Precision Analog Microcontroller, 12-Bit Analog Input/Output with MDIO Interface, Arm Cortex-M33

Data Sheet

ADuCM420

FEATURES

- **Analog input/output**
  - **Multichannel, 12-bit, 2 MSPS ADC**
    - **Up to 12 external channels**
    - **On-chip die temperature monitor**
    - **3 power monitor channels**
    - **Single-ended mode**
    - **0 V to VREF analog input range**
    - **Input buffers**
  - **12-bit voltage output DACs**
    - **8× 0 V to 2.5 V, 1 kΩ load**
    - **4× 0 V to 2.5 V, 2.5 kΩ load**
  - **On-chip low drift voltage reference, 1.25 V or 2.5 V**
    - **Buffered 1.25 V or 2.5 V output**
  - **4 voltage comparators**
- **Microcontroller**
  - **32-bit Arm Cortex-M33 core, 32-bit RISC architecture, FPU**
  - **Serial wire port supports code download and debug**
- **Clocking options**
  - **16 MHz on-chip oscillator**
  - **160 MHz PLL output with programmable divider**
  - **External clock source**
- **Memory**
  - **2× 256 kB independent Flash/EE memories with ECC**
    - **10,000-cycle Flash/EE endurance**
    - **20-year Flash/EE retention**
  - **64 kB SRAM with ECC**
- **Software triggered, in circuit reprogrammability via MDIO or I²C**
- **On-chip peripherals**
  - **2× UART, 2× SPI, 3× I²C serial input/output**
  - **Multilevel voltage (3.3 V, 1.8 V, 1.2 V) GPIOs**
  - **MDIO slave up to 10 MHz**
  - **5 general-purpose timers**
  - **Wake-up timer (WUTs)**
  - **Watchdog timers (WDTs)**
  - **32-element PLA**
  - **16-bit PWM**
  - **All GPIOs support external interrupt, 5 can support wake-up**
- **Power**
  - **Multiple supplies: 3.3 V for voltage DACs and ADCs, and 3.3 V, 1.8 V, or 1.2 V for digital inputs/outputs**
  - **Flexible operating modes for low power applications**
- **Package and temperature range**
  - **3.46 mm × 3.46 mm 64-ball WLCSP**
  - **Fully specified for −40°C to +105°C operation**
- **Tools**
  - **Low cost quick start development system**
  - **Full third-party support**

APPLICATIONS

- **Optical networking 100 Gbps/200 Gbps/400 Gbps and higher frequency modules**

GENERAL DESCRIPTION

The ADuCM420 is a fully integrated, single package device that incorporates high performance analog peripherals together with digital peripherals (controlled by a 160 MHz Arm® Cortex™-M33 processor) and integrated flash for code and data.

The analog-to-digital converter (ADC) on the ADuCM420 provides 12-bit, 2 MSPS data acquisition using up to 12 input pins for single-ended mode. Additionally, the die temperature and supply voltages can be measured.

The ADC input voltage is 0 V to VREF. A sequencer is provided that allows a user to select a set of ADC channels to be measured in sequence without software involvement during the sequence. The sequence can optionally repeat automatically at a user-selectable rate.

Up to 12 channels of 12-bit digital-to-analog converters (DACs) are provided with output buffers supported.

The ADuCM420 can be configured so that the digital and analog outputs retain their output voltages through a watchdog or software reset sequence. Therefore, a product can remain functional even while the ADuCM420 is resetting itself.

The ADuCM420 has a low power Arm Cortex-M33 processor and a 32-bit reduced instruction set computer (RISC) machine that offers up to 240 MIPS peak performance with a floating-point unit (FPU). Also integrated on chip are 2× 256 kB Flash/EE memories and 64 kB of static random access memory (SRAM), both with with single-error correction (SEC) and double error detection (DED) error checking and correction (ECC). The flash comprises two separate 256 kB blocks supporting execution from one flash block and simultaneous writing and/or erasing of the other flash block.

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Rev. 0 **Document Feedback**

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REVISION HISTORY

1/2021—Revision 0: Initial Version

The ADuCM420 operates from an on-chip oscillator and has a phase-locked loop (PLL) of 160 MHz. This clock can optionally be divided down to reduce current consumption. Additional low power modes can be set via the ADuCM420 software.

