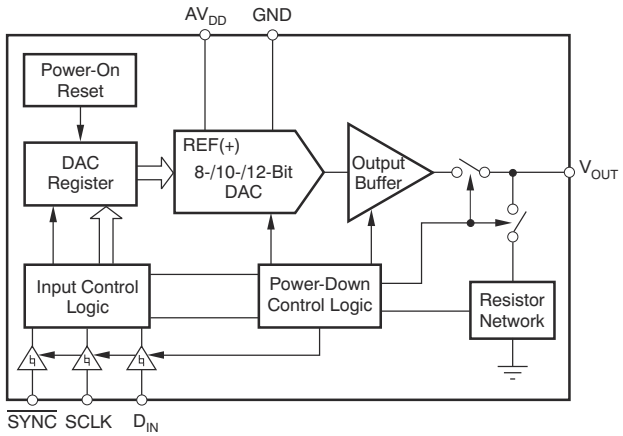
# DACx311 采用 SC70 封装的 2V 至 5.5V、80µA、8 位、10 位和 12 位低功耗、单通道数模转换器

## 1 特性

- 相对精度：
  - 0.25 LSB INL（DAC5311：8 位）
  - 0.5 LSB INL（DAC6311：10 位）
  - 1 LSB INL（DAC7311：12 位）
- *微* 功耗运行：2.0 V 时为 80 µA
- 断电：5V 时为 0.5 µA，2.0V 时为 0.1 µA
- 宽电源：2.0V 至 5.5V
- 上电复位至零标度
- 直接二进制数据格式
- 具有施密特触发输入的低功耗串口：高达 50MHz
- 片上输出缓冲放大器，轨到轨运行
- $\overline{\text{SYNC}}$ 中断设施
- 工作温度范围为 –40°C 至 +125°C
- 采用微型 6 引脚 SC70 封装的引脚兼容系列

## 2 应用

- 便携式电池供电仪器
- 4mA 至 20mA 环路供电应用
- 过程控制和工业自动化
- 可编程电压源和电流源




简化原理图

## 3 说明

8 位 DAC5311、10 位 DAC6311 和 12 位 DAC7311 (DACx311) 是低功耗、单通道、电压输出数模转换器 (DAC)。DACx311 在正常工作状态下具有低功耗（5V 时为 0.55mW，断电模式下可降至 2.5 µW），使其成为便携式电池供电应用的理想选择。

这些器件采用单调性设计，提供出色的线性度，并且大大降低了有害的码字间瞬态电压，同时在引脚兼容系列中提供简单的升级路径。所有器件均使用一个以高达 50MHz 的时钟速率运行的多功能 3 线制串行接口，并与标准 SPI、QSPI、Microwire 和数字信号处理器 (DSP) 接口兼容。

所有器件均使用外部电源作为基准电压来设置输出范围。该器件包含一个上电复位 (POR) 电路，可在 0V 时为 DAC 输出上电，并保持为 0V，直到对器件进行有效写入。DACx311 包含一个由串口访问的断电特性，这将器件处于断电模式时在电压为 2.0V 时的功耗减少至 0.1 µA。

这些器件与 DAC8311 和 DAC8411 引脚兼容，可从 8 位、10 位和 12 位分辨率轻松升级到 14 位和 16 位。所有器件均采用小型 6 引脚 SC70 (SOT) 封装。此封装可使本系列中的 DAC 在 –40°C 至 +125°C 的工作温度范围内具有灵活性、实现引脚兼容和功能兼容并且可直接插入使用。

**器件信息(1)**

| 器件型号(2) | 分辨率 | 封装尺寸(3) |
|---|---|---|
| DAC7311 | 12 位 | DCK（SC70，6）2mm × 1.5mm |
| DAC6311 | 10 位 | |
| DAC5311 | 8 位 | |

(1) 如需了解所有可用封装，请参阅数据表末尾的封装选项附录。
(2) 请参阅*器件比较表*。
(3) 封装尺寸（长 × 宽）为标称值，并包括引脚（如适用）。

本文档旨在为方便起见，提供有关 TI 产品中文版本的信息，以确认产品的概要。有关适用的官方英文版本的最新信息，请访问 www.ti.com，其内容始终优先。TI 不保证翻译的准确性和有效性。在实际设计之前，请务必参考最新版本的英文版本。

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## 4 Revision History

注：以前版本的页码可能与当前版本的页码不同

**Changes from Revision C (July 2015) to Revision D (August 2023)** — **Page**

- 更新了整个文档中的表格、图和交叉参考的编号格式.....1
- 将英文器件信息表中的“body size”更改为“package size”，并添加了内容以显示不同器件之间的差异.....1
- Changed power dissipation max value for normal mode at $AV_{DD}$ = 3.6 V to 5.5 V from 0.88 mW to 0.99 mW in *Electrical Characteristics* .....5
- Changed $I_{DD}$ max value for normal mode at $AV_{DD}$ = 3.6 V to 5.5 V from 160 µA to 180 µA in *Electrical Characteristics* .....5

**Changes from Revision B (May 2013) to Revision C (July 2015)** — **Page**

- 添加了 *ESD 等级* 表和*特性说明*、*器件功能模式*、*应用和实施*、*电源相关建议*、*布局*、*器件和文档支持* 以及 *机械、封装和可订购信息* 部分.....1
- Added *Device Comparison* section and moved existing tables to this new section.....3
- Moved *Operating Temperature* parameter from *Electrical Characteristics* table to *Recommended Operating Conditions* table .....4
- Deleted *Parameter Definitions* section; definitions moved to new *Glossary* section.....33

**Changes from Revision A (August 2011) to Revision B (May 2013)** — **Page**

- 将整个数据表中的所有 1.8V 更改为 2.0V.....1
- Deleted the 1.8-V Typical Characteristics section.....8
- Changed X-axis for Figure 7-36, Power-Supply Current vs Power-Supply Voltage.....8
- Changed X-axis for Figure 7-37, Power-Down Current vs Power-Supply Voltage.....8

**Changes from Revision * (August, 2008) to Revision A (August, 2011)** — **Page**

- Changed specifications and test conditions for input low voltage parameter.....5
- Changed specifications and test conditions for input high voltage parameter.....5


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# 5 Device Comparison

表 5-1. Related Devices

| RELATED DEVICES | 16-BIT | 14-BIT | 12-BIT | 10-BIT | 8-BIT |
|---|---|---|---|---|---|
| Pin and Function Compatible | DAC8411 | DAC8311 | DAC7311 | DAC6311 | DAC5311 |

表 5-2. Relative Accuracy and Differential Nonlinearity

| DEVICE | MAXIMUM RELATIVE ACCURACY (LSB) | MAXIMUM DIFFERENTIAL NONLINEARITY (LSB) |
|---|---|---|
| DAC5311 | ±0.25 | ±0.25 |
| DAC6311 | ±0.5 | ±0.5 |
| DAC7311 | ±1 | ±1 |

# 6 Pin Configuration and Functions

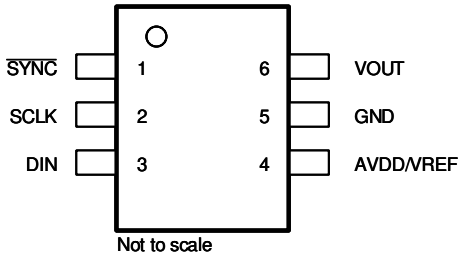


图 6-1. DCK Package, 6-Pin SC70 (Top View)

表 6-1. Pin Functions

| PIN | | TYPE | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| $AV_{DD}/V_{REF}$ | 4 | Input | Power supply input, 2.0 V to 5.5 V. |
| $D_{IN}$ | 3 | Input | Serial Data Input. Data are clocked into the 16-bit input shift register on the falling edge of the serial clock input. |
| GND | 5 | — | Ground reference point for all circuitry on the part. |
| SCLK | 2 | Input | Serial clock input. Data are transferred at rates up to 50 MHz. |
| $\overline{SYNC}$ | 1 | Input | Level-triggered control input (active low). This pin is the frame synchronization signal for the input data. When $\overline{SYNC}$ goes low, the input shift register is enabled and data are transferred in on the falling edges of the following clocks. The DAC is updated following 16th clock cycle, unless $\overline{SYNC}$ is taken high before this edge, in which case the rising edge of $\overline{SYNC}$ acts as an interrupt and the write sequence is ignored by the DACx311. See the *SYNC Interrupt* section for more details. |
| $V_{OUT}$ | 6 | Output | Analog output voltage from DAC. The output amplifier has rail-to-rail operation. |

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# 7 Specifications

## 7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| | Voltage | $AV_{DD}$ to GND | –0.3 | +6 | V |
| | | Digital input voltage to GND | –0.3 | $+AV_{DD}$ + 0.3 | V |
| | | $V_{OUT}$ to GND | –0.3 | $+AV_{DD}$ + 0.3 | V |
| $T_J$ | Junction temperature | | | 150 | °C |
| $T_{stg}$ | Storage temperature | | –65 | 150 | °C |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which 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 free-air temperature range (unless otherwise noted)

| | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
| $T_A$ | Operating temperature | –40 | | 125 | °C |
| $AV_{DD}$ | Supply voltage | 2 | | 5.5 | V |

## 7.4 Thermal Information

| THERMAL METRIC(1) | | DACx311 DCK (SC70) 6 PINS | UNIT |
|---|---|---|---|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 216.4 | °C/W |
| $R_{\theta JC(top)}$ | Junction-to-case (top) thermal resistance | 52.1 | °C/W |
| $R_{\theta JB}$ | Junction-to-board thermal resistance | 65.9 | °C/W |
| $\psi_{JT}$ | Junction-to-top characterization parameter | 1.3 | °C/W |
| $\psi_{JB}$ | Junction-to-board characterization parameter | 65.2 | °C/W |
| $R_{\theta JC(bot)}$ | Junction-to-case (bottom) thermal resistance | N/A | °C/W |

(1) For more information about traditional and new thermal metrics, see the application report, *Semiconductor and IC Package Thermal Metrics* application note.


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## 7.5 Electrical Characteristics

at $AV_{DD}$ = 2.0 V to 5.5 V, $R_L$ = 2 kΩ to GND, $C_L$ = 200 pF to GND, and $T_A$ = –40°C to +125°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **STATIC PERFORMANCE**(1) | | | | | | |
| DAC5311 | Resolution | | 8 | | | Bits |
| DAC6311 | | | 10 | | | Bits |
| DAC7311 | | | 12 | | | Bits |
| DAC5311 | Relative accuracy | Measured by the line passing through codes 3 and 252 | | ±0.01 | ±0.25 | LSB |
| DAC6311 | | Measured by the line passing through codes 12 and 1012 | | ±0.06 | ±0.5 | LSB |
| DAC7311 | | Measured by the line passing through codes 30 and 4050 | | ±0.3 | ±1 | LSB |
| DAC5311 | Differential nonlinearity | | | ±0.01 | ±0.25 | LSB |
| DAC6311 | | | | ±0.03 | ±0.5 | LSB |
| DAC7311 | | | | ±0.2 | ±1 | LSB |
| Offset error | | Measured by the line passing through two codes(2) | | ±0.05 | ±4 | mV |
| Offset error drift | | | | 3 | | µV/°C |
| Zero code error | | All zeros loaded to the DAC register | | 0.2 | | mV |
| Full-scale error | | All ones loaded to DAC register | | 0.04 | 0.2 | % of FSR |
| Gain error | | | | 0.05 | ±0.15 | % of FSR |
| Gain temperature coefficient | | $AV_{DD}$ = 5 V | | ±0.5 | | ppm of FSR/°C |
| | | $AV_{DD}$ = 2.0 V | | ±1.5 | | |
| **OUTPUT CHARACTERISTICS** | | | | | | |
| Output voltage range | | | 0 | | $AV_{DD}$ | V |
| Output voltage settling time(3) | | $R_L$ = 2 kΩ, $C_L$ = 200 pF, $AV_{DD}$ = 5 V, 1/4 scale to 3/4 scale | | 6 | 10 | µs |
| | | $R_L$ = 2 MΩ, $C_L$ = 470 pF | | 12 | | µs |
| Slew rate | | | | 0.7 | | V/µs |
| Capacitive load stability | | $R_L$ = ∞ | | 470 | | pF |
| | | $R_L$ = 2 kΩ | | 1000 | | pF |
| Code change glitch impulse | | 1 LSB change around major carry | | 0.5 | | nV-s |
| Digital feedthrough | | | | 0.5 | | nV-s |
| Power-on glitch impulse | | $R_L$ = 2 kΩ, $C_L$ = 200 pF, $AV_{DD}$ = 5 V | | 17 | | mV |
| DC output impedance | | | | 0.5 | | Ω |
| Short circuit current | | $AV_{DD}$ = 5 V | | 50 | | mA |
| | | $AV_{DD}$ = 3 V | | 20 | | mA |
| Power-up time | | Coming out of power-down mode | | 50 | | µs |
| **AC PERFORMANCE** | | | | | | |
| SNR | | $T_A$ = 25°C, BW = 20 kHz, 12-bit level, $AV_{DD}$ = 5 V, $f_{OUT}$ = 1 kHz, 1st 19 harmonics removed for SNR calculation | | 81 | | dB |
| THD | | | | –65 | | dB |
| SFDR | | | | 65 | | dB |
| SINAD | | | | 65 | | dB |

