.1 Power-Down Modes

The DAC756xT, DAC816xT, and DAC856xT devices have two separate sets of power-down commands. One set is for the DAC channels and the other set is for the internal reference. The internal reference is forced to a powered-down state while both DAC channels are powered down, and is only enabled if any DAC channel is also in the normal mode of operation. For more information on the internal reference control, see the [Internal Reference Enable Register](#) section.

8.4.1.1 DAC Power-Down Commands

The DAC756xT, DAC816xT, and DAC856xT DACs use four modes of operation. These modes are accessed by setting the serial interface command bits to 100. Once the command bits are set correctly, the four different power-down modes are software programmable by setting bits DB5 and DB4 in the shift register. [Table 5](#) and [Table 6](#) show the different power-down options. For more information on how to set the DAC operating mode see [Table 17](#).

Table 5. DAC-n Operating Modes

| DB5 | DB4 | DAC Modes of Operation |
|-----|-----|--|
| 0 | 0 | Selected DACs power up (normal mode, default) |
| 0 | 1 | Selected DACs power down, output 1 kΩ to GND |
| 1 | 0 | Selected DACs power down, output 100 kΩ to GND |
| 1 | 1 | Selected DACs power down, output Hi-Z to GND |

Table 6. DAC-n Selection for Operating Modes

| DAC-B (DB1), DAC-A (DB0) | Operating Mode |
|--------------------------|--|
| 0 | DAC-n does not change operating mode |
| 1 | DAC-n operating mode set to value on PD1 and PD0 |

It is possible to write to the DAC register or buffer of the DAC channel that is powered down. When the DAC channel is then powered up, it powers up to this new value.

The advantage of the available power-down modes is that the output impedance of the device is known while it is in power-down mode. As described in [Table 5](#), there are three different power-down options. V_{OUT} can be connected internally to GND through a 1-kΩ resistor, a 100-kΩ resistor, or open-circuited (Hi-Z). The DAC power-down circuitry is shown in [Figure 92](#).

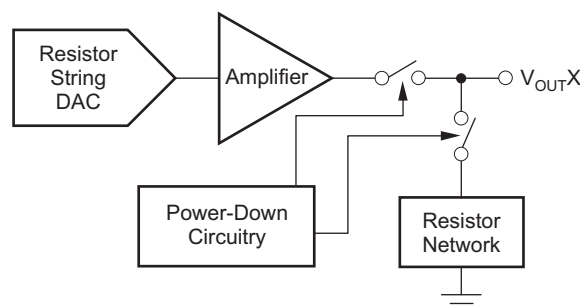


Figure 92. Output Stage

8.4.2 Gain Function

The gain register controls the GAIN setting in the DAC transfer function:

$$V_{OUT} = \left(\frac{D_{IN}}{2^n} \right) \times V_{REF} \times \text{Gain} \quad (2)$$

The DAC756xT, DAC816xT, and DAC856xT devices have a gain register for each channel. The gain for each channel, in [Equation 2](#), is either 1 or 2. This gain is automatically set to 2 when using the internal reference, and is automatically set to 1 when the internal reference is disabled (default). However, each channel can have either gain by setting the registers appropriately. The gain registers are accessible by setting the serial interface command bits to 000, address bits to 010, and using DB1 for DAC-B and DB0 for DAC-A. See [Table 7](#) and [Table 17](#) for the full command structure. The gain registers are automatically reset to provide either gain of 1 or 2 when the internal reference is powered off or on, respectively. After the reference is powered off or on, the gain register is again accessible to change the gain.

Table 7. DAC-n Selection for Gain Register Command

| DB1, DB0 | Value | Gain |
|----------|-------|---|
| DB0 | 0 | DAC-A uses gain = 2 (default with internal reference) |
| | 1 | DAC-A uses gain = 1 (default with external reference) |
| DB1 | 0 | DAC-B uses gain = 2 (default with internal reference) |
| | 1 | DAC-B uses gain = 1 (default with external reference) |

8.4.3 Software Reset Function

The DAC756xT, DAC816xT, and DAC856xT devices contain a software reset feature. The software reset function is accessed by setting the serial interface command bits to 101. The software reset command contains two reset modes which are software-programmable by setting bit DB0 in the shift register. [Table 8](#) and [Table 17](#) show the available software reset commands.

Table 8. Software Reset

| DB0 | Registers Reset to Default Values |
|-----|---|
| 0 | DAC registers Input registers |
| 1 | DAC registers Input registers LDAC registers Power-down registers Internal reference register Gain registers |

8.4.4 Internal Reference Enable Register

The internal reference in the DAC756xT, DAC816xT, and DAC856xT devices is disabled by default for debugging, evaluation purposes, or when using an external reference. The internal reference can be powered up and powered down by setting the serial interface command bits to 111 and configuring DB0 (see [Table 9](#)). The internal reference is forced to a powered down state while both DAC channels are powered down, and can only be enabled if any DAC channel is in normal mode of operation. During the time that the internal reference is disabled, the DAC functions normally using an external reference. At this point, the internal reference is disconnected from the V_{REFIN}/V_{REFOUT} pin (Hi-Z output).

Table 9. Internal Reference

| DB0 | Internal Reference Configuration |
|-----|---|
| 0 | Disable internal reference and reset DACs to gain = 1 |
| 1 | Enable internal reference and reset DACs to gain = 2 |

8.4.4.1 Enabling Internal Reference

To enable the internal reference, refer to the command structure in [Table 17](#). When performing a power cycle to reset the device, the internal reference is switched off (default mode). In the default mode, the internal reference is powered down until a valid write sequence powers up the internal reference. However, the internal reference is forced to a disabled state while both DAC channels are powered down, and remains disabled until either DAC channel is returned to the normal mode of operation. See [DAC Power-Down Commands](#) for more information on DAC channel modes of operation.

8.4.4.2 Disabling Internal Reference

To disable the internal reference, refer to the command structure in [Table 17](#). When performing a power cycle to reset the device, the internal reference is disabled (default mode).

8.4.5 CLR Functionality

The edge-triggered \overline{CLR} pin can be used to set the input and DAC registers immediately according to [Table 10](#). When the \overline{CLR} pin receives a falling edge signal the clear mode is activated and changes the DAC output voltages accordingly. The device exits clear mode on the 24th falling edge of the next write to the device. If the \overline{CLR} pin receives a falling edge signal during a write sequence in normal operation, the clear mode is activated and changes the input and DAC registers immediately according to [Table 10](#).

Table 10. Clear Mode Reset Values

| DEVICE | DAC Output Entering Clear Mode |
|------------------------------|--------------------------------|
| DAC8562T, DAC8162T, DAC7562T | Zero-scale |
| DAC8563T, DAC8163T, DAC7563T | Mid-scale |

8.4.6 LDAC Functionality

The DAC756xT, DAC816xT, and DAC856xT devices offer both a software and hardware simultaneous update and control function. The DAC double-buffered architecture has been designed so that new data can be entered for each DAC without disturbing the analog outputs.

DAC756xT, DAC816xT, and DAC856xT data updates can be performed either in *synchronous* or in *asynchronous* mode.

In *asynchronous* mode, the $\overline{\text{LDAC}}$ pin is used as a negative edge-triggered timing signal for simultaneous DAC updates. Multiple single-channel writes can be done in order to set different channel buffers to desired values and then make a falling edge on $\overline{\text{LDAC}}$ pin to simultaneously update the DAC output registers. Data buffers of all channels must be loaded with desired data before an $\overline{\text{LDAC}}$ falling edge. After a high-to-low $\overline{\text{LDAC}}$ transition, all DACs are simultaneously updated with the last contents of the corresponding data buffers. If the content of a data buffer is not changed, the corresponding DAC output remains unchanged after the $\overline{\text{LDAC}}$ pin is triggered. $\overline{\text{LDAC}}$ must be returned high before the next serial command is initiated.

In *synchronous* mode, data are updated with the falling edge of the 24th SCLK cycle, which follows a falling edge of SYNC. For such *synchronous* updates, the $\overline{\text{LDAC}}$ pin is not required, and it must be connected to GND permanently or asserted and held low before sending commands to the device.

Alternatively, all DAC outputs can be updated simultaneously using the built-in software function of LDAC. The LDAC register offers additional flexibility and control by allowing the selection of which DAC channel(s) should be updated simultaneously when the $\overline{\text{LDAC}}$ pin is being brought low. The LDAC register is loaded with a 2-bit word (DB1 and DB0) using command bits C2, C1, and C0 (see Table 17). The default value for each bit, and therefore for each DAC channel, is zero. If the LDAC register bit is set to 1, it overrides the $\overline{\text{LDAC}}$ pin (the $\overline{\text{LDAC}}$ pin is internally tied low for that particular DAC channel) and this DAC channel updates synchronously after the falling edge of the 24th SCLK cycle. However, if the LDAC register bit is set to 0, the DAC channel is controlled by the $\overline{\text{LDAC}}$ pin.

The combination of software and hardware simultaneous update functions is particularly useful in applications when updating a DAC channel, while keeping the other channel unaffected; see Table 11 and Table 17 for more information.

