

## 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× I<sup>2</sup>C 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

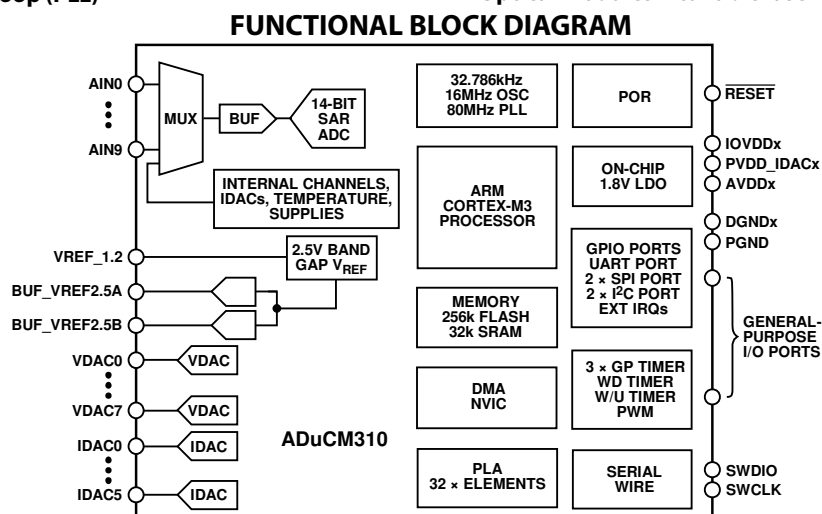


Figure 1.

Rev. C

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### REVISION HISTORY

#### 2/2019—Rev. B to Rev. C

Changes to IDAC0 and IDAC1 Parameter, Table 1 .....	7
Added Allowed Power-Up Time for DV <sub>DD</sub> Supply Parameter, Table 1 .....	10
Changes to Ordering Guide .....	27

#### 7/2017—Rev. A to Rev. B

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Added Endnote 1, Table 1; Renumbered Sequentially .....	12

#### 11/2015—Rev. 0 to Rev. A

Change to Features Section .....	1
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Changes to Table 6 and Figure 5.....	15
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#### 5/2015—Revision 0: Initial Version

## 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 I<sup>2</sup>C 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 × I<sup>2</sup>C, 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
<b>ADC CHANNEL SPECIFICATIONS</b>					
ADC Power-Up Time		5		$\mu\text{s}$	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		$\pm 2$		LSB	2.5 V internal reference
Enabled		$\pm 1.5^1$		LSB	2.5 V internal reference
Disabled		$\pm 2.5$		LSB	External reference
Enabled		$\pm 2$		LSB	External reference
Disabled		$\pm 1.5^1$		LSB	External reference
Differential Nonlinearity	$-0.99$	$\pm 0.7$	$+1.5^1$	LSB	2.5 V external reference; no missing codes
	$-0.99$	$\pm 0.7$	$+2.0$	LSB	2.5 V external reference; no missing codes
DC Code Distribution		$\pm 3$		LSB	ADC input voltage = 1.25 V dc
		$\pm 5$			
<b>ENDPOINT ERRORS</b>					
Offset Error (All Channels Except the Internal Channels)					ADC update rate up to 800 kSPS
Buffer On or Buffer Off	$-0.8$	$\pm 0.2$	$+0.8$	mV	Buffer on, chop mode on and automatic zero or buffer off
	$-0.6^1$	$\pm 0.2$	$+0.6^1$	mV	Buffer on, chop mode on and automatic zero or buffer off
Offset Error Drift <sup>2</sup>					
Buffer On or Buffer Off		$\pm 3.2$		$\mu\text{V}/^\circ\text{C}$	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	$-0.75$	$\pm 0.2$	$+0.75$	mV	Excluding internal channels
Internal Channels	$-0.7^1$	$\pm 0.2$	$+0.6^1$	mV	Excluding internal channels
		$\pm 0.2$	$+1$	% of full scale	Input buffer on; $AV_{DD}/2$ , $IOV_{DD}/2$ , $PV_{DD}$ voltage on PVDD_IDAC2 pin
		$\pm 0.2$	$\pm 0.6^1$	% 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 <sup>2</sup>		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
<b>DYNAMIC PERFORMANCE<sup>2</sup></b>					
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
<b>ANALOG INPUT</b>					
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 <sup>3</sup>					
Buffered Mode					$V_{IN} = 0.15$ V to 2.5 V
AIN0, AIN1, AIN2, and AIN3	$-10^2$	$\pm 5$	$+13^2$	nA	ADC sampling rate $\leq 100$ kSPS
	-40	$\pm 15$	+60	nA	ADC sampling rate $\leq 500$ kSPS
	$-60^2$	$\pm 25$	$+90^2$	nA	ADC sampling rate $\leq 800$ kSPS
Input Current Drift		$\pm 20$		pA/ $^{\circ}$ C	Input buffer on, ADC sampling rate $\leq 500$ kSPS
		$\pm 10^1$		pA/ $^{\circ}$ C	Input buffer on, ADC sampling rate $\leq 500$ kSPS
		$\pm 34$		pA/ $^{\circ}$ C	Input buffer on, ADC sampling rate $\leq 800$ kSPS
		$\pm 20^1$		pA/ $^{\circ}$ C	Input buffer on, ADC sampling rate $\leq 800$ kSPS
AIN4 to AIN9	$-50^2$	$\pm 20$	$+50^2$	nA	AIN4 to AIN9 $\leq 100$ kSPS
	$-215^2$	$\pm 50$	$+110^2$	nA	ADC sampling rate $\leq 500$ kSPS
	$-350^2$	-90	$+90^2$	nA	ADC sampling rate $\leq 800$ 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
		$\pm 530$		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 $\mu$ F from VREF_1.2 to AGND
Output Voltage		2.505		V	
Accuracy <sup>4</sup>			$\pm 5$	mV	$T_A = 25^\circ\text{C}$
Reference Temperature Coefficient <sup>2,5</sup>		15	30 <sup>1</sup>	ppm/ $^\circ\text{C}$	
Power Supply Rejection Ratio		15	44	ppm/ $^\circ\text{C}$	
Output Impedance		70		dB	
Internal $V_{\text{REF}}$ Power-On Time <sup>2</sup>		3	50	$\Omega$	For ADC_CAPP, $T_A = 25^\circ\text{C}$
Internal $V_{\text{REF}}$ Power-On Time <sup>2</sup>		38		ms	Turned on by default
EXTERNAL REFERENCE INPUT <sup>2</sup>					
Input Voltage Range <sup>2</sup>	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			$\pm 5$	mV	$T_A = 25^\circ\text{C}$ , load = 0.4 mA
Reference Temperature Coefficient <sup>2</sup>		15	30 <sup>1</sup>	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		$\Omega$	$T_A = 25^\circ\text{C}$
Power Supply Rejection Ratio		70	1.2	dB	
IDAC CHANNEL SPECIFICATIONS <sup>6,7</sup>					
Voltage Compliance Range <sup>2</sup>					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 $\Omega$ external resistor
Temperature Coefficient <sup>2,5</sup>		7	25	ppm/ $^\circ\text{C}$	If the external resistor ( $R_{\text{EXT}}$ ) value drops below 1.580 k $\Omega$ , IDAC output currents disable
Over Heat Shutdown		135		$^\circ\text{C}$	Using internal reference; Junction temperature
Resolution					
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 <sup>1</sup>				Current sink
Integral Nonlinearity	-3	±1.5	+4	LSB	11-bit
	-2.5 <sup>1</sup>	±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 <sup>1</sup>	±0.25	+1 <sup>1</sup>	%	
	-3.0	±0.25	+1.3	%	
IDAC4 and IDAC 5	-0.7 <sup>1</sup>	±0.25	±0.7	%	
	-1	±0.25	+0.7	%	
IDAC2	-1.75 <sup>1</sup>	±0.25	±0.65	%	
	-1.77	±0.25		%	
IDAC3	-2 <sup>1</sup>	±0.25	±1.4 <sup>1</sup>	%	
	-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 <sup>1</sup>	-12	+30 <sup>1</sup>	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 <sup>1</sup>	+55 <sup>1</sup>	+145 <sup>1</sup>	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 <sup>8</sup>					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 <sup>1</sup>		+75 <sup>1</sup>	µA	Reduced -10°C to +85°C range
	-180		+115	µA	
Pull-Down Current	-135	-115	-100	µA	
IDAC4 and IDAC5	-25 <sup>1</sup>		+15	µA	
	-31		+15	µA	
Pull-Down Current	-30	-24	-22	µA	