The device includes a management data input/output (MDIO) interface capable of operating up to 10 MHz. User programming is eased by incorporating physical address (PHYADR) and device address (DEVADD) hardware comparators. The nonerasable kernel code combined with flags in user flash allow user code to reliably switch between the two hardware independent flash blocks.

The ADuCM420 integrates a range of on-chip peripherals that can be configured under software control, as required in the application. These peripherals include 2× universal asynchronous receiver transmitter (UART), 3× I^2C, and 2× serial peripheral interface (SPI) serial input/output communication controllers, general-purpose inputs/outputs (GPIOs), a 32-element programmable logic array (PLA), five general-purpose timers, a wake-up timer (WUT), and a system watchdog timer (WDT). A 16-bit pulse-width modulation (PWM) with eight output channels is also provided.

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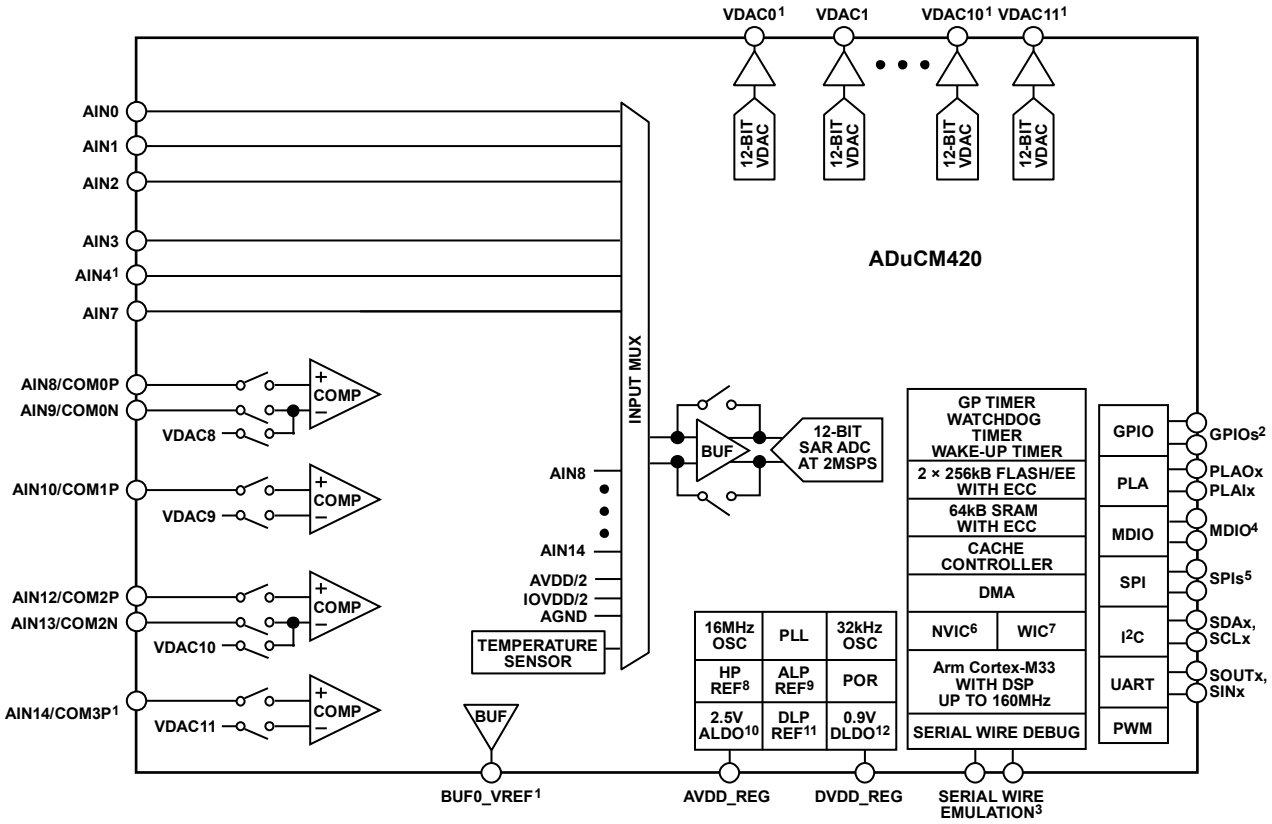
The GPIO pins (Px.x) power up in high impedance input mode. In output mode, the software chooses between open-drain mode and push/pull mode. The pull-up and pull-down resistors can be disabled and enabled in the software. The GPIO pins can be configured with different voltage levels according to the IOVDDx pin, such as 3.3 V, 1.8 V, and 1.2 V. In GPIO output mode, the inputs can remain enabled to monitor the GPIO pins. The GPIO pins can also be programmed to handle digital or analog peripheral signals, in which case, the pin characteristics are matched to the specific requirement.