Table 11. DAC-n Selection for LDAC Register Command

| DB1, DB0 | Value | $\overline{\text{LDAC}}$ Pin Functionality |
|----------|-------|--|
| DB0 | 0 | DAC-A uses $\overline{\text{LDAC}}$ pin |
| | 1 | DAC-A operates in synchronous mode |
| DB1 | 0 | DAC-B uses $\overline{\text{LDAC}}$ pin |
| | 1 | DAC-B operates in synchronous mode |

8.5 Programming

The DAC756xT, DAC816xT, and DAC856xT devices have a three-wire serial interface ($\overline{\text{SYNC}}$, SCLK, and D_{IN} ; see the table) compatible with SPI, QSPI, and Microwire interface standards, as well as most DSPs. See the Serial Write Operation timing diagram (Figure 1) for an example of a typical write sequence.

The DAC756xT, DAC816xT, or DAC856xT input shift register is 24 bits wide, consisting of two *don't care* bits (DB23 to DB22), three command bits (DB21 to DB19), three address bits (DB18 to DB16), and 16 data bits (DB15 to DB0). All 24 bits of data are loaded into the DAC under the control of the serial clock input, SCLK. DB23 (MSB) is the first bit that is loaded into the DAC shift register. DB23 is followed by the rest of the 24-bit word pattern, left-aligned. This configuration means that the first 24 bits of data are latched into the shift register, and any further clocking of data is ignored.

The write sequence begins by bringing the $\overline{\text{SYNC}}$ line low. Data from the D_{IN} line are clocked into the 24-bit shift register on each falling edge of SCLK. The serial clock frequency can be as high as 50 MHz, making the DAC756xT, DAC816xT, and DAC856xT devices compatible with high-speed DSPs. On the 24th falling edge of the serial clock, the last data bit is clocked into the shift register and the shift register locks. Further clocking does not change the shift register data.

After receiving the 24th falling clock edge, the DAC756xT, DAC816xT, and DAC856xT devices decode the three command bits, three address bits and 16 data bits to perform the required function, without waiting for a $\overline{\text{SYNC}}$ rising edge. After the 24th falling edge of SCLK is received, the $\overline{\text{SYNC}}$ line may be kept low or brought high. In either case, the minimum delay time from the 24th falling SCLK edge to the next falling $\overline{\text{SYNC}}$ edge must be met in order to begin the next cycle properly; see the Serial Write Operation timing diagram (Figure 1).

A rising edge of $\overline{\text{SYNC}}$ before the 24-bit sequence is complete resets the SPI interface; no data transfer occurs. A new write sequence starts at the next falling edge of $\overline{\text{SYNC}}$. To assure the lowest power consumption of the device, care should be taken that the levels are as close to each rail as possible.

8.5.1 $\overline{\text{SYNC}}$ Interrupt

In a normal write sequence, the $\overline{\text{SYNC}}$ line stays low for at least 24 falling edges of SCLK and the addressed DAC register updates on the 24th falling edge. However, if $\overline{\text{SYNC}}$ is brought high before the 23rd falling edge, it acts as an interrupt to the write sequence; the shift register resets and the write sequence is discarded. Neither an update of the data buffer contents, DAC register contents, nor a change in the operating mode occurs (as shown in Figure 93).

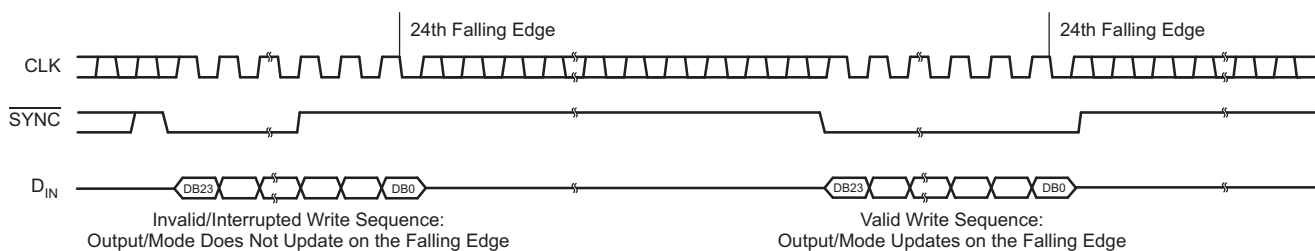


Figure 93. $\overline{\text{SYNC}}$ Interrupt Facility

Programming (continued)

8.5.2 DAC Register Configuration

When the DAC registers are being written to, the DAC756xT, DAC816xT, and DAC856xT devices receive all 24 bits of data, ignore DB23 and DB22, and decode the next three bits (DB21 to DB19) in order to determine the DAC operating or control mode (see [Table 12](#)). Bits DB18 to DB16 are used to address the DAC channels (see [Table 13](#)).

Table 12. Commands for the DAC756xT, DAC816xT, and DAC856xT Devices

| C2 (DB21) | C1 (DB20) | C0 (DB19) | Command |
|-----------|-----------|-----------|---|
| 0 | 0 | 0 | Write to input register n (Table 13) |
| 0 | 0 | 1 | Software LDAC, update DAC register n (Table 13) |
| 0 | 1 | 0 | Write to input register n (Table 13) and update all DAC registers |
| 0 | 1 | 1 | Write to input register n and update DAC register n (Table 13) |
| 1 | 0 | 0 | Set DAC power up or -down mode |
| 1 | 0 | 1 | Software reset |
| 1 | 1 | 0 | Set LDAC registers |
| 1 | 1 | 1 | Enable or disable the internal reference |

Table 13. Address Select for the DAC756xT, DAC816xT, and DAC856xT Devices

| A2 (DB18) | A1 (DB17) | A0 (DB16) | Channel (n) |
|-----------|-----------|-----------|----------------------------------|
| 0 | 0 | 0 | DAC-A |
| 0 | 0 | 1 | DAC-B |
| 0 | 1 | 0 | Gain (only use with command 000) |
| 0 | 1 | 1 | Reserved |
| 1 | 0 | 0 | Reserved |
| 1 | 0 | 1 | Reserved |
| 1 | 1 | 0 | Reserved |
| 1 | 1 | 1 | DAC-A and DAC-B |

When writing to the DAC input registers the next 16, 14, or 12 bits of data that follow are decoded by the DAC to determine the equivalent analog output (see [Table 14](#) through [Table 16](#)). The data format is straight binary, with all 0s corresponding to 0-V output and all 1s corresponding to full-scale output. For all documentation purposes, the data format and representation used here is a true 16-bit pattern (that is, FFFFh data word for full scale) that the DAC756xT, DAC816xT, and DAC856xT devices require.

Table 14. DAC856xT Data Input Register Format

| | | COMMAND | | | ADDRESS | | | DATA | | | | | | | | | | | | | | | |
|------------------|---|---------|----|----|---------|----|----|------|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|-----|
| X ⁽¹⁾ | X | C2 | C1 | C0 | A2 | A1 | A0 | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| DB23 | | | | | | | | | | | | | | | | | | | | | | | DB0 |

(1) X denotes *don't care* bits.

Table 15. DAC816xT Data Input Register Format

| | | COMMAND | | | ADDRESS | | | DATA | | | | | | | | | | | | | | | |
|------|---|---------|----|----|---------|----|----|------|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|---|-----|
| X | X | C2 | C1 | C0 | A2 | A1 | A0 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | X | X |
| DB23 | | | | | | | | | | | | | | | | | | | | | | | DB0 |

Table 16. DAC756xT Data Input Register Format

| | | COMMAND | | | ADDRESS | | | DATA | | | | | | | | | | | | | | | | |
|------|---|---------|----|----|---------|----|----|------|-----|----|----|----|----|----|----|----|----|----|----|---|---|---|-----|--|
| X | X | C2 | C1 | C0 | A2 | A1 | A0 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | X | X | X | X | |
| DB23 | | | | | | | | | | | | | | | | | | | | | | | DB0 | |

In addition to DAC input register updates, the DAC756xT, DAC816xT, and DAC856xT devices support a number of functional mode commands (such as write to LDAC register, power down DACs and so on). The complete set of functional mode commands is shown in Table 17.