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
IDAC2 and IDAC3	−350 <sup>1</sup>		+280 <sup>1</sup>	μA	
	−460		+300	μA	
Pull-Down Current for IDAC2	−300	−288	−160	μA	
Zero-Scale Error Drift <sup>2</sup>					
IDAC0 and IDAC1	−850 <sup>1</sup>	±300	+1200 <sup>1</sup>	nA/°C	
	−1400	±300	+1400	nA/°C	
IDAC4 and IDAC5	−120	±50	+205 <sup>1</sup>	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 <sup>2</sup>			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]
<b>VDAC CHANNEL SPECIFICATIONS<sup>6, 9, 10</sup></b>					
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 <sup>1</sup>	% 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 <sup>2</sup>			±0.7 <sup>1</sup>	%	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 <sup>1</sup>		$AV_{DD} - 600 \text{ mV}$	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 <sup>1</sup>		$AV_{DD} - 300 \text{ mV}$	V	$R_L = 300 \Omega$ , 10 mA maximum, $V_{OUT}$ maximum = 3 V
VDAC6	0 + Actual Offset <sup>1</sup>		$VDACV_{DD} - 250 \text{ mV}$	V	$R_L = 500 \Omega$ , 10 mA maximum, $V_{OUT}$ maximum = 5 V
VDAC7	0 + Actual Offset <sup>1</sup>		$VDACV_{DD} - 700 \text{ mV}$	V	$R_L = 100 \Omega$ , 50 mA maximum, $V_{OUT}$ maximum = 5 V

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

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

<sup>1</sup> Reduced temperature range of  $-10^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

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

<sup>3</sup> 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.

<sup>4</sup> 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.

<sup>5</sup> Measured using the following box method:

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

<sup>6</sup> 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

<sup>7</sup> Analog Devices, Inc., production IDAC full-scale trimming conditions include PVDD\_IDACx pin voltage = 0.7 V, all IDACs on.

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

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

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

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

## TIMING SPECIFICATIONS

### I<sup>2</sup>C Timing

Table 2. I<sup>2</sup>C Timing in Standard Mode (100 kHz)

Parameter	Description	Slave			Unit
		Min	Typ	Max	
t <sub>L</sub>	SCLx low pulse width	4.7			μs
t <sub>H</sub>	SCLx high pulse width	4.0			ns
t <sub>SHD</sub>	Start condition hold time	4.0			μs
t <sub>DSU</sub>	Data setup time	250			ns
t <sub>DHD</sub>	Data hold time (SDAx held internally for 300 ns after falling edge of SCLx)	0		3.45	μs
t <sub>RSU</sub>	Setup time for repeated start	4.7			μs
t <sub>PSU</sub>	Stop condition setup time	4.0			μs
t <sub>BUF</sub>	Bus free time between a stop condition and a start condition	4.7			μs
t <sub>R</sub>	Rise time for both SCLx and SDAx			1	μs
t <sub>F</sub>	Fall time for both SCLx and SDAx		15	300	ns
t <sub>VD;DAT</sub>	Data valid time			3.45	μs
t <sub>VD;ACK</sub>	Data valid acknowledge time			3.45	μs

Table 3. I<sup>2</sup>C Timing in Fast Mode (400 kHz)