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## 7.5 Electrical Characteristics (continued)

at $AV_{DD}$ = 2.0 V to 5.5 V, $R_L$ = 2 kΩ to GND, $C_L$ = 200 pF to GND, and $T_A$ = –40°C to +125°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| DAC output noise density(4) | | $T_A$ = 25°C, at zero-scale input, $f_{OUT}$ = 1 kHz, $AV_{DD}$ = 5 V | | | 17 | | nV/√Hz |
| | | $T_A$ = 25°C, at mid-code input, $f_{OUT}$ = 1 kHz, $AV_{DD}$ = 5 V | | | 110 | | nV/√Hz |
| DAC output noise(5) | | $T_A$= +25°C, at mid-code input, 0.1 Hz to 10 Hz, $AV_{DD}$ = 5 V | | | 3 | | μ $V_{PP}$ |
| **LOGIC INPUTS**(3) | | | | | | | |
| Input current | | | | | | ±1 | μ A |
| $V_{IN}L$, Input low voltage | | $AV_{DD}$ = 2.7 V to 5.5 V | | | | 0.3 × $AV_{DD}$ | V |
| | | $AV_{DD}$ = 2.0 V to 2.7 V | | | | 0.1 × $AV_{DD}$ | V |
| $V_{IN}H$, Input high voltage | | $AV_{DD}$ = 2.7 V to 5.5 V | | 0.7 × $AV_{DD}$ | | | V |
| | | $AV_{DD}$ = 2.0 V to 2.7 V | | 0.9 × $AV_{DD}$ | | | V |
| Pin capacitance | | | | | 1.5 | 3 | pF |
| **POWER REQUIREMENTS** | | | | | | | |
| $AV_{DD}$ | | | | 2.0 | | 5.5 | V |
| $I_{DD}$ | Normal mode | $V_{IN}H$ = $AV_{DD}$ and $V_{IN}L$ = GND, at midscale code(6) | $AV_{DD}$ = 3.6 V to 5.5 V | | 110 | 180 | μ A |
| | | | $AV_{DD}$ = 2.7 V to 3.6 V | | 95 | 150 | μ A |
| | | | $AV_{DD}$ = 2.0 V to 2.7 V | | 80 | 140 | μ A |
| | All power-down mode | $V_{IN}H$ = $AV_{DD}$ and $V_{IN}L$ = GND, at midscale code(6) | $AV_{DD}$ = 3.6 V to 5.5 V | | 0.5 | 3.5 | μ A |
| | | | $AV_{DD}$ = 2.7 V to 3.6 V | | 0.4 | 3 | μ A |
| | | | $AV_{DD}$ = 2.0 V to 2.7 V | | 0.1 | 2 | μ A |
| Power dissipation | Normal mode | $V_{IN}H$ = $AV_{DD}$ and $V_{IN}L$ = GND, at midscale code(6) | $AV_{DD}$ = 3.6 V to 5.5 V | | 0.55 | 0.99 | mW |
| | | | $AV_{DD}$ = 2.7 V to 3.6 V | | 0.25 | 0.54 | mW |
| | | | $AV_{DD}$ = 2.0 V to 2.7 V | | 0.14 | 0.38 | mW |
| | All power-down mode | $V_{IN}H$ = $AV_{DD}$ and $V_{IN}L$ = GND, at midscale code(6) | $AV_{DD}$ = 3.6 V to 5.5 V | | 2.50 | 19.2 | μW |
| | | | $AV_{DD}$ = 2.7 V to 3.6 V | | 1.08 | 10.8 | μW |
| | | | $AV_{DD}$ = 2.0 V to 2.7 V | | 0.72 | 8.1 | μW |

(1) Linearity calculated using a reduced code range of 3 to 252 for 8-bit, 12 to 1012 for 10bit, and 30 to 4050 for 12-bit, output unloaded.
(2) Straight line passing through codes 3 and 252 for 8-bit, 12 and 1012 for 10-bit, and 30 and 4050 for 12-bit, output unloaded.
(3) Specified by design and characterization, not production tested.
(4) For more details, see 图 7-23.
(5) For more details, see 图 7-24.
(6) For more details, see 图 7-16 and 图 7-58.


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## 7.6 Timing Requirements

at –40°C to 125°C, and $AV_{DD}$ = 2 V to 5.5 V (unless otherwise noted)(1)

| | | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|---|
| $f_{(SCLK)}$ | Serial clock frequency | $AV_{DD}$ = 2.0 V to 3.6 V | | | 20 | MHz |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | | | 50 | |
| $t_1$ | SCLK cycle time | $AV_{DD}$ = 2.0 V to 3.6 V | 50 | | | ns |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | 20 | | | |
| $t_2$ | SCLK high time | $AV_{DD}$ = 2.0 V to 3.6 V | 25 | | | ns |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | 10 | | | |
| $t_3$ | SCLK low time | $AV_{DD}$ = 2.0 V to 3.6 V | 25 | | | ns |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | 10 | | | |
| $t_4$ | $\overline{SYNC}$ to SCLK rising edge setup time | $AV_{DD}$ = 2.0 V to 3.6 V | 0 | | | ns |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | 0 | | | |
| $t_5$ | Data setup time | $AV_{DD}$ = 2.0 V to 3.6 V | 5 | | | ns |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | 5 | | | |
| $t_6$ | Data hold time | $AV_{DD}$ = 2.0 V to 3.6 V | 4.5 | | | ns |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | 4.5 | | | |
| $t_7$ | SCLK falling edge to $\overline{SYNC}$ rising edge | $AV_{DD}$ = 2.0 V to 3.6 V | 0 | | | ns |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | 0 | | | |
| $t_8$ | Minimum $\overline{SYNC}$ high time | $AV_{DD}$ = 2.0 V to 3.6 V | 50 | | | ns |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | 20 | | | |
| $t_9$ | 16th SCLK falling edge to $\overline{SYNC}$ falling edge | $AV_{DD}$ = 2.0 V to 3.6 V | 100 | | | ns |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | 100 | | | |
| $t_{10}$ | $\overline{SYNC}$ rising edge to 16th SCLK falling edge (for successful $\overline{SYNC}$ interrupt) | $AV_{DD}$ = 2.0 V to 3.6 V | 15 | | | ns |
| | | $AV_{DD}$ = 3.6 V to 5.5 V | 15 | | | |

(1) All input signals are specified with $t_R = t_F$ = 3 ns (10% to 90% of $AV_{DD}$) and timed from a voltage level of $(V_{IL} + V_{IH}) / 2$.

## 7.7 Timing Diagrams

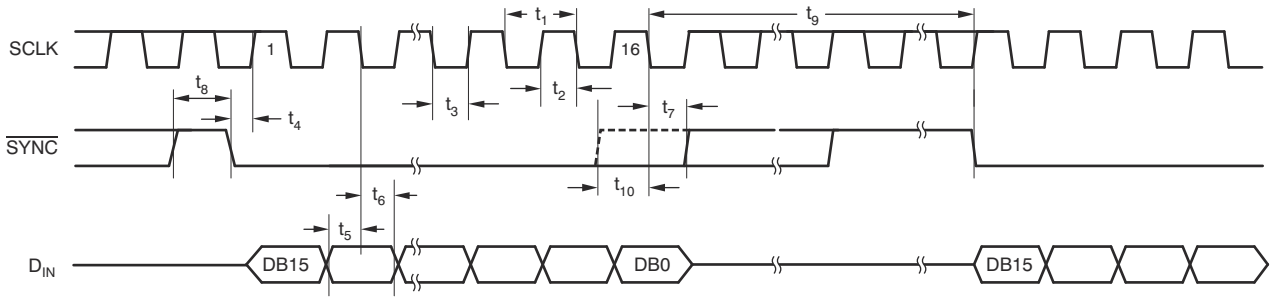


**图 7-1. Serial Write Operation**

## 7.8 Typical Characteristics: $AV_{DD}$ = 5 V

at $T_A$ = 25°C, $AV_{DD}$ = 5 V, and DAC loaded with midscale code (unless otherwise noted)

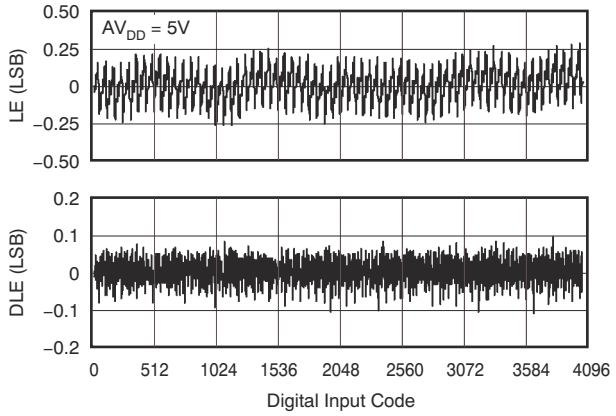


**图 7-2. DAC7311 12-Bit Linearity Error and Differential Linearity Error vs Code ( – 40°C)**

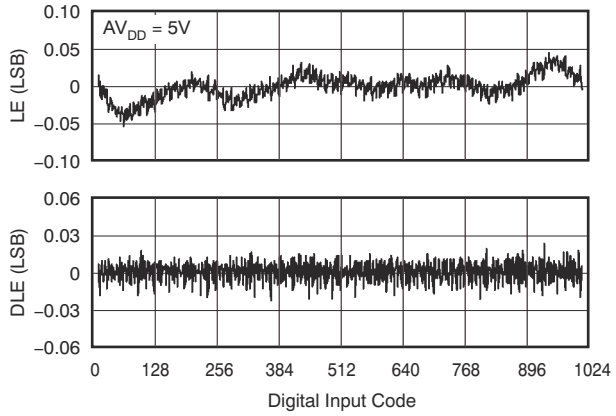


**图 7-3. DAC6311 10-Bit Linearity Error and Differential Linearity Error vs Code ( – 40°C)**

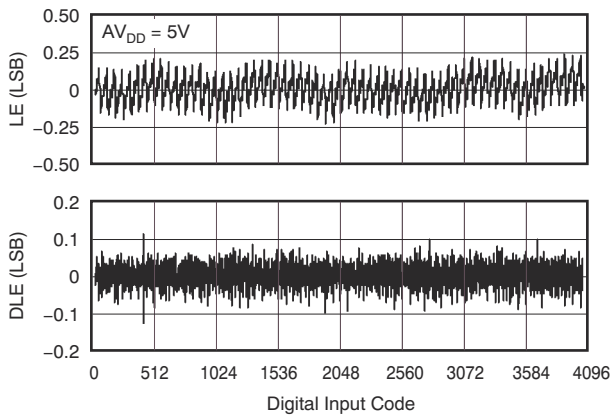


**图 7-4. DAC7311 12-Bit Linearity Error and Differential Linearity Error vs Code (25°C)**

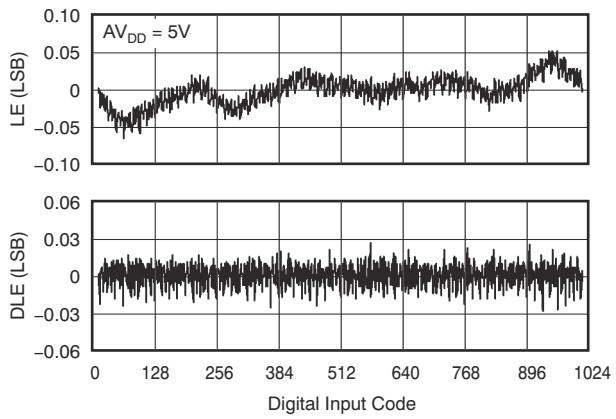


**图 7-5. DAC6311 10-Bit Linearity Error and Differential Linearity Error vs Code (25°C)**

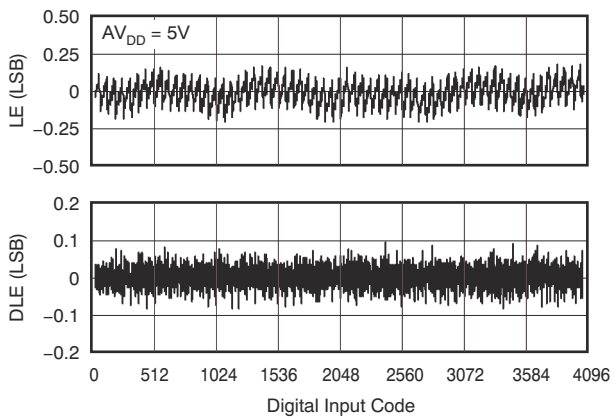


**图 7-6. DAC7311 12-Bit Linearity Error and Differential Linearity Error vs Code (125°C)**

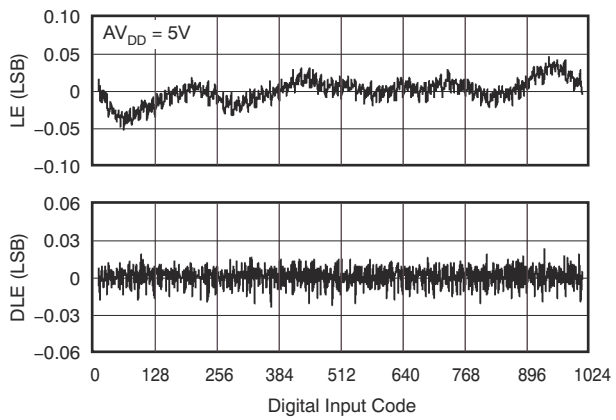


**图 7-7. DAC6311 10-Bit Linearity Error and Differential Linearity Error vs Code (125°C)**


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## 7.8 Typical Characteristics: $AV_{DD}$ = 5 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 5 V, and DAC loaded with midscale code (unless otherwise noted)

