

FEATURES
Analog input/output

- 22-channel, 14-bit, 800 kSPS analog-to-digital converter (ADC)
 - 10 external channels
 - 1 on-chip die temperature monitor
 - 6 current output digital-to-analog converter (IDAC) monitor channels
 - 3 power monitor channels
 - 2 buffered reference output channels
- Fully differential and single-ended modes
0 V to 2.5 V analog input range
6 low noise, 12-/14-bit IDAC outputs
1× 250 mA, 1× 200 mA, 2× 100 mA, and 2× 20 mA
Semiconductor optical amplifier (SOA) IDAC pull-down to -3.0 V for fast current sink

Eight 12-bit voltage output DACs (VDACs)

- Channel 0 and Channel 1: 0 V to 3 V, 75 Ω load
- Channel 2 and Channel 3: -5 V to 0 V, 500 Ω load
- Channel 4 and Channel 5: 0 V to 3 V, 300 Ω load
- Channel 6: 0 V to 5 V, 500 Ω load
- Channel 7: 0 V to 5 V, 100 Ω load

- 2.5 V, on-chip voltage reference
- 2 buffered 2.5 V outputs

Microcontroller

- ARM Cortex-M3 processor, 32-bit RISC architecture
- Serial wire port supports code download and debugging

Clocking options

- Trimmed on-chip oscillator (±3%)
- 80 MHz phase-locked loop (PLL)

External 16 MHz crystal option

External clock source

Memory

- 2× 128 kB Flash/EE memories, 32 kB SRAM
- In-circuit download, SW-DP-based debugging
- Software triggered in-circuit reprogrammability

On-chip peripherals

- UART, 2× I²C and 2× SPI serial input/output
- 28-pin general-purpose input/output (GPIO) port
- 3 general-purpose timers
- Wake-up (W/U) timer
- Watchdog timer (WDT)
- 32-element programmable logic array (PLA)

Vectored interrupt controller

- Interrupt on edge or level external pin inputs
- 9× external interrupts

Power

- Multiple supplies
- 5 V for VDAC6 and VDAC7
- 3.3 V for digital and analog inputs/outputs
- 1.8 V to 2.7 V for IDACs
- 5 V supply for IDAC3 and VDAC2/VDAC3

Package and temperature range

- 6 mm × 6 mm, 112-ball CSP_BGA package
- Fully specified for -40°C to +85°C ambient operation

Tools

- QuickStart™ development system
- Full third party support

APPLICATIONS

Optical modules—tunable laser modules

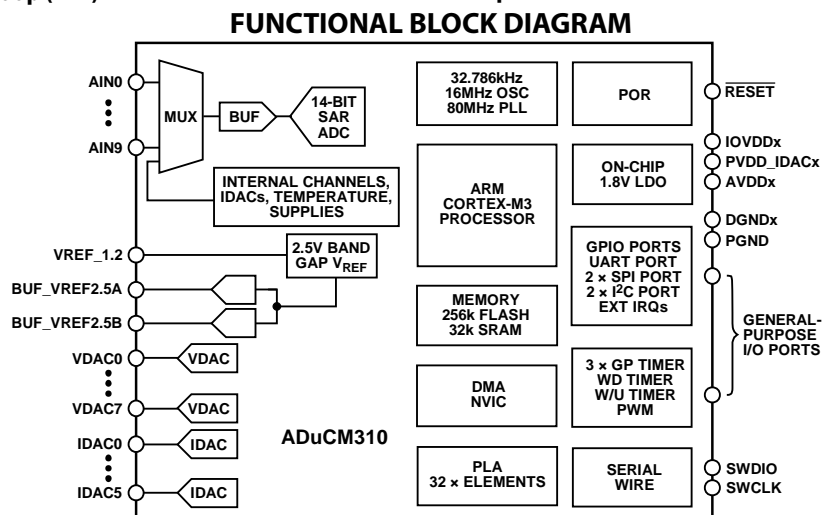


Figure 1.

Rev. C

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One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
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| Added Allowed Power-Up Time for DV _{DD} Supply Parameter, Table 1 | 10 | Change to Features Section..... | 1 |
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GENERAL DESCRIPTION

The [ADuCM310](#) is a multichip stack, on-chip system designed for diagnostic control of tunable laser optical module applications.

The [ADuCM310](#) features a 16-bit (14-bit accurate) multichannel successive approximation register (SAR) ADC, an ARM Cortex™-M3 processor, eight voltage DACs (VDACs), six current output DACs, and Flash/EE memory packaged in a 6 mm × 6 mm, 112-ball CSP_BGA package.

The bottom die in the stack supports the bulk of the low voltage analog circuitry and is the largest of the three die. It contains the ADC, VDACs, main IDAC circuits, as well as other analog support circuits, such as the low drift precision 2.5 V voltage reference source.

The middle die in the stack supports the bulk of the digital circuitry, including the ARM Cortex-M3 processor, the flash and SRAM blocks, and all of the digital communication peripherals. In addition, this die provides the clock sources for the whole chip. A 16 MHz internal oscillator is the source of the internal PLL that outputs an 80 MHz system clock.

The top die, which is the smallest die, was developed on a high voltage process, and this die supports the –5 V and +5 V VDAC outputs. It also implements the SOA IDAC current sink circuit that allows the external SOA diode to pull to a –3.0 V level to implement the fast shutdown of the laser output.

Regarding the individual blocks, the ADC is capable of operating at conversion rates up to 800 kSPS. There are 10 external inputs to the ADC, which can be single ended or differential. Several internal channels are included, such as the supply monitor channels, an on-chip temperature sensor, and internal voltage reference monitors.

The VDACs are 12-bit string DACs with output buffers capable of sourcing between 10 mA and 50 mA, and these DACs are all capable of driving 10 nF capacitive loads.

The low drift current DACs have 14-bit resolution and varied full-scale output ranges from 0 mA to 20 mA to 0 mA to 250 mA on the SOA IDAC (IDAC3). The SOA IDAC also comes with a 0 mA to –80 mA current sink capability.

A precision 2.5 V on-chip reference source is available. The internal ADC, IDACs, and VDAC circuits use this on-chip

reference source to ensure low drift performance for all of these peripherals

The [ADuCM310](#) also provides 2× buffered reference outputs capable of sourcing up to 1.2 mA. These outputs can be used externally to the chip.

The [ADuCM310](#) integrates an 80 MHz ARM Cortex-M3 processor. It is a 32-bit reduced instruction set computer (RISC) machine, offering up to 100 DMIPS peak performance. The ARM Cortex-M3 processor also has a flexible 14-channel direct memory access (DMA) controller supporting serial peripheral interface (SPI), UART, and I²C communication peripherals. The [ADuCM310](#) has 256 kB of nonvolatile Flash/EE memory and 32 kB of SRAM integrated on-chip.

A 16 MHz on-chip oscillator generates the 80 MHz system clock. This clock internally divides to allow the processor to operate at lower frequency, thus saving power. A low power internal 32 kHz oscillator is available and can clock the timers. The [ADuCM310](#) includes three general-purpose timers, a wake-up timer (which can be used as a general-purpose timer), and a system watchdog timer.

A range of communication peripherals can be configured as required in a specific application. These peripherals include UART, 2 × I²C, 2 × SPI, GPIO ports, and pulse-width modulation (PWM).

On-chip factory firmware supports in-circuit serial download via the UART, while nonintrusive emulation and program download are supported via the serial wire debug port (SW-DP) interface. These features are supported on the [EVAL-ADuCM310QSPZ](#) development system.

The [ADuCM310](#) operates from 2.9 V to 3.6 V and is specified over a temperature range of –40°C to +85°C.

Note that, throughout this data sheet, multifunction pins, such as P1.0/SIN/ECLKIN/PLAI[4], are referred to either by the entire pin name or by a single function of the pin, for example, P1.0, when only that function is relevant.

For additional information on the [ADuCM310](#), see the [ADuCM310](#) reference manual, *How to Set Up and Use the ADuCM310*.

SPECIFICATIONS

$AV_{DD} = IOV_{DD} = DV_{DD} = 2.9\text{ V to }3.6\text{ V}$ (the input supply voltages). The difference between AV_{DD} , IOV_{DD} , and DV_{DD} must be $\leq 0.3\text{ V}$. AV_{NEG} (the supply voltage) = $-5.5\text{ V to }-4.65\text{ V}$. $VDACV_{DD}$ (the VDAC supply voltage) = $3.07\text{ V to }5.35\text{ V}$ (for VDAC6 and VDAC7), and $VDACV_{DD}$ must be $\geq AV_{DD}$. PV_{DD} (the IDAC supply voltage) for the IDACs = $1.8\text{ V to }2.7\text{ V}$. $AV_{DD} \geq PV_{DD} + 0.4\text{ V}$. $V_{REF} = 2.5\text{ V}$ internal reference, $f_{CORE} = 80\text{ MHz}$, $T_A = -40^\circ\text{C to }+85^\circ\text{C}$, unless otherwise noted.

For power sequencing, connect the AGND, DGND, PGND, and IOGND pins to ground before applying power to the AV_{NEG} or $VDACV_{DD}$ pins.

For register and bit information, see the [ADuCM310](#) reference manual, *How to Set Up and Use the ADuCM310*.

Table 1.

| Parameter | Min | Typ | Max | Unit | Test Conditions/Comments |
|--|----------|-------------|-------------|------------------------------|--|
| ADC CHANNEL SPECIFICATIONS | | | | | |
| ADC Power-Up Time | | 5 | | μs | All measurements in single-ended mode, unless otherwise stated $f_{\text{SAMPLE}} \geq 500\text{ kSPS}$ |
| DC Accuracy | | | | | |
| Resolution | 14 | | | Bits | |
| Integral Nonlinearity | | | | | |
| Input Buffer | | | | | |
| Disabled | | ± 2 | | LSB | 2.5 V internal reference |
| Enabled | | $\pm 1.5^1$ | | LSB | 2.5 V internal reference |
| Disabled | | ± 2.5 | | LSB | |
| Enabled | | ± 2 | | LSB | External reference |
| Disabled | | $\pm 1.5^1$ | | LSB | External reference |
| Differential Nonlinearity | -0.99 | ± 0.7 | $+1.5^1$ | LSB | 2.5 V external reference; no missing codes |
| | -0.99 | ± 0.7 | $+2.0$ | LSB | 2.5 V external reference; no missing codes |
| DC Code Distribution | | ± 3 | | LSB | ADC input voltage = 1.25 V dc |
| | | ± 5 | | | |
| ENDPOINT ERRORS | | | | | |
| Offset Error (All Channels Except the Internal Channels) | | | | | ADC update rate up to 800 kSPS |
| Buffer On or Buffer Off | -0.8 | ± 0.2 | $+0.8$ | mV | Buffer on, chop mode on and automatic zero or buffer off |
| | -0.6^1 | ± 0.2 | $+0.6^1$ | mV | Buffer on, chop mode on and automatic zero or buffer off |
| Offset Error Drift ² | | | | | |
| Buffer On or Buffer Off | | ± 3.2 | | $\mu\text{V}/^\circ\text{C}$ | Buffer on, chop mode on and automatic zero or buffer off |
| | | $\pm 2.5^1$ | | $\mu\text{V}/^\circ\text{C}$ | Buffer on, chop mode on and automatic zero or buffer off |
| Full-Scale Error | | | | | ADC update rate up to 800 kSPS |
| Buffer On or Buffer Off | -0.75 | ± 0.2 | $+0.75$ | mV | Excluding internal channels |
| Internal Channels | -0.7^1 | ± 0.2 | $+0.6^1$ | mV | Excluding internal channels |
| | | ± 0.2 | $+1$ | % of full scale | Input buffer on; $AV_{DD}/2$, $IOV_{DD}/2$, PV_{DD} voltage on PVDD_IDAC2 pin |
| | | ± 0.2 | $\pm 0.6^1$ | % of full scale | Input buffer on; $AV_{DD}/2$, $IOV_{DD}/2$, PV_{DD} voltage on PVDD_IDAC2 pin |
| | | 0.75 | 2 | % of full scale | Input buffer on; IDAC0 to IDAC5; measured with 1.5 V on the IDAC0 to IDAC5 pins |
| | | 0.75 | 1.5^1 | % of full scale | Input buffer on; IDAC0 to IDAC5; measured with 1.5 V on the IDAC0 to IDAC5 pins |
| Gain Error Drift ² | | 2 | | $\mu\text{V}/^\circ\text{C}$ | Full-scale error drift minus offset error drift; all modes; internal reference |