A large support ecosystem is available for the Arm Cortex-M33 processor to ease product development of the ADuCM420. Access is via the Arm serial wire debug port. On-chip factory firmware supports in-circuit serial download via MDIO or I^2C. These features are incorporated into a low cost quick start development system supporting this precision analog microcontroller

Note that throughout this data sheet, multifunction pins, such as AIN4/VDAC0, are referred to either by the entire pin name or by a single function of the pin, for example, AIN4, when only that function is relevant.

FUNCTIONAL BLOCK DIAGRAM



[1]THIS IS A PARTIAL FUNCTION OF A MULTIFUNCTION PIN. FOR EXAMPLE, VDAC0 AND AIN4 ARE SEPARATE FUNCTIONS ON THE SAME PIN, AIN4/VDAC0.
[2]GPIOs REFER TO Px.x.
[3]SERIAL WIRE EMULATION REFERS TO SWDIO, SWCLK, AND SWO.
[4]MDIO REFERS TO PRTADDRx, MDIO, AND MCK.
[5]SPIs REFER TO SCLKx, $\overline{CS}$x, MOSIx, SRDYx, AND MISOx.
[6]NVIC IS NESTED VECTORED INTERRUPT CONTROLLER.
[7]WAKE-UP INTERRUPT CONTROLLER.
[8]HP REF IS HIGH POWER REFERENCE.
[9]ALP REF IS ANALOG LOW POWER REFERENCE.
[10]ALDO IS ANALOG LOW DROPOUT REGULATOR.
[11]DLP REF IS DIGITAL LOW POWER REFERENCE.
[12]DLDO IS DIGITAL LOW DROPOUT REGULATOR.

Figure 1.

SPECIFICATIONS

AVDD = IOVDD0 = 2.85 V to 3.6 V, IOVDD1 = 1.2 V or 1.8 V, DVDD = 1.8 V to 3.6 V, VREF = 2.5 V for the internal reference, the core frequency (f_{CORE}) = 160 MHz, and T_A = −40°C to +105°C, unless otherwise noted. HCLK is the high speed system clock.

Table 1.

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
ADC CHANNEL SPECIFICATIONS					Single-ended mode only
ADC Power-Up Time		5		µs	
Data Rate (f_{ADC})			2	MSPS	
Resolution	12			Bits	2.5 V internal reference
Integral Nonlinearity		±1	±2	LSB	
Differential Nonlinearity		±0.6	±0.9	LSB	
DC Code Distribution[1]					Minimum and maximum range from mean ADC codes for 1000 samples
		±2		LSB	ADC input 1.25 V, single ended; f_{ADC} = 1 MSPS
ENDPOINT ERRORS					
Offset Error	−920	±400	+720	µV	External channels
Offset Error Drift					
Offset Error Drift Matching		±4		µV/°C	
		±1		µV/°C	Matching compared to AIN0; for voltage input channels
Full-Scale Error	−1500	±500	+1000	µV	External channels
Gain Error Drift		±5		ppm/°C	
Gain Error Drift Matching		±0.5		ppm/°C	Matching compared to AIN0; for voltage input channels
DYNAMIC PERFORMANCE					Input frequency (f_{IN}) = 500 Hz sine wave, sampling frequency (f_{SAMPLE}) = 1 MSPS internally
Signal-to-Noise Ratio (SNR)		73		dB	Includes distortion and noise components; voltage input
Total Harmonic Distortion (THD)		−85		dB	
Peak Harmonic or Spurious Noise		−82		dB	
Channel to Channel Crosstalk		−96		dB	Measured on adjacent channels
ANALOG INPUT					
Input Voltage Ranges					
Single-Ended Mode	0		2.5	V	
Leakage Current		±5		nA	Input voltage to AINx = 0.15 V to 2.5 V
Input Current		±50		nA	At 100 kHz sample rate from 0.15 V to 2.5 V
		±230	±420	nA	2 MSPS ADC sample rate
Input Capacitance		30		pF	During ADC acquisition
ON-CHIP VOLTAGE REFERENCE					4.7 µF decoupling capacitor between ADCREFP and ADCREFN
Output Voltage		2.5		V	
Accuracy			±5	mV	T_A = 25°C
Reference Temperature Coefficient		10	30	ppm/°C	T_A = −40°C to +25°C range
		10	20	ppm/°C	T_A = 25°C to 105°C range
Power Supply Rejection Ratio (PSRR)					
DC		70		dB	AVDD change effects, 2.85 V to 3.6 V
AC		60		dB	Tested with AVDD noise of 1 kHz, 10 kHz, 100 kHz, and 1 MHz
Output Impedance		2		Ω	Do not use as external reference source; T_A = 25°C
EXTERNAL REFERENCE INPUT					
Input Voltage Range		2.5		V	Only supports 2.5 V external reference input
Input Impedance		5		kΩ	Do not use as external reference source