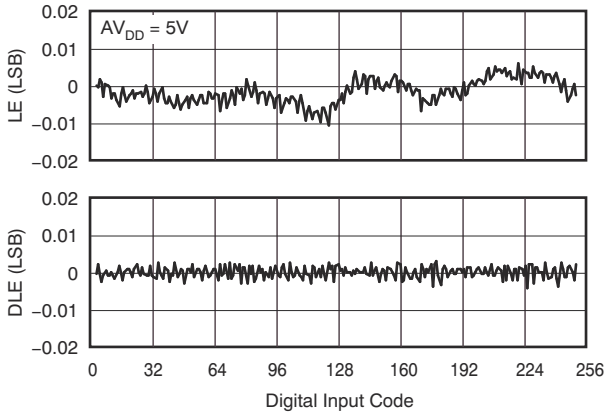


**图 7-8. DAC5311 8-Bit Linearity Error and Differential Linearity Error vs Code ( – 40°C)**

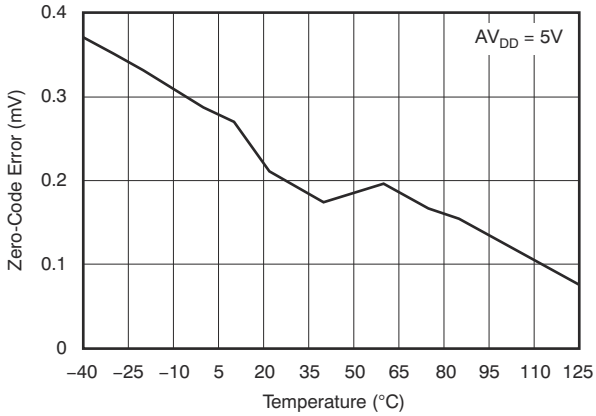


**图 7-9. Zero-Code Error vs Temperature**

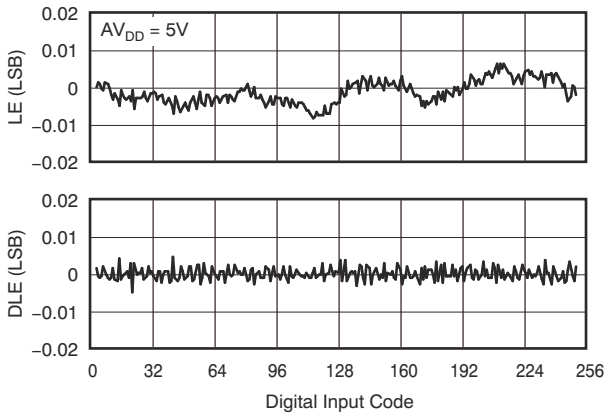


**图 7-10. DAC5311 8-Bit Linearity Error and Differential Linearity Error vs Code (25°C)**

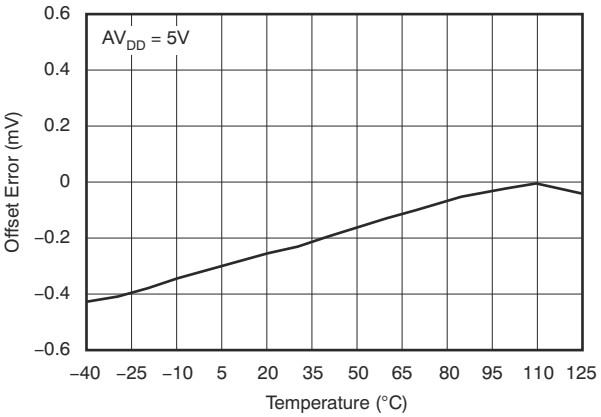


**图 7-11. Offset Error vs Temperature**

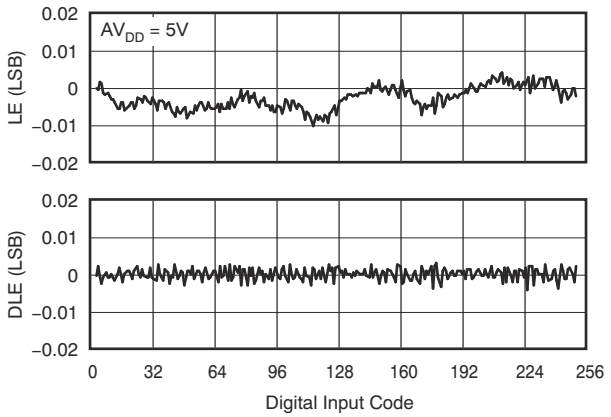


**图 7-12. DAC5311 8-Bit Linearity Error and Differential Linearity Error vs Code (125°C)**

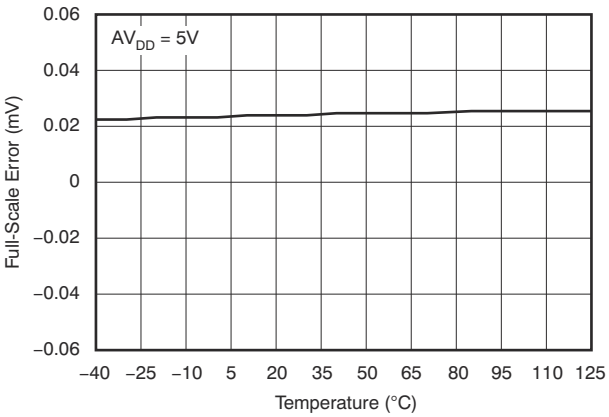


**图 7-13. Full-Scale Error vs Temperature**

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## 7.8 Typical Characteristics: $AV_{DD}$ = 5 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 5 V, and DAC loaded with midscale code (unless otherwise noted)

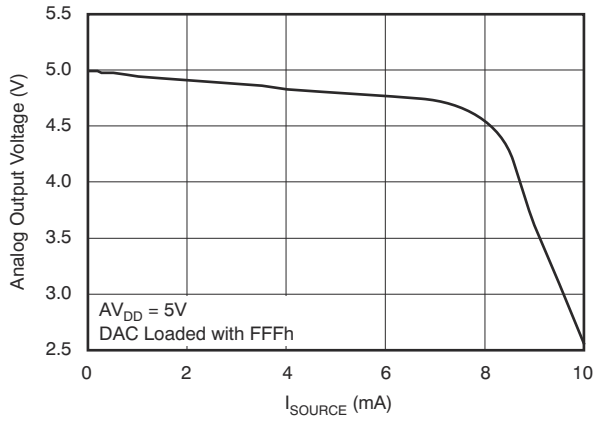


图 7-14. Source Current at Positive Rail

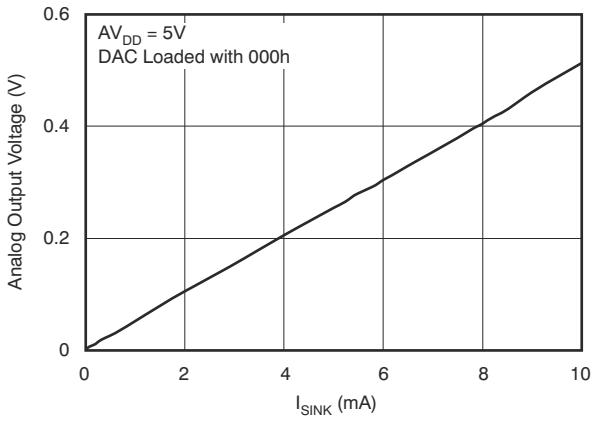


图 7-15. Sink Current at Negative Rail

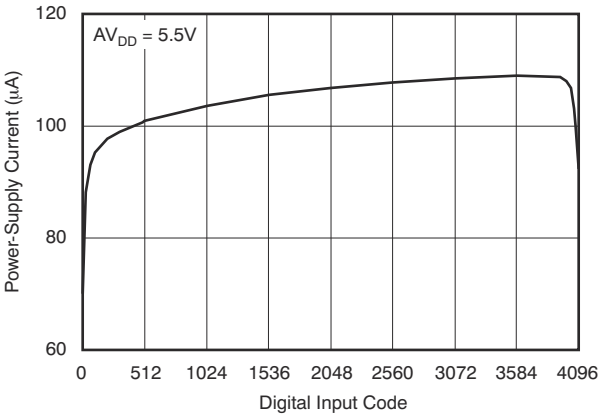


图 7-16. Power-Supply Current vs Digital Input Code

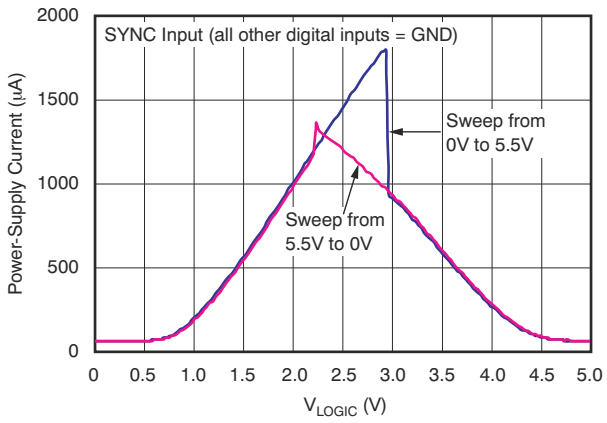


图 7-17. Power-Supply Current vs Logic Input Voltage

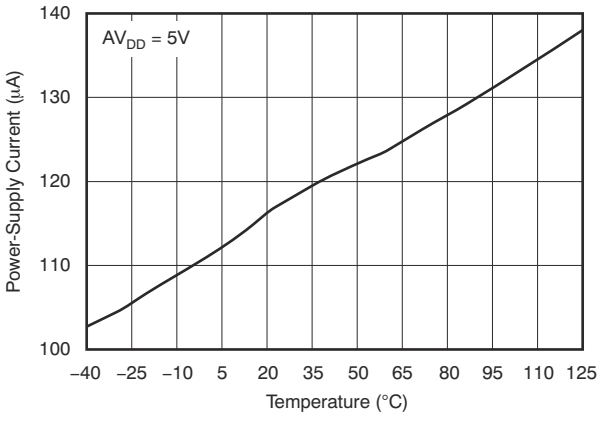


图 7-18. Power-Supply Current vs Temperature

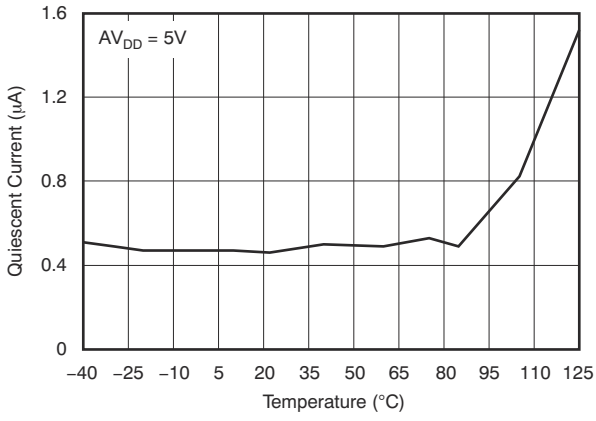


图 7-19. Power-Down Current vs Temperature


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## 7.8 Typical Characteristics: $AV_{DD}$ = 5 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 5 V, and DAC loaded with midscale code (unless otherwise noted)

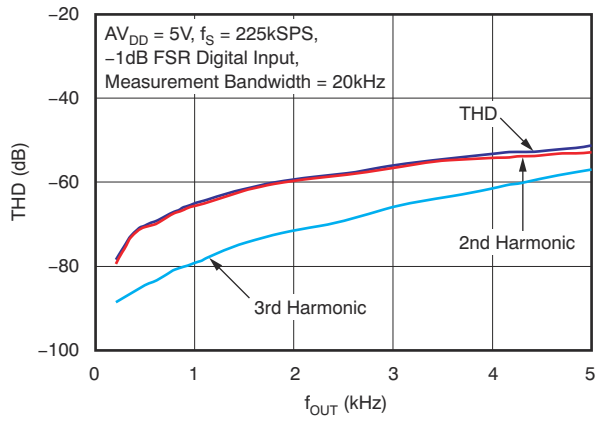


图 7-20. Total Harmonic Distortion vs Output Frequency

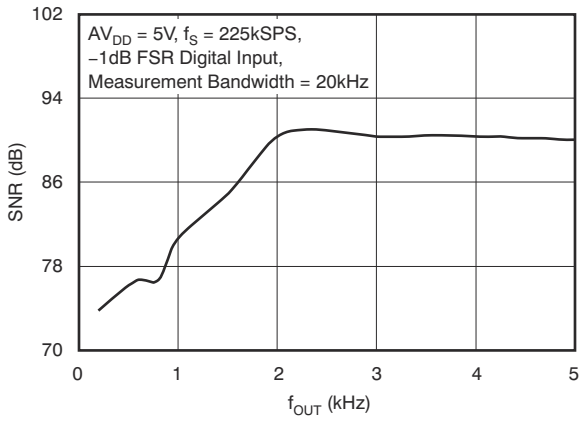


图 7-21. Signal-to-Noise Ratio vs Output Frequency

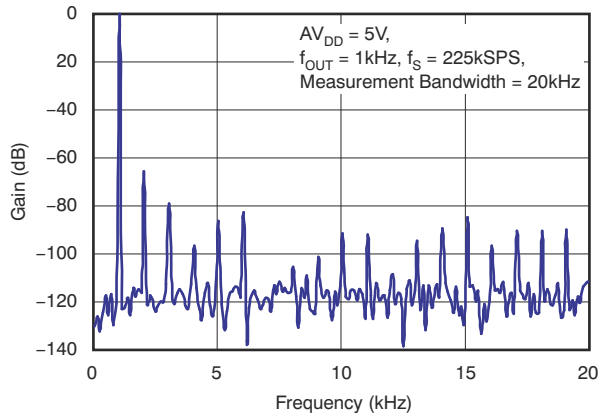


图 7-22. Power Spectral Density

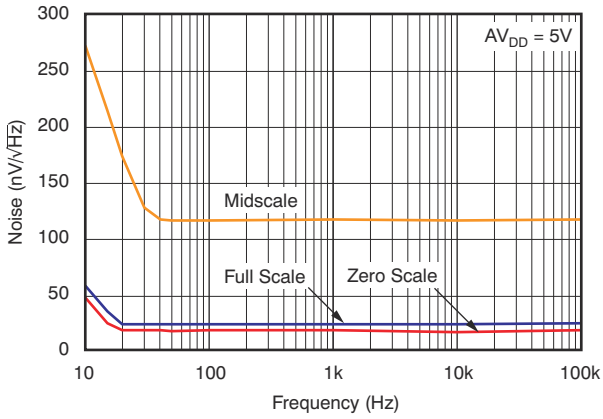


图 7-23. DAC Output Noise Density vs Frequency

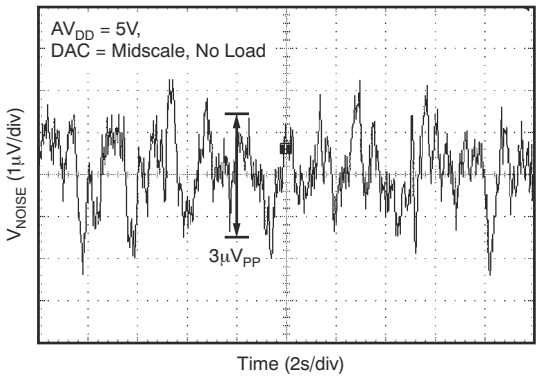


图 7-24. DAC Output Noise, 0.1-Hz to 10-Hz Bandwidth

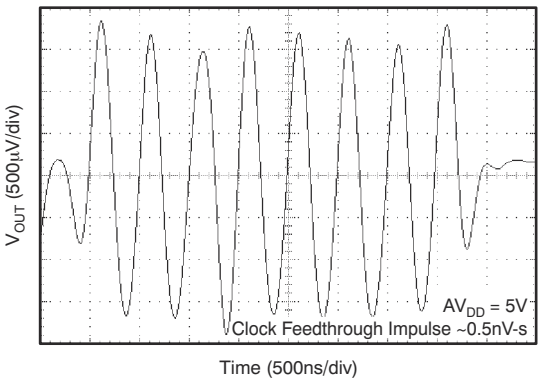


图 7-25. Clock Feedthrough, 5-V, 2-MHz, Midscale

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## 7.8 Typical Characteristics: $AV_{DD}$ = 5 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 5 V, and DAC loaded with midscale code (unless otherwise noted)