Table 17. Command Matrix for the DAC756xT, DAC816xT, and DAC856xT Devices

| DB23-DB22 | Command | | | Address | | | Data | | | | | | DESCRIPTION | | |
|------------------|---------|----|----|---------|----|----|------------------------------|-----|-----|---------|-----|-----|---|---|--|
| | C2 | C1 | C0 | A2 | A1 | A0 | DB15-DB6 | DB5 | DB4 | DB3-DB2 | DB1 | DB0 | | | |
| X ⁽¹⁾ | 0 | 0 | 0 | 0 | 0 | 0 | 16-, 14-, or 12-bit DAC data | | | | | | Write to DAC-A input register | | |
| | | | | 0 | 0 | 1 | 16-, 14-, or 12-bit DAC data | | | | | | Write to DAC-B input register | | |
| | | | | 1 | 1 | 1 | 16-, 14-, or 12-bit DAC data | | | | | | Write to DAC-A and DAC-B input registers | | |
| X | 0 | 1 | 0 | 0 | 0 | 0 | 16-, 14-, or 12-bit DAC data | | | | | | Write to DAC-A input register and update all DACs | | |
| | | | | 0 | 0 | 1 | 16-, 14-, or 12-bit DAC data | | | | | | Write to DAC-B input register and update all DACs | | |
| | | | | 1 | 1 | 1 | 16-, 14-, or 12-bit DAC data | | | | | | Write to DAC-A and DAC-B input register and update all DACs | | |
| X | 0 | 1 | 1 | 0 | 0 | 0 | 16-, 14-, or 12-bit DAC data | | | | | | Write to DAC-A input register and update DAC-A | | |
| | | | | 0 | 0 | 1 | 16-, 14-, or 12-bit DAC data | | | | | | Write to DAC-B input register and update DAC-B | | |
| | | | | 1 | 1 | 1 | 16-, 14-, or 12-bit DAC data | | | | | | Write to DAC-A and DAC-B input register and update all DACs | | |
| X | 0 | 0 | 1 | 0 | 0 | 0 | X | | | | | | Update DAC-A | | |
| | | | | 0 | 0 | 1 | X | | | | | | Update DAC-B | | |
| | | | | 1 | 1 | 1 | X | | | | | | Update all DACs | | |
| X | 0 | 0 | 0 | 0 | 1 | 0 | X | | | | | | 0 | 0 | Gain: DAC-B gain = 2, DAC-A gain = 2 (default with internal V _{REF}) |
| | | | | | | | | | | | | | 0 | 1 | Gain: DAC-B gain = 2, DAC-A gain = 1 |
| | | | | | | | | | | | | | 1 | 0 | Gain: DAC-B gain = 1, DAC-A gain = 2 |
| | | | | | | | | | | | | | 1 | 1 | Gain: DAC-B gain = 1, DAC-A gain = 1 (power-on default) |
| X | 1 | 0 | 0 | X | | | X | 0 | 0 | X | 0 | 1 | Power up DAC-A | | |
| | | | | | | | | | | | 1 | 0 | Power up DAC-B | | |
| | | | | | | | | | | | 1 | 1 | Power up DAC-A and DAC-B | | |
| X | 1 | 0 | 0 | X | | | X | 0 | 1 | X | 0 | 1 | Power down DAC-A; 1 kΩ to GND | | |
| | | | | | | | | | | | 1 | 0 | Power down DAC-B; 1 kΩ to GND | | |
| | | | | | | | | | | | 1 | 1 | Power down DAC-A and DAC-B; 1 kΩ to GND | | |
| X | 1 | 0 | 0 | X | | | X | 1 | 0 | X | 0 | 1 | Power down DAC-A; 100 kΩ to GND | | |
| | | | | | | | | | | | 1 | 0 | Power down DAC-B; 100 kΩ to GND | | |
| | | | | | | | | | | | 1 | 1 | Power down DAC-A and DAC-B; 100 kΩ to GND | | |
| X | 1 | 0 | 0 | X | | | X | 1 | 1 | X | 0 | 1 | Power down DAC-A; Hi-Z | | |
| | | | | | | | | | | | 1 | 0 | Power down DAC-B; Hi-Z | | |
| | | | | | | | | | | | 1 | 1 | Power down DAC-A and DAC-B; Hi-Z | | |
| X | 1 | 0 | 1 | X | | | X | | | | | | X | 0 | Reset DAC-A and DAC-B input register and update all DACs |
| | | | | | | | | | | | | | X | 1 | Reset all registers and update all DACs (Power-on-reset update) |
| X | 1 | 1 | 0 | X | | | X | | | | | | 0 | 0 | $\overline{\text{LDAC}}$ pin active for DAC-B and DAC-A |
| | | | | | | | | | | | | | 0 | 1 | $\overline{\text{LDAC}}$ pin active for DAC-B; inactive for DAC-A |
| | | | | | | | | | | | | | 1 | 0 | $\overline{\text{LDAC}}$ pin inactive for DAC-B; active for DAC-A |
| | | | | | | | | | | | | | 1 | 1 | $\overline{\text{LDAC}}$ pin inactive for DAC-B and DAC-A |
| X | 1 | 1 | 1 | X | | | X | | | | | | X | 0 | Disable internal reference and reset DACs to gain = 1 |
| | | | | | | | | | | | | | X | 1 | Enable internal reference and reset DACs to gain = 2 |

(1) X denotes *don't care* bits.

9 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

9.1.1 DAC Internal Reference

The internal reference of the DAC756xT, DAC816xT, and DAC856xT devices does not require an external load capacitor for stability because it is stable without any capacitive load. However, for improved noise performance, an external load capacitor of 150 nF or larger connected to the V_{REFIN}/V_{REFOUT} output is recommended. Figure 94 shows the typical connections required for operation of the DAC756xT, DAC816xT, and DAC856xT internal reference. A supply bypass capacitor at the AV_{DD} input is also recommended.

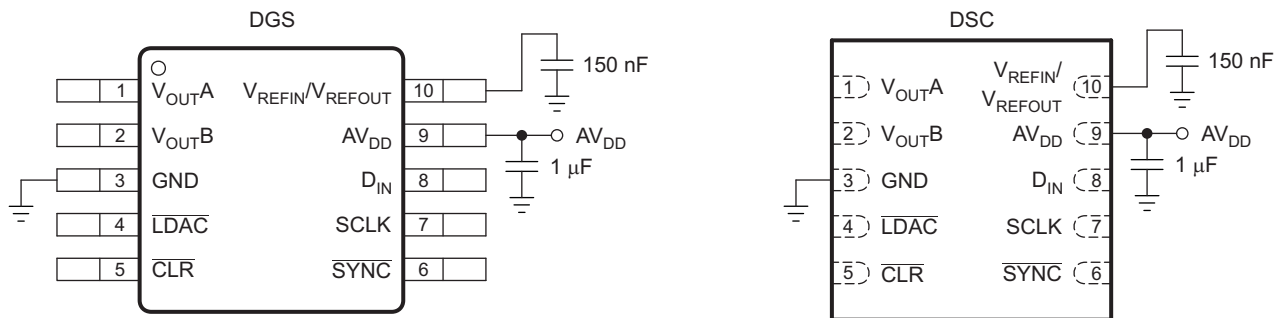


Figure 94. Typical Connections for Operating the DAC756xT, DAC816xT, and DAC856xT Internal Reference

9.1.1.1 Supply Voltage

The internal reference features an extremely low dropout voltage. It can be operated with a supply of only 5 mV above the reference output voltage in an unloaded condition. For loaded conditions, see the [Load Regulation](#) section. The stability of the internal reference with variations in supply voltage (line regulation, dc PSRR) is also exceptional. Within the specified supply voltage range of 2.7 V to 5.5 V, the variation at V_{REFIN}/V_{REFOUT} is typically 50 μ V/V; see [Figure 7](#).

9.1.1.2 Temperature Drift

The internal reference is designed to exhibit minimal drift error, defined as the change in reference output voltage over varying temperature. The drift is calculated using the box method described by [Equation 3](#):

$$\text{Drift Error} = \left(\frac{V_{REF_MAX} - V_{REF_MIN}}{V_{REF} \times T_{RANGE}} \right) \times 10^6 \text{ (ppm/}^\circ\text{C)} \quad (3)$$

where:

V_{REF_MAX} = maximum reference voltage observed within temperature range T_{RANGE} .

V_{REF_MIN} = minimum reference voltage observed within temperature range T_{RANGE} .

V_{REF} = 2.5 V, target value for reference output voltage.

T_{RANGE} = the characterized range from -40°C to 125°C (165 $^\circ\text{C}$ range)

The internal reference features an exceptional typical drift coefficient of 4 ppm/ $^\circ\text{C}$ from -40°C to 125°C . Characterizing a large number of units, a maximum drift coefficient of 10 ppm/ $^\circ\text{C}$ is observed. Temperature drift results are summarized in [Figure 3](#).

Application Information (continued)

9.1.1.3 Noise Performance

Typical 0.1-Hz to 10-Hz voltage noise and noise spectral density performance are listed in the [Electrical Characteristics](#). Additional filtering can be used to improve output noise levels, although care should be taken to ensure the output impedance does not degrade the ac performance. The output noise spectrum at the V_{REFIN}/V_{REFOUT} pin, both unloaded and with an external 4.7- μ F load capacitor, is shown in [Figure 6](#). Internal reference noise impacts the DAC output noise when the internal reference is used.

9.1.1.4 Load Regulation

Load regulation is defined as the change in reference output voltage as a result of changes in load current. The load regulation of the internal reference is measured using force and sense contacts as shown in [Figure 95](#). The force and sense lines reduce the impact of contact and trace resistance, resulting in accurate measurement of the load regulation contributed solely by the internal reference. Measurement results are shown in [Figure 4](#). Force and sense lines should be used for applications that require improved load regulation.

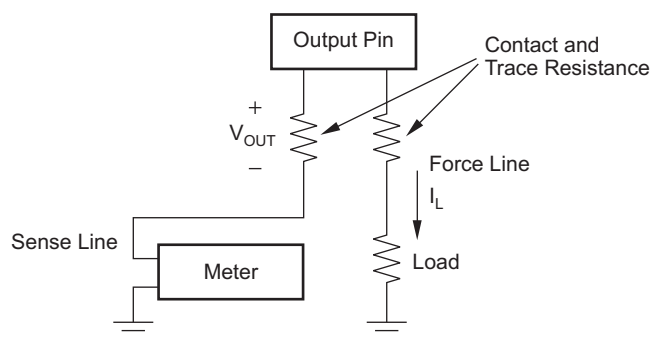


Figure 95. Accurate Load Regulation of the DAC756xT, DAC816xT, and DAC856xT Internal Reference

9.1.1.4.1 Long-Term Stability

Long-term stability or aging refers to the change of the output voltage of a reference over a period of months or years. This effect lessens as time progresses. The typical drift value for the internal reference is listed in the [Electrical Characteristics](#) and measurement results are shown in [Figure 5](#). This parameter is characterized by powering up multiple devices and measuring them at regular intervals.