Parameter	Description	Slave			Unit
		Min	Typ	Max	
t <sub>L</sub>	SCLx low pulse width	1.3			μs
t <sub>H</sub>	SCLx high pulse width	0.6			ns
t <sub>SHD</sub>	Start condition hold time	0.3			μs
t <sub>DSU</sub>	Data setup time	100			ns
t <sub>DHD</sub>	Data hold time (SDAx held internally for 300 ns after falling edge of SCLx)	0			μs
t <sub>RSU</sub>	Setup time for repeated start	0.6			μs
t <sub>PSU</sub>	Stop condition setup time	0.3			μs
t <sub>BUF</sub>	Bus free time between a stop condition and a start condition	1.3			μs
t <sub>R</sub>	Rise time for both SCLx and SDAx	20		300	ns
t <sub>F</sub>	Fall time for both SCLx and SDAx		15	300	ns
t <sub>VD;DAT</sub>	Data valid time			0.9	μs
t <sub>VD;ACK</sub>	Data valid acknowledge time			0.9	μs

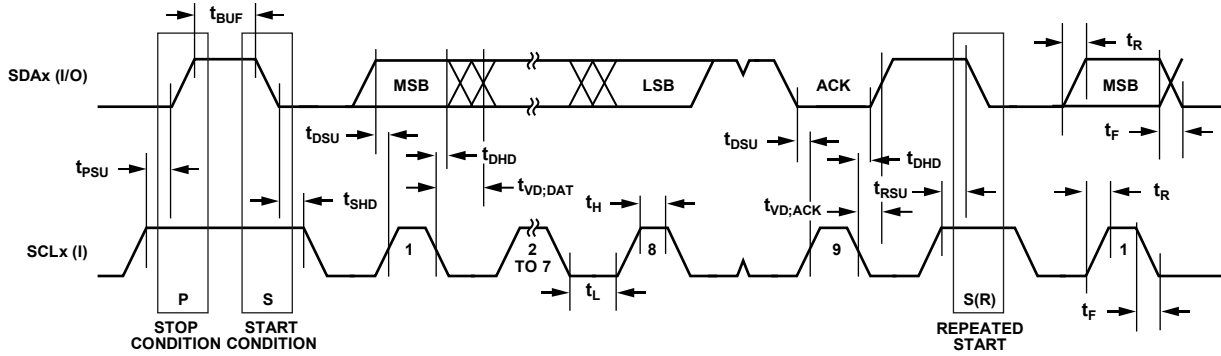


Figure 2. I<sup>2</sup>C Compatible Interface Timing

13040-302

**SPI Timing**

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

Parameter	Description	Min	Typ	Max	Unit
t <sub>SL</sub>	SCLKx low pulse width		$(SPIxDIV^1 + 1) \times t_{HCLK}^2/2$		ns
t <sub>SH</sub>	SCLKx high pulse width		$(SPIxDIV^1 + 1) \times t_{HCLK}^2/2$		ns
t <sub>DAV</sub>	Data output valid after SCLKx edge	0	3		ns
t <sub>DSU</sub>	Data input setup time before SCLKx edge		½ SCLKx		ns
t <sub>DHD</sub>	Data input hold time after SCLKx edge		SCLKx		ns
t <sub>DF</sub>	Data output fall time		SCLKx		ns
t <sub>DR</sub>	Data output rise time		25		ns
t <sub>SR</sub>	SCLKx rise time		25		ns
t <sub>SF</sub>	SCLKx fall time		20		ns

<sup>1</sup> For SPI0, x is 0, and for SPI1, x is 1.

<sup>2</sup> t<sub>HCLK</sub> is the divided system clock, UCLK/CLKCON1[2:0].

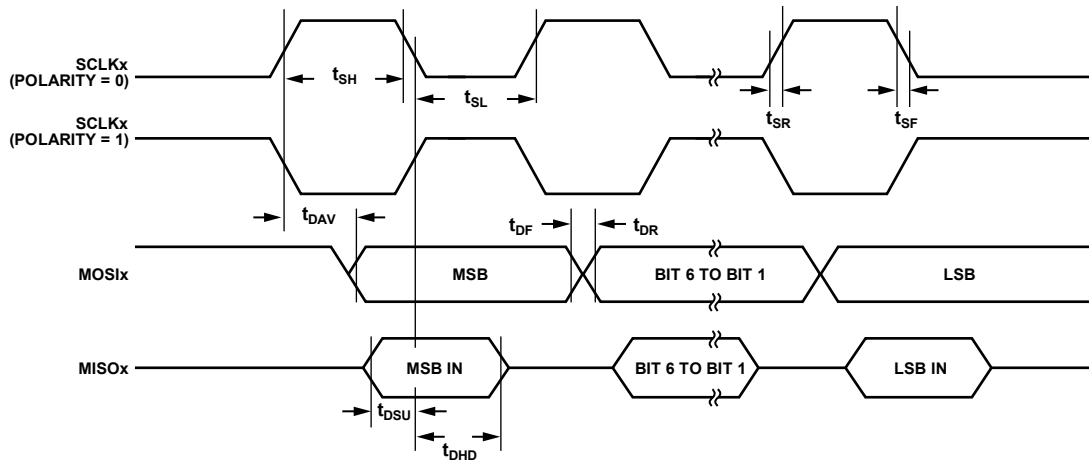


Figure 3. SPI Master Mode Timing (Phase Mode = 1)

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

<sup>1</sup> For SPI0, x is 0, and for SPI1, x is 1.