| Parameter | Min | Typ | Max | Unit | Test Conditions/Comments |
|--|-------------|-------------|------------|------------------|---|
| DYNAMIC PERFORMANCE² | | | | | |
| Signal-to-Noise Ratio (SNR) | | | | | $f_{IN} = 665.283$ Hz sine wave; $f_{SAMPLE} = 100$ kSPS; internally unbuffered channels; the filter on the analog inputs is a $15\ \Omega$ resistor and a 2 nF capacitor |
| Input Buffer | | | | | |
| Disabled | | 80 | | dB | Includes distortion and noise components |
| Enabled | | 78 | | dB | Chop mode on |
| Total Harmonic Distortion (THD) | | 74 | | dB | Automatic zero |
| Input Buffer | | | | | |
| Disabled | | -86 | | dB | |
| Enabled | | -86 | | dB | Chop mode on and automatic zero |
| Peak Harmonic or Spurious Noise | | -88 | | dB | Buffer on and off |
| Channel-to-Channel Crosstalk | | -95 | | dB | Measured on adjacent channels; $f_{IN} = 25$ kHz sine wave; buffer on and off |
| ANALOG INPUT | | | | | |
| Absolute Input Voltage Range | | | | | |
| Unbuffered Mode | AGND | | AV_{DD} | V | Voltage level on AINx pin |
| Buffered Mode | AGND + 0.15 | | 2.5 | V | Voltage level on AINx pin |
| Input Voltage Ranges | | | | | |
| Differential Mode | $-V_{REF}$ | | $+V_{REF}$ | V | Voltage difference between AIN+ (positive input) and AIN- (negative input) |
| Common-Mode Voltage Range | 0.9 | | 1.6 | V | |
| Single-Ended Mode | AGND | | V_{REF} | V | Voltage difference between AIN+ and AIN- |
| Input Current ³ | | | | | |
| Buffered Mode | | | | | $V_{IN} = 0.15$ V to 2.5 V |
| AIN0, AIN1, AIN2, and AIN3 | -10^2 | ± 5 | $+13^2$ | nA | ADC sampling rate ≤ 100 kSPS |
| | -40 | ± 15 | +60 | nA | ADC sampling rate ≤ 500 kSPS |
| | -60^2 | ± 25 | $+90^2$ | nA | ADC sampling rate ≤ 800 kSPS |
| Input Current Drift | | ± 20 | | pA/ $^{\circ}$ C | Input buffer on, ADC sampling rate ≤ 500 kSPS |
| | | $\pm 10^1$ | | pA/ $^{\circ}$ C | Input buffer on, ADC sampling rate ≤ 500 kSPS |
| | | ± 34 | | pA/ $^{\circ}$ C | Input buffer on, ADC sampling rate ≤ 800 kSPS |
| | | $\pm 20^1$ | | pA/ $^{\circ}$ C | Input buffer on, ADC sampling rate ≤ 800 kSPS |
| AIN4 to AIN9 | -50^2 | ± 20 | $+50^2$ | nA | AIN4 to AIN9 ≤ 100 kSPS |
| | -215^2 | ± 50 | $+110^2$ | nA | ADC sampling rate ≤ 500 kSPS |
| | -350^2 | -90 | $+90^2$ | nA | ADC sampling rate ≤ 800 kSPS |
| Unbuffered Mode | -1100^2 | +750 | $+1700^2$ | nA | $V_{IN} = 0$ V to 2.5 V, all channels, all sampling rates |
| Input Current Drift | | $\pm 140^1$ | | pA/ $^{\circ}$ C | $V_{IN} = 1$ V |
| | | ± 530 | | pA/ $^{\circ}$ C | $V_{IN} = 1$ V |
| Input Capacitance | | 20 | | pF | During ADC acquisition, buffer on |
| Input Leakage Current | -1.6^2 | +1 | $+3.5^2$ | nA | ADC off, buffer off or buffer on, AINx connected 2.5 V |

| Parameter | Min | Typ | Max | Unit | Test Conditions/Comments |
|--|------|----------------------------------|----------------------------------|-----------------------|---|
| ON-CHIP VOLTAGE REFERENCE | | | | | 0.47 μ F from VREF_1.2 to AGND |
| Output Voltage | | 2.505 | | V | |
| Accuracy ⁴ | | | ± 5 | mV | $T_A = 25^\circ\text{C}$ |
| Reference Temperature Coefficient ^{2,5} | | 15 | 30 ¹ | ppm/ $^\circ\text{C}$ | |
| Power Supply Rejection Ratio | | 15 | 44 | ppm/ $^\circ\text{C}$ | |
| Output Impedance | | 70 | | dB | |
| Internal V_{REF} Power-On Time ² | | 3 | 50 | Ω | For ADC_CAPP, $T_A = 25^\circ\text{C}$ |
| Internal V_{REF} Power-On Time ² | | 38 | | ms | Turned on by default |
| EXTERNAL REFERENCE INPUT ² | | | | | |
| Input Voltage Range ² | 1.8 | | 2.5 | V | ADC maximum reference voltage = 2.5 V |
| Switching Time | | | | | |
| External to Internal Reference | | 2.5 | | ms | |
| Internal to External Reference | | 1 | | ms | |
| BUFFERED VREF OUTPUTS (BUF_VREF2.5x PINS) | | | | | |
| Output Voltage | | 2.5 | | V | |
| Accuracy | | | ± 5 | mV | $T_A = 25^\circ\text{C}$, load = 0.4 mA |
| Reference Temperature Coefficient ² | | 15 | 30 ¹ | ppm/ $^\circ\text{C}$ | 100 nF capacitor required on both outputs |
| Load Regulation | | 15 | 50 | ppm/ $^\circ\text{C}$ | |
| Output Impedance | | 2.5 | | mV/mA | |
| Load Current | | 3 | | Ω | $T_A = 25^\circ\text{C}$ |
| Power Supply Rejection Ratio | | 70 | 1.2 | dB | |
| IDAC CHANNEL SPECIFICATIONS ^{6,7} | | | | | |
| Voltage Compliance Range ² | | | | | Output voltage compliance; minimum compliance if IDACx set to full scale, see Figure 15 to Figure 20 |
| IDAC0, IDAC1, and IDAC2 | 0.4 | $PV_{\text{DD}} - 200\text{ mV}$ | $PV_{\text{DD}} - 275\text{ mV}$ | V | |
| IDAC4 and IDAC5 | 0.4 | | $PV_{\text{DD}} - 200\text{ mV}$ | V | |
| IDAC3 | 0.5 | | $PV_{\text{DD}} - 450\text{ mV}$ | V | |
| Reference Current Generator Reference Current | -3.7 | -3.0 | | V | At -3.5 V, maximum sink current is 80 mA; pin voltage clamped to -3.5 V, tolerance of clamping voltage is $\pm 200\text{ mV}$ |
| IDAC Reference Current Shutdown Threshold | | 0.38 | | mA | Using internal reference, 0.1%, $\leq 5\text{ ppm}$, 3.16 k Ω external resistor |
| Temperature Coefficient ^{2,5} | | 0.76 | | mA | If the external resistor (R_{EXT}) value drops below 1.580 k Ω , IDAC output currents disable |
| Over Heat Shutdown | | 7 | 25 | ppm/ $^\circ\text{C}$ | Using internal reference; |
| Resolution | | 135 | | $^\circ\text{C}$ | Junction temperature |
| IDAC0, IDAC1, IDAC4, and IDAC5 | | 14 | | Bits | 11-bit MSBs and 5-bit LSBs are guaranteed monotonic |
| IDAC2 | | 14 | | Bits | 11-bit MSBs and 5-bit LSBs are guaranteed monotonic |
| IDAC3 | | 14 | | Bits | 0 V to 2 V compliant range, 11-bit MSBs and 5-bit LSBs are guaranteed monotonic |
| IDAC3 | 8 | | | Bits | -4.5 V to 0 V compliant range |

| Parameter | Min | Typ | Max | Unit | Test Conditions/Comments |
|--|--------------------|------------------|-------------------|-------------------|--|
| Full-Scale Output | | | | | |
| IDAC0 and IDAC1 | | 100 | | mA | |
| IDAC4 and IDAC5 | | 20 | | mA | |
| IDAC2 | | 200 | | mA | |
| IDAC3 | | 250 | | mA | Current source |
| | -90 | | | | Current sink |
| | -80 ¹ | | | | Current sink |
| Integral Nonlinearity | -3 | ±1.5 | +4 | LSB | 11-bit |
| | -2.5 ¹ | ±1.5 | +4 | LSB | 11-bit |
| Noise Current | | | | | RMS noise; maximum bandwidth setting, IDACxCON[5:2] = 0000b |
| IDAC0 and IDAC1 | | 1.5 | | µA | Measured driving 10 Ω |
| IDAC4 and IDAC5 | | 0.3 | | µA | Measured driving 100 Ω |
| IDAC2 | | 4 | | µA | Measured driving 5 Ω |
| IDAC3 | | 5 | | µA | Measured driving 5 Ω |
| Full-Scale Error | | | | | |
| IDAC0 and IDAC1 | -2.3 ¹ | ±0.25 | +1 ¹ | % | |
| | -3.0 | ±0.25 | +1.3 | % | |
| IDAC4 and IDAC 5 | -0.7 ¹ | ±0.25 | ±0.7 | % | |
| | -1 | ±0.25 | +0.7 | % | |
| IDAC2 | -1.75 ¹ | ±0.25 | ±0.65 | % | |
| | -1.77 | ±0.25 | | % | |
| IDAC3 | -2 ¹ | ±0.25 | ±1.4 ¹ | % | |
| | -2.4 | ±0.25 | +1.6 | % | |
| Full-Scale Error Drift vs. Temperature | | | | | Including internal reference drift and 5 ppm external resistor |
| IDAC4 and IDAC5 | -40 ¹ | -12 | +30 ¹ | ppm/°C | |
| | -58 | -12 | +58 | ppm/°C | |
| IDAC2 and IDAC3 | | +55 | | ppm/°C | Full temperature range |
| IDAC2 and IDAC3 | | +40 | | ppm/°C | Reduced 25°C to 85°C range |
| IDAC0 and IDAC1 | -145 ¹ | +55 ¹ | +145 ¹ | ppm/°C | |
| | -205 | +90 | +205 | ppm/°C | Full temperature range |
| IDAC0 and IDAC1 | -100 | +40 | +100 | ppm/°C | Reduced 25°C to 85°C range |
| Full-Scale Error Drift vs. Time ⁸ | | | | | Long-term stability |
| IDAC0 | | 200 | | µA/ 1000 hours | |
| IDAC1 | | 450 | | µA/ 1000 hours | |
| IDAC2 | | 500 | | µA/ 1000 hours | |
| IDAC3 | | 2250 | | µA/ 1000 hours | |
| IDAC4 and IDAC5 | | 40 | | µA/ 1000 hours | |
| Zero-Scale Error | | | | | Pull-down current off |
| IDAC0 and IDAC1 | -120 ¹ | | +75 ¹ | µA | Reduced -10°C to +85°C range |
| | -180 | | +115 | µA | |
| Pull-Down Current | -135 | -115 | -100 | µA | |
| IDAC4 and IDAC5 | -25 ¹ | | +15 | µA | |
| | -31 | | +15 | µA | |
| Pull-Down Current | -30 | -24 | -22 | µA | |