9.1.1.5 Thermal Hysteresis

Thermal hysteresis for a reference is defined as the change in output voltage after operating the device at 25°C, cycling the device through the operating temperature range, and returning to 25°C. Hysteresis is expressed by [Equation 4](#):

$$V_{HYST} = \left[\frac{V_{REF_PRE} - V_{REF_POST}}{V_{REF_NOM}} \right] \times 10^6 (\text{ppm}/^\circ\text{C}) \quad (4)$$

where:

V_{HYST} = thermal hysteresis.

V_{REF_PRE} = output voltage measured at 25°C pre-temperature cycling.

V_{REF_POST} = output voltage measured after the device cycles through the temperature range of –40°C to 125°C, and returns to 25°C.

V_{REF_NOM} = 2.5 V, target value for reference output voltage.

9.1.2 DAC Noise Performance

Output noise spectral density at the V_{OUT-n} pin versus frequency is depicted in [Figure 45](#) and [Figure 46](#) for full-scale, mid-scale, and zero-scale input codes. The typical noise density for mid-scale code is 90 nV/ $\sqrt{\text{Hz}}$ at 1 kHz. High-frequency noise can be improved by filtering the reference noise. Integrated output noise between 0.1 Hz and 10 Hz is close to 2.5 μ V_{PP} (mid-scale), as shown in [Figure 47](#).

9.2 Typical Applications

9.2.1 Combined Voltage and Current Analog Output Module Using the XTR300

The design features two independent outputs that can source and sink voltage and current over the standard industrial output ranges. The possible outputs of the design include: -24 mA to 24 mA , 4 mA – 20 mA , 0 mA to 24 mA , 0 V to 5 V , 0 V to 10 V , -5 V to 5 V , and -10 V to 10 V .

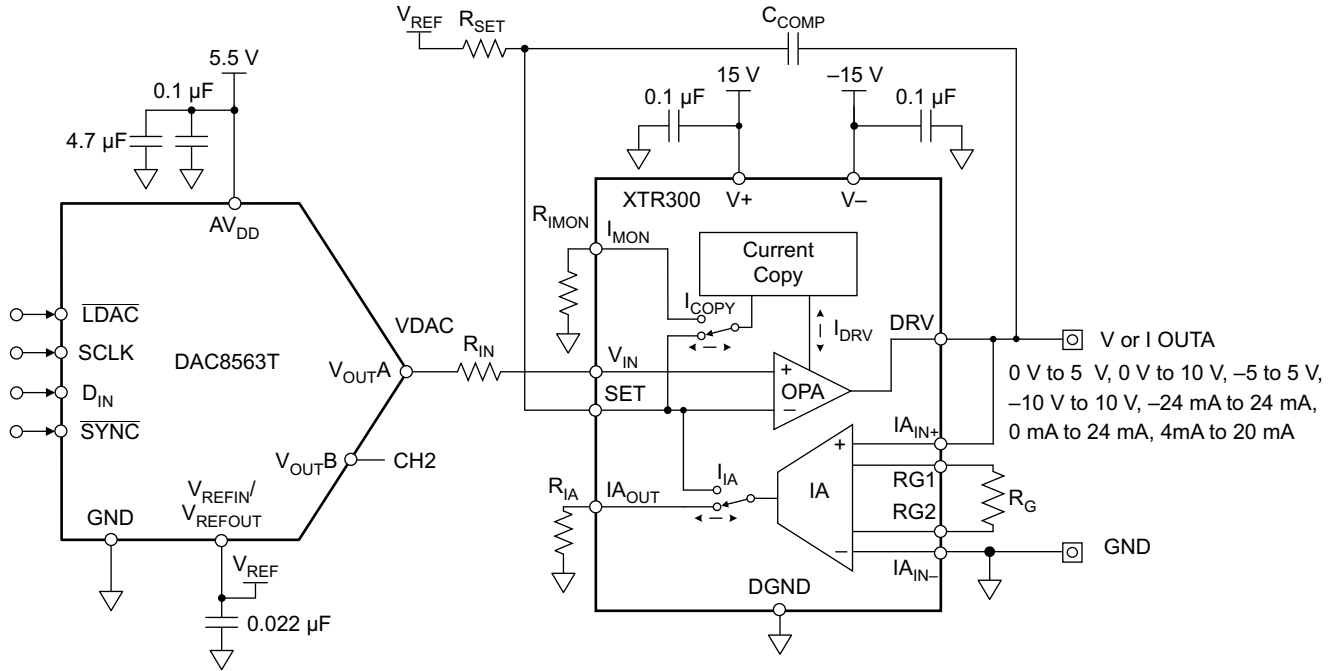


Figure 96. DAC8563T and XTR300 Discrete Analog Output Module

9.2.1.1 Design Requirements

The design uses a DAC and a current-or-voltage output driver to create a discrete analog output design that can output either voltage or current from the same pin while focusing on high-accuracy specifications. The choice of the DAC8563T device takes advantage of its 16-bit resolution as well as its low typical offset error of 1 mV and gain error of 0.01% FSR. The choice of the XTR300 device is based on its strong dc performance, having a typical error of $400\text{ }\mu\text{V}$ and 0.04% FSR gain error. The XTR300 device allows a variety of both current and voltage outputs on the same pin while providing load monitoring and error status pins.

The power-on reset-to-midscale feature of the DAC8563T makes the bipolar output of the XTR300 power up at 0 V or 0 A . If using a unipolar output, the recommended device to achieve a system power-on output of 0 V , 0 A or 4 mA is the DAC8562T device.

A recommendation for minimizing the introduction of errors into the system is to use $\pm 0.01\%$ tolerance R_G and R_{SET} resistors. The bypass capacitors on AV_{DD} , V_{REF} , V_+ and V_- should have values between 100 nF and $10\text{ }\mu\text{F}$. Smaller capacitors filter fast low-energy transients, whereas the large capacitors filter the slow high-energy transients. If there is an expectation of both types of signals in the system, the recommendation is to use a pair of small and large values as shown on the AV_{DD} pin of the DAC8563T device in Figure 96.

9.2.1.2 Detailed Design Procedure

When configured for voltage mode, the output of the instrumentation amplifier (IA), internal to the XTR300 device, is routed to the SET pin. The SET output provides feedback for the IA based on the IA input voltage. The feedback from the IA provides high-impedance remote sensing of the voltage at the output load. Using the output voltage can overcome errors from PCB traces and protection component impedances. The DAC provides a unipolar input voltage to the V_{IN} pin of the XTR300 device. The XTR300 device offsets the V_{DAC} range by a negative V_{REF} and amplifies the difference by a value set by the R_G and R_{SET} resistors, as shown in Equation 5.

Typical Applications (continued)

$$V_{OUT} = \frac{R_G}{2} \times \left(\frac{V_{DAC} - V_{REF}}{R_{SET}} \right) \quad (5)$$

When configured for current mode, the XTR300 routes the internal output of its current copy circuitry to the SET pin. This provides feedback for the internal OPA driver based on 1 / 10th of the output current, resulting in a voltage-to-current transfer function. Generating bipolar current outputs from the single-ended DAC output voltage, V_{DAC} , requires the application of an offset to the XTR300 SET pin. Connect the R_{SET} resistor from the SET pin to V_{REF} to apply the offset and obtain the transfer function shown in [Equation 6](#).

$$I_{OUT} = 10 \times \left(\frac{V_{DAC} - V_{REF}}{R_{SET}} \right) \quad (6)$$

The desired output ranges for V_{DAC} and V_{REF} voltages determine the R_{SET} and R_G resistor values, calculated using [Equation 7](#) and [Equation 8](#). The system design requires a V_{DAC} voltage range of 0.04 V to 4.96 V in order to operate the DAC8563T in the specified linear output range from codes 512 to 65 024.

$$R_{SET} = 10 \times \left(\frac{V_{DAC} - V_{REF}}{I_{OUT}} \right) = 10 \times \left(\frac{4.96 \text{ V} - 2.5 \text{ V}}{0.024 \text{ A}} \right) = 1025 \ \Omega \quad (7)$$

$$R_G = \frac{2 \times V_{OUT_MAX} \times R_{SET}}{V_{DAC} - V_{REF}} = \frac{2 \times 10 \text{ V} \times 1020 \ \Omega}{4.96 \text{ V} - 2.5 \text{ V}} = 8292 \ \Omega \quad (8)$$

I_{MON} and I_{A_OUT} accomplish load monitoring. The sizing of R_{IMON} and R_{IA} determine the monitoring output voltage across the resistors. Size the resistors according to [Equation 9](#) and [Equation 10](#) and the expected output load current I_{DRV} .