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
BUFFERED VREF OUTPUT (BUF0_VREF)					1 µF capacitor required on output
Output Voltage		1.25 or 2.5		V	
Accuracy			±6	mV	T_A = 25°C, load capacitance (C_L) = 4 mA
Reference Temperature Coefficient		10	30	ppm/°C	T_A = −40°C to +25°C range
		10	20	ppm/°C	T_A = 25°C to 105°C range
Load Regulation		2.5		mV/mA	
Output Impedance		2.5		Ω	
Load Current			4	mA	
PSRR		70		dB	
VOLTAGE DAC (VDAC) CHANNEL SPECIFICATIONS					VDAC Channel 0 to Channel 7: buffer on, load resistance (R_L) = 1 kΩ, C_L = 100 pF, DACCONx, Bit 9 = 0 (normal drive, unless otherwise stated); VDAC Channel 8 to Channel 11: buffer on, R_L = 2.5 kΩ, C_L = 100 pF
DC Accuracy					
Resolution	12			Bits	
Relative Accuracy[2]	−2	±1.5	+3	LSB	
Differential Nonlinearity[1]	−0.9	±0.5	+0.9	LSB	Guaranteed monotonic
Calculated Offset Error	−13.5	±5	+15.5	mV	2.5 V internal reference
Actual Offset Error	−15	+2	+15	mV	Measured at Code 0
	−15	+2	+15	mV	VDAC Channel 0 to Channel 7: DACCONx, Bit 9 = 1; R_L = 250 Ω; C_L = 100 pF
Gain Error	−0.7	±0.2	+0.5	% of FS[3]	
	−0.7	±0.2	+0.5	% of FS[3]	VDAC Channel 0 to Channel 7: DACCONx, Bit 9 = 1; R_L = 250 Ω; C_L = 100 pF
Offset Error Drift		±10		µV/°C	
Gain Error Drift		15		ppm/°C	
Short-Circuit Current		±32		mA	VDAC Channel 0 to Channel 7
		±15		mA	VDAC Channel 8 to Channel 11
VDAC OUTPUTS					
Output Range[1]	0		2.5	V	VDAC Channel 0 to Channel 7
	0		Lower of 2.5 or AVDD − 0.7	V	VDAC Channel 8 to Channel 11
Output Impedance		1		Ω	
VDAC AC CHARACTERISTICS					
Slew Rate		2.5		V/µs	
Voltage Output Settling Time		10		µs	
Digital to Analog Glitch Energy		±20		nV-sec	1 LSB change at major carry (where maximum number of bits simultaneously changes in the DACDATx register)
COMPARATOR INPUT					
Offset Voltage		±15		mV	The offset voltage is dependent on the comparator being enabled with its input pins connected to external biasing circuits; if the comparator is left powered down or if the inputs to the comparator are left floating, over time the offset error may increase
Bias Current	−30	+3	+43	nA	Noninverting (positive) input
		10		nA	Inverting (negative) input, hysteresis disabled
		50		nA	Inverting (negative) input, hysteresis = 10 mV
	740	840	940	nA	Inverting (negative) input, hysteresis = 210 mV