| Parameter | Min | Typ | Max | Unit | Test Conditions/Comments |
|---|-------------------|----------|--------------------|-----------------|--|
| IDAC2 and IDAC3 | -350 ¹ | | +280 ¹ | μA | |
| | -460 | | +300 | μA | |
| Pull-Down Current for IDAC2 | -300 | -288 | -160 | μA | |
| Zero-Scale Error Drift ² | | | | | |
| IDAC0 and IDAC1 | -850 ¹ | ±300 | +1200 ¹ | nA/°C | |
| | -1400 | ±300 | +1400 | nA/°C | |
| IDAC4 and IDAC5 | -120 | ±50 | +205 ¹ | nA/°C | |
| | -120 | ±50 | +230 | nA/°C | |
| IDAC2 and IDAC3 | | ±1 | | μA/°C | |
| Settling Time | | | | | |
| IDAC0, IDAC1, IDAC2, and IDAC3 | | 1 | | ms | To 0.1%, IDACxCON[5:2] = 0101b, ±1 mA change in output current |
| IDAC4 and IDAC5 | | 2 | | ms | |
| IDAC0, IDAC1, IDAC2, and IDAC3 | | 250 | | μs | To 1%, IDACxCON[5:2] = 0101b, ±1 mA change in output current |
| IDAC4 and IDAC5 | | 1.2 | | ms | |
| IDAC0, IDAC1, IDAC2, and IDAC3 | | 50 | | μs | To 1%, IDACxCON[5:2] = 0000b, ±1 mA change in output current |
| IDAC4 and IDAC5 | | 1.1 | | ms | |
| IDAC3 Switching Time ² | | | 1 | μs | Time to switch from current source to current sink |
| Transconductance | | | | | Analog input signal coupled on to CDAMP_IDACx pin via 1 nF capacitor; frequency range = 100 kHz to 1000 kHz; voltage is the peak to peak voltage on the CDAMP_IDACx pin of the associated IDAC; current is peak-to-peak current change |
| IDAC0 and IDAC1 | | 7.99/100 | | mA/mV | |
| IDAC2 | | 12.6/100 | | mA/mV | |
| IDAC3 | | 18.6/100 | | mA/mV | |
| IDAC4 and IDAC5 | | 1.16/100 | | mA/mV | |
| IDAC Shutdown Temperature | | 125 | | °C | Die temperature; enabled via IDACxCON[6] |
| VDAC CHANNEL SPECIFICATIONS^{6, 9, 10} | | | | | |
| DC Accuracy | | | | | |
| Resolution | 12 | | | Bits | |
| Relative Accuracy | | | | | |
| VDAC0, VDAC1, and VDAC2 | -6.3 | ±1 | +10 | LSB | |
| VDAC4 and VDAC5 | -7.3 | ±2 | +11 | LSB | |
| VDAC3, VDAC6, and VDAC7 | -7 | ±2 | +8.5 | LSB | |
| Differential Nonlinearity | -0.99 | ±0.6 | +1 | LSB | Guaranteed monotonic |
| Offset Error | | | | | |
| Calculated | | ±5 | | mV | 2.5 V internal reference |
| Actual | | | | | Measured at Code 0 |
| VDAC0, VDAC1, VDAC4, and VDAC5 | | 4 | 7 | mV | |
| VDAC6 and VDAC7 | | 15 | 22 | mV | |
| VDAC2 and VDAC3 | -30 | -20 | | mV | |
| Full-Scale Error | | | ±0.7 ¹ | % of full scale | For VDAC2, VDAC3, VDAC4, VDAC5, and VDAC6 |
| | | | ±0.9 | % of full scale | For VDAC2, VDAC3, VDAC4, VDAC5, and VDAC6 |
| VDAC0, VDAC1, and VDAC7 ² | | | ±0.7 ¹ | % | With 500 Ω load |
| | | | ±0.9 | % | With 500 Ω load |

| Parameter | Min | Typ | Max | Unit | Test Conditions/Comments |
|--|--------------------------------|------|-------------------------------|--------|--|
| VDAC0 and VDAC1 | | ±0.5 | | % | With 75 Ω load, over full temperature range |
| VDAC7 | | ±0.5 | | % | With 100 Ω load, over full temperature range |
| Gain Mismatch Error | | 0.1 | | % | VDAC0 relative to VDAC1 |
| | | 0.2 | | % | VDAC2 relative to VDAC3 |
| | | 0.1 | | % | VDAC4 relative to VDAC5 |
| | | 0.35 | | % | VDAC6 relative to VDAC7; both driving a 500 Ω load |
| Offset Error Drift | | | | | |
| Calculated | | | | | |
| VDAC0, VDAC1, VDAC4, and VDAC5 | | ±5 | | μV/°C | |
| VDAC2, VDAC3, VDAC6, and VDAC7 | | ±25 | | μV/°C | |
| Actual | | | | | Measured at Code 0 |
| VDAC0, VDAC1, VDAC4, and VDAC5 | | ±13 | | μV/°C | |
| VDAC2, VDAC3, VDAC6, and VDAC7 | | ±75 | | μV/°C | |
| Gain Error Drift | | | | | Excluding internal reference drift |
| VDAC0, VDAC1, VDAC4, and VDAC5 | | 5 | | ppm/°C | |
| VDAC2, VDAC3, VDAC6, and VDAC7 | | 10 | | ppm/°C | |
| Output Impedance | | | | | |
| VDAC0, VDAC1, VDAC4, VDAC5, VDAC6, and VDAC7 | | 1 | | Ω | |
| VDAC2 and VDAC3 | | 1.5 | | Ω | |
| Short-Circuit Current | | | | | Measured with VDAC shorted to ground and to associated power supply |
| VDAC0 and VDAC1 | | ±200 | | mA | |
| VDAC2 and VDAC3 | | ±170 | | mA | |
| VDAC4 and VDAC5 | | ±200 | | mA | |
| VDAC6 and VDAC7 | | ±200 | | mA | |
| VDAC Outputs | | | | | Capacitive load up to 0.01 μF |
| Output Impedance | | | | | |
| VDAC0, VDAC1, and VDAC4 to VDAC7 | | 1.8 | | Ω | |
| VDAC2 and VDAC3 | | 1.2 | | Ω | |
| Output Range | | | | | Buffer on |
| VDAC0 and VDAC1 | 0 + Actual Offset ¹ | | $AV_{DD} - 600 \text{ mV}$ | V | $R_L = 75 \Omega$, 40 mA maximum, V_{OUT} maximum = 3 V |
| VDAC2 and VDAC3 | $AV_{NEG} + 250 \text{ mV}$ | | -0.15 | V | $R_L = 500 \Omega$, 10 mA maximum, V_{OUT} maximum = -5 V, gain = -2.25 V |
| VDAC4 and VDAC5 | 0 + Actual Offset ¹ | | $AV_{DD} - 300 \text{ mV}$ | V | $R_L = 300 \Omega$, 10 mA maximum, V_{OUT} maximum = 3 V |
| VDAC6 | 0 + Actual Offset ¹ | | $VDACV_{DD} - 250 \text{ mV}$ | V | $R_L = 500 \Omega$, 10 mA maximum, V_{OUT} maximum = 5 V |
| VDAC7 | 0 + Actual Offset ¹ | | $VDACV_{DD} - 700 \text{ mV}$ | V | $R_L = 100 \Omega$, 50 mA maximum, V_{OUT} maximum = 5 V |

| Parameter | Min | Typ | Max | Unit | Test Conditions/Comments |
|---|-------------------------------------|---------|-------------------------------------|------------|--|
| DAC AC CHARACTERISTICS | | | | | |
| Slew Rate | | 3 | | V/ μ s | |
| VDAC0, VDAC1, VDAC4, and VDAC5 | | | | | |
| VDAC2, VDAC3, and VDAC6 | | 1.1 | | V/ μ s | |
| Voltage Output Settling Time | | 10 | | μ s | Load = 100 pF |
| | | 0.05 | | ms | Load = 0.01 μ F |
| Digital-to-Analog Glitch Energy | | 20 | | nV/sec | 1 LSB change at major carry (DACxDAT register change from 0x07FF0000 to 0x08000000) |
| AC PSRR 100 Hz | | | | | |
| VDAC0, VDAC1, VDAC4, and VDAC5 | | 72 | | dB | |
| VDAC2 and VDAC3 | | 67 | | dB | |
| VDAC6 and VDAC7 | | 64 | | dB | |
| AC PSRR 1 kHz | | | | | |
| VDAC0, VDAC1, VDAC4, and VDAC5 | | 56 | | dB | |
| VDAC2 and VDAC3 | | 53 | | dB | |
| VDAC6 and VDAC7 | | 50 | | dB | |
| POWER-ON RESET (POR) | | | | | |
| POR Trip Level | 2.80 | 2.85 | 2.9 | V | Refers to voltage at DVDD pin |
| | 2.74 | 2.79 | 2.83 | V | Power-on level |
| | | 65 | | mV | Power-down level |
| POR Hysteresis | | | | | |
| Allowed Power-Up Time for DVDD Supply | 0.2 | | 100 | ms | |
| EXTERNAL RESET | | | | | |
| External Reset Minimum Pulse Width ² | 1.5 | | | μ s | Minimum pulse width required on external $\overline{\text{RESET}}$ pin to trigger a reset sequence |
| Reset Pin Glitch Immunity ² | | | 50 | ns | Maximum low pulse width on $\overline{\text{RESET}}$ pin that does not generate a reset |
| TEMPERATURE SENSOR | | | | | |
| Accuracy ² | 1.25 | 1.37 | 1.494 | V | Indicates die temperature; ADC measured voltage for temperature sensor channel without calibration, $T_A = 25^\circ\text{C}$ |
| FLASH/EE MEMORY | | | | | |
| Endurance | 10,000 | | | Cycles | |
| Data Retention | 20 | | | Years | $T_J = 85^\circ\text{C}$ |
| INTERNAL HIGH POWER OSCILLATOR | | | | | |
| Accuracy | -2.25 ¹ | 16 | +2.25 ¹ | MHz | Used as input to PLL to generate 80 MHz clock |
| | -3.0 | | +3 | % | |
| | | | | % | |
| INTERNAL LOW POWER OSCILLATOR | | | | | |
| Accuracy | -12 ¹ | 32.768 | +12 | kHz | |
| | -22 | ± 8 | +12 | % | |
| | | ± 8 | +12 | % | |
| LOGIC INPUTS | | | | | |
| Input Low Voltage (V_{INL}) | | | $0.2 \times \text{IOV}_{\text{DD}}$ | V | |
| Input High Voltage (V_{INH}) | $0.7 \times \text{IOV}_{\text{DD}}$ | | | V | |
| Short-Circuit Current ² | | | 12 | mA | |
| LOGIC OUTPUTS | | | | | |
| Output High Voltage (V_{OH}) ¹¹ | $\text{IOV}_{\text{DD}} - 0.4$ | | | V | $I_{\text{SOURCE}} = 2 \text{ mA}$ |
| Output Low Voltage (V_{OL}) ¹¹ | | | 0.4 | V | $I_{\text{SINK}} = 2 \text{ mA}$ |
| Short-Circuit Current ² | | | 12 | mA | |

| Parameter | Min | Typ | Max | Unit | Test Conditions/Comments |
|--|------|--------|-----|------------------|--|
| INPUT LEAKAGE CURRENT | | | | | |
| Logic 1 | | 80 | | μA | $V_{\text{INH}} = 3.6\text{ V}$ |
| Internal Pull-Up Disabled | -22 | +6 | +22 | nA | |
| Logic 0 | | 80 | | μA | $V_{\text{INH}} = 0\text{ V}$ |
| Internal Pull-Up Disabled | -22 | +6 | +22 | nA | |
| Pull-Up | 30 | 40 | 72 | k Ω | If not disabled, disabled at reset; pull-up can be described as an 80 μA (typical) current source |
| CRYSTAL INPUTS XCLKI AND XCLKO (16 MHz) | | | | | |
| Logic Inputs, XCLKI Only | | | | | |
| Input Low Voltage (V_{INL}) | | 1.1 | | V | |
| Input High Voltage (V_{INH}) | | 1.7 | | V | |
| XCLKI Input Capacitance | | 8 | | pF | |
| XCLKO Output Capacitance | | 8 | | pF | |
| MICROCONTROLLER UNIT CLOCK RATE | | | | | |
| Using PLL Output ² | 0.05 | | 80 | MHz | |
| PROCESSOR START-UP TIME | | | | | |
| At Power-On ² | | 38 | 50 | ms | Includes kernel power-on execution time |
| After Reset Event | | 1.44 | | ms | Includes kernel power-on execution time |
| After Processor Power Down Mode 1, Mode 2, or Mode 3 | | 3 to 5 | | f_{CLK} | |
| POWER REQUIREMENTS | | | | | |
| Power Supply Voltage Range | | | | | |
| AV_{DD} | 2.9 | 3.3 | 3.6 | V | Measured between $AV_{\text{DD}x}$ and AGND |
| IOV_{DD} | 2.9 | 3.3 | 3.6 | V | Measured between $IOV_{\text{DD}x}$ and AGND |
| Analog Power Supply Currents | | | | | |
| AV_{DD} Current | | 6.5 | 7.2 | mA | ADC, VDACS, IDACS off |
| Digital Power Supply Current | | | | | |
| Current in Normal Mode | | | | | |
| DV_{DD} | | 29 | 32 | mA | $\text{CLKCON1}[2:0] = [000b]$ |
| IOV_{DD} | | 2.7 | 5.1 | mA | All GPIO pull-ups enabled |
| Additional Power Supply Currents | | | | | |
| ADC ² | | 3.1 | 3.6 | mA | ADC continuously converting at 100 kSPS |
| ADC Input Buffer ² | | 4.1 | 4.8 | mA | Both buffers enabled |
| IDAC ² | | 26.5 | 30 | mA | |
| DAC ² | | 2.7 | 3.1 | mA | Total for all VDACS driving maximum allowed load with $\text{DACxDAT} = 0$ |
| VDAC2 and VDAC3 ² | | -1.7 | | mA | I_{DD} when VDAC2 and VDAC3 are driving maximum allowed load with DACxDAT set to 0 |
| VDAC6 and VDAC7 ² | | 1 | | mA | I_{DD} sourced from the $VDACV_{\text{DD}}$ supply when VDAC6 and VDAC7 are driving the maximum allowed load with DACxDAT set to 0 |

¹ Reduced temperature range of -10°C to +85°C.