$$R_{IMON} = \frac{10 \times V_{IMON}}{I_{DRV}} \quad (9)$$

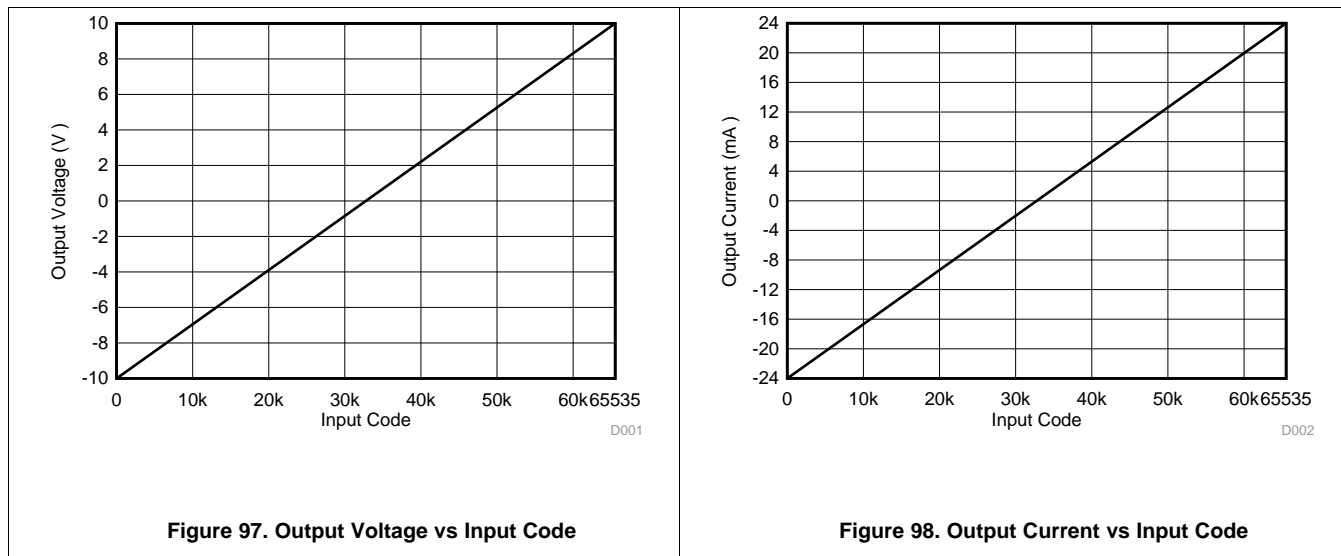
$$R_{IA} = \frac{10 \times V_{IA}}{I_{IA}} \quad (10)$$

For more detailed information about the design procedure of this circuit and how to isolate it, see *Two-Channel Source/Sink Combined Voltage & Current Output, Isolated, EMC/EMI Tested Reference Design (TIDU434)*.

Typical Applications (continued)

9.2.1.3 Application Curves

Figure 97 shows the transfer function for the bipolar ± 10 V voltage range. This design also supports output voltage ranges of 0–5 V, 0–10 V and ± 5 V. Figure 98 shows the transfer function for the unipolar 0–24 mA current range. This design also supports output current ranges of ± 24 mA and 4 mA–20 mA.



Typical Applications (continued)

9.2.2 Up to ±15-V Bipolar Output Using the DAC8562T

The DAC8562T is designed to be operate from a single power supply providing a maximum output range of AV_{DD} volts. However, the DAC can be placed in the configuration shown in Figure 99 in order to be designed into bipolar systems. Depending on the ratio of the resistor values, the output of the circuit can range anywhere from ±5 V to ±15 V. The design example below shows that the DAC is configured to have its internal reference enabled and the DAC8562T internal gain set to 2, however, an external 2.5-V reference could also be used (with DAC8562T internal gain set to 2).

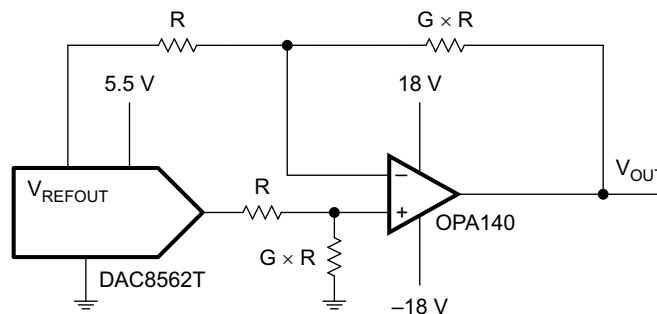


Figure 99. Bipolar Output Range Circuit Using DAC8562T

The transfer function shown in Equation 11 can be used to calculate the output voltage as a function of the DAC code, reference voltage and resistor ratio:

$$V_{OUT} = G \times V_{REFOUT} \left(2 \times \frac{D_{IN}}{65,536} - 1 \right) \quad (11)$$

where:

D_{IN} = decimal equivalent of the binary code that is loaded to the DAC register, ranging from 0 to 65,535 for DAC8562T (16 bit).

V_{REFOUT} = reference output voltage with the internal reference enabled from the DAC V_{REFIN}/V_{REFOUT} pin

G = ratio of the resistors

An example configuration to generate a ±10-V output range is shown below in Equation 6 with $G = 4$ and $V_{REFOUT} = 2.5$ V:

$$V_{OUT} = 20 \times \frac{D_{IN}}{65,536} - 10 \text{ V} \quad (12)$$

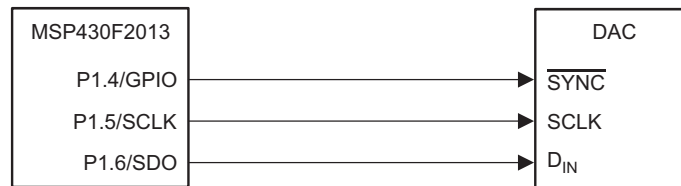
In this example, the range is set to ±10 V by using a resistor ratio of four, V_{REFOUT} of 2.5 V, and DAC8562T internal gain of 2. The resistor sizes must be selected keeping in mind the current sink or source capability of the DAC8562T internal reference. Using larger resistor values, for example, $R = 10$ kΩ or larger, is recommended. The operational amplifier is selectable depending on the requirements of the system.

The DAC8562TEVM and DAC7562TEVM boards have the option to evaluate the bipolar output application by installing the components on the pre-placed footprints. For more information see either the [DAC8562EVM](#) or [DAC7562EVM](#) product folder.

9.3 System Examples

9.3.1 MSP430 Microprocessor Interfacing

Figure 100 shows a serial interface between the DAC756xT, DAC816xT, or DAC856xT device and a typical MSP430 USI port such as the one found on the MSP430F2013. The port is configured in SPI master mode by setting bits 3, 5, 6, and 7 in USICTL0. The USI counter interrupt is set in USICTL1 to provide an efficient means of SPI communication with minimal software overhead. The serial clock polarity, source, and speed are controlled by settings in the USI clock control register (USICKCTL). The SYNC signal is derived from a bit-programmable pin on port 1; in this case, port line P1.4 is used. When data are to be transmitted to the DAC756xT, DAC816xT, or DAC856xT device, P1.4 is taken low. The USI transmits data in 8-bit bytes; thus, only eight falling clock edges occur in the transmit cycle. To load data to the DAC, P1.4 is left low after the first eight bits are transmitted; then, a second write cycle is initiated to transmit the second byte of data. P1.4 is taken high following the completion of the third write cycle.

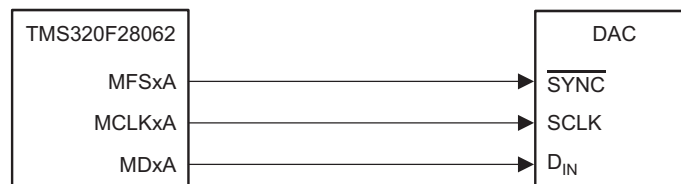


NOTE: Additional pins omitted for clarity.

Figure 100. DAC756xT, DAC816xT, or DAC856xT Device to MSP430 Interface

9.3.2 TMS320 McBSP Microprocessor Interfacing

Figure 101 shows an interface between the DAC756xT, DAC816xT, or DAC856xT device and any TMS320 series DSP from Texas Instruments with a multi-channel buffered serial port (McBSP). Serial data are shifted out on the rising edge of the serial clock and are clocked into the DAC756xT, DAC816xT, or DAC856xT device on the falling edge of the SCLK signal.

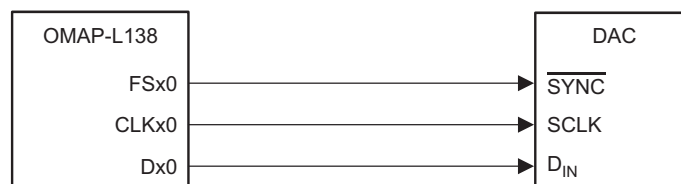


NOTE: Additional pins omitted for clarity.

Figure 101. DAC756xT, DAC816xT, or DAC856xT Device to TMS320 McBSP Interface

9.3.3 OMAP-L1x Processor Interfacing

Figure 102 shows a serial interface between the DAC756xT, DAC816xT, or DAC856xT device and the OMAP-L138 processor. The transmit clock CLKx0 of the L138 drives SCLK of the DAC756xT, DAC816xT, or DAC856xT device, and the data transmit (Dx0) output drives the serial data line of the DAC. The SYNC signal is derived from the frame sync transmit (FSx0) line, similar to the TMS320 interface.



NOTE: Additional pins omitted for clarity.

Figure 102. DAC756xT, DAC816xT, or DAC856xT Device to OMAP-L1x Processor

10 Power Supply Recommendations

These devices can operate within the specified supply voltage range of 2.7 V to 5.5 V. The power applied to AV_{DD} should be well-regulated and low-noise. In order to further minimize noise from the power supplies, a strong recommendation is to include a pair of 100-pF and 1-nF capacitors and a 0.1- μ F to 1- μ F bypass capacitor. The current consumption of the AV_{DD} pin, the short-circuit current limit, and the load current for these devices are listed in the [Electrical Characteristics](#) table. Choose the power supplies for these devices to meet the aforementioned current requirements.