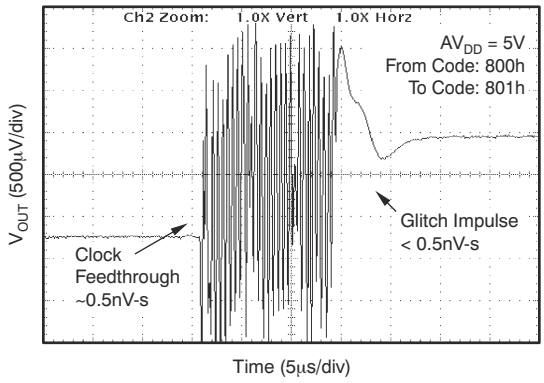


图 7-26. Glitch Energy, 5-V, 12-Bit, 1-LSB Step, Rising Edge

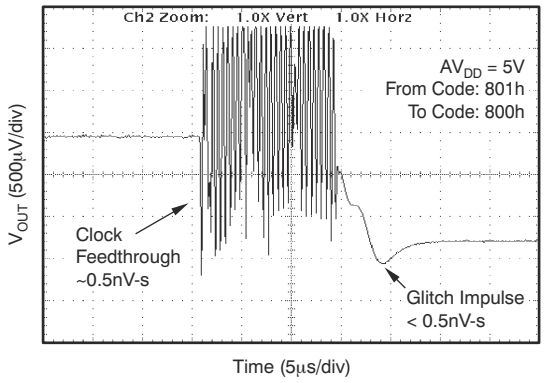


图 7-27. Glitch Energy, 5-V, 12-Bit, 1-LSB Step, Falling Edge

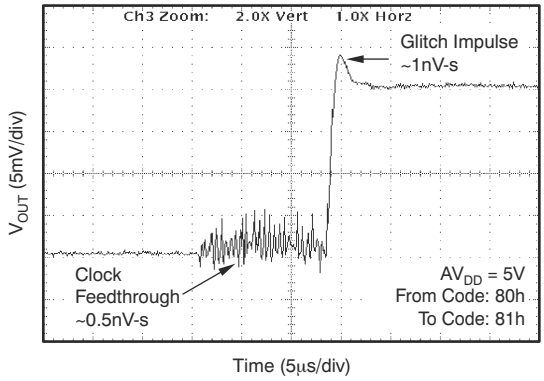


图 7-28. Glitch Energy, 5-V, 8-Bit, 1-LSB Step, Rising Edge

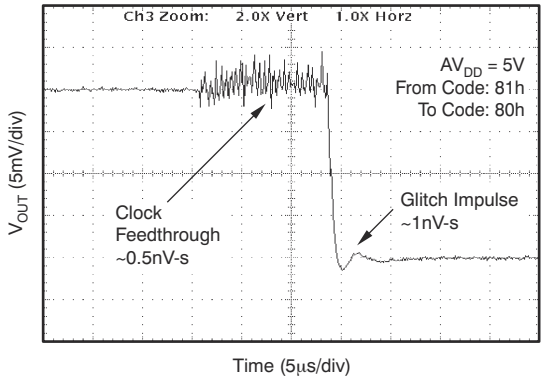


图 7-29. Glitch Energy, 5-V, 8-Bit, 1-LSB Step, Falling Edge

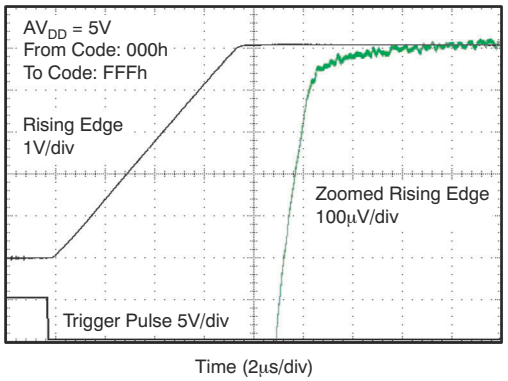


图 7-30. Full-Scale Settling Time, 5-V Rising Edge

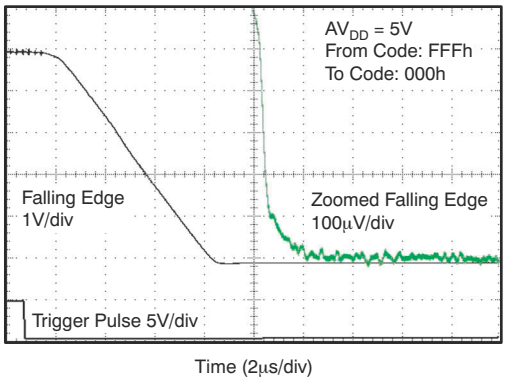


图 7-31. Full-Scale Settling Time, 5-V Falling Edge


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## 7.8 Typical Characteristics: $AV_{DD}$ = 5 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 5 V, and DAC loaded with midscale code (unless otherwise noted)

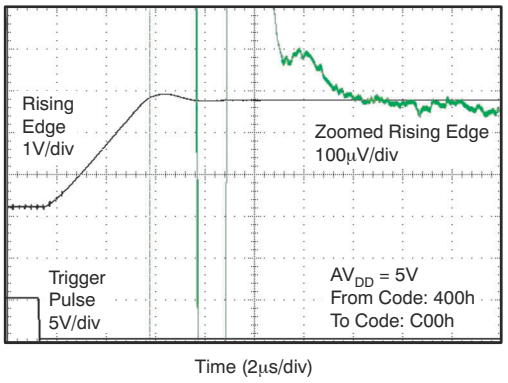


图 7-32. Half-Scale Settling Time, 5-V Rising Edge

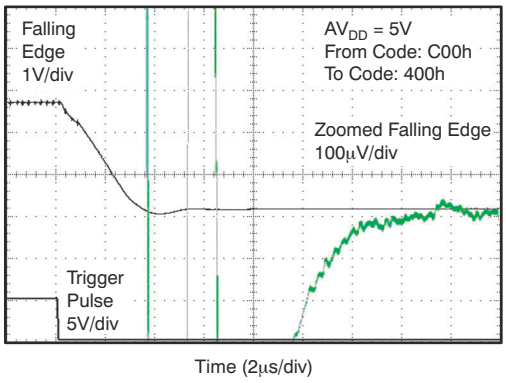


图 7-33. Half-Scale Settling Time 5-V Falling Edge

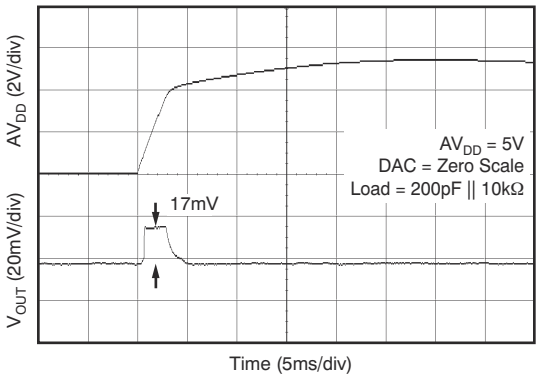


图 7-34. Power-On Reset to 0-V Power-On Glitch

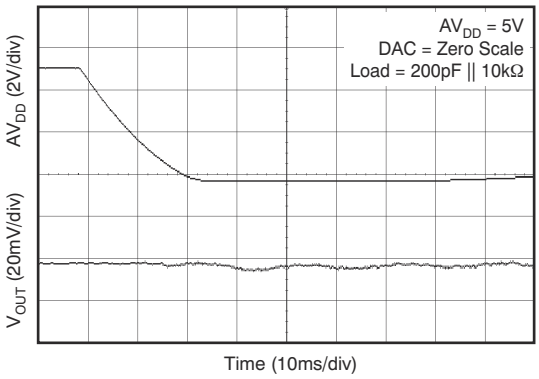


图 7-35. Power-Off Glitch

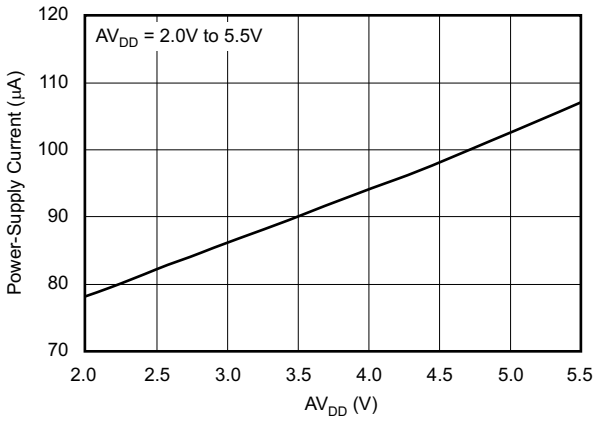


图 7-36. Power-Supply Current vs Power-Supply Voltage

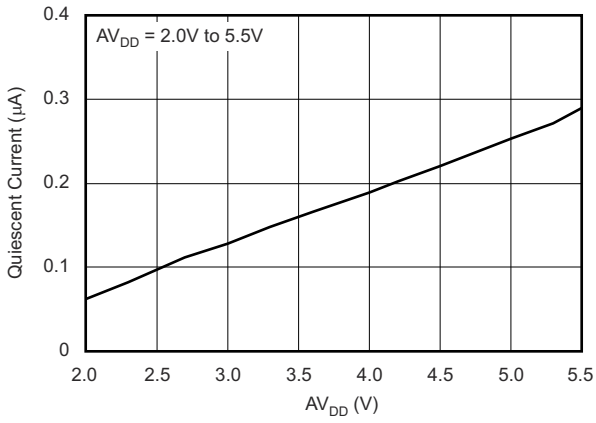


图 7-37. Power-Down Current vs Power-Supply Voltage

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## 7.8 Typical Characteristics: $AV_{DD}$ = 5 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 5 V, and DAC loaded with midscale code (unless otherwise noted)

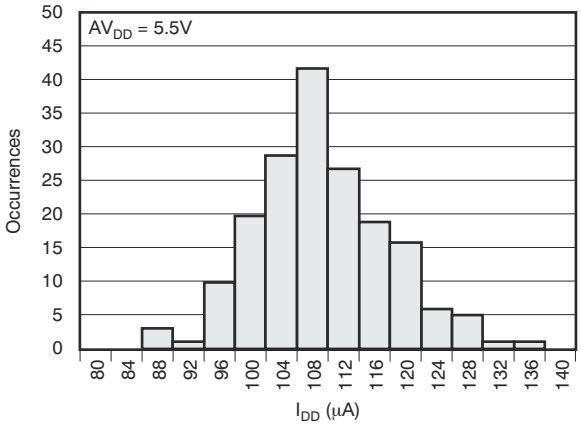


**图 7-38. Power-Supply Current Histogram**


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## 7.9 Typical Characteristics: $AV_{DD}$ = 3.6 V

at $T_A$ = 25°C, $AV_{DD}$ = 3.6 V, and DAC loaded with midscale code (unless otherwise noted)

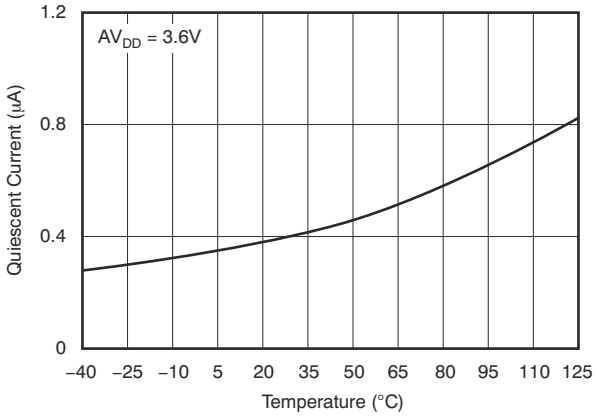


图 7-39. Power-Down Current vs Temperature

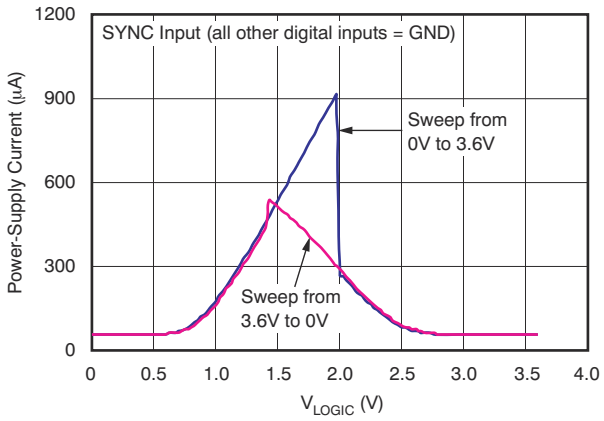


图 7-40. Power-Supply Current vs Logic Input Voltage

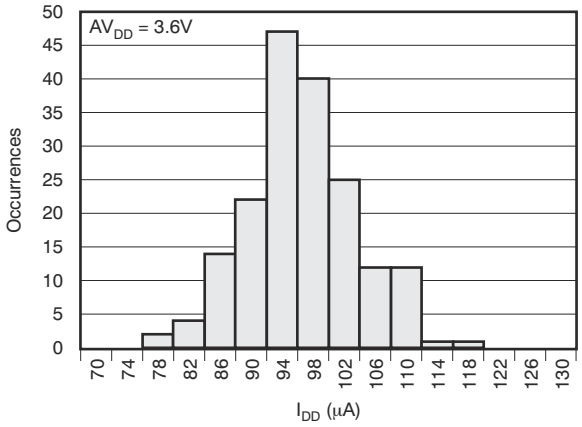


图 7-41. Power-Supply Current Histogram

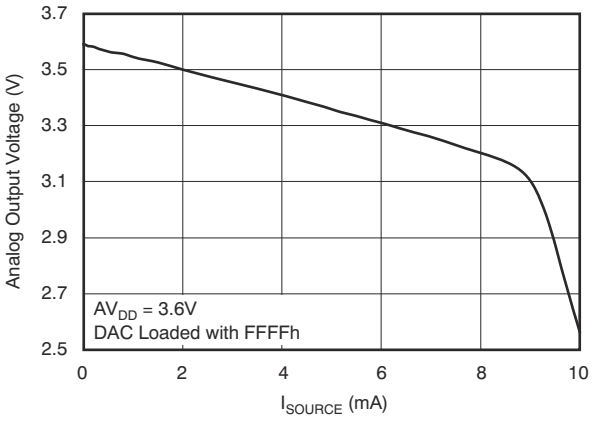


图 7-42. Source Current at Positive Rail

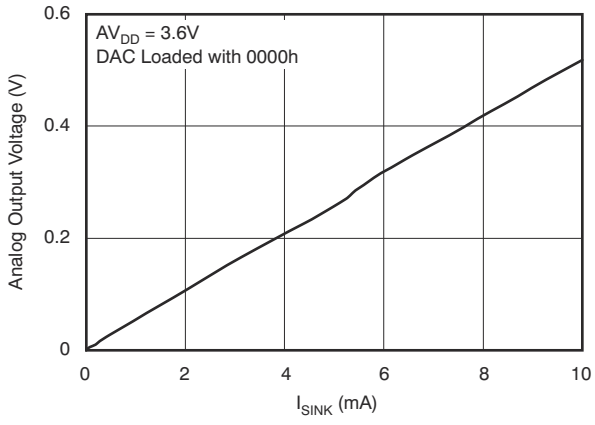


图 7-43. Sink Current at Negative Rail

## 7.10 Typical Characteristics: $AV_{DD}$ = 2.7 V

at $T_A$ = 25°C, $AV_{DD}$ = 2.7 V, and DAC loaded with midscale code (unless otherwise noted)