² These numbers are not production tested but are guaranteed by design or characterization data at production release.

³ The input current is the total input current including the input pad and mux leakage plus the charge current for the full input circuit. The input current relates to the ADC sampling frequency.

⁴ The internal reference calibration and trimming are performed when the processor operates in normal mode with CD = 0, when ADC is enabled and converting, when IDACs are all on, and when VDACS are on. V_{REF} accuracy can vary under other operating conditions.

⁵ Measured using the following box method:

$$\frac{V_{REF} \text{ Maximum (at Any Temperature)} - V_{REF} \text{ Minimum (at Any Temperature)}}{2.5 \times (\text{Temperature Maximum} - \text{Temperature Minimum})} \times 10^6$$

⁶ VDAC linearity specifications are calculated with following ranges:

VDAC0 and VDAC1 = +150 mV to +2.699 V

VDAC2 and VDAC3: -150 mV to -4.22 V

VDAC4 and VDAC5: +150 mV to +2.98 V

VDAC6: +150 mV to +4.747 V

VDAC7: +150 mV to +4.297 V

⁷ Analog Devices, Inc., production IDAC full-scale trimming conditions include PVDD_IDACx pin voltage = 0.7 V, all IDACs on.

⁸ The long-term stability specifications is noncumulative. The drift in subsequent 1000 hour periods is significantly lower than in the first 1000 hour period.

⁹ For all VDAC specifications for VDAC0, VDAC1, VDAC4, and VDAC5, DACxCON[10:9] = 11.

¹⁰ VDACx minimum and maximum limits apply to the internal reference only (DACxCON[1:0] = 00_b). AVDDx supply valid only with typical specifications.

¹¹ The average current from the GPIO pins must not exceed 3 mA per pin. See Figure 22.

TIMING SPECIFICATIONS

I²C Timing

Table 2. I²C Timing in Standard Mode (100 kHz)

| Parameter | Description | Slave | | | Unit |
|---------------------|---|-------|-----|------|------|
| | | Min | Typ | Max | |
| t _L | SCLx low pulse width | 4.7 | | | μs |
| t _H | SCLx high pulse width | 4.0 | | | ns |
| t _{SHD} | Start condition hold time | 4.0 | | | μs |
| t _{DSU} | Data setup time | 250 | | | ns |
| t _{DHD} | Data hold time (SDAx held internally for 300 ns after falling edge of SCLx) | 0 | | 3.45 | μs |
| t _{RSU} | Setup time for repeated start | 4.7 | | | μs |
| t _{PSU} | Stop condition setup time | 4.0 | | | μs |
| t _{BUF} | Bus free time between a stop condition and a start condition | 4.7 | | | μs |
| t _R | Rise time for both SCLx and SDAx | | | 1 | μs |
| t _F | Fall time for both SCLx and SDAx | | 15 | 300 | ns |
| t _{VD;DAT} | Data valid time | | | 3.45 | μs |
| t _{VD;ACK} | Data valid acknowledge time | | | 3.45 | μs |

Table 3. I²C Timing in Fast Mode (400 kHz)

| Parameter | Description | Slave | | | Unit |
|---------------------|---|-------|-----|-----|------|
| | | Min | Typ | Max | |
| t _L | SCLx low pulse width | 1.3 | | | μs |
| t _H | SCLx high pulse width | 0.6 | | | ns |
| t _{SHD} | Start condition hold time | 0.3 | | | μs |
| t _{DSU} | Data setup time | 100 | | | ns |
| t _{DHD} | Data hold time (SDAx held internally for 300 ns after falling edge of SCLx) | 0 | | | μs |
| t _{RSU} | Setup time for repeated start | 0.6 | | | μs |
| t _{PSU} | Stop condition setup time | 0.3 | | | μs |
| t _{BUF} | Bus free time between a stop condition and a start condition | 1.3 | | | μs |
| t _R | Rise time for both SCLx and SDAx | 20 | | 300 | ns |
| t _F | Fall time for both SCLx and SDAx | | 15 | 300 | ns |
| t _{VD;DAT} | Data valid time | | | 0.9 | μs |
| t _{VD;ACK} | Data valid acknowledge time | | | 0.9 | μs |

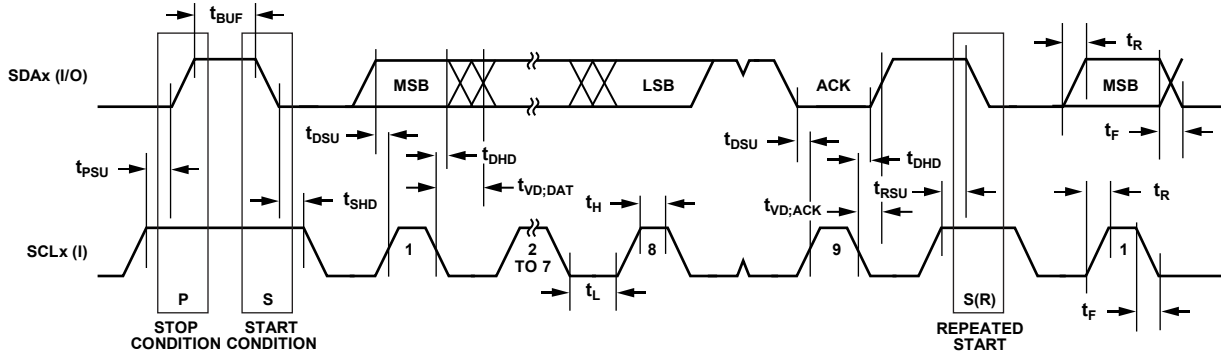


Figure 2. I²C Compatible Interface Timing

13040-302

SPI Timing

Table 4. SPI Master Mode Timing (Phase Mode = 1)

| Parameter | Description | Min | Typ | Max | Unit |
|------------------|---|-----|---------------------------------------|-----|------|
| t _{SL} | SCLKx low pulse width | | $(SPIxDIV^1 + 1) \times t_{HCLK}^2/2$ | | ns |
| t _{SH} | SCLKx high pulse width | | $(SPIxDIV^1 + 1) \times t_{HCLK}^2/2$ | | ns |
| t _{DAV} | Data output valid after SCLKx edge | 0 | 3 | | ns |
| t _{DSU} | Data input setup time before SCLKx edge | | 1/2 SCLKx | | ns |
| t _{DHD} | Data input hold time after SCLKx edge | | SCLKx | | ns |
| t _{DF} | Data output fall time | | SCLKx | | ns |
| t _{DR} | Data output rise time | | 25 | | ns |
| t _{SR} | SCLKx rise time | | 25 | | ns |
| t _{SF} | SCLKx fall time | | 20 | | ns |

¹ For SPI0, x is 0, and for SPI1, x is 1.

² t_{HCLK} is the divided system clock, UCLK/CLKCON1[2:0].

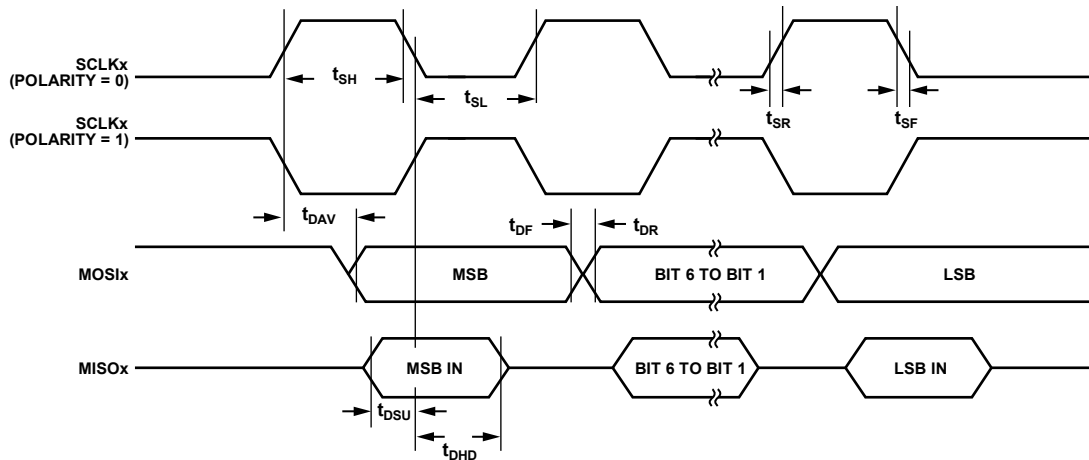


Figure 3. SPI Master Mode Timing (Phase Mode = 1)

13040-303

Table 5. SPI Master Mode Timing (Phase Mode = 0)

| Parameter | Description | Min | Typ | Max | Unit |
|------------|---|-----|---------------------------------------|-----|------|
| t_{SL} | SCLKx low pulse width | | $(SPIxDIV^1 + 1) \times t_{HCLK}^2/2$ | | ns |
| t_{SH} | SCLKx high pulse width | | $(SPIxDIV^1 + 1) \times t_{HCLK}^2/2$ | | ns |
| t_{DAV} | Data output valid after SCLKx edge | 0 | 3 | | ns |
| t_{DOSU} | Data output setup before SCLKx edge | | $\frac{1}{2} SCLKx$ | | ns |
| t_{DSU} | Data input setup time before SCLKx edge | | SCLKx | | ns |
| t_{DHD} | Data input hold time after SCLKx edge | | SCLKx | | ns |
| t_{DF} | Data output fall time | | 25 | | ns |
| t_{DR} | Data output rise time | | 25 | | ns |
| t_{SR} | SCLKx rise time | | 20 | | ns |
| t_{SF} | SCLKx fall time | | 20 | | ns |

¹ For SPI0, x is 0, and for SPI1, x is 1.

² t_{HCLK} is the divided system clock, UCLK/CLKCON1[2:0].