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
Voltage Range	0.5		AVDD – 1.2	V	Negative input range (reference node of the comparator)
	AGND		AVDD	V	Positive input range to comparator
	0		2.0	V	Differential input range; positive input – negative input voltage
Capacitance		7		pF	
Hysteresis	10	50	210	mV	16 configurable options[4]
Hysteresis Voltage Accuracy		10	35	% of target hysteresis	10 mV to 35 mV settings
		5	15	% of target hysteresis	50 mV to 210 mV settings
Response Time		5		µs	
POWER-ON RESET (POR)					Refers to voltage at DVDD pin
POR Trip Level (DVDD)	1.6		1.77	V	Power-on level (see Figure 17)
	1.62	1.66	1.7	V	Power-down level (brownout)
Timeout from POR		32		ms	
FLASH MEMORY					
Endurance	10,000			Cycles	
Data Retention	10			Years	Junction temperature (T_J) = 125°C
	20			Years	T_J = 85°C
INTERNAL HIGH POWER OSCILLATOR		16		MHz	
Accuracy			±3	%	
TEMPERATURE SENSOR					Indicates die temperature
Voltage Output at 25°C		0.13625		V	
Voltage Temperature Coefficient		0.4568		mV/°C	
Accuracy with No Calibration	−3	±2	+4.4	°C	
INTERNAL LOW POWER OSCILLATOR		32		kHz	
Accuracy	−10	±7	+10	%	
3.3 V GPIO					IOVDD0 = 3.3 V
Logic Inputs					
Input Low Voltage (V_{INL})			0.99	V	IOVDD0 × 0.3
Input High Voltage (V_{INH})	2			V	
Pull-Up Current	120	160	210	µA	Input voltage (V_{IN}) = 0 V
Pull-Down Current	115	163	210	µA	V_{IN} = 3.3 V
Internal Pull-Up or Pull-Down Disabled	−32	+1	+65	nA	
Logic Outputs					
Output High Voltage (V_{OH})	2.4			V	Source current (I_{SOURCE}) = 12 mA
Output Low Voltage (V_{OL})			0.4	V	Sink current (I_{SINK}) = 12 mA for SCL0 and SDA0 (I^2C0); and for SCL2 and SDA2 (I^2C2), I_{SINK} = 20 mA
Input Capacitor			10	pF	
Short-Circuit Current		13		mA	
1.8 V GPIO					IOVDD1 = 1.8 V
Logic Inputs					
V_{INL}			0.54	V	
V_{INH}	1.26			V	
Pull-Up Current	150	194	240	µA	V_{IN} = 0 V
Pull-Down Current	170	217	270	µA	V_{IN} = 1.8 V
Internal Pull-Up or Pull-Down Disabled	−520	+25	+2000	nA	IOVDD1 power source

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
Logic Outputs					
V_{OH}	1.4			V	I_{SOURCE} = 12 mA
V_{OL}			0.36	V	I_{SINK} = 12 mA
Input Capacitor			10	pF	
Short-Circuit Current		17		mA	
1.2 V GPIO					IOVDD1 = 1.2 V
Logic Inputs					
V_{INL}			0.36	V	
V_{INH}	0.84			V	
Pull-Up Current	55	76	100	µA	V_{IN} = 0 V
Pull-Down Current	55	82	110	µA	V_{IN} = 1.2 V
Internal Pull-Up or Pull-Down Disabled	−450	+20	+1510	nA	IOVDD1 power source
Logic Outputs					
V_{OH}	1.0			V	I_{SOURCE} = 6 mA
V_{OL}			0.18	V	I_{SINK} = 6 mA
Input Capacitor			10	pF	
Short-Circuit Current		7		mA	
MDIO					
Logic Inputs					
V_{INL}			0.36	V	
V_{INH}	0.84			V	
Logic Output					
V_{OH}	1.0			V	I_{SOURCE} = 4 mA
V_{OL}			0.2	V	I_{SINK} = 4 mA
Input Capacitor			10	pF	
Short-Circuit Current		7		mA	
MICROCONTROLLER UNIT (MCU) CLOCK RATE					
Using PLL Output		160	163	MHz	
EXTERNAL RESET					
Minimum Pulse Duration	10			µs	Pin voltage must stay low for this period
PROCESSOR START-UP TIME					
At Power-On		32		ms	Includes kernel execution time
After Reset Event		1		ms	Includes kernel execution time
After Processor Power-Down					
Core Sleep Mode (Mode 1)		30		HCLK cycles	Fixed number of HCLK periods
System Sleep Mode (Mode 2)		85		µs	HCLK = 160 MHz from PLL
Hibernate Mode (Mode 3)		3		µs	HCLK = 16 MHz from internal oscillator
POWER REQUIREMENTS					
Power Supply Voltage Range					
AVDD to AGND	2.85	3.3	3.6	V	
DVDD to DGND	1.7	1.8 or 3.3	3.6	V	
IOVDD0 to IOGND	2.85	3.3	3.6	V	
IOVDD1 to IOGND	1.08	1.2 or 1.8	1.98	V	If unused, can be tied to DVDD_REG or to DGND
Analog Power Supply Currents					
AVDD Current		900	1050	µA	Analog peripherals in idle mode
Digital Power Supply Current					
Current in Normal Mode					
IOVDD0		175	200	µA	
IOVDD1		20	60	µA	