11 Layout

11.1 Layout Guidelines

A precision analog component requires careful layout, adequate bypassing, and clean, well-regulated power supplies. The DAC756xT, DAC816xT, and DAC856xT devices offer single-supply operation, and are often 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 is to keep digital noise from appearing at the output. As a result of the single ground pin of the DAC756xT, DAC816xT, and DAC856xT devices, all return currents (including digital and analog return currents for the DAC) must flow through a single point. 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 AV_{DD} should be well-regulated and low noise. Switching power supplies and dc-dc converters 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. As with the GND connection, AV_{DD} should be connected to a power-supply plane or trace that is separate from the connection for digital logic until they are connected at the power-entry point. In addition, a pair of 100-pF to 1-nF capacitors and a 0.1- μ F to 1- μ F bypass capacitor are strongly recommended. In some situations, additional bypassing may be required, such as a 100- μ F electrolytic capacitor or even a pi filter made up of inductors and capacitors – all designed essentially to provide low-pass filtering for the supply and remove the high-frequency noise.

11.2 Layout Example

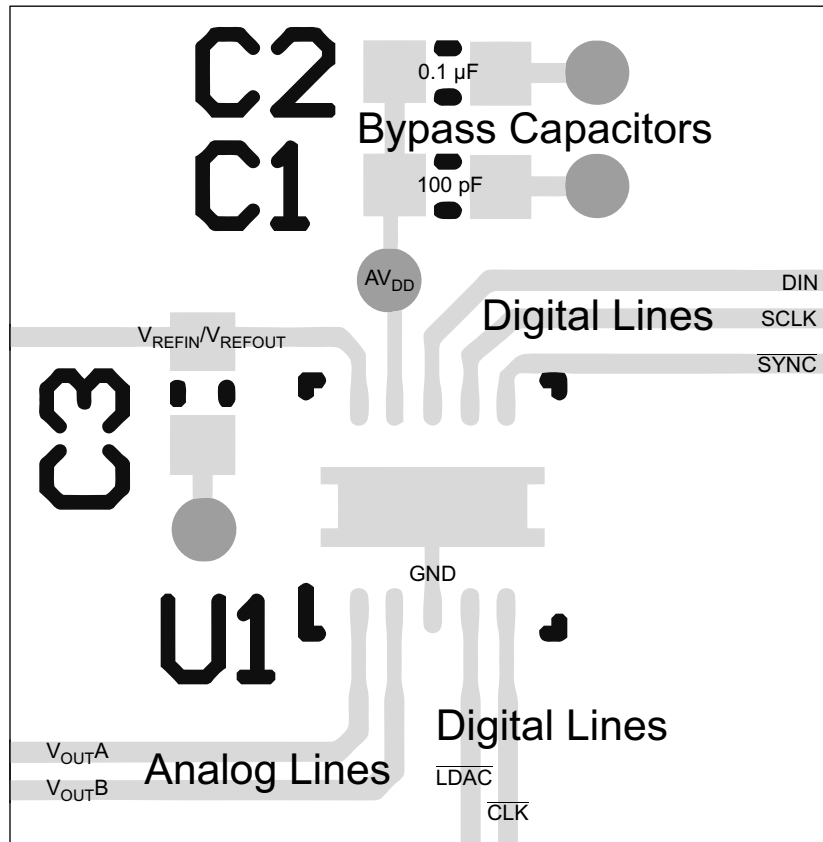


Figure 103. DACxx6xT Layout Example

12 器件和文档支持

12.1 相关链接

下面的表格列出了快速访问链接。 范围包括技术文档、支持与社区资源、工具和软件，以及样片或购买的快速访问。

Table 18. 相关链接

| 器件 | 产品文件夹 | 样片与购买 | 技术文档 | 工具与软件 | 支持与社区 |
|----------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| DAC7562T | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 |
| DAC7563T | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 |
| DAC8162T | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 |
| DAC8163T | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 |
| DAC8562T | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 |
| DAC8563T | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 | 请单击此处 |

12.2 社区资源

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

TI E2E™ Online Community *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.3 Trademarks

SPI, QSPI are trademarks of Motorola, Inc.
All other trademarks are the property of their respective owners.

12.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments 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.

12.5 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 机械、封装和可订购信息

以下页中包括机械、封装和可订购信息。 这些信息是针对指定器件可提供的最新数据。 本数据随时可能发生变更并且不对本文档进行修订，恕不另行通知。 要获得这份数据表的浏览器版本，请查阅左侧的导航窗格。

PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| DAC7562TDGSR | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 75T2 |
| DAC7562TDGSR.A | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 75T2 |
| DAC7562TDGST | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 75T2 |
| DAC7562TDGST.A | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 75T2 |
| DAC7562TDSCR | Active | Production | WSON (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 7562T |
| DAC7562TDSCR.A | Active | Production | WSON (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 7562T |
| DAC7562TDSCT | Active | Production | WSON (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 7562T |
| DAC7562TDSCT.A | Active | Production | WSON (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 7562T |
| DAC7563TDGSR | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 75T3 |
| DAC7563TDGSR.A | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 75T3 |
| DAC7563TDGST | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 75T3 |
| DAC7563TDGST.A | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 75T3 |
| DAC7563TDSCR | Active | Production | WSON (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 7563T |
| DAC7563TDSCR.A | Active | Production | WSON (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 7563T |
| DAC7563TDSCT | Active | Production | WSON (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 7563T |
| DAC7563TDSCT.A | Active | Production | WSON (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 7563T |
| DAC8162TDGSR | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 81T2 |
| DAC8162TDGSR.A | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 81T2 |
| DAC8162TDGST | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 81T2 |
| DAC8162TDGST.A | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 81T2 |
| DAC8162TDSCR | Active | Production | WSON (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8162T |
| DAC8162TDSCR.A | Active | Production | WSON (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8162T |
| DAC8162TDSCT | Active | Production | WSON (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8162T |
| DAC8162TDSCT.A | Active | Production | WSON (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8162T |
| DAC8163TDGSR | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 81T3 |
| DAC8163TDGSR.A | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 81T3 |
| DAC8163TDGST | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 81T3 |
| DAC8163TDGST.A | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 81T3 |
| DAC8163TDSCR | Active | Production | WSON (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8163T |

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| DAC8163TDSCR.A | Active | Production | WSOP (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8163T |
| DAC8163TDSC | Active | Production | WSOP (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8163T |
| DAC8163TDSC.T.A | Active | Production | WSOP (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8163T |
| DAC8562TDGSR | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 85T2 |
| DAC8562TDGSR.A | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 85T2 |
| DAC8562TDGST | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 85T2 |
| DAC8562TDGST.A | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 85T2 |
| DAC8562TDSCR | Active | Production | WSOP (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8562T |
| DAC8562TDSCR.A | Active | Production | WSOP (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8562T |
| DAC8562TDSC | Active | Production | WSOP (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8562T |
| DAC8562TDSC.T.A | Active | Production | WSOP (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8562T |
| DAC8563TDGSR | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 85T3 |
| DAC8563TDGSR.A | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 85T3 |
| DAC8563TDGST | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 85T3 |
| DAC8563TDGST.A | Active | Production | VSSOP (DGS) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 85T3 |
| DAC8563TDSCR | Active | Production | WSOP (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8563T |
| DAC8563TDSCR.A | Active | Production | WSOP (DSC) 10 | 3000 LARGE T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8563T |
| DAC8563TDSC | Active | Production | WSOP (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8563T |
| DAC8563TDSC.T.A | Active | Production | WSOP (DSC) 10 | 250 SMALL T&R | Yes | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | 8563T |

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

(2) **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.

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

(4) **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.

(5) **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.

(6) **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.

Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION



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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| DAC7562TDGSR | VSSOP | DGS | 10 | 2500 | 330.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC7562TDGST | VSSOP | DGS | 10 | 250 | 180.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC7562TDSCR | WSO | DSC | 10 | 3000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| DAC7562TDSCT | WSO | DSC | 10 | 250 | 180.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| DAC7563TDGSR | VSSOP | DGS | 10 | 2500 | 330.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC7563TDGST | VSSOP | DGS | 10 | 250 | 180.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC7563TDSCR | WSO | DSC | 10 | 3000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| DAC7563TDSCT | WSO | DSC | 10 | 250 | 180.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| DAC8162TDGSR | VSSOP | DGS | 10 | 2500 | 330.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC8162TDGST | VSSOP | DGS | 10 | 250 | 180.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC8162TDSCR | WSO | DSC | 10 | 3000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| DAC8162TDSCT | WSO | DSC | 10 | 250 | 180.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| DAC8163TDGSR | VSSOP | DGS | 10 | 2500 | 330.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC8163TDGST | VSSOP | DGS | 10 | 250 | 180.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC8163TDSCR | WSO | DSC | 10 | 3000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| DAC8163TDSCT | WSO | DSC | 10 | 250 | 180.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |

| 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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| DAC8562TDGSR | VSSOP | DGS | 10 | 2500 | 330.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC8562TDGST | VSSOP | DGS | 10 | 250 | 180.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC8562TDSCR | WSON | DSC | 10 | 3000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| DAC8562TDSCT | WSON | DSC | 10 | 250 | 180.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| DAC8563TDGSR | VSSOP | DGS | 10 | 2500 | 330.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC8563TDGST | VSSOP | DGS | 10 | 250 | 180.0 | 12.4 | 5.3 | 3.3 | 1.3 | 8.0 | 12.0 | Q1 |
| DAC8563TDSCR | WSON | DSC | 10 | 3000 | 330.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |
| DAC8563TDSCT | WSON | DSC | 10 | 250 | 180.0 | 12.4 | 3.3 | 3.3 | 1.1 | 8.0 | 12.0 | Q2 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| DAC7562TDGSR | VSSOP | DGS | 10 | 2500 | 367.0 | 367.0 | 38.0 |
| DAC7562TDGST | VSSOP | DGS | 10 | 250 | 213.0 | 191.0 | 35.0 |
| DAC7562TDSCR | WSON | DSC | 10 | 3000 | 346.0 | 346.0 | 33.0 |
| DAC7562TDSCT | WSON | DSC | 10 | 250 | 210.0 | 185.0 | 35.0 |
| DAC7563TDGSR | VSSOP | DGS | 10 | 2500 | 367.0 | 367.0 | 38.0 |
| DAC7563TDGST | VSSOP | DGS | 10 | 250 | 213.0 | 191.0 | 35.0 |
| DAC7563TDSCR | WSON | DSC | 10 | 3000 | 346.0 | 346.0 | 33.0 |
| DAC7563TDSCT | WSON | DSC | 10 | 250 | 210.0 | 185.0 | 35.0 |
| DAC8162TDGSR | VSSOP | DGS | 10 | 2500 | 367.0 | 367.0 | 38.0 |
| DAC8162TDGST | VSSOP | DGS | 10 | 250 | 213.0 | 191.0 | 35.0 |
| DAC8162TDSCR | WSON | DSC | 10 | 3000 | 346.0 | 346.0 | 33.0 |
| DAC8162TDSCT | WSON | DSC | 10 | 250 | 210.0 | 185.0 | 35.0 |
| DAC8163TDGSR | VSSOP | DGS | 10 | 2500 | 367.0 | 367.0 | 38.0 |
| DAC8163TDGST | VSSOP | DGS | 10 | 250 | 213.0 | 191.0 | 35.0 |
| DAC8163TDSCR | WSON | DSC | 10 | 3000 | 346.0 | 346.0 | 33.0 |
| DAC8163TDSCT | WSON | DSC | 10 | 250 | 210.0 | 185.0 | 35.0 |
| DAC8562TDGSR | VSSOP | DGS | 10 | 2500 | 367.0 | 367.0 | 38.0 |
| DAC8562TDGST | VSSOP | DGS | 10 | 250 | 213.0 | 191.0 | 35.0 |

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|---------------------|------------------------|-------------|------------|--------------------|-------------------|--------------------|
| DAC8562TDSCR | WSON | DSC | 10 | 3000 | 346.0 | 346.0 | 33.0 |
| DAC8562TDSCT | WSON | DSC | 10 | 250 | 210.0 | 185.0 | 35.0 |
| DAC8563TDGSR | VSSOP | DGS | 10 | 2500 | 367.0 | 367.0 | 38.0 |
| DAC8563TDGST | VSSOP | DGS | 10 | 250 | 213.0 | 191.0 | 35.0 |
| DAC8563TDSCR | WSON | DSC | 10 | 3000 | 346.0 | 346.0 | 33.0 |
| DAC8563TDSCT | WSON | DSC | 10 | 250 | 210.0 | 185.0 | 35.0 |

DGS0010A



PACKAGE OUTLINE

VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



4221984/A 05/2015

NOTES:

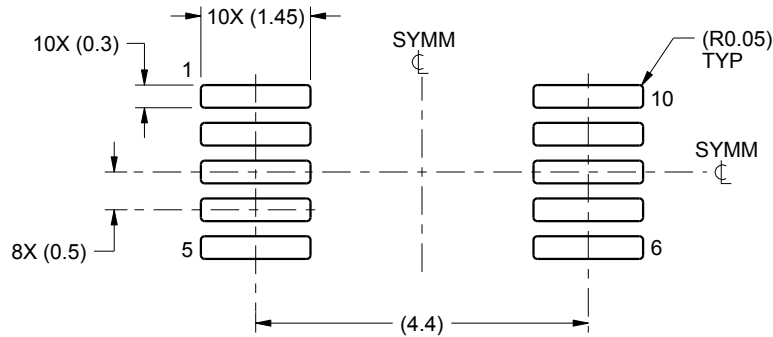
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187, variation BA.

EXAMPLE BOARD LAYOUT

DGS0010A

VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
SCALE:10X



SOLDER MASK DETAILS
NOT TO SCALE

4221984/A 05/2015

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DGS0010A

VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:10X

4221984/A 05/2015

NOTES: (continued)

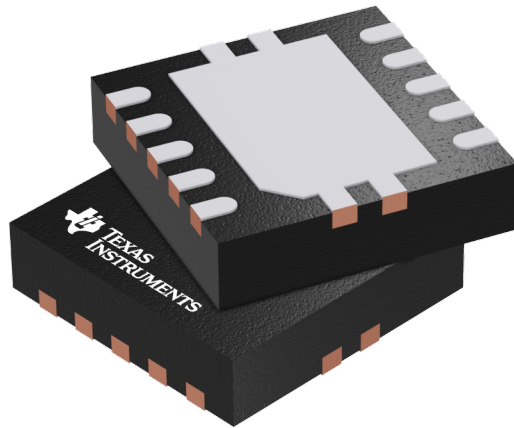
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

GENERIC PACKAGE VIEW

DSC 10

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD

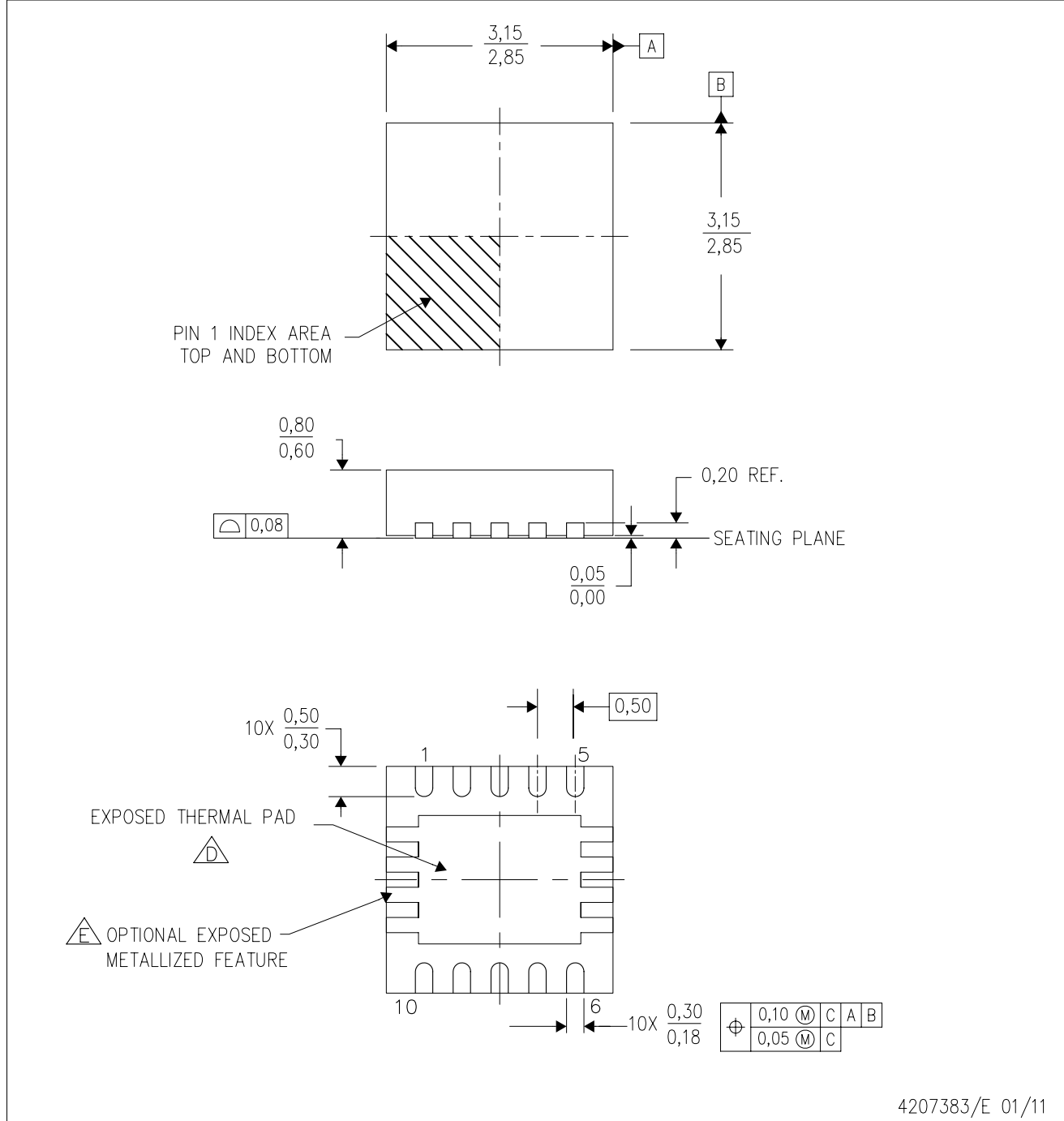




Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4207383/F

DSC (S-PWSON-N10)

PLASTIC SMALL OUTLINE NO-LEAD



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Small Outline No-Lead (SON) package configuration.
 -  The package thermal pad must be soldered to the board for thermal and mechanical performance.
 -  See the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.