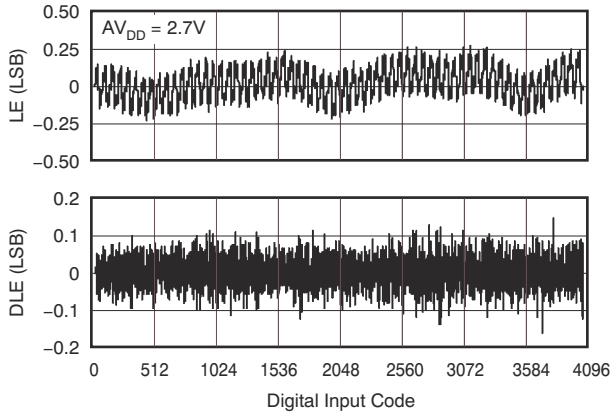


**图 7-44. DAC7311 12-Bit Linearity Error and Differential Linearity Error vs Code ( – 40°C)**

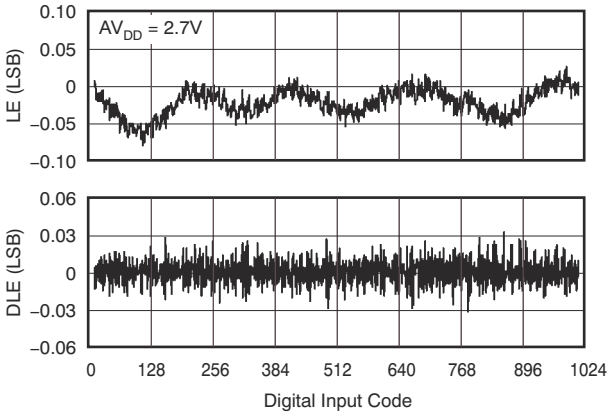


**图 7-45. DAC6311 10-Bit Linearity Error and Differential Linearity Error vs Code ( – 40°C)**

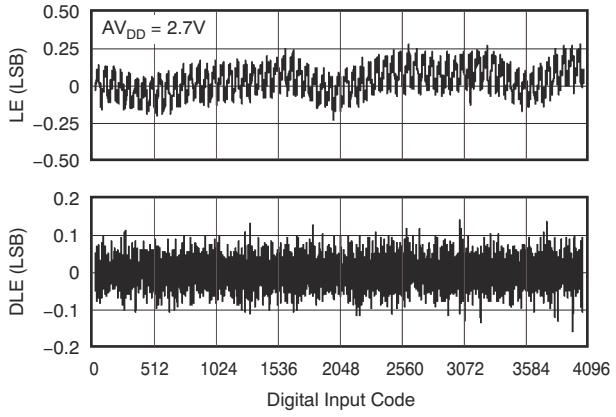


**图 7-46. DAC7311 12-Bit Linearity Error and Differential Linearity Error vs Code (25°C)**

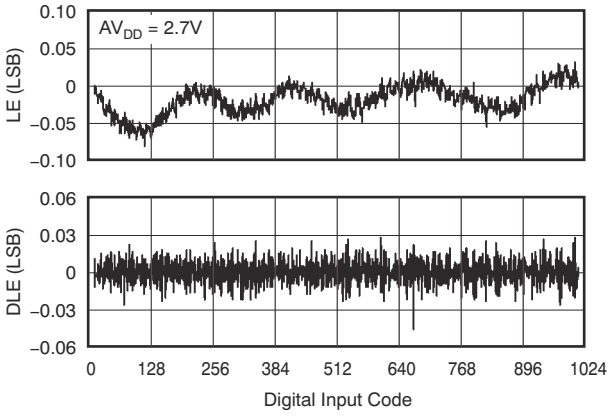


**图 7-47. DAC6311 10-Bit Linearity Error and Differential Linearity Error vs Code (25°C)**

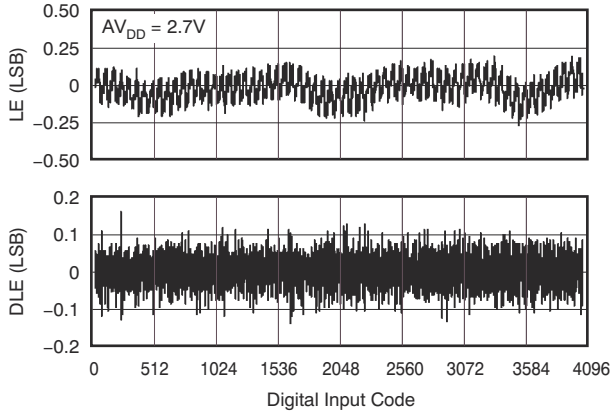


**图 7-48. DAC7311 12-Bit Linearity Error and Differential Linearity Error vs Code (125°C)**

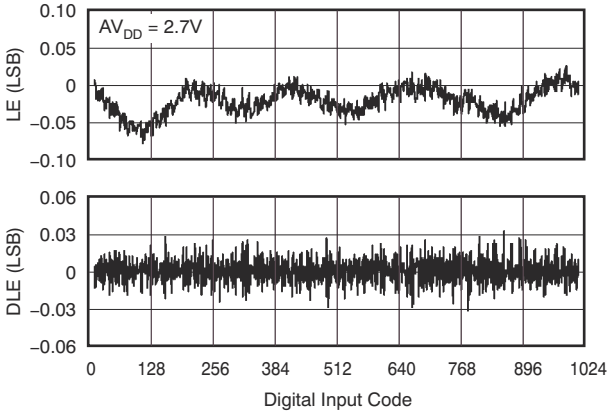


**图 7-49. DAC6311 10-Bit Linearity Error and Differential Linearity Error vs Code (125°C)**


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## 7.10 Typical Characteristics: $AV_{DD}$ = 2.7 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 2.7 V, and DAC loaded with midscale code (unless otherwise noted)

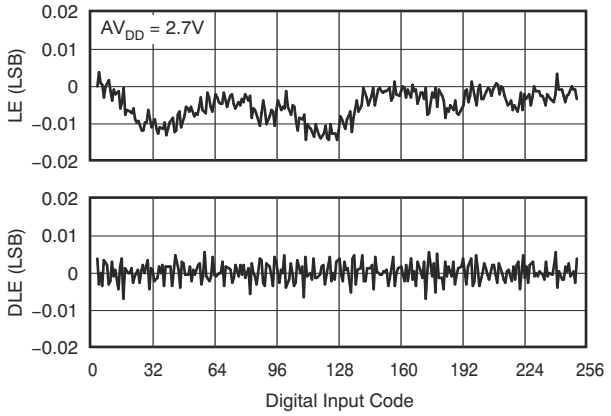


图 7-50. DAC5311 8-Bit Linearity Error and Differential Linearity Error vs Code ( – 40°C)

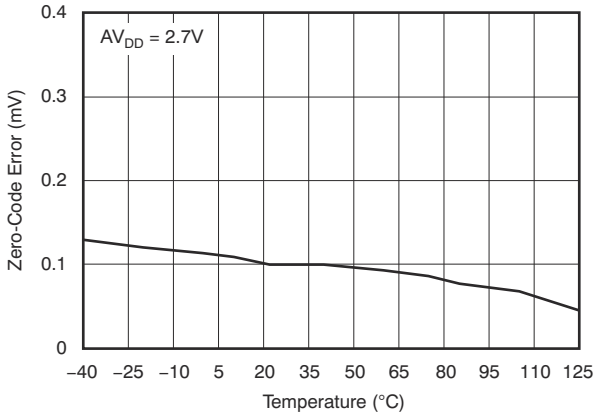


图 7-51. Zero-Code Error vs Temperature

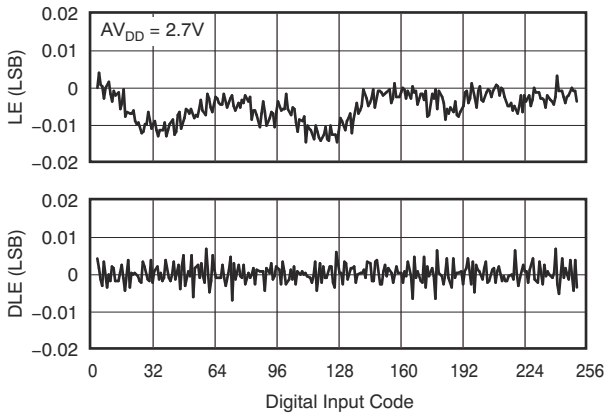


图 7-52. DAC5311 8-Bit Linearity Error and Differential Linearity Error vs Code (25°C)

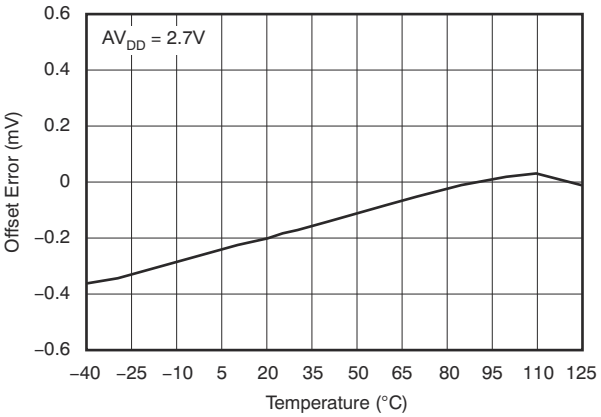


图 7-53. Offset Error vs Temperature

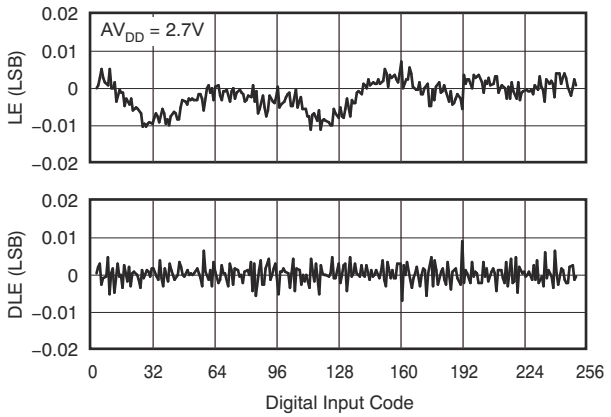


图 7-54. DAC5311 8-Bit Linearity Error and Differential Linearity Error vs Code (125°C)

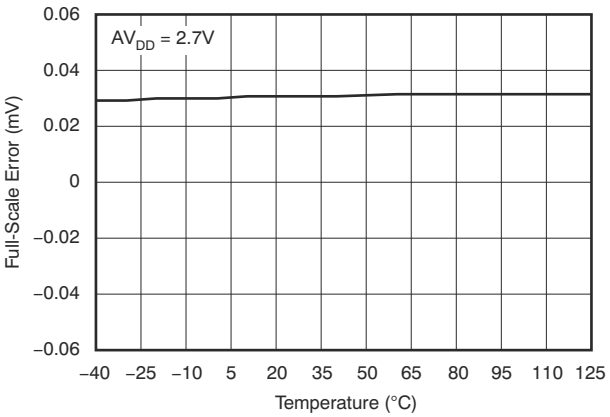


图 7-55. Full-Scale Error vs Temperature

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## 7.10 Typical Characteristics: $AV_{DD}$ = 2.7 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 2.7 V, and DAC loaded with midscale code (unless otherwise noted)