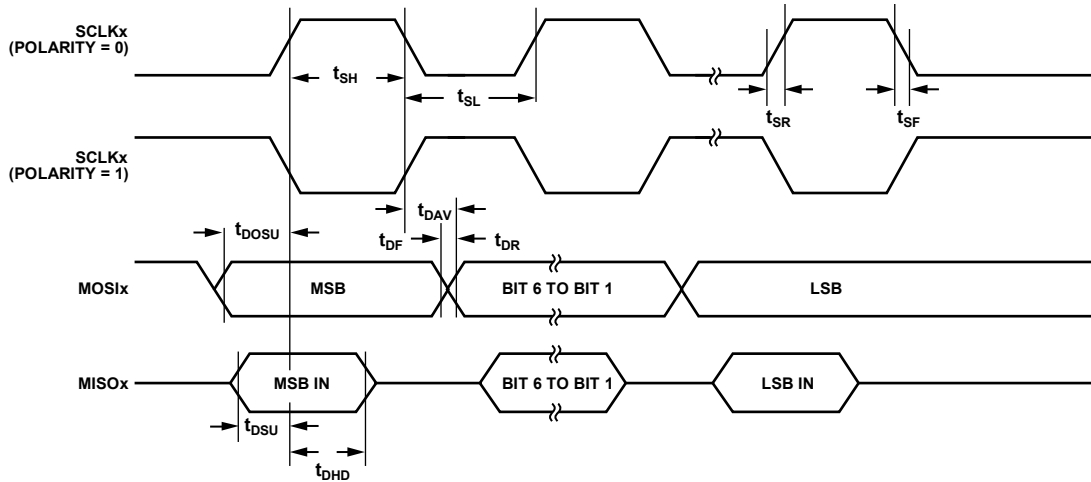


Figure 4. SPI Master Mode Timing (Phase Mode = 0)

1394G-004

Table 6. SPI Slave Mode Timing (Phase Mode = 1)

| Parameter | Description | Min | Typ | Max | Unit |
|-------------------|--|-------|-------------------------------------|-----|------|
| t_{CS0}/t_{CS1} | $\overline{CS0}/\overline{CS1}$ to SCLKx edge | 10 | | | ns |
| t_{CSM} | $\overline{CS0}/\overline{CS1}$ high time between active periods | SCLKx | | | ns |
| t_{SL} | SCLKx low pulse width | | $(SPIxDIV^1 + 1) \times t_{HCLK}^2$ | | ns |
| t_{SH} | SCLKx high pulse width | | $(SPIxDIV^1 + 1) \times t_{HCLK}^2$ | | ns |
| t_{DAV} | Data output valid after SCLKx edge | | 20 | | ns |
| t_{DSU} | Data input setup time before SCLKx edge | 10 | | | ns |
| t_{DHD} | Data input hold time after SCLKx edge | 10 | | | ns |
| t_{DF} | Data output fall time | | 25 | | ns |
| t_{DR} | Data output rise time | | 25 | | ns |
| t_{SR} | SCLKx rise time | 1 | | | ns |
| t_{SF} | SCLKx fall time | 1 | | | ns |
| t_{SFS} | $\overline{CS0}/\overline{CS1}$ high after SCLKx edge | 20 | | | ns |

¹ For SPI0, x is 0, and for SPI1, x is 1.

² t_{HCLK} is the divided system clock, UCLK/CLKCON1[2:0].

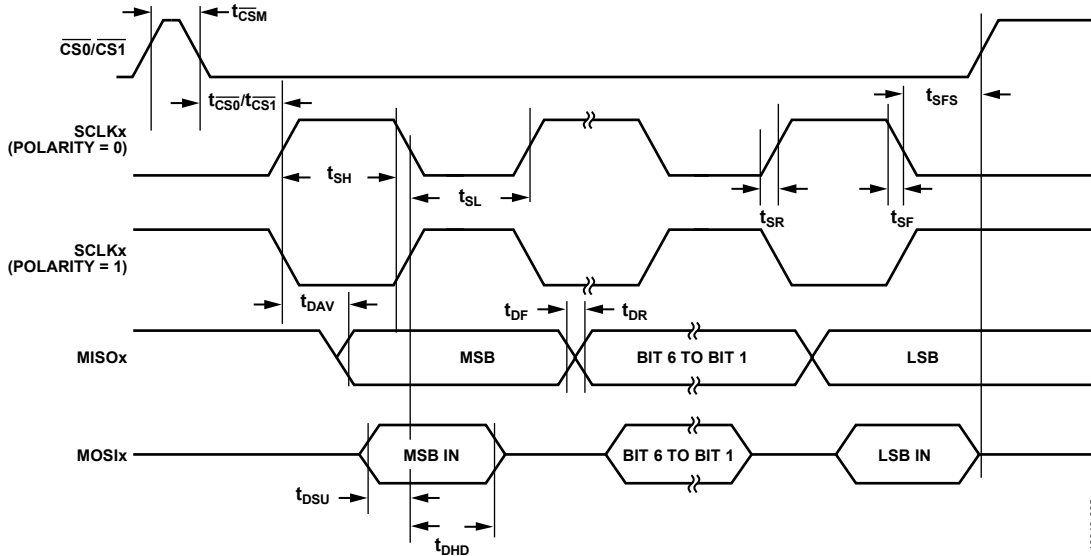


Figure 5. SPI Slave Mode Timing (Phase Mode = 1)

13394-005

Table 7. SPI Slave Mode Timing (Phase Mode = 0)

| Parameter | Description | Min | Typ | Max | Unit |
|-------------------------------------|--|-------|-------------------------------------|-----|------|
| $t_{\overline{CS0}/\overline{CS1}}$ | $\overline{CS0}/\overline{CS1}$ to SCLKx edge | 10 | | | ns |
| $t_{\overline{CSM}}$ | $\overline{CS0}/\overline{CS1}$ high time between active periods | SCLKx | | | ns |
| t_{SL} | SCLKx low pulse width | | $(SPIxDIV^1 + 1) \times t_{HCLK}^2$ | | ns |
| t_{SH} | SCLKx high pulse width | | $(SPIxDIV^1 + 1) \times t_{HCLK}^2$ | | ns |
| t_{DAV} | Data output valid after SCLKx edge | | 20 | | ns |
| t_{DSU} | Data input setup time before SCLKx edge | 10 | | | ns |
| t_{DHD} | Data input hold time after SCLKx edge | 10 | | | ns |
| t_{DF} | Data output fall time | | 25 | | ns |
| t_{DR} | Data output rise time | | 25 | | ns |
| t_{SR} | SCLKx rise time | 1 | | | ns |
| t_{SF} | SCLKx fall time | 1 | | | ns |
| t_{DOCS} | Data output valid after $\overline{CS0}/\overline{CS1}$ edge | 20 | | | ns |
| t_{SFS} | $\overline{CS0}/\overline{CS1}$ high after SCLKx edge | 10 | | | ns |

¹ For SPI0, x is 0, and for SPI1, x is 1

² t_{HCLK} is the divided system clock, UCLK/CLKCON1[2:0].

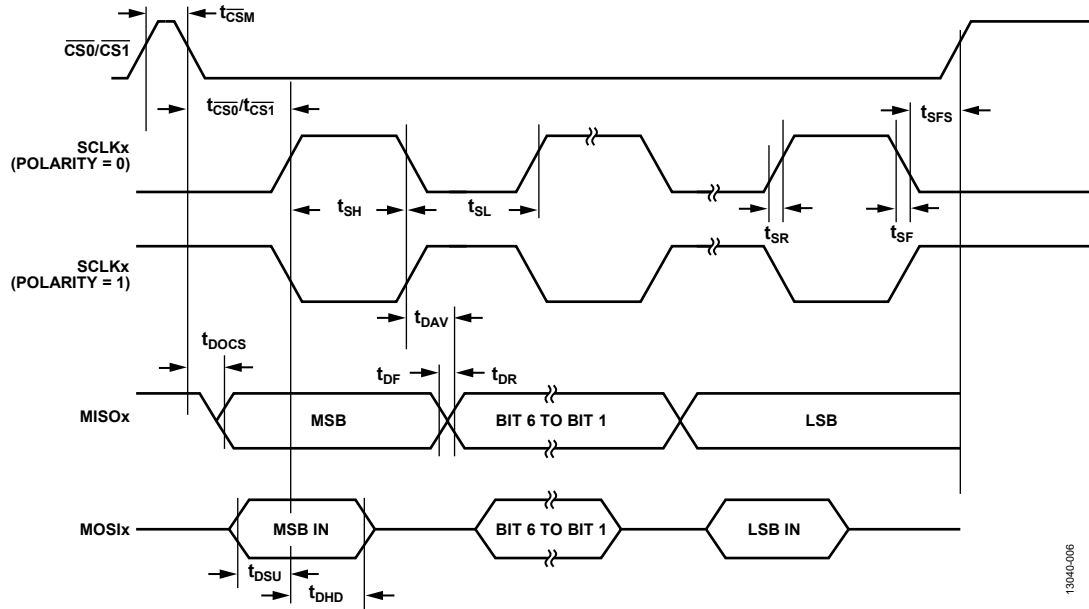


Figure 6. SPI Slave Mode Timing (Phase Mode = 0)

13940-006

ABSOLUTE MAXIMUM RATINGS

$T_A = 25^\circ\text{C}$, unless otherwise noted.

Table 8.

| Parameter | Rating |
|--|-----------------------------|
| AV_{DD} to AGNDx | -0.3 V to +3.96 V |
| AV_{NEG} to AGNDx | -5.5 V to +0.3 V |
| $VDACV_{DD}$ to AGNDx | -0.3 V to +5.5 V |
| IOVDDx to DGNDx | -0.3 V to +3.96 V |
| Digital Input Voltage to DGNDx | -0.3 V to IOVDDx + 0.3 V |
| Digital Output Voltage to DGNDx | -0.3 V to IOVDDx + 0.3 V |
| Analog Inputs to AGNDx | -0.3 V to $AV_{DD} + 0.3$ V |
| Total Positive GPIO Pins Current | 0 mA to 30 mA |
| Total Negative GPIO Pins Current | -30 mA to 0 mA |
| IDAC3 Pull-Down Voltage | $AV_{NEG} - 0.3$ V |
| IDAC3 Pull-Down Current | -100 mA |
| Operating Temperature Range | -40°C to +85°C |
| Storage Temperature Range | -65°C to +150°C |
| Junction Temperature | 150°C |
| ESD Rating, All Pins | |
| Human Body Model (HBM) | 1 kV |
| Field-Induced Charged Device Model (FICDM) | 1.25 kV |

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

THERMAL RESISTANCE

θ_{JA} is specified for the worst-case conditions, that is, a device soldered in a circuit board for surface-mount packages.

Table 9. Thermal Resistance

| Package Type | θ_{JA} | θ_{JC} | Unit |
|------------------|---------------|---------------|---------------------------|
| 112-Ball CSP_BGA | 44.5 | 11 | $^\circ\text{C}/\text{W}$ |

ESD CAUTION



ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS



Figure 7. Pin Configuration

Table 10. Pin Function Descriptions

| Pin No. | Mnemonic | Type ¹ | Description |
|---------|-----------------------|-------------------|---|
| D2 | RESET | I | Reset Input (Active Low). An internal pull-up is included on this pin. |
| E3 | P0.0/SCLK0/PLAI[0] | I/O | General-Purpose Input and Output Port 0.0/SPI0 Clock/Input to PLA Element 0. This pin defaults as an input with the internal pull-up resistor disabled. |
| E2 | P0.1/MISO0/PLAI[1] | I/O | General-Purpose Input and Output Port 0.1/SPI0 Data Master Input-Slave Output/Input to PLA Element 1. This pin defaults as an input with the internal pull-up disabled. |
| F3 | P0.2/MOSI0/PLAI[2] | I/O | General-Purpose Input and Output Port 0.2/SPI0 Data Master Output-Slave Input/Input of PLA Element 2. This pin defaults as an input with the internal pull-up disabled. |
| F2 | P0.3/IRQ0/CS0/PLAI[3] | I/O | General-Purpose Input and Output Port 0.3/External Interrupt Request 0/SPI0 Chip Select Input/Input of PLA Element 3. This pin defaults as an input with the internal pull-up disabled. If SPI0 is used, configure this pin as CS0. |
| G4 | P0.4/SCL0/PLAO[2] | I/O | General-Purpose Input and Output Port 0.4/I ² C Interface Clock for I2C0/Output of PLA Element 2. This pin defaults as an input with the internal pull-up disabled. |