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

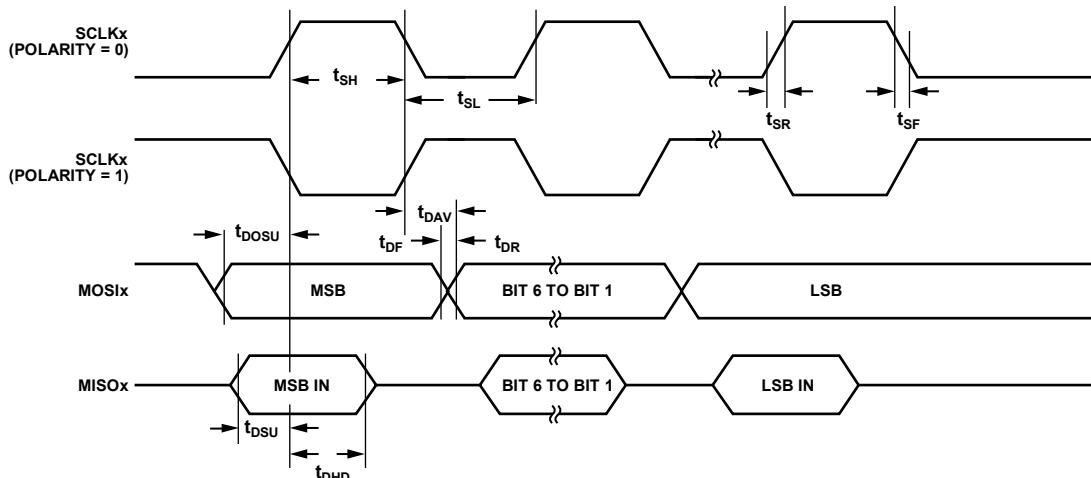


Figure 4. SPI Master Mode Timing (Phase Mode = 0)

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

<sup>1</sup> For SPI0, x is 0, and for SPI1, x is 1.

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

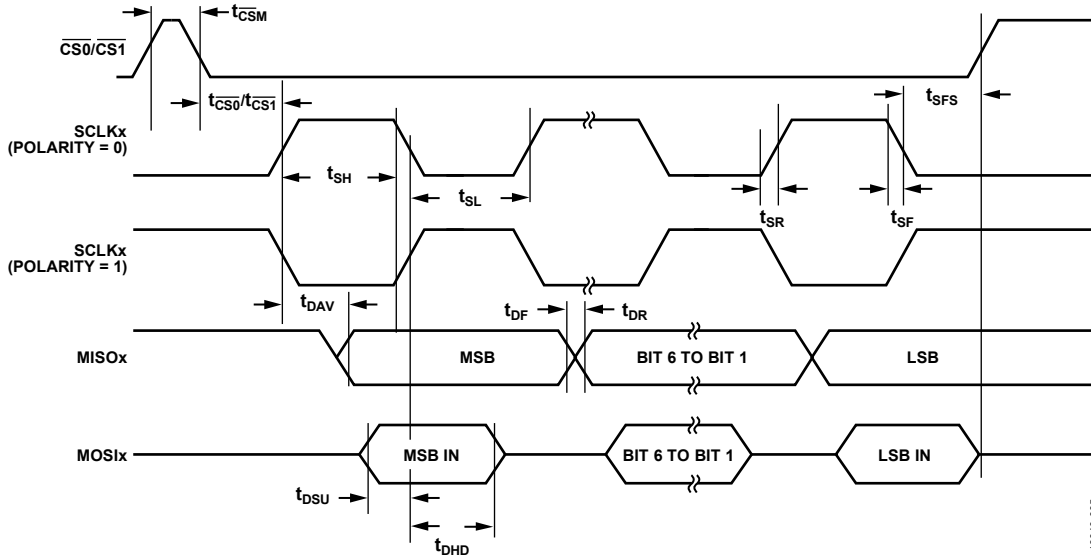


Figure 5. SPI Slave Mode Timing (Phase Mode = 1)

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

<sup>1</sup> For SPI0, x is 0, and for SPI1, x is 1

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

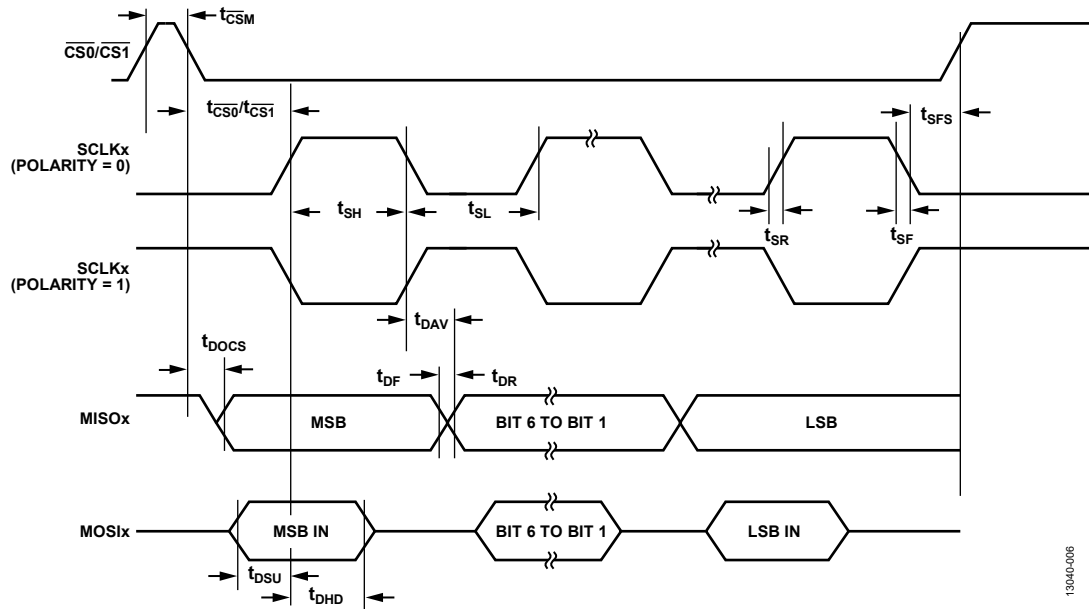


Figure 6. SPI Slave Mode Timing (Phase Mode = 0)

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

$\theta_{JA}$  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	$\theta_{JA}$	$\theta_{JC}$	Unit
112-Ball CSP_BGA	44.5	11	°C/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 <sup>1</sup>	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 <sup>2</sup> 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 <sup>1</sup>	Description
G3	P0.5/SDA0/PLAO[3]	I/O	General-Purpose Input and Output Port 0.5/I <sup>2</sup> 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 <sup>2</sup> 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 <sup>2</sup> 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 <sup>1</sup>	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 $\Omega$ external resistor (R <sub>EXT</sub> ).
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 <sup>1</sup>	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 <sub>DD</sub>	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 <sub>NEG</sub>	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.