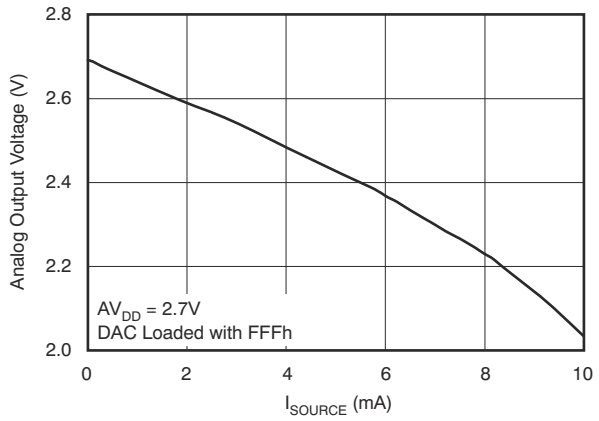


图 7-56. Source Current at Positive Rail

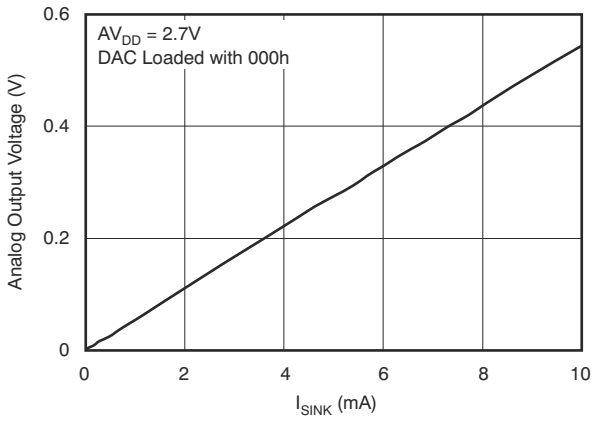


图 7-57. Sink Current at Negative Rail

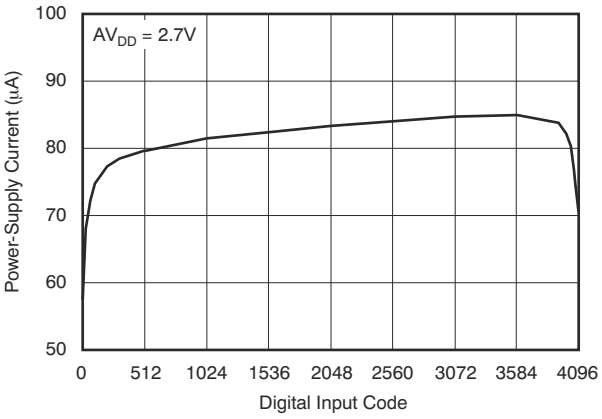


图 7-58. Power-Supply Current vs Digital Input Code

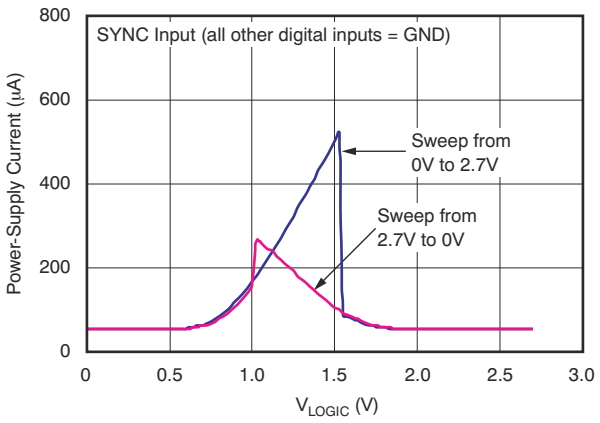


图 7-59. Power-Supply Current vs Logic Input Voltage

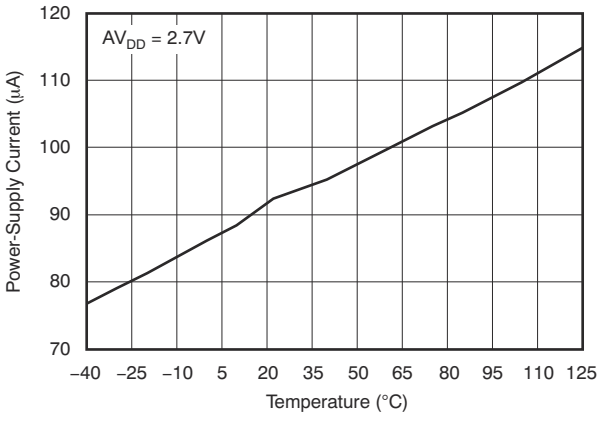


图 7-60. Power-Supply Current vs Temperature

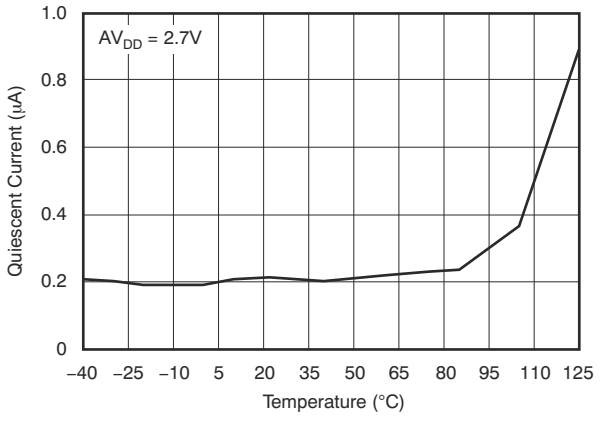


图 7-61. Power-Down Current vs Temperature


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## 7.10 Typical Characteristics: $AV_{DD}$ = 2.7 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 2.7 V, and DAC loaded with midscale code (unless otherwise noted)

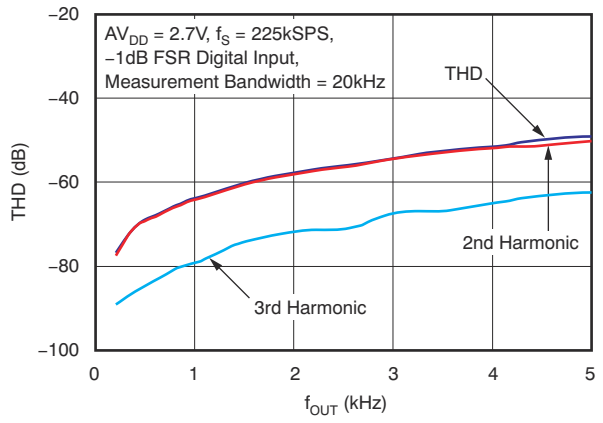


图 7-62. Total Harmonic Distortion vs Output Frequency

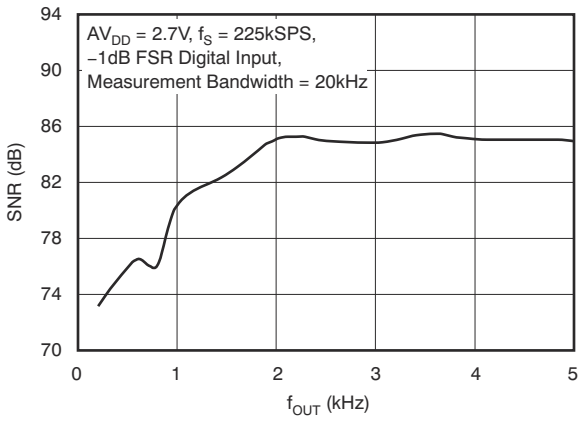


图 7-63. Signal-to-Noise Ratio vs Output Frequency

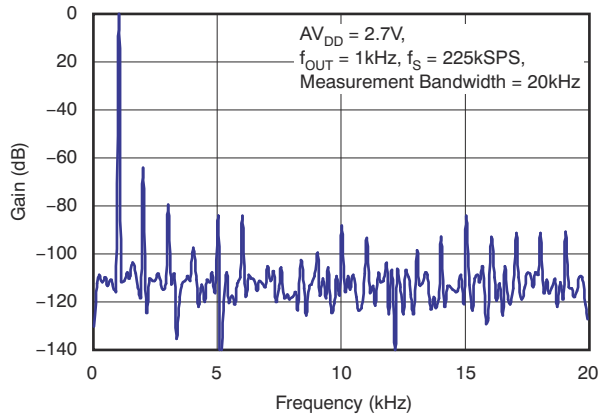


图 7-64. Power Spectral Density

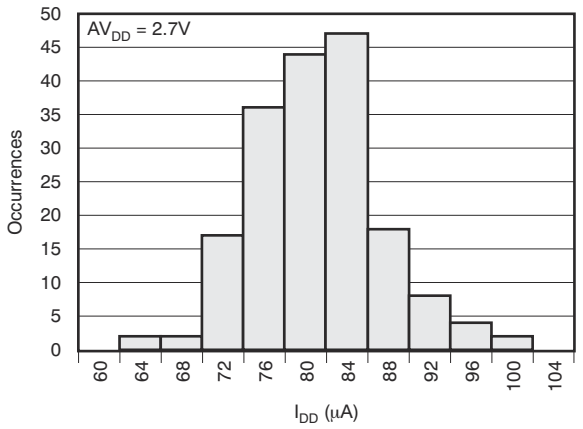


图 7-65. Power-Supply Current Histogram

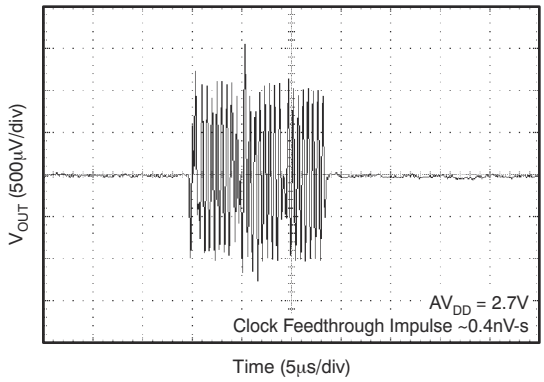


图 7-66. Clock Feedthrough 2.7-V, 20-MHz, Midscale

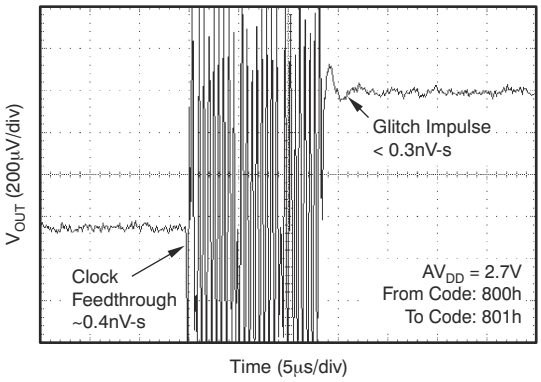


图 7-67. Glitch Energy, 2.7-V, 12-Bit, 1-LSB Step, Rising Edge

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## 7.10 Typical Characteristics: $AV_{DD}$ = 2.7 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 2.7 V, and DAC loaded with midscale code (unless otherwise noted)

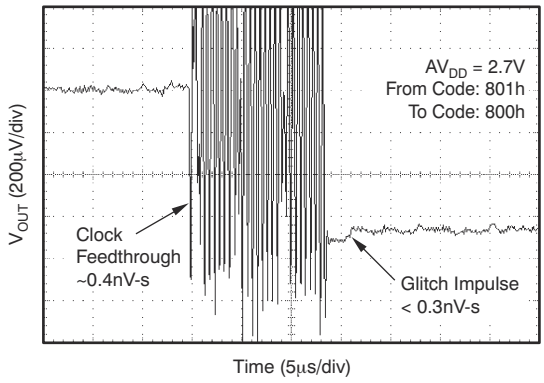


图 7-68. Glitch Energy, 2.7-V, 12-Bit, 1-LSB Step, Falling Edge

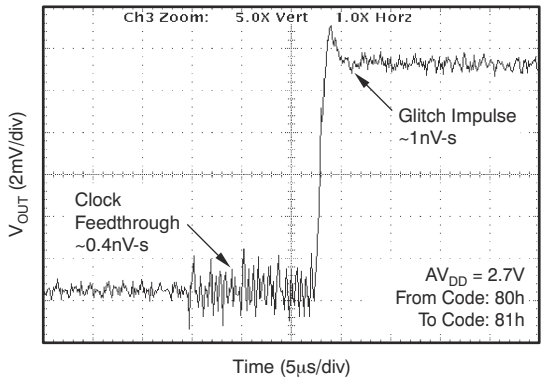


图 7-69. Glitch Energy, 2.7-V, 8-Bit, 1-LSB Step, Rising Edge

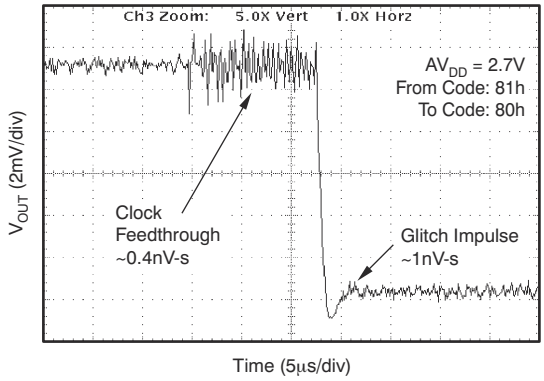


图 7-70. Glitch Energy, 2.7-V, 8-Bit, 1-LSB Step, Falling Edge

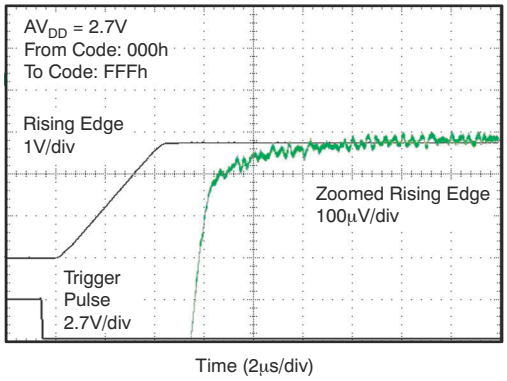


图 7-71. Full-Scale Settling Time, 2.7-V Rising Edge

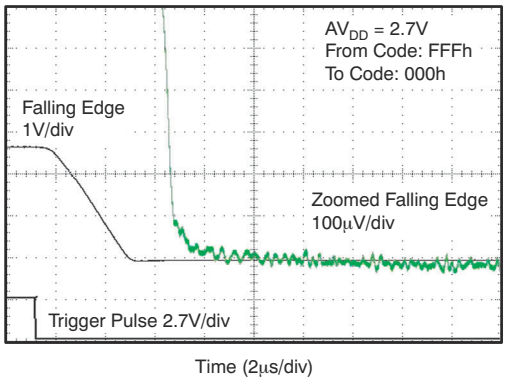


图 7-72. Full-Scale Settling Time, 2.7-V Falling Edge

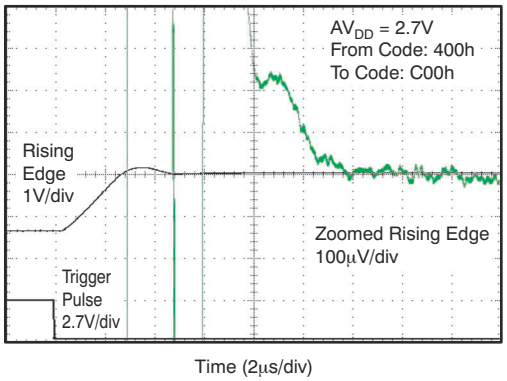


图 7-73. Half-Scale Settling Time, 2.7-V Rising Edge


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## 7.10 Typical Characteristics: $AV_{DD}$ = 2.7 V (continued)

at $T_A$ = 25°C, $AV_{DD}$ = 2.7 V, and DAC loaded with midscale code (unless otherwise noted)