| Pin No. | Mnemonic | Type ¹ | Description |
|---------|---|-------------------|---|
| G3 | P0.5/SDA0/PLAO[3] | I/O | General-Purpose Input and Output Port 0.5/I ² C Interface Data for I2C0/Output of PLA Element 3. This pin defaults as an input with internal pull-up disabled. |
| G2 | P0.6/SCL1/PLAO[4] | I/O | General-Purpose Input and Output Port 0.6/I ² C Interface Clock for I2C1/Output of PLA Element 4. This pin defaults as an input with internal pull-up disabled. |
| G1 | P0.7/SDA1/PLAO[5] | I/O | General-Purpose Input and Output Port 0.7/I ² C Interface Data for I2C1/Output of PLA Element 5. This pin defaults as an input with internal pull-up disabled. |
| C4 | P1.0/SIN/ECLKIN/PLAI[4] | I/O | General-Purpose Input and Output Port 1.0/UART Input Pin/External Input Clock/Input to PLA Element 4. The ECLKIN pin is used for the UART downloader. This pin defaults as an input with internal pull-up disabled. |
| D5 | P1.1/SOUT/PLACK1/PLAI[5] | I/O | General-Purpose Input and Output Port 1.1/UART Output Pin/PLA Input Clock/Input to PLA Element 5. The PLACK1 pin is used for the UART downloader. This pin defaults as an input with internal pull-up disabled. |
| C5 | P1.2/PWM0/PLAI[6] | I/O | General-Purpose Input and Output Port 1.2/PWM0 Output/Input to PLA Element 6. This pin defaults as an input with internal pull-up disabled. |
| C6 | P1.3/PWM1/PLAI[7] | I/O | General-Purpose Input and Output Port 1.3/PWM1 Output/Input to PLA Element 7. This pin defaults as an input with internal pull-up disabled. |
| C7 | P1.4/PWM2/SCLK1/PLAO[10] | I/O | General-Purpose Input and Output Port 1.4/PWM2 Output/SPI1 Clock/Output of PLA Element 10. This pin defaults as an input with internal pull-up disabled. |
| C8 | P1.5/PWM3/MISO1/PLAO[11] | I/O | General-Purpose Input and Output Port 1.5/PWM3 Output/SPI1 Data Master Input-Slave Output/Output of PLA Element 11. This pin defaults as an input with internal pull-up disabled. |
| C9 | P1.6/PWM4/MOSI1/PLAO[12] | I/O | General-Purpose Input and Output Port 1.6/PWM4 Output/SPI1 Data Master Output-Slave Input/Output of PLA Element 12. This pin defaults as an input with internal pull-up disabled. |
| D9 | P1.7/IRQ1/PWM5/ $\overline{CS1}$ /PLAO[13] | I/O | General-Purpose Input and Output Port 1.7/External Interrupt Request 1/PWM5 Output/SPI1 Chip Select Input/Output of PLA Element 13. This pin defaults as an input with internal pull-up disabled. If SPI1 is used, configure this pin as $\overline{CS1}$. |
| D4 | P2.0/IRQ2/PWMTRIP/PLACK2/PLAI[8] | I/O | General-Purpose Input and Output Port 2.0/External Interrupt Request 2/PWM Trip Input Source/PLA Input Clock/Input to PLA Element 8. This pin defaults as an input with the internal pull-up disabled. |
| E8 | P2.1/IRQ3/PWMSYNC/PLAI[9] | I/O | General-Purpose Input and Output Port 2.1/External Interrupt Request 3/PWM Sync Input/Input to PLA Element 9. This pin defaults as an input with the internal pull-up disabled. |
| E4 | P2.2/IRQ4/ \overline{MRST} /CLKOUT/PLAI[10] | I/O | General-Purpose Input and Output Port 2.2/External Interrupt Request 4/Reset Out Pin/Clock Output/Input to PLA Element 10. This pin defaults as an input with the internal pull-up disabled. |
| C3 | P2.3/BM | I/O | General-Purpose Input and Output Port 2.3/BM pin. If this pin is low, then the device enters UART download after the next rest sequence. This pin defaults as an input with the internal pull-up disabled. |
| D7 | P2.4/IRQ5/ADCCONV/PWM6/PLAO[18] | I/O | General-Purpose Input and Output Port 2.4/External Interrupt Request 5/External Input to Start ADC Conversions/PWM6 Output/Output of PLA Element 18. This pin defaults as an input with the internal pull-up disabled. |
| D8 | P2.5/IRQ6/PWM7/PLAO[19] | I/O | General-Purpose Input and Output Port 2.5/External Interrupt Request 6/PWM7 Output/Output of PLA Element 19. This pin defaults as an input with the internal pull-up disabled. |
| H1 | P2.6/IRQ7/PLAO[20] | I/O | General-Purpose Input and Output Port 2.6/External Interrupt Request 7/Output of PLA Element 20. This pin defaults as an input with the internal pull-up disabled. |
| H2 | P2.7/IRQ8/PLAO[21] | I/O | General-Purpose Input and Output Port 2.7/External Interrupt Request 8/Output of PLA Element 21. This pin defaults as an input with the internal pull-up disabled. |
| H3 | P3.0/PLAI[12] | I/O | General-Purpose Input and Output Port 3.0/Input to PLA Element 12. This pin defaults as an input with the internal pull-up disabled. |

| Pin No. | Mnemonic | Type ¹ | Description |
|-------------------------------|---|-------------------|---|
| J3 | P3.1/PLAI[13] | I/O | General-Purpose Input and Output Port 3.1/Input to PLA Element 13. This pin defaults as an input with the internal pull-up disabled. |
| D3 | P3.2/PLAI[14] | I/O | General-Purpose Input and Output Port 3.2/Input to PLA Element 14. This pin defaults as an input with the internal pull-up disabled. |
| J1 | P3.4/PLAO[26] | I/O | General-Purpose Input and Output Port 3.4/Output of PLA Element 26. This pin defaults as an input with the internal pull-up disabled. |
| E10 | SWCLK | I | Serial Wire Debug Clock Input Pin. |
| E9 | SWDIO | I/O | Serial Wire Debug Data Input/Output Input Pin. |
| G11 | VREF_1.2 | AO | 1.2 V Reference Output. This pin cannot be used to source current externally. Connect this pin to AGND via a 470 nF capacitor. |
| D11 | IREF | AI | This pin generates the reference current for the IDACs. Connect this pin to analog ground via a 5 ppm, 3.16 k Ω external resistor (R _{EXT}). |
| J6 | AIN0 | AI | Single-Ended or Differential Analog Input 0. |
| H7 | AIN1 | AI | Single-Ended or Differential Analog Input 1. |
| J7 | AIN2 | AI | Single-Ended or Differential Analog Input 2. |
| K7 | AIN3 | AI | Single-Ended or Differential Analog Input 3. |
| G8 | AIN4 | AI | Single-Ended or Differential Analog Input 4. This is also the input for the digital comparator. |
| H8 | AIN5 | AI | Single-Ended or Differential Analog Input 5. |
| J8 | AIN6 | AI | Single-Ended or Differential Analog Input 6. |
| K8 | AIN7 | AI | Single-Ended or Differential Analog Input 7. |
| L8 | AIN8 | AI | Single-Ended or Differential Analog Input 8. |
| L9 | AIN9 | AI | Single-Ended or Differential Analog Input 9. |
| L4 | VDAC0 | AO | 12-Bit VDAC Output 0, 0 V to 3 V Range. |
| K4 | VDAC1 | AO | 12-Bit VDAC Output 1, 0 V to 3 V Range. |
| J9 | VDAC2 | AO | 12-Bit VDAC Output 2, -5 V to 0 V Range. |
| K9 | VDAC3 | AO | 12-Bit VDAC Output 3, -5 V to 0 V Range. |
| J4 | VDAC4 | AO | 12-Bit VDAC Output 4, 0 V to 3 V Range. |
| H5 | VDAC5 | AO | 12-Bit VDAC Output 5, 0 V to 3 V Range. |
| H9 | VDAC6 | AO | 12-Bit VDAC Output 6, 0 V to 5 V Range. |
| H10 | VDAC7 | AO | 12-Bit VDAC Output 7, 0 V to 5 V Range. |
| A2 | IDAC0 | AO | IDAC0 (100 mA). |
| A3 | PVDD_IDAC0 | S | Power for IDAC0. |
| B2 | CDAMP_IDAC0 | AI | Damping Capacitor Pin for IDAC0. Connect this pin to the PVDD supply. |
| A10 | IDAC1 | AO | IDAC1 (100 mA). |
| A9 | PVDD_IDAC1 | S | Power for IDAC1. |
| B10 | CDAMP_IDAC1 | AI | Damping capacitor pin for IDAC1. Connect this pin to the PVDD supply. |
| B11 | IDAC5 | AO | IDAC5 (20 mA). |
| C11 | PVDD_IDAC5 | S | Power for IDAC5. |
| C10 | CDAMP_IDAC5 | AI | Damping capacitor pin for IDAC5. Connect this pin to the PVDD supply. |
| B1 | IDAC4 | AO | IDAC4 (20 mA). |
| C1 | PVDD_IDAC4 | S | Power for IDAC4. |
| C2 | CDAMP_IDAC4 | AI | Damping capacitor pin for IDAC4. Connect this pin to the PVDD supply. |
| A4, B4 | IDAC2 | AO | IDAC2 (200 mA). |
| A5, B5 | PVDD_IDAC2 | S | Power for IDAC2. |
| B3 | CDAMP_IDAC2 | AI | Damping Capacitor for IDAC2. Connect this pin to the PVDD supply. |
| A6, B6 | IDAC3 | AO | IDAC3 (250 mA). |
| A8, B8 | PVDD_IDAC3 | S | Power for IDAC3. |
| B9 | CDAMP_IDAC3 | AI | Damping Capacitor Pin for IDAC3. Connect this pin to the PVDD supply. |
| A7, B7 | PGND | S | Power Supply Ground of the IDACs. |
| K5, G9, L6, J11, H4, L7 | AGND1, AGND2, AGND3, AGND4, AGND5, AGND6 | S | Analog Ground Pins. |

| Pin No. | Mnemonic | Type ¹ | Description |
|-----------------------------|------------------------|-------------------|---|
| J5 | DVDD | S | Digital Supply Pin. This pin is the supply for the 16 MHz oscillator, PLL, POR, and digital core, including the flash that requires a regulated 1.8 V supply and a 3 V supply. |
| F9 | VDACV _{DD} | S | 5 V Analog Supply Pin. |
| L5, H11 | AVDD3, AVDD4 | S | Analog Supply Pin (3.3 V). |
| K3 | DVDD_REG1 | S | Output of 2.5 V on Chip Low Dropout (LDO) Regulator. Connect a 470 nF capacitor to this pin and DGND. This regulator supplies the inter-die digital interface. |
| L3 | DVDD_REG2 | S | Output of 1.8 V on chip LDO regulator. Connect a 470 nF capacitor to this pin and DGND. This regulator supplies flash and the Cortex-M3 processor. |
| F10 | AVDD_REG1 | S | Output of 2.5 V on chip LDO regulator. Connect a 470 nF capacitor to this pin and DGND. This regulator supplies the ADC. |
| G10 | AVDD_REG2 | S | Output of 2.5 V on chip LDO regulator. Connect a 470 nF capacitor to this pin and DGND. This regulator supplies the IDACs. |
| K6 | AV _{NEG} | S | –5 V Supply Pin. |
| E1 | IOVDD1 | S | 3.3 V GPIO Supply Pin. |
| L2, D10 | DGND1, DGND2 | S | Digital Ground Pins. |
| E11, K1 | IOVDD2, IOVDD3 | S | 3.3 V GPIO Supply Pins. |
| F1, F11, L1 | IOGND1, IOGND2, IOGND3 | S | GPIO Ground Pins. |
| J2 | XTALO | DO | Output from the Crystal Oscillator Inverter. If an external crystal is not used, leave this pin unconnected. |
| K2 | XTALI | DI | Input to the Crystal Oscillator Inverter and Input to the Internal Clock Generator Circuits. If an external crystal is not used, connect this pin to the DGND system ground. |
| J10 | BUF_VREF2.5A | AO | Buffered 2.5 V Bias, Maximum Load = 1.2 mA. Connect this pin to AGND via a 100 nF capacitor. |
| K11 | BUF_VREF2.5B | AO | Buffered 2.5 V Bias, Maximum Load = 1.2 mA. Connect this pin to AGND via a 100 nF capacitor. |
| K10, L10 | ADC_CAPN | S | Decoupling Capacitor Connection for ADC Reference Buffer. Connect this pin to AGND. |
| L11 | ADC_CAPP | S | Decoupling Capacitor Connection for ADC Reference Buffer. Connect this pin to a 4.7 μF capacitor and connect the other side of the capacitor to the AGND and the ADC_CAPN pins. |
| A1, A11, D1, F4, F8, D6, H6 | RESERVED | | Reserved. Do not connect to this pin. |

¹ I is input, I/O is input/output, AO is analog output, AI is analog input, S is supply, DO is digital output, and DI is digital input.