<sup>1</sup> 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

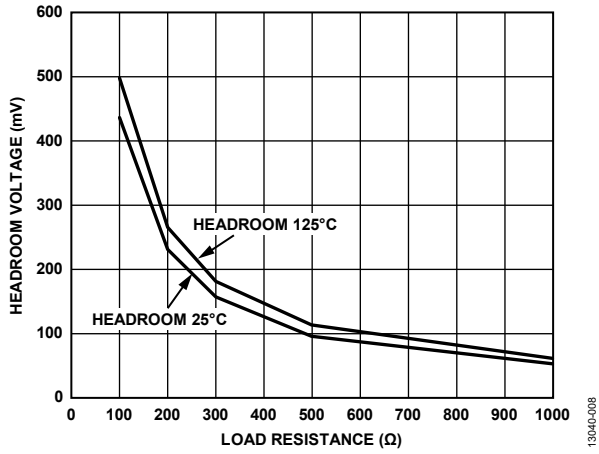


Figure 8. Typical Headroom Voltage vs. Load Resistance for VDAC7,  $V_{DACV_{DD}} = 3\text{ V}$ ;  $\text{Headroom} = V_{DACV_{DD}} - \text{VDAC Output Voltage}$

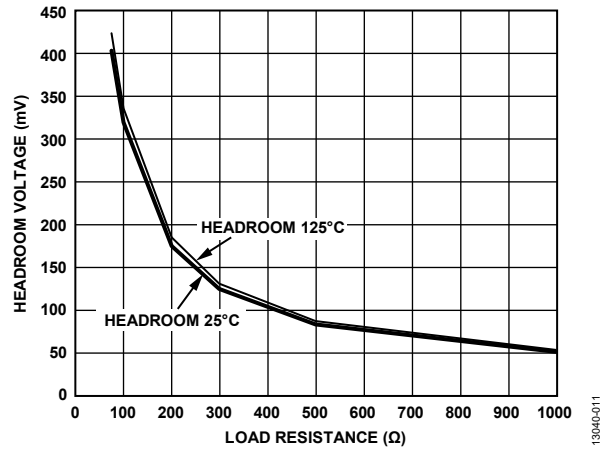


Figure 11. Typical Headroom Voltage vs. Load Resistance for VDAC0,  $AV_{DD} = 3\text{ V}$ ;  $\text{Headroom} = AV_{DD} - \text{VDAC Output Voltage}$

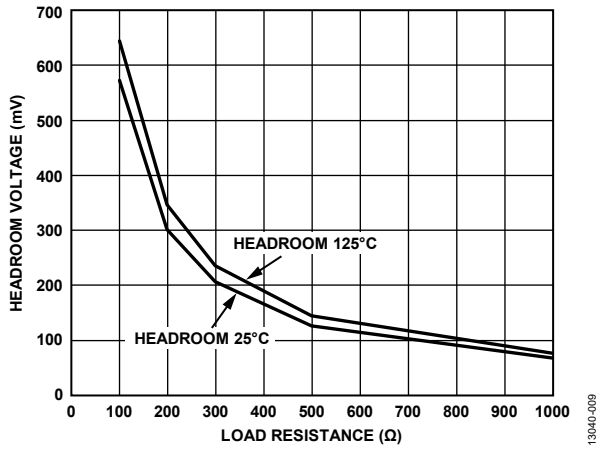


Figure 9. Typical Headroom Voltage vs. Load Resistance for VDAC7,  $V_{DACV_{DD}} = 5\text{ V}$ ;  $\text{Headroom} = V_{DACV_{DD}} - \text{VDAC Output Voltage}$

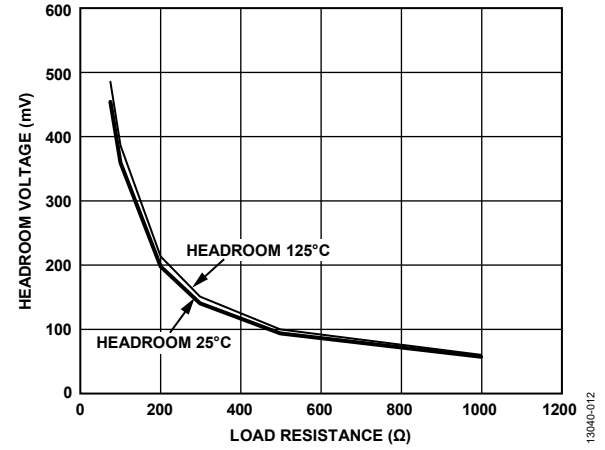


Figure 12. Typical Headroom Voltage vs. Load Resistance for VDAC4,  $AV_{DD} = 3\text{ V}$ ;  $\text{Headroom} = AV_{DD} - \text{VDAC Output Voltage}$

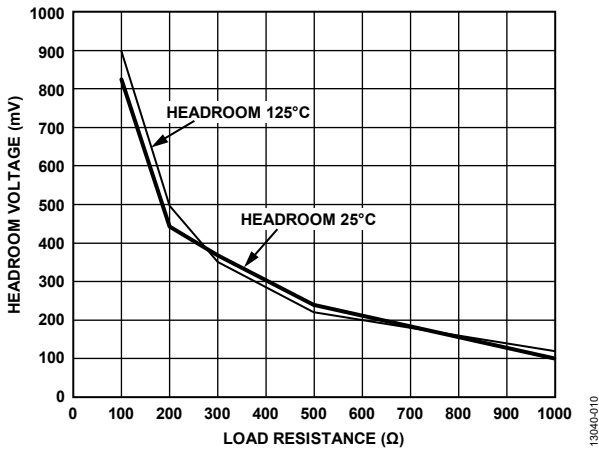


Figure 10. Typical Headroom Voltage vs. Load Resistance for VDAC2,  $AV_{NEG} = -5\text{ V}$ ;  $\text{Headroom} = AV_{NEG} - \text{VDAC Output Voltage}$