Parameter	Min	Typ	Max	Unit	Test Conditions/Comments
DVDD Current					
Active Mode					Executing typical code
		16		mA	HCLK = 160 MHz clock
		4.8		mA	HCLK = 16 MHz from internal oscillator
Core Sleep Mode (Mode 1)		11		mA	HCLK = 160 MHz clock
		4.3		mA	HCLK = 16 MHz from internal oscillator
System Sleep Mode (Mode 2)		2.46	19	mA	
Hibernate Mode (Mode 1)		2.44	20	mA	HCLK = 160 MHz clock
Additional Power Supply Currents					
ADC		2.8	3.4	mA	Continuously converting at 2 MSPS
DAC		330	350	µA	Per powered up DAC, excluding load current
Total Supply Current		18.8		mA	Active mode with PLL clock of 160 MHz and ADC enabled

[1] These numbers are not production tested but are guaranteed by design and/or characterization data at production release.
[2] VDAC linearity specifications generated using reduced DAC code range of 82 to 4095. For VDAC Channel 8 to Channel 11, end code of 4095 only used when AVDD – 0.7 V > 2.5 V.
[3] FS is full scale.
[4] These options include 10 mV, 25 mV, 35 mV, 50 mV, 60 mV, 75 mV, 100 mV, 110 mV, 125 mV, 135 mV, 150 mV, 160 mV, 175 mV, 185 mV, 200 mV, and 210 mV.

TIMING SPECIFICATIONS

I²C Timing

Table 2. I²C Timing in Standard Mode (100 kHz)—Slave/Master

Parameter	Description	Min	Typ	Max	Unit
t_L	SCLx low pulse width	4.7			µs
t_H	SCLx high pulse width	4.0			µs
t_{SHD}	Start condition hold time	4.0			µs
t_{DSU}	Data setup time	250			ns
t_{DHD}	Data hold time (SDAx held internally after falling edge of SCLx, duration set via TCTL register, THDATIN bits)	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
C_B	Capacitive load for each bus line (not shown in Figure 2)			400	pF

Table 3. I²C Timing in Fast Mode (400 kHz)—Slave/Master

Parameter	Description	Min	Typ	Max	Unit
t_L	SCLx low pulse width	1.3			µs
t_H	SCLx high pulse width	0.6			µs
t_{SHD}	Start condition hold time	0.6			µs
t_{DSU}	Data setup time	100			ns
t_{DHD}	Data hold time (SDAx held internally after falling edge of SCLx, duration set via TCTL register, THDATIN bits)	0			µs
t_{RSU}	Setup time for repeated start	0.6			µs
t_{PSU}	Stop condition setup time	0.6			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
C_B	Capacitive load for each bus line (not shown in Figure 2)			400	pF

I²C GPIOs (P0.7 to P0.4 and P1.3 to P1.2) drive strength set to 20 mA.

Table 4. I²C Timing in Fast Mode Plus (1 MHz)—Slave/Master

Parameter	Description	Min	Typ	Max	Unit
t_L	SCLx low pulse width	0.5			µs
t_H	SCLx high pulse width	0.26			µs
t_{SHD}	Start condition hold time	0.26			µs
t_{DSU}	Data setup time	50			ns
t_{DHD}	Data hold time (SDAx held internally after falling edge of SCLx, duration set via TCTL register, THDATIN bits)	0			µs
t_{RSU}	Setup time for repeated start	0.26			µs
t_{PSU}	Stop condition setup time	0.26			µs
t_{BUF}	Bus free time between a stop condition and a start condition	0.5			µs
t_R	Rise time for both SCLx and SDAx			120	ns
t_F	Fall time for both SCLx and SDAx			120	ns
$t_{VD; DAT}$	Data valid time			0.45	µs
$t_{VD; ACK}$	Data valid acknowledge time			0.45	µs
C_B	Capacitive load for each bus line (not shown in Figure 2)			550	pF

I²C GPIOs (P0.7 to P0.4 and P1.3 to P1.2) drive strength set to 20 mA.