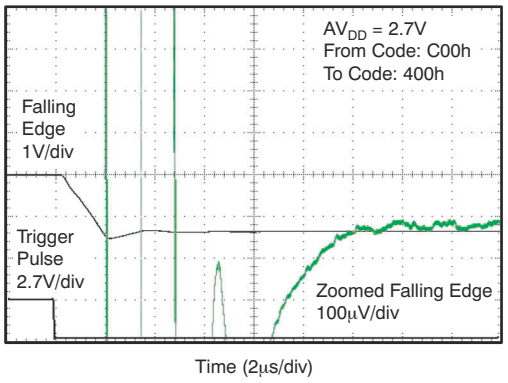



图 7-74. Half-Scale Settling Time, 2.7-V Falling Edge

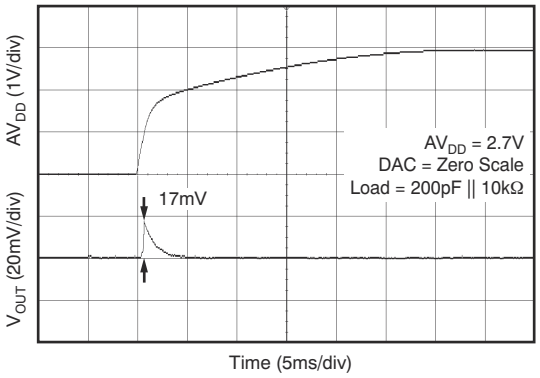



图 7-75. Power-On Reset to 0-V Power-On Glitch

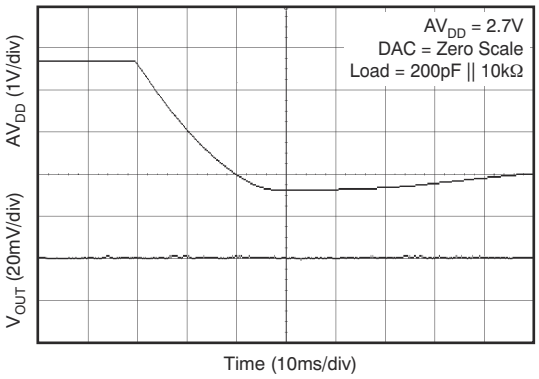


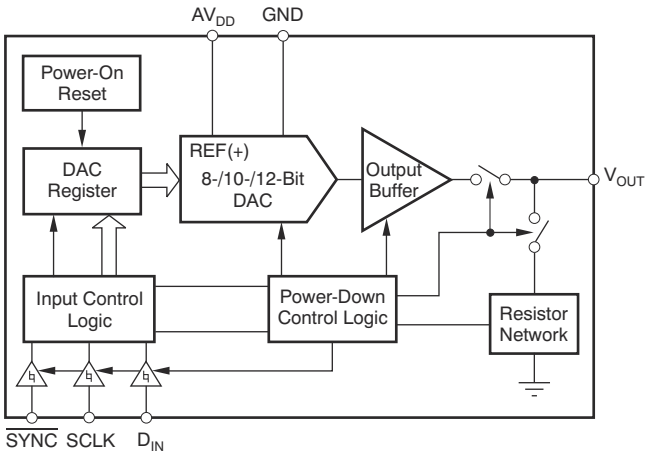

图 7-76. Power-Off Glitch

# 8 Detailed Description

## 8.1 Overview

The 8-bit DAC5311, 10-bit DAC6311, and 12-bit DAC7311 devices (DACx311) are low-power, single-channel, voltage output DACs. These devices are monotonic by design, provide excellent linearity, and minimize undesired code-to-code transient voltages while offering an easy upgrade path within a pin-compatible family. All devices use a versatile, three-wire serial interface that operates at clock rates of up to 50 MHz and is compatible with standard SPI, QSPI, Microwire, and digital signal processor (DSP) interfaces.

## 8.2 Functional Block Diagram




## 8.3 Feature Description

### 8.3.1 DAC Section

The DACx311 are fabricated using Texas Instruments' proprietary HPA07 process technology. The architecture consists of a string DAC followed by an output buffer amplifier. Because there is no reference input pin, the power supply ($AV_{DD}$) acts as the reference. 图 8-1 shows a block diagram of the DAC architecture.

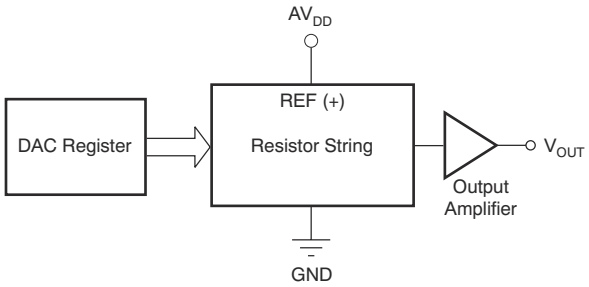



**图 8-1. DACx311 Architecture**

The input coding to the DACx311 is straight binary, so the ideal output voltage is given by:

$$V_{OUT} = AV_{DD} \times \frac{D}{2^n} \quad (1)$$

where

- n = resolution in bits; either 8 (DAC5311), 10 (DAC6311), or 12 (DAC7311).
- D = decimal equivalent of the binary code that is loaded to the DAC register. D ranges from 0 to 255 for 8-bit DAC5311, 0 to 1023 for the 10-bit DAC6311, and 0 to 4095 for the 12-bit DAC7311.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### 8.3.2 Resistor String

图 8-2 shows the resistor string section, which is 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 is inherently monotonic.

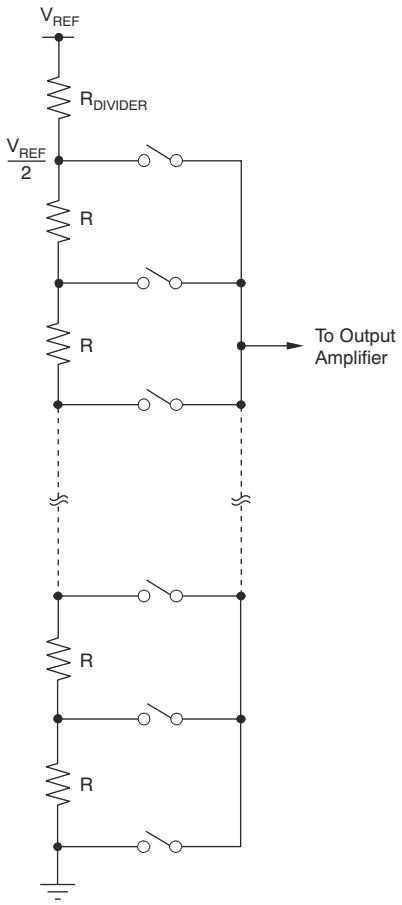


**图 8-2. Resistor String**

### 8.3.3 Output Amplifier

The output buffer amplifier is capable of generating rail-to-rail voltages on the output, which gives an output range of 0 V to $AV_{DD}$. The output amplifier is capable of driving a load of 2 kΩ in parallel with 1000 pF to GND. The source and sink capabilities of the output amplifier can be seen in the *Typical Characteristics* section for the given voltage input. The slew rate is 0.7 V/μs with a half-scale settling time of typically 6 μs with the output unloaded.

### 8.3.4 Power-On Reset

The DACx311 contain a power-on reset circuit that controls the output voltage during power up. On power up, the DAC register is filled with zeros and the output voltage is 0 V. The DAC register remains that way until a valid write sequence is made to the DAC. This design is useful in applications where knowing the state of the DAC output while powering up is important.

The occurring power-on glitch impulse is only a few millivolts (typically, 17 mV; see 图 7-34).

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## 8.4 Device Functional Modes

### 8.4.1 Power-Down Modes

The DACx311 contain four separate modes of operation. These modes are programmable by setting two bits (PD1 and PD0) in the control register. 表 8-1 shows how the state of the bits corresponds to the mode of operation of the device.

**表 8-1. Modes of Operation for the DACx311**

| PD1 | PD0 | OPERATING MODE |
|---|---|---|
| **NORMAL MODE** | | |
| 0 | 0 | Normal Operation |
| **POWER-DOWN MODES** | | |
| 0 | 1 | Output 1 kΩ to GND |
| 1 | 0 | Output 100 kΩ to GND |
| 1 | 1 | High-Z |

When both bits are set to 0, the device works normally with a standard power consumption of typically 80 μA at 2 V. However, for the three power-down modes, the typical supply current falls to 0.5 μA at 5 V, 0.4 μA at 3 V, and 0.1 μA at 2 V. Not only does the supply current fall, but the output stage is also internally switched from the output of the amplifier to a resistor network of known values. The advantage of this architecture is that the output impedance of the part is known while the part is in power-down mode. There are three different options: the output is connected internally to GND either through a 1-kΩ resistor or a 100-kΩ resistor, or is left open-circuited (High-Z). 图 8-3 illustrates the output stage.

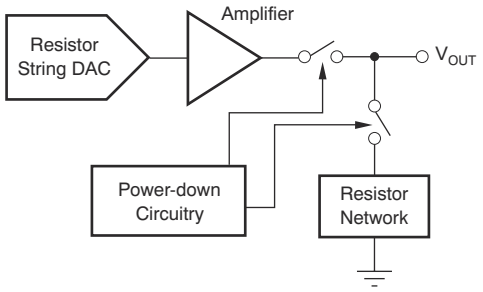


**图 8-3. Output Stage During Power-Down**

All linear circuitry is shut down when the power-down mode is activated. However, the contents of the DAC register are unaffected when in power-down. The time to exit power-down is typically 50 μs for $AV_{DD}$ = 5 V and $AV_{DD}$ = 3 V.


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## 8.5 Programming

### 8.5.1 Serial Interface

The DACx311 has a 3-wire serial interface ($\overline{SYNC}$, SCLK, and DIN) compatible with SPI, QSPI, and Microwire interface standards, as well as most DSPs. For an example of a typical write sequence, see 图 7-1.

#### *8.5.1.1 Input Shift Register*

The input shift register is 16 bits wide, as shown in 表 8-2. The first two bits (PD0 and PD1) are reserved control bits that set the desired mode of operation (normal mode or any one of three power-down modes) as indicated in 表 8-1.

The remaining data bits are either 12 (DAC7311), 10 (DAC6311), or 8 (DAC5311) data bits, followed by *don't care* bits, as shown in 表 8-2, 表 8-3, and 表 8-4, respectively.

**表 8-2. DAC5311 8-Bit Data Input Register**

| DB15 | DB14 | | | | | | | | DB6 | DB5 | | | | | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PD1 | PD0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | X | X | X | X | X | X |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

**表 8-3. DAC6311 10-Bit Data Input Register**

| DB15 | DB14 | | | | | | | | | | DB4 | DB3 | | | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PD1 | PD0 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | X | X | X | X |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

**表 8-4. DAC7311 12-Bit Data Input Register**

| DB15 | DB14 | | | | | | | | | | | | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PD1 | PD0 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | X | X |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

The write sequence begins by bringing the $\overline{SYNC}$ line low. Data from the DIN line are clocked into the 16-bit shift register on each falling edge of SCLK. The serial clock frequency can be as high as 50 MHz, making

the DACx311 compatible with high-speed DSPs. On the 16th falling edge of the serial clock, the last data bit is clocked in and the programmed function is executed.

At this point, the $\overline{SYNC}$ line can be kept low or brought high. In either case, $\overline{SYNC}$ must be brought high for a minimum of 20 ns before the next write sequence so that a falling edge of $\overline{SYNC}$ can initiate the next write sequence.

#### *8.5.1.2 $\overline{SYNC}$ Interrupt*

In a normal write sequence, the $\overline{SYNC}$ line is kept low for at least 16 falling edges of SCLK and the DAC is updated on the 16th falling edge. However, bringing $\overline{SYNC}$ high before the 16th falling edge acts as an interrupt to the write sequence. The shift register is reset and the write sequence is seen as invalid. Neither an update of the DAC register contents nor a change in the operating mode occurs, as shown in 图 8-4.

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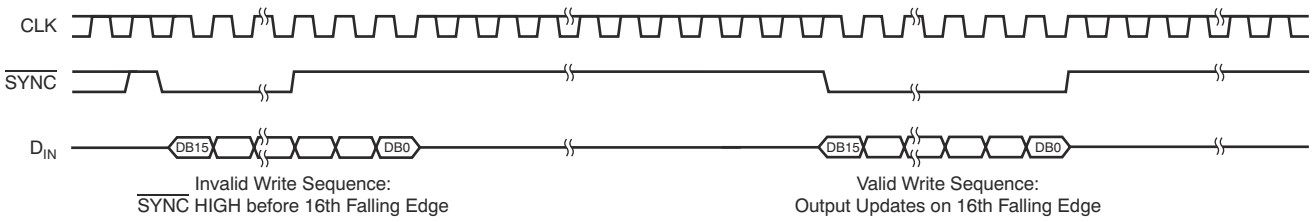


**图 8-4. DACx311 $\overline{\text{SYNC}}$ Interrupt Facility**


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# 9 Application and Implementation

**备注**

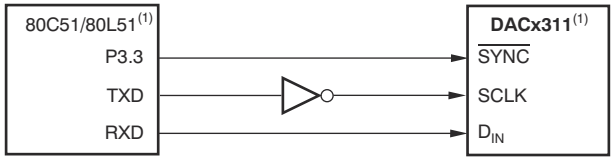
以下应用部分中的信息不属于 TI 器件规格的范围，TI 不担保其准确性和完整性。TI 的客 户应负责确定器件是否适用于其应用。客户应验证并测试其设计，以确保系统功能。

## 9.1 Application Information

### 9.1.1 Microprocessor Interfacing

#### *9.1.1.1 DACx311 to 8051 Interface*

图 9-1 shows a serial interface between the DACx311 and a typical 8051-type microcontroller. The setup for the interface is as follows: TXD of the 8051 drives SCLK of the DACx311, while RXD drives the serial data line of the device. The SYNC signal is derived from a bit programmable pin on the port. In this case, port line P3.3 is used. When data are to be transmitted to the DACx311, P3.3 is taken low. The 8051 transmits data only in 8-bit bytes; thus, only eight falling clock edges occur in the transmit cycle. To load data to the DAC, P3.3 remains low after the first eight bits are transmitted, and a second write cycle is initiated to transmit the second byte of data. P3.3 is taken high following the completion of this cycle. The 8051 outputs the serial data in a format that has the LSB first. The DACx311 requires data with the MSB as the first bit received. Therefore, the 8051 transmit routine must take this requirement into account, and *mirror* the data as needed.

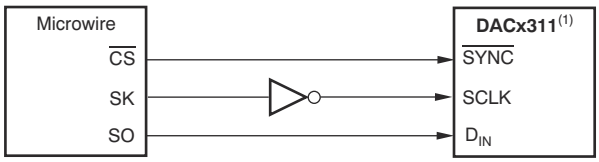



NOTE: (1) Additional pins omitted for clarity.

**图 9-1. DACx311 to 80C51/80I51 Interfaces**

#### *9.1.1.2 DACx311 to Microwire Interface*

图 9-2 shows an interface between the DACx311 and any Microwire-compatible device. Serial data (SO) are shifted out on the falling edge of the serial clock (SK) and are clocked into the DACx311 on the rising edge of the SK signal.

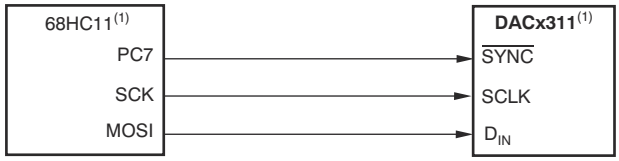



NOTE: (1) Additional pins omitted for clarity.

**图 9-2. DACx311 to Microwire Interface**

#### 9.1.1.3 DACx311 to 68HC11 Interface

图 9-3 shows a serial interface between the DACx311 and the 68HC11 microcontroller. SCK of the 68HC11 drives the SCLK of the DACx311, while the MOSI output drives the serial data line of the DAC. The $\overline{\text{SYNC}}$ signal is derived from a port line (PC7), similar to what was done for the 8051.