THERMAL PAD MECHANICAL DATA

DSC (S-PWSON-N10)

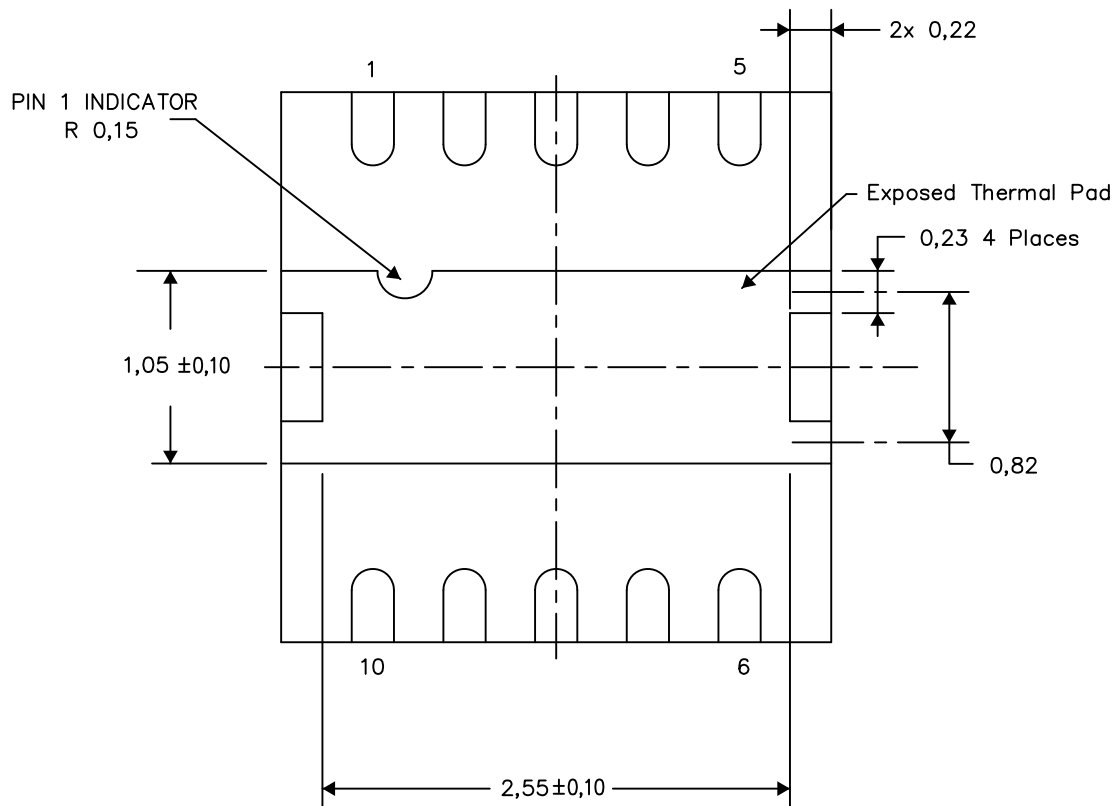
PLASTIC SMALL OUTLINE NO-LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

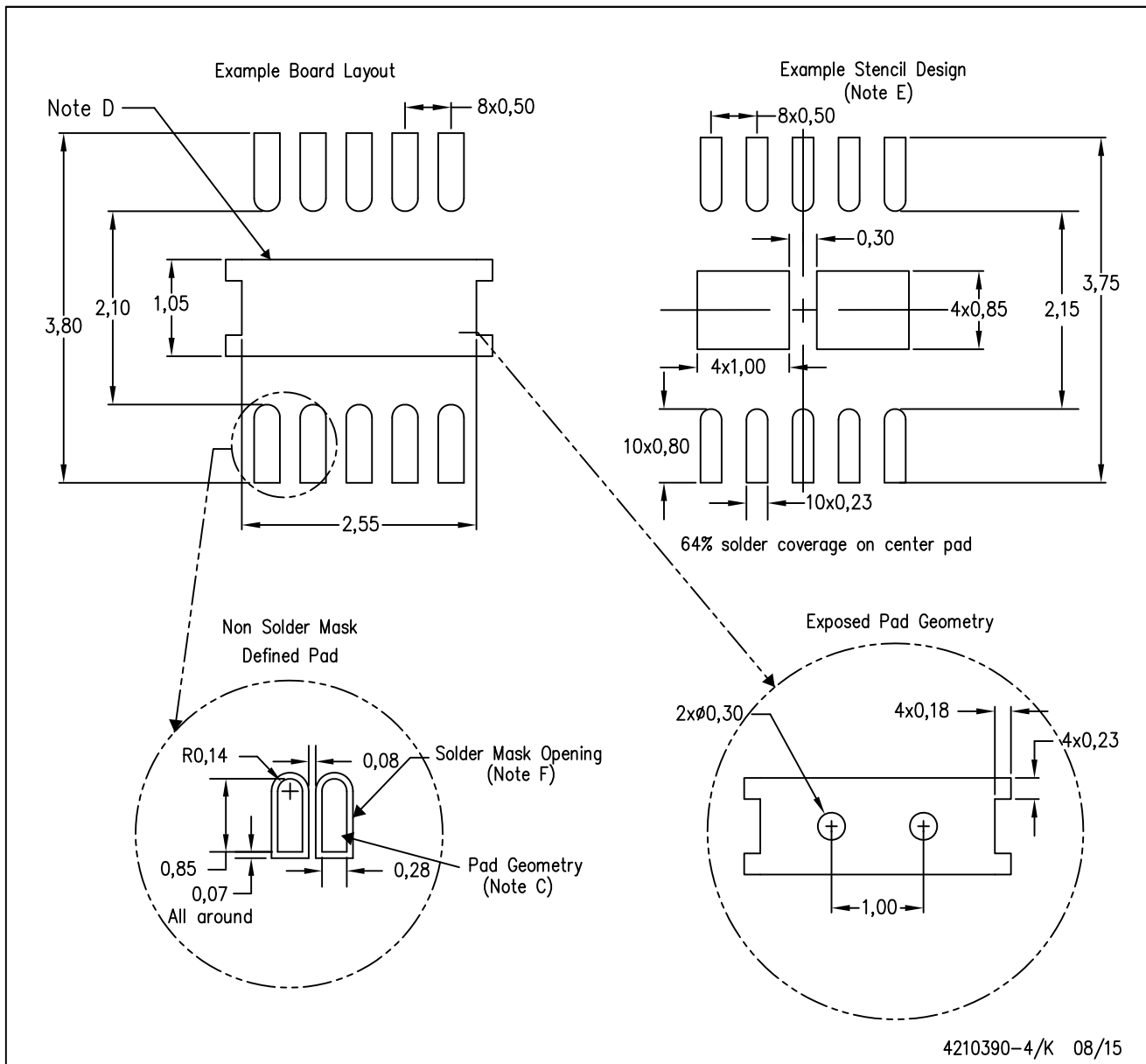
Exposed Thermal Pad Dimensions

4210391-4/Q 08/15

NOTE: A. All linear dimensions are in millimeters

DSC (S-PWSON-N10)

PLASTIC SMALL OUTLINE NO-LEAD



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
 - Customers should contact their board fabrication site for minimum solder mask web tolerances between signal pads.

重要通知和免责声明

TI“按原样”提供技术和可靠性数据（包括数据表）、设计资源（包括参考设计）、应用或其他设计建议、网络工具、安全信息和其他资源，不保证没有瑕疵且不做任何明示或暗示的担保，包括但不限于对适销性、与某特定用途的适用性或不侵犯任何第三方知识产权的暗示担保。

这些资源可供使用 TI 产品进行设计的熟练开发人员使用。您将自行承担以下全部责任：(1) 针对您的应用选择合适的 TI 产品，(2) 设计、验证并测试您的应用，(3) 确保您的应用满足相应标准以及任何其他安全、安保法规或其他要求。

这些资源如有变更，恕不另行通知。TI 授权您仅可将这些资源用于研发本资源所述的 TI 产品的相关应用。严禁以其他方式对这些资源进行复制或展示。您无权使用任何其他 TI 知识产权或任何第三方知识产权。对于因您对这些资源的使用而对 TI 及其代表造成的任何索赔、损害、成本、损失和债务，您将全额赔偿，TI 对此概不负责。

TI 提供的产品受 [TI 销售条款](#)、[TI 通用质量指南](#) 或 [ti.com](#) 上其他适用条款或 TI 产品随附的其他适用条款的约束。TI 提供这些资源并不会扩展或以其他方式更改 TI 针对 TI 产品发布的适用的担保或担保免责声明。除非德州仪器 (TI) 明确将某产品指定为定制产品或客户特定产品，否则其产品均为按确定价格收入目录的标准通用器件。

TI 反对并拒绝您可能提出的任何其他或不同的条款。

版权所有 © 2025，德州仪器 (TI) 公司

最后更新日期：2025 年 10 月