TYPICAL PERFORMANCE CHARACTERISTICS

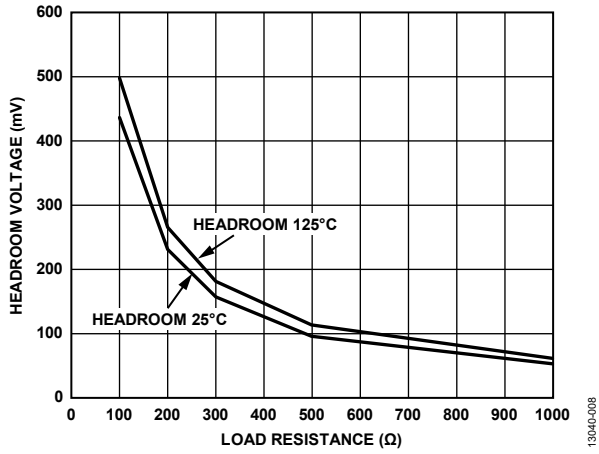


Figure 8. Typical Headroom Voltage vs. Load Resistance for VDAC7, $V_{DACV_{DD}} = 3\text{ V}$; $\text{Headroom} = V_{DACV_{DD}} - \text{VDAC Output Voltage}$

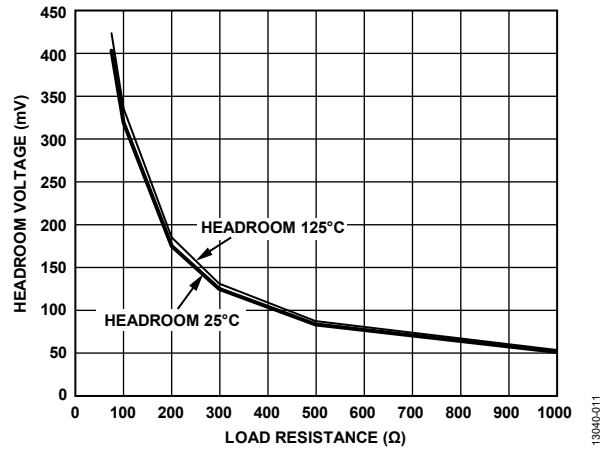


Figure 11. Typical Headroom Voltage vs. Load Resistance for VDAC0, $AV_{DD} = 3\text{ V}$; $\text{Headroom} = AV_{DD} - \text{VDAC Output Voltage}$

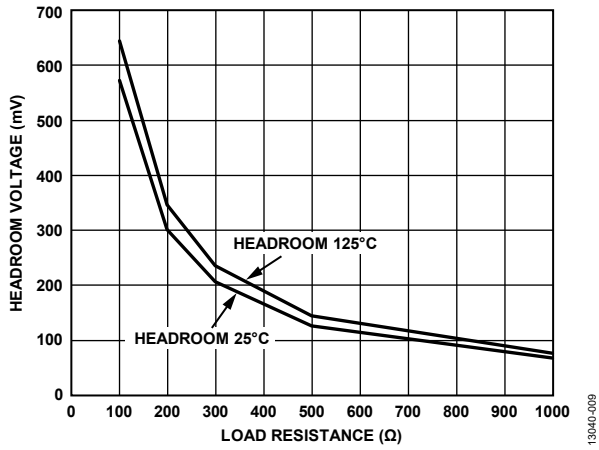


Figure 9. Typical Headroom Voltage vs. Load Resistance for VDAC7, $V_{DACV_{DD}} = 5\text{ V}$; $\text{Headroom} = V_{DACV_{DD}} - \text{VDAC Output Voltage}$

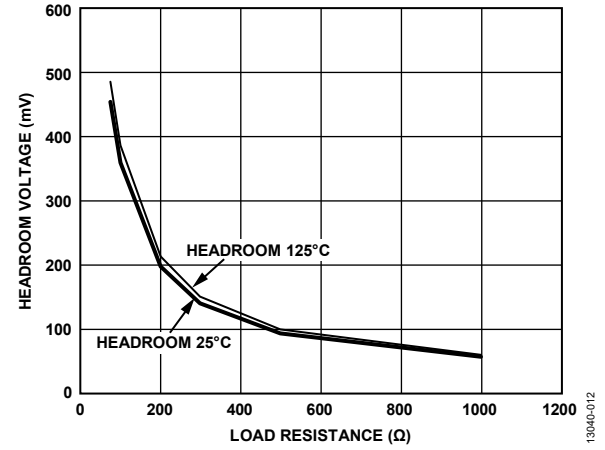


Figure 12. Typical Headroom Voltage vs. Load Resistance for VDAC4, $AV_{DD} = 3\text{ V}$; $\text{Headroom} = AV_{DD} - \text{VDAC Output Voltage}$

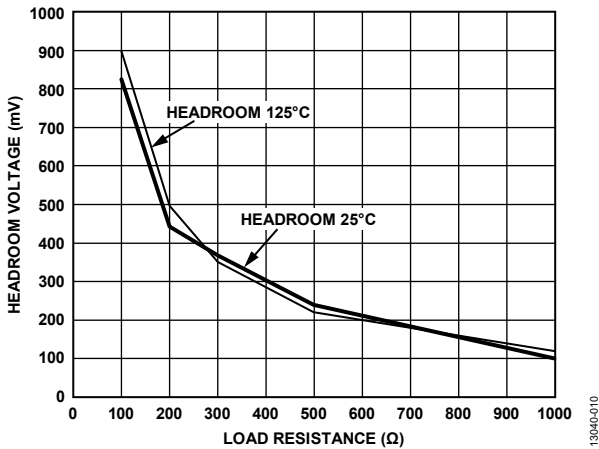


Figure 10. Typical Headroom Voltage vs. Load Resistance for VDAC2, $AV_{NEG} = -5\text{ V}$; $\text{Headroom} = AV_{NEG} - \text{VDAC Output Voltage}$

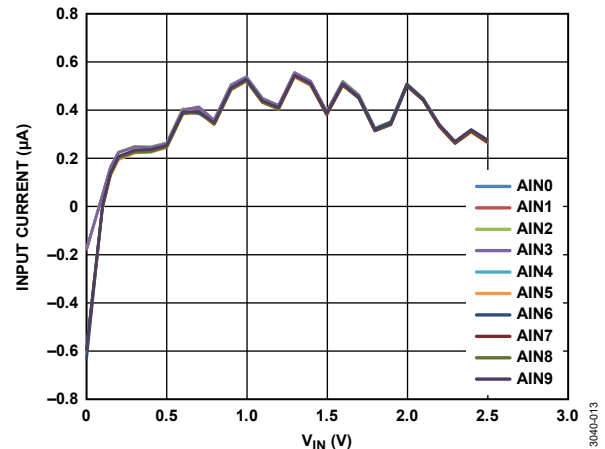


Figure 13. Input Current vs. V_{IN} , $V_{DD} = 3.3\text{ V}$, $T_A = 25^\circ\text{C}$, Unbuffered Mode, 100 KSPS

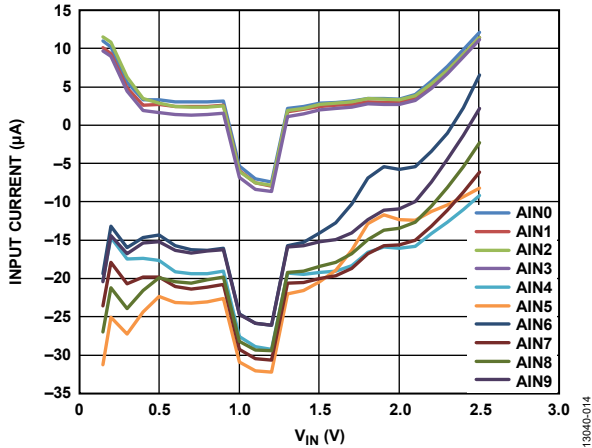


Figure 14. Input Current vs. V_{IN} , $V_{DD} = 3.3\text{ V}$, $T_A = 25^\circ\text{C}$, Buffered Mode, 100 kSPS

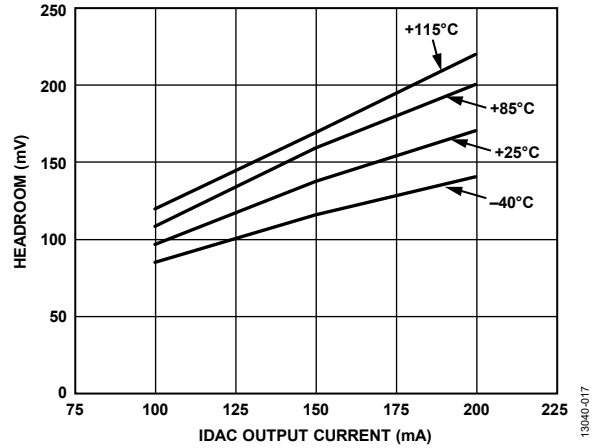


Figure 17. Typical IDAC2 PVDD_IDAC2 Pin Voltage Headroom vs. Output Current for Different Temperatures; $PV_{DD} = 1.8\text{ V}$

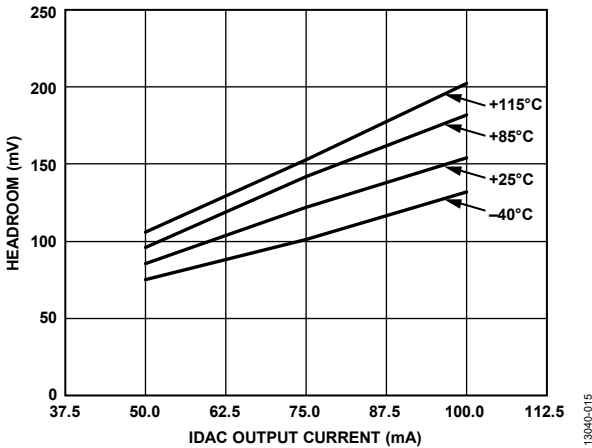


Figure 15. Typical IDAC0 PVDD_IDAC0 Pin Voltage Headroom vs. Output Current for Different Temperatures; $PV_{DD} = 1.8\text{ V}$

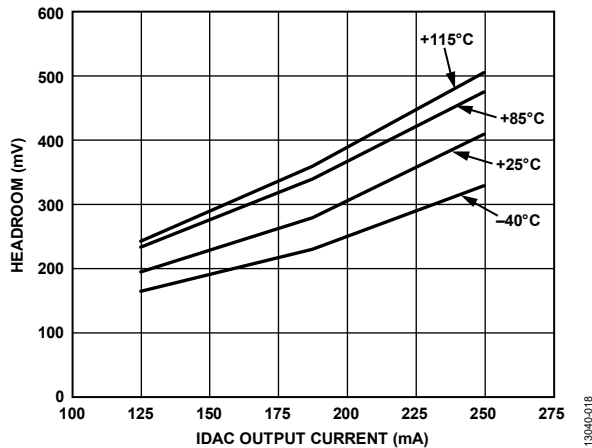


Figure 18. Typical IDAC3 PVDD_IDAC3 Pin Voltage Headroom vs. Output Current for Different Temperatures; $PV_{DD} = 1.8\text{ V}$

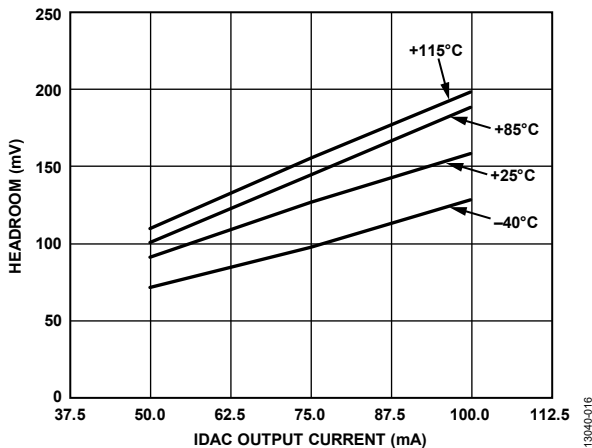


Figure 16. Typical IDAC1 PVDD_IDAC1 Pin Voltage Headroom vs. Output Current for Different Temperatures; $PV_{DD} = 1.8\text{ V}$