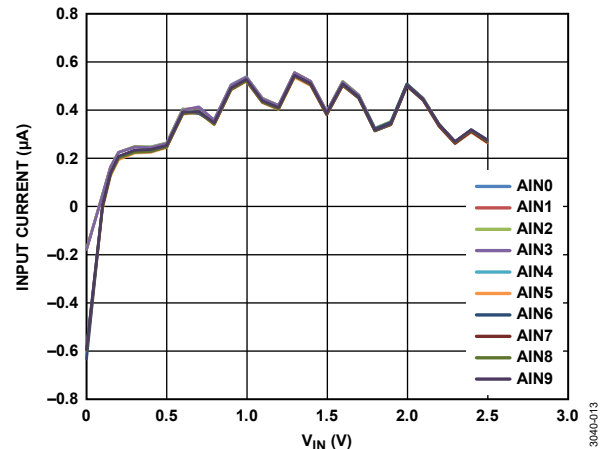


Figure 13. Input Current vs.  $V_{IN}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , Unbuffered Mode, 100 KSPS

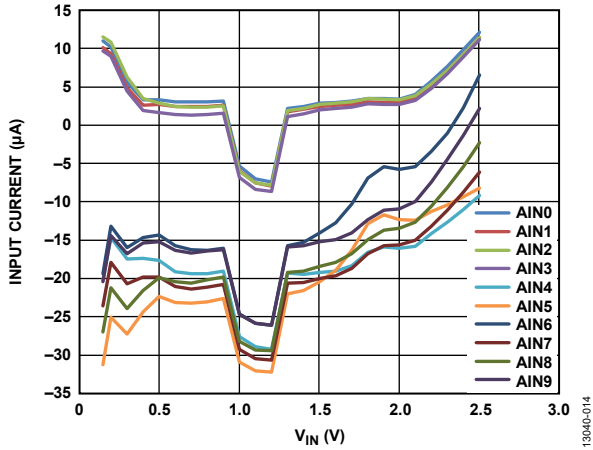


Figure 14. Input Current vs.  $V_{IN}$ ,  $V_{DD} = 3.3\text{ V}$ ,  $T_A = 25^\circ\text{C}$ , Buffered Mode, 100 kSPS

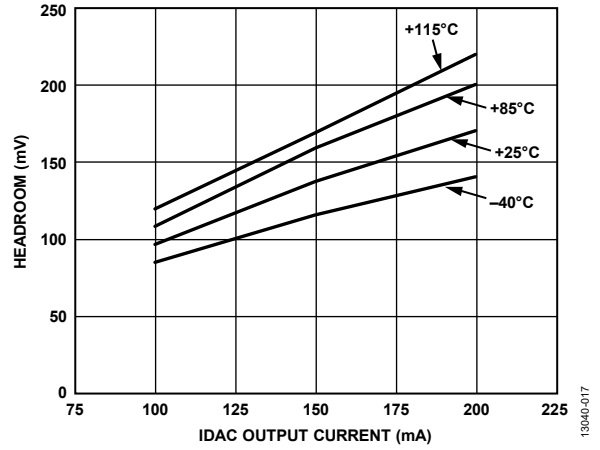


Figure 17. Typical IDAC2 PVDD\_IDAC2 Pin Voltage Headroom vs. Output Current for Different Temperatures;  $PV_{DD} = 1.8\text{ V}$

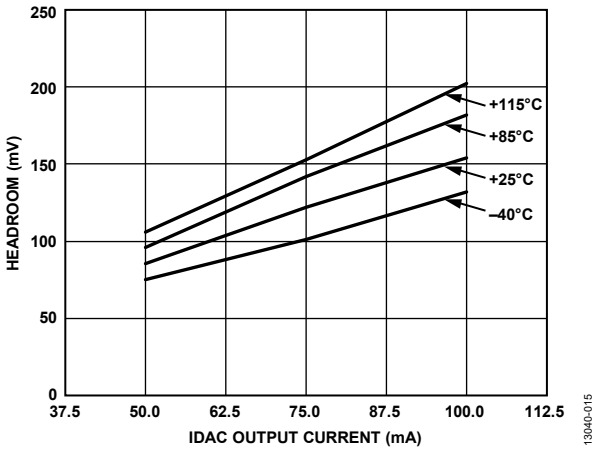


Figure 15. Typical IDAC0 PVDD\_IDAC0 Pin Voltage Headroom vs. Output Current for Different Temperatures;  $PV_{DD} = 1.8\text{ V}$

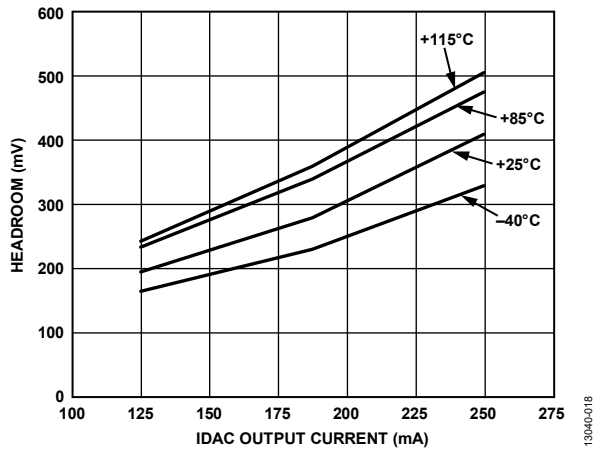


Figure 18. Typical IDAC3 PVDD\_IDAC3 Pin Voltage Headroom vs. Output Current for Different Temperatures;  $PV_{DD} = 1.8\text{ V}$