NOTE: (1) Additional pins omitted for clarity.

**图 9-3. DACx311 to 68HC11 Interface**

Configure the 68HC11 so that the CPOL bit is 0 and the CPHA bit is 1. This configuration causes data appearing on the MOSI output to be valid on the falling edge of SCK. When data are being transmitted to the DAC, the $\overline{\text{SYNC}}$ line is taken low (PC7). Serial data from the 68HC11 are transmitted in 8-bit bytes with only eight falling clock edges occurring in the transmit cycle. Data are transmitted MSB first. To load data to the DACx311, PC7 is held low after the first eight bits are transferred, and a second serial write operation is performed to the DAC; PC7 is taken high at the end of this procedure.

## 9.2 Typical Applications

### 9.2.1 Loop Powered Transmitter

The described loop powered transmitter can accurately source currents from 4 mA to 20 mA.

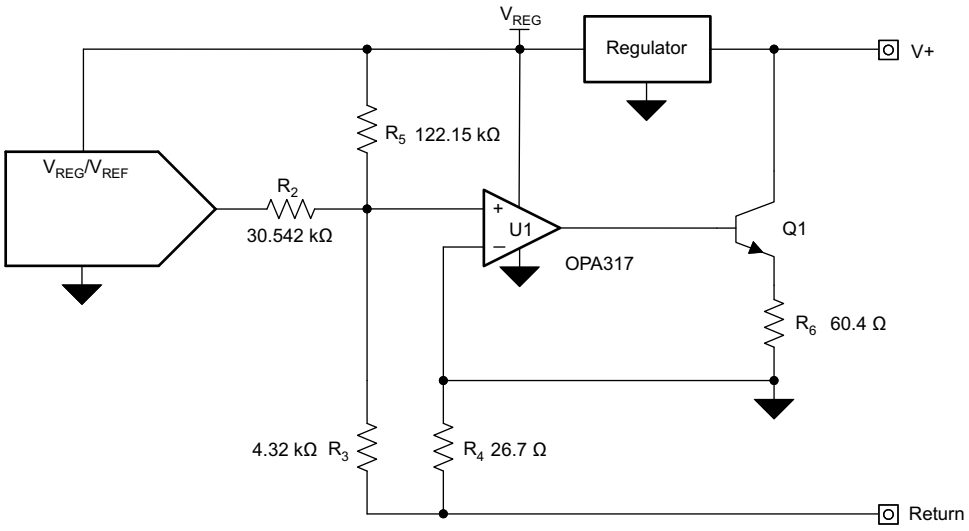



**图 9-4. Loop Powered Transmitter Schematic**

#### 9.2.1.1 Design Requirements

The transmitter has only two external input pins; a supply connection and a ground (or return) connection. The transmitter communicates back to the host, typically a PLC analog input module, by precisely controlling the magnitude of the return current. To conform to the 4-mA to 20-mA communication standards, the complete transmitter must consume less than 4 mA of current.

The complete design of this circuit is outlined in TIPD158, *Low Cost Loop-Powered 4-20mA Transmitter EMC/EMI Tested Reference Design*. The design is expected to be low-cost and deliver immunity to the IEC61000-4 suite of tests with minimum impact on the accuracy of the system. Reference design TIPD158 includes the design goals, simulated results, and measured performance.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### 9.2.1.2 Detailed Design Procedure

Amplifier U1 uses negative feedback to make sure that the potentials at the inverting (V –) and noninverting (V+) input terminals are equal. In this configuration, V – is directly tied to the local GND; therefore, the potential at the noninverting input terminal is driven to local ground. Thus, the voltage difference across $R_2$ is the DAC output voltage (VOUT), and the voltage difference across $R_5$ is the regulator voltage (VREG). These voltage differences cause currents to flow through $R_2$ and $R_5$, as illustrated in 图 9-5.

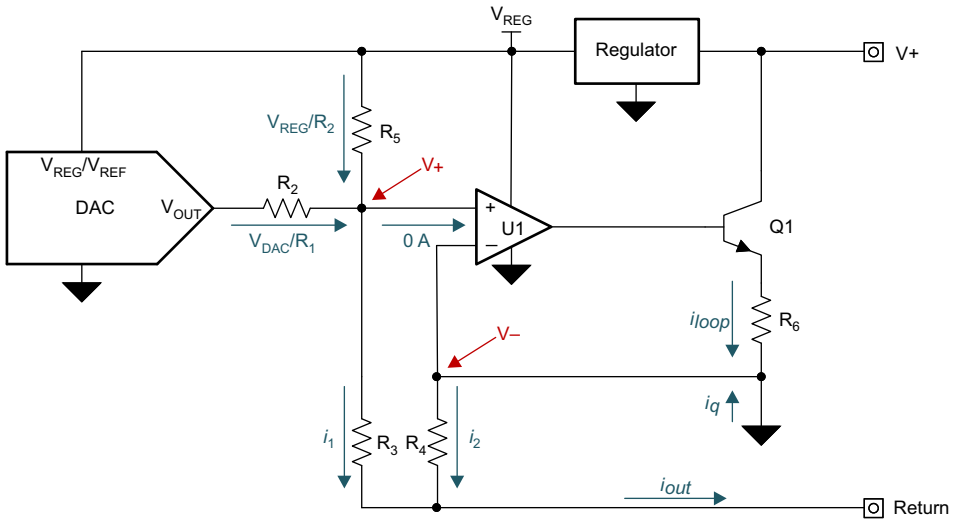


**图 9-5. Voltage to Current Conversion**

The currents from $R_2$ and $R_5$ sum into $i_1$ (defined in 方程式 2), and $i_1$ flows through $R_3$.

$$i_1 = \frac{V_{DAC}}{R_2} + \frac{V_{REG}}{R_5} \tag{2}$$

Amplifier U2 drives the base of Q1, the NPN bipolar junction transistor (BJT), to allow current to flow through $R_4$ so that the voltage drops across $R_3$ and $R_4$ remain equal. This design keeps the inverting and noninverting terminals at the same potential. A small part of the current through $R_4$ is sourced by the quiescent current of all of the components used in the transmitter design (regulator, amplifier, and DAC). The voltage drops across $R_3$ and $R_4$ are equal; therefore, different-sized resistors cause different current flow through each resistor. Use these different-sized resistors to apply gain to the current flow through $R_4$ by controlling the ratio of resistor $R_3$ to $R_4$, as shown in 方程式 3:

$$\begin{aligned} V+ &= i_1 \cdot R_3 \\ V- &= i_2 \cdot R_4 \Rightarrow i_2 = \frac{i_1 \cdot R_3}{R_4} \\ V+ &= V- \end{aligned} \tag{3}$$

The current gain in the circuit helps allow a majority of the output current to come directly from the loop through Q1 instead of from the voltage-to-current converter. This current gain, in addition to the low-power components, keeps the current consumption of the voltage-to-current converter low. Currents $i_1$ and $i_2$ sum to form output current $i_{out}$, as shown in 方程式 4:

$$i_{out} = i_1 + i_2 = \frac{V_{DAC}}{R_2} + \frac{V_{REG}}{R_5} + \frac{R_3}{R_4} \cdot \left( \frac{V_{DAC}}{R_2} + \frac{V_{REG}}{R_5} \right) = \left( \frac{V_{DAC}}{R_2} + \frac{V_{REG}}{R_5} \right) \cdot \left( 1 + \frac{R_3}{R_4} \right) \tag{4}$$

The complete transfer function, arranged as a function of input code, is shown in 方程式 5. The remaining sections divide this circuit into blocks for simplified discussion.

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$$i_{out}(Code) = \left( \frac{V_{REG} \cdot Code}{2^{Resolution} \cdot R_2} + \frac{V_{REG}}{R_5} \right) \cdot \left( 1 + \frac{R_3}{R_4} \right) \quad (5)$$

Resistor $R_6$ is included to reduce the gain of transistor Q1, and therefore, reduce the closed-loop gain of the voltage-to-current converter for a stable design. Size resistors $R_2$, $R_3$, $R_4$, and $R_5$ based on the full-scale range of the DAC, regulator voltage, and the desired current output range of the design.

#### 9.2.1.3 Application Curves

图 9-6 shows the measured transfer function of the circuit. 图 9-7 shows the total unadjusted error (TUE) of the circuit, staying below 0.15 %FSR.

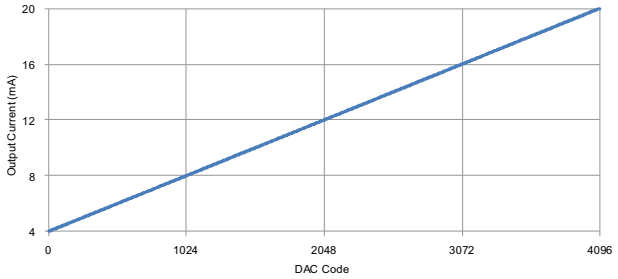


图 9-6. Output Current vs Code

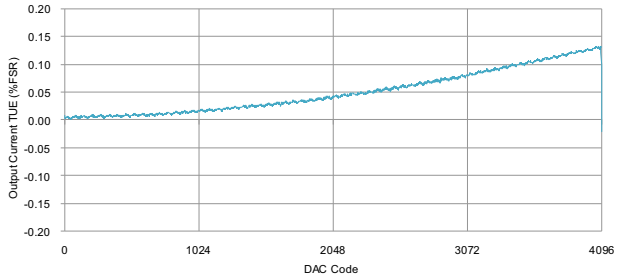


图 9-7. Current Total Unadjusted Error vs Code

### 9.2.2 Using the REF5050 as a Power Supply for the DACx311

As a result of the extremely low supply current required by the DACx311, an alternative option is to use a REF5050 5-V precision voltage reference to supply the required voltage to the part, as shown in 图 9-8. This option is especially useful if the power supply is too noisy or if the system supply voltages are at some value other than 5 V. The REF5050 outputs a steady supply voltage for the DACx311. If the REF5050 is used, the current needed to supply DACx311 is typically 110 μA at 5 V, with no load on the output of the DAC. When the DAC output is loaded, the REF5050 also needs to supply the current to the load. The total current required (with a 5 kΩ load on the DAC output) is:

$$110\ \mu A + (5\ V / 5\ k\Omega) = 1.11\ mA \quad (6)$$

The load regulation of the REF5050 is typically 0.002%/mA, which results in an error of 90 μV for the 1.1 mA current drawn from the device. This value corresponds to a 0.07 LSB error at 12 bits (DAC7311).

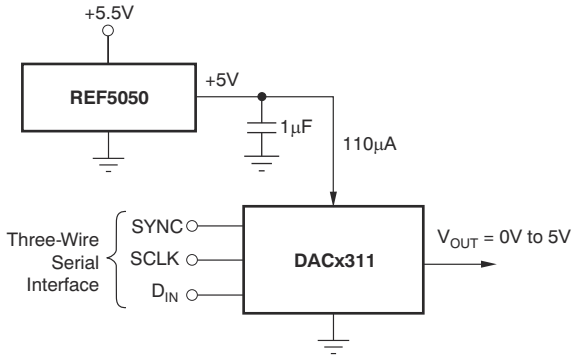


图 9-8. REF5050 as Power Supply to DACx311

For other power-supply voltages, alternative references such as the REF3030 (3 V), REF3033 (3.3 V), or REF3220 (2.048 V) are recommended. For a full list of available voltage references from TI, see the TI web site at www.ti.com.


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### 9.2.3 Bipolar Operation Using the DACx311

The DACx311 has been designed for single-supply operation but a bipolar output range is also possible using the circuit in 图 9-9. The circuit shown gives an output voltage range of ±5 V. Rail-to-rail operation at the amplifier output is achievable using an OPA211, OPA340, or OPA703 as the output amplifier. For a full list of available operational amplifiers from TI, see the TI web site at www.ti.com

The output voltage for any input code can be calculated as follows:

$$V_O = \left[ AV_{DD} \times \left( \frac{D}{2^n} \right) \times \left( \frac{R_1 + R_2}{R_1} \right) - AV_{DD} \times \left( \frac{R_2}{R_1} \right) \right] \quad (7)$$

where

- n = resolution in bits; either 8 (DAC5311), 10 (DAC6311), or 12 (DAC7311).
- D = decimal equivalent of the binary code that is loaded to the DAC register. D ranges from 0 to 255 for 8-bit DAC5311, 0 to 1023 for the 10-bit DAC6311 and 0 to 4095 for the 12-bit DAC7311.

With $AV_{DD}$ = 5 V, $R_1$ = $R_2$ = 10 kΩ:

$$V_O = \left( \frac{10 \times D}{2^n} \right) - 5V \quad (8)$$

The resulting output voltage range is ±5 V. Code 000h corresponds to a –5-V output and FFFh (12-bit level) corresponding to a +5-V output.

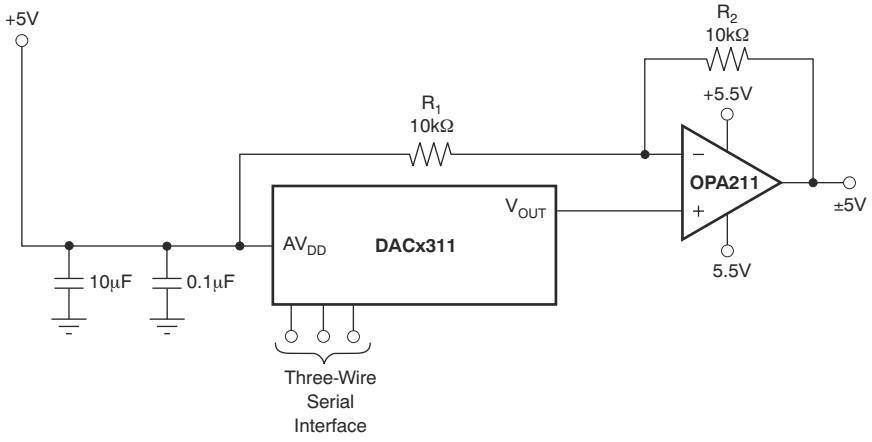


**图 9-9. Bipolar Operation With the DACx311**

## 9.3 Power Supply Recommendations

The DACx311 is designed to operate with a unipolar analog power supply ranging from 2.0 V to 5.5 V on the $AV_{DD}$ pin. The $AV_{DD}$ pin supplies power to the digital and analog circuits (including the resistor string) inside the DAC. The current consumption of this pin is specified in the *Electrical Characteristics* table. Use a 1 µF to 10 µF capacitor in parallel with a 0.1 µF bypass capacitor on this pin to remove high-frequency noise.

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