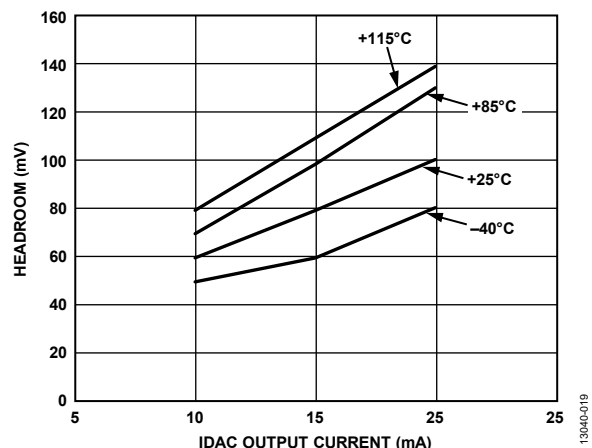


Figure 19. Typical IDAC4 PVDD_IDAC4 Pin Voltage Headroom vs. Output Current for Different Temperatures; $PV_{DD} = 1.8\text{ V}$

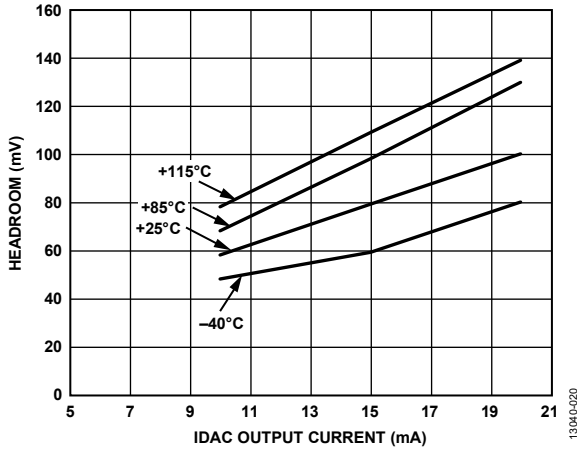


Figure 20. Typical IDAC5 PVDD_IDAC5 Pin Voltage Headroom vs. Output Current for Different Temperatures, $PV_{DD} = 1.8V$

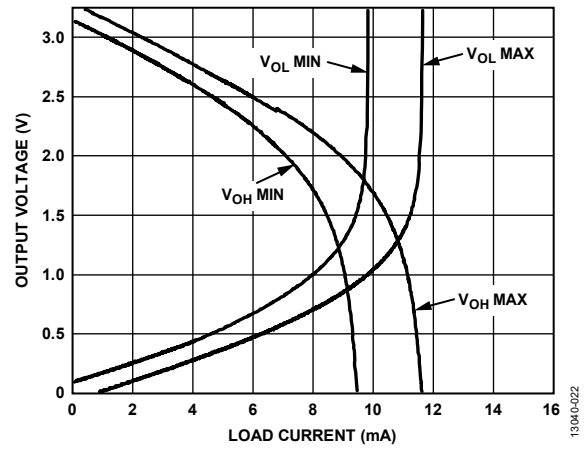


Figure 22. Typical Output Voltage vs. Load Current

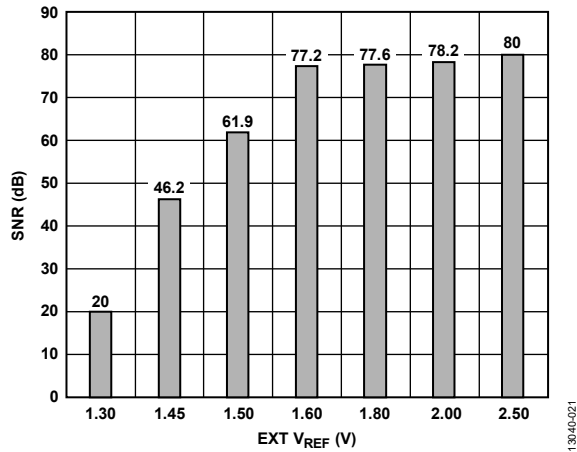


Figure 21. ADC SNR vs. External Reference Voltage ($EXT V_{REF}$)

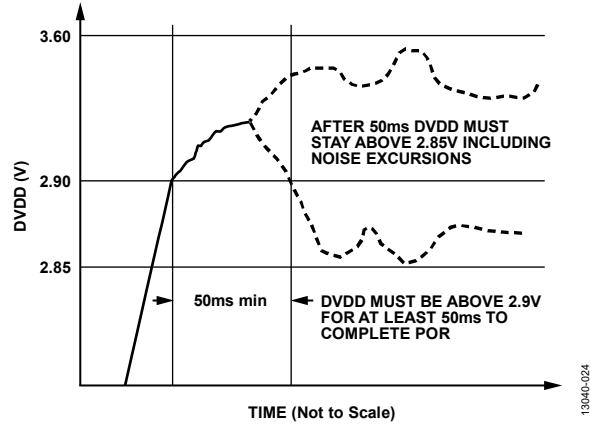


Figure 23. DVDD Power-On Requirements

RECOMMENDED CIRCUIT AND COMPONENT VALUES

Figure 24 shows a typical connection diagram for the ADuCM310.

There are four digital supply balls: IOVDD1, IOVDD2, IOVDD3, and DVDD. Decouple these balls with a 0.1 μF capacitor placed as close as possible to each of the four balls and a 10 μF capacitor at the supply source. Similarly, the analog supply pins, AVDD3 and AVDD4, each require a 0.1 μF capacitor placed as close as possible to each ball with a 10 μF capacitor at the supply source.

The IDACs source their output currents from the PV_{DD} supply balls, PVDD_IDACx. Connect a 100 nF capacitor close to each PVDD supply ball. Place at least one 10 μF capacitor at the source of the PVDD supply (PVDD_IDACx balls).

The IDAC output filters depend on a 10 nF capacitor placed between the CDAMP_IDACx ball and the PVDD_IDACx ball.

The ADC reference requires a 4.7 μF capacitor between the ADC_CAPN and ADC_CAPP balls. Directly connect ADC_CAPN to the analog ground (AGND).

The ADuCM310 contains four internal regulators. These regulators require external decoupling capacitors. The DVDD_REG1 and DVDD_REG2 balls each requires a 0.47 μF capacitor to the digital ground (DGND). The AVDD_REG1 and AVDD_REG2 balls each requires a decoupling capacitor to the AGND.

To generate an accurate and low drift reference current, connect the IREF ball to the analog ground via a low parts per million (ppm) 3.16 k Ω resistor.

Connect the VREF_1.2 ball to AGND via a 0.47 μF capacitor.

See Figure 24 for more details.

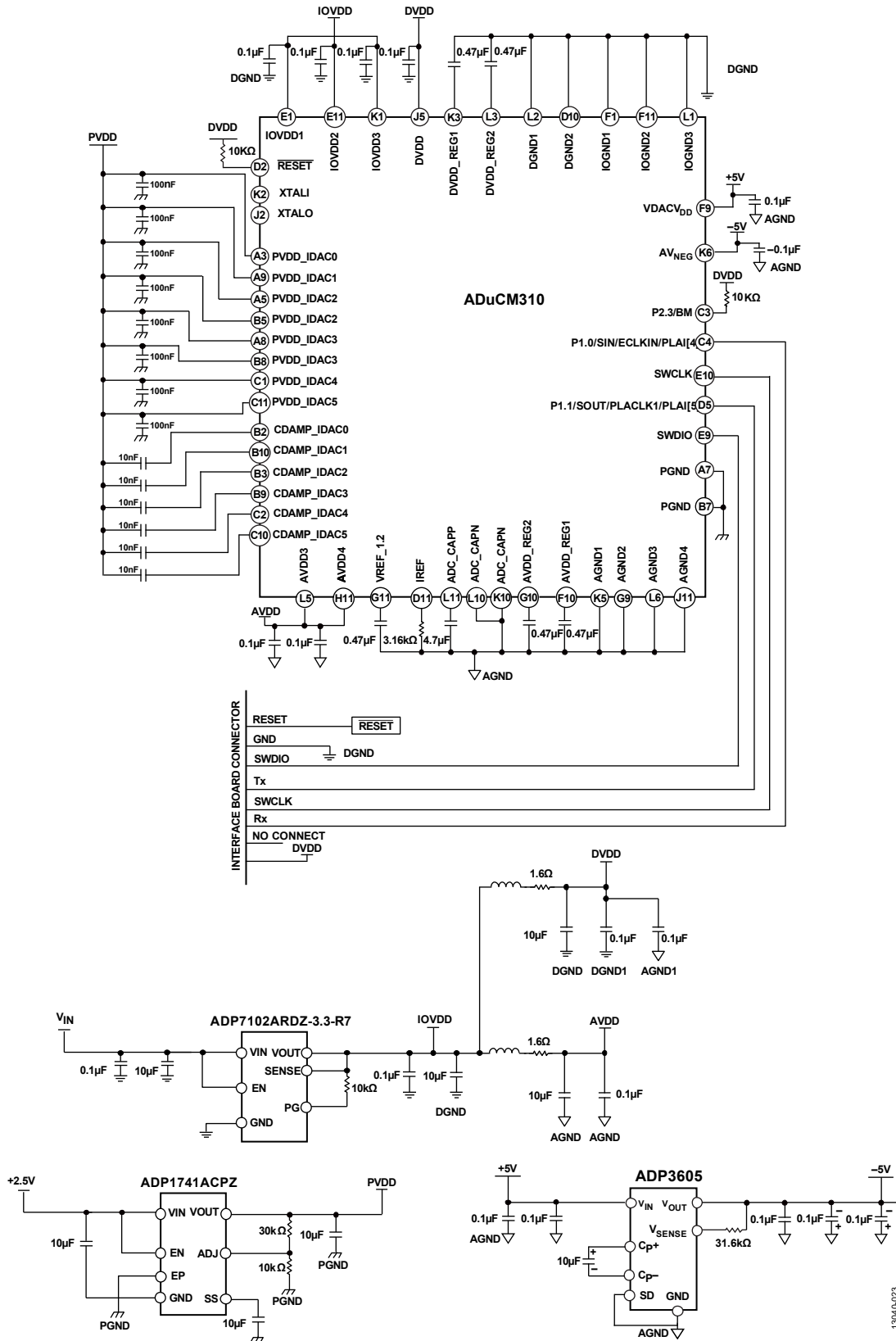
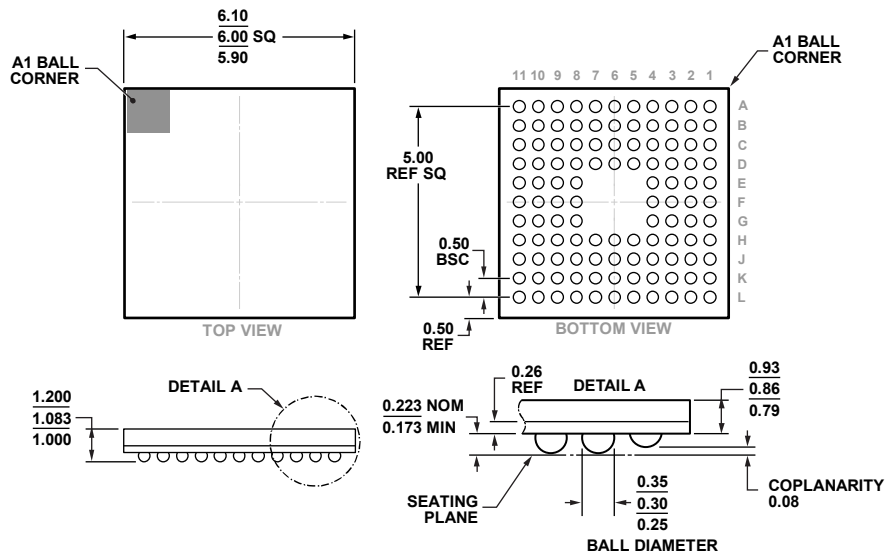


Figure 24. Typical Connection Diagram

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-195-AC
WITH THE EXCEPTION TO BALL COUNT

Figure 25. 112-Ball Chip Scale Package Ball Grid Array [CSP_BGA]
(BC-112-4)

Dimensions shown in millimeters

04-02-2013-A

ORDERING GUIDE

| Model ¹ | Temperature Range | Package Description | Package Option |
|--------------------|-------------------|---|----------------|
| ADuCM310BBCZ | -40°C to +85°C | 112-Ball Chip Scale Package Ball Grid Array [CSP_BGA] | BC-112-4 |
| ADuCM310BBCZ-RL | -40°C to +85°C | 112-Ball Chip Scale Package Ball Grid Array [CSP_BGA] | BC-112-4 |
| EVAL-ADuCM310QSPZ | | Evaluation Board with QuickStart Development System | |

¹ Z = RoHS Compliant Part.

I²C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).