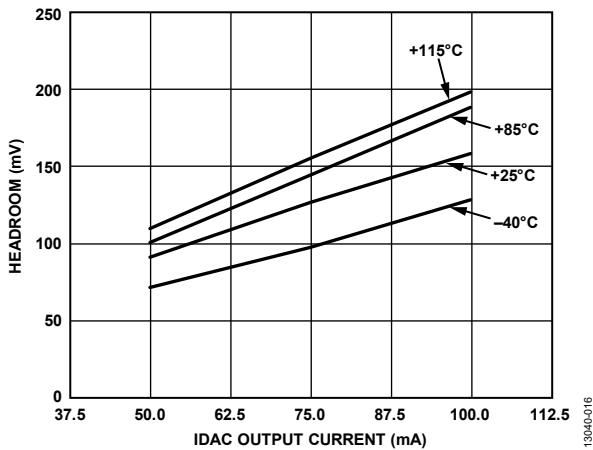


Figure 16. Typical IDAC1 PVDD\_IDAC1 Pin Voltage Headroom vs. Output Current for Different Temperatures;  $PV_{DD} = 1.8\text{ V}$

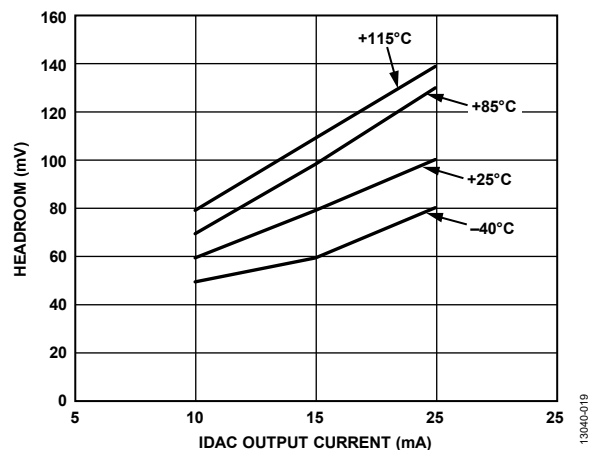


Figure 19. Typical IDAC4 PVDD\_IDAC4 Pin Voltage Headroom vs. Output Current for Different Temperatures;  $PV_{DD} = 1.8\text{ V}$

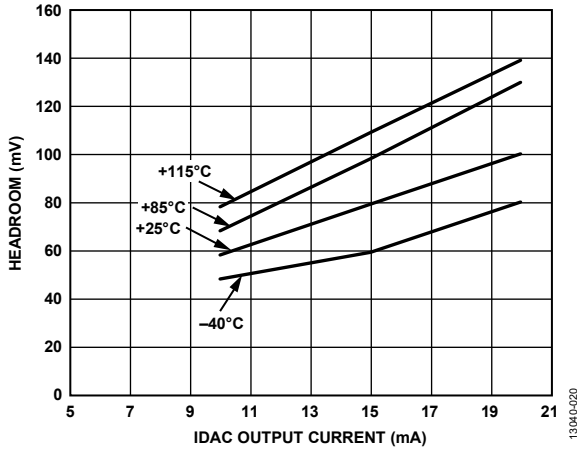


Figure 20. Typical IDAC5 PVDD\_IDAC5 Pin Voltage Headroom vs. Output Current for Different Temperatures,  $PV_{DD} = 1.8V$

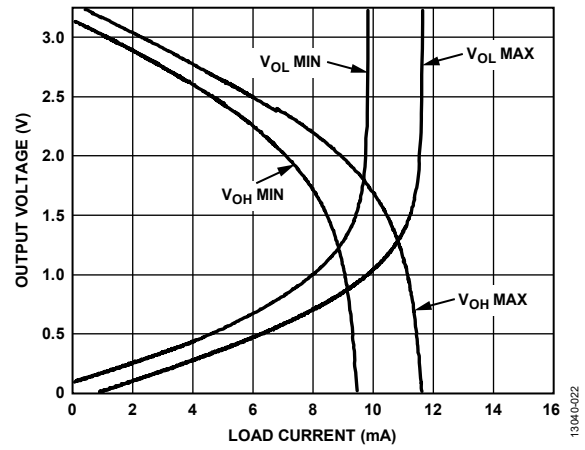


Figure 22. Typical Output Voltage vs. Load Current

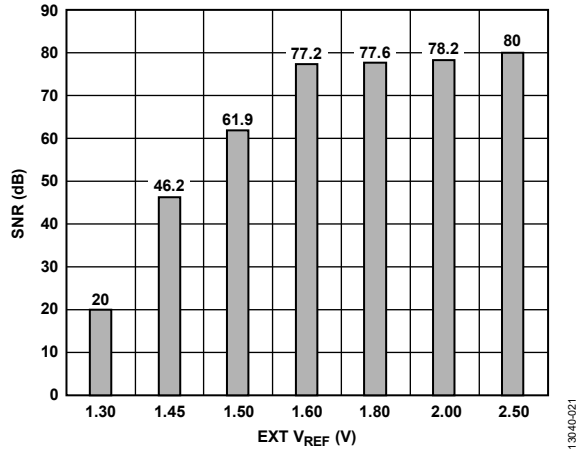


Figure 21. ADC SNR vs. External Reference Voltage ( $EXT V_{REF}$ )

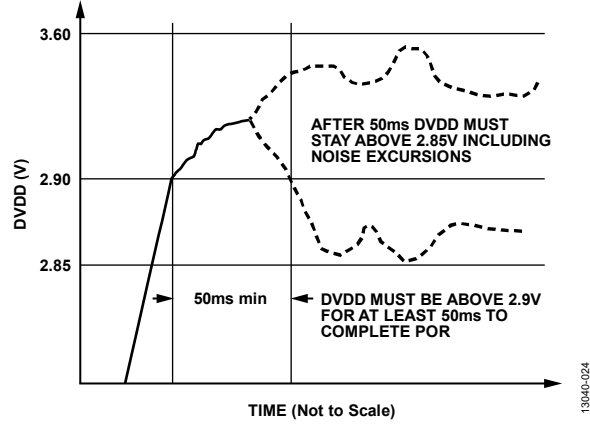


Figure 23. DVDD Power-On Requirements



## 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  $\mu\text{F}$  capacitor placed as close as possible to each of the four balls and a 10  $\mu\text{F}$  capacitor at the supply source. Similarly, the analog supply pins, AVDD3 and AVDD4, each require a 0.1  $\mu\text{F}$  capacitor placed as close as possible to each ball with a 10  $\mu\text{F}$  capacitor at the supply source.

The IDACs source their output currents from the PV<sub>DD</sub> supply balls, PVDD\_IDACx. Connect a 100 nF capacitor close to each PVDD supply ball. Place at least one 10  $\mu\text{F}$  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  $\mu\text{F}$  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  $\mu\text{F}$  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 $\Omega$  resistor.

Connect the VREF\_1.2 ball to AGND via a 0.47  $\mu\text{F}$  capacitor.

See Figure 24 for more details.

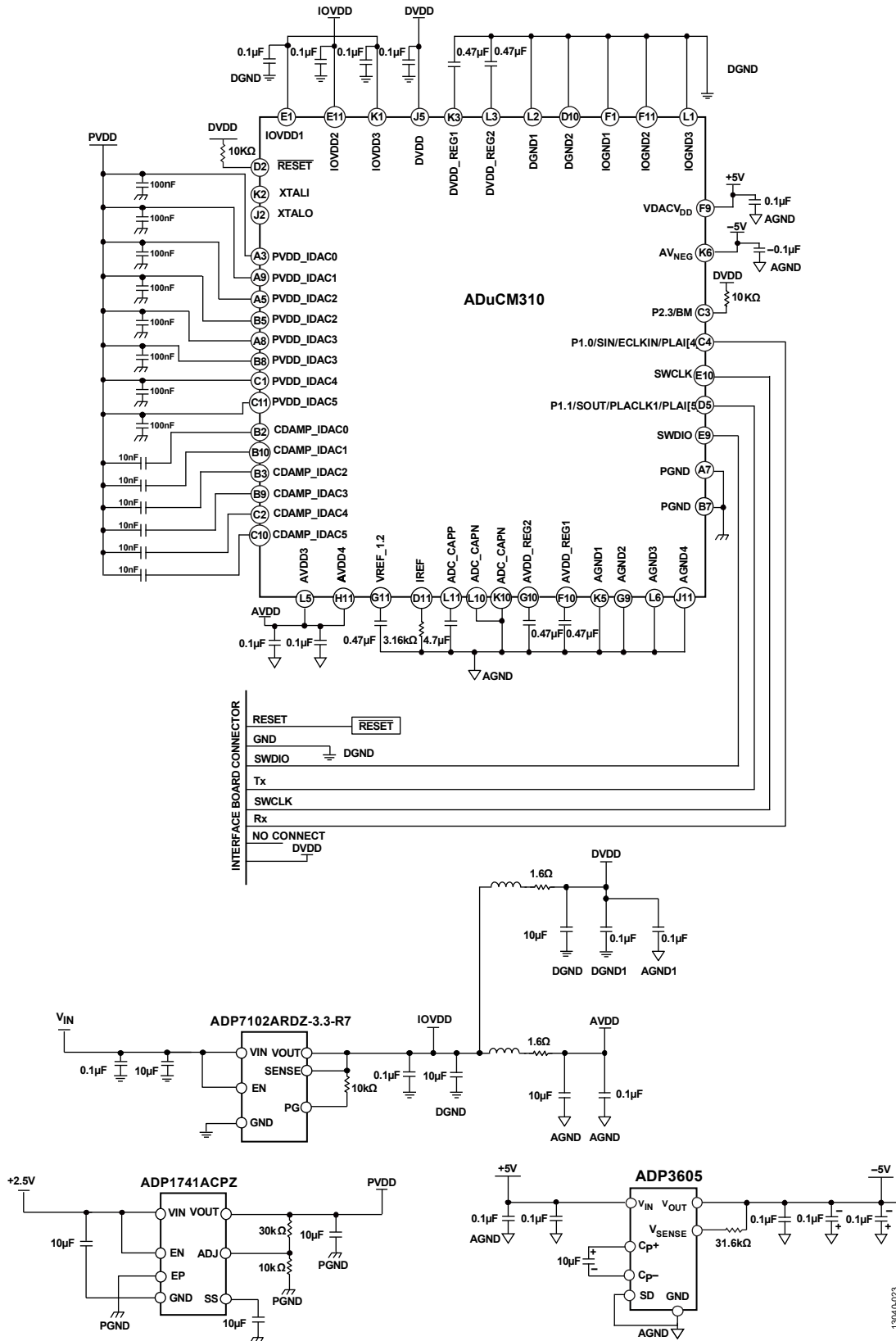
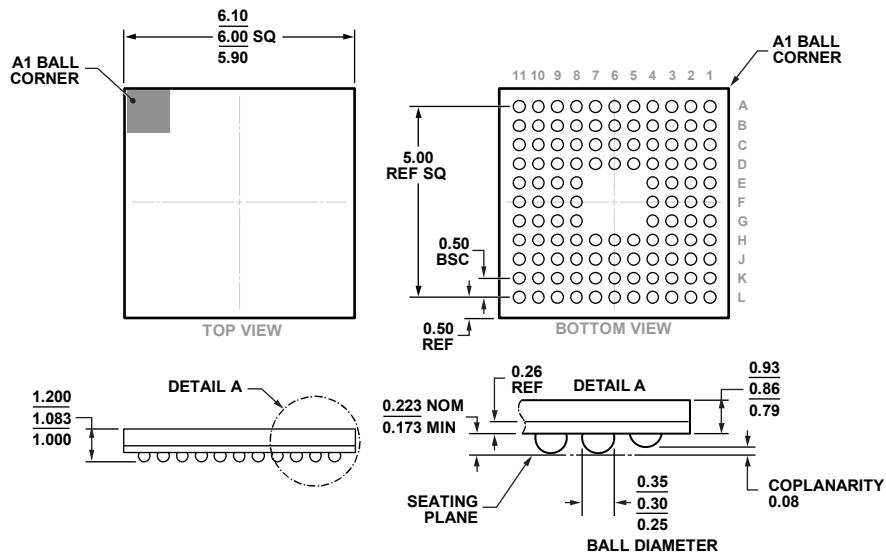


Figure 24. Typical Connection Diagram

# 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 <sup>1</sup>	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	

<sup>1</sup> Z = RoHS Compliant Part.

I<sup>2</sup>C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).