Table 5. I²C Timing in High Speed Mode (3.4 MHz)—Slave Only

Parameter	Description	Min	Typ	Max	Unit
t_L	SCLx low pulse width	160			ns
t_H	SCLx high pulse width	60			ns
t_{SHD}	Start condition hold time	160			ns
t_{DSU}	Data setup time	10			ns
t_{DHD}	Data hold time (SDAx held internally after falling edge of SCLx, duration set via TCTL register, THDATIN bits)	0			ns
t_{RSU}	Setup time for repeated start	160			ns
t_{PSU}	Stop condition setup time	160			ns
t_{BUF}	Bus free time between a stop condition and a start condition	200			ns
t_R	Rise time for both SCLx and SDAx	10		40	ns
	Up to C_B = 100 pF				
	Up to C_B = 400 pF			80	ns
t_F	Fall time for both SCLx and SDAx	10		40	ns
	Up to C_B = 400 pF			80	ns
C_B	Capacitive load for each bus line (not shown in Figure 2)			400	pF

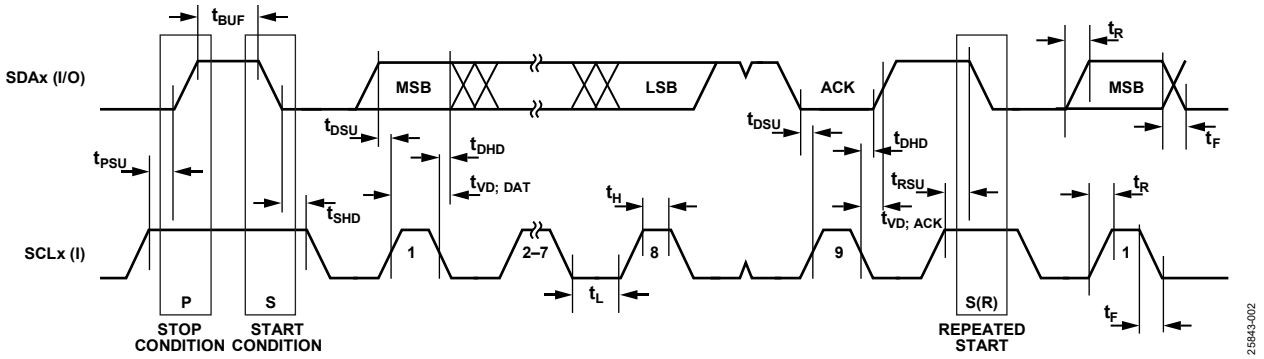


Figure 2. I²C-Compatible Interface Timing

SPI Timing Specifications: Slave Mode

SPI GPIOs (P0.3 to P0.0, P1.7 to P1.4) drive strength set to 12 mA, IOVDD1 ≥ 1.2 V, and 40 MHz SPI clock. See Figure 3 and Figure 4.

Table 6. SPI Slave Mode Timing

Parameter	Symbol	Min	Typ	Max	Unit
TIMING REQUIREMENTS					
$\overline{CSx}$ to SCLKx Edge	$t_{\overline{CS}}$	25			ns
Minimum Valid $\overline{CSx}$ Inactive Period	$t_{\overline{CSM}}$	25			ns
SCLKx Low Pulse Width	t_{SL}		10		ns
SCLKx High Pulse Width	t_{SH}		10		ns
Data Input Setup Time Before SCLKx Edge	t_{DSU}	5			ns
Data Input Hold Time After SCLKx Edge	t_{DHD}	5			ns
SCLKx Rise Time	t_{SR}		5		ns
SCLKx Fall Time	t_{SF}		5		ns
SWITCHING CHARACTERISTICS					
Data Output Valid After SCLKx Edge	t_{DAV}		10		ns
Data Output Valid After $\overline{CSx}$ Edge	t_{DOCS}		15		ns
$\overline{CSx}$ High After SCLKx Edge	t_{SFS}		8.75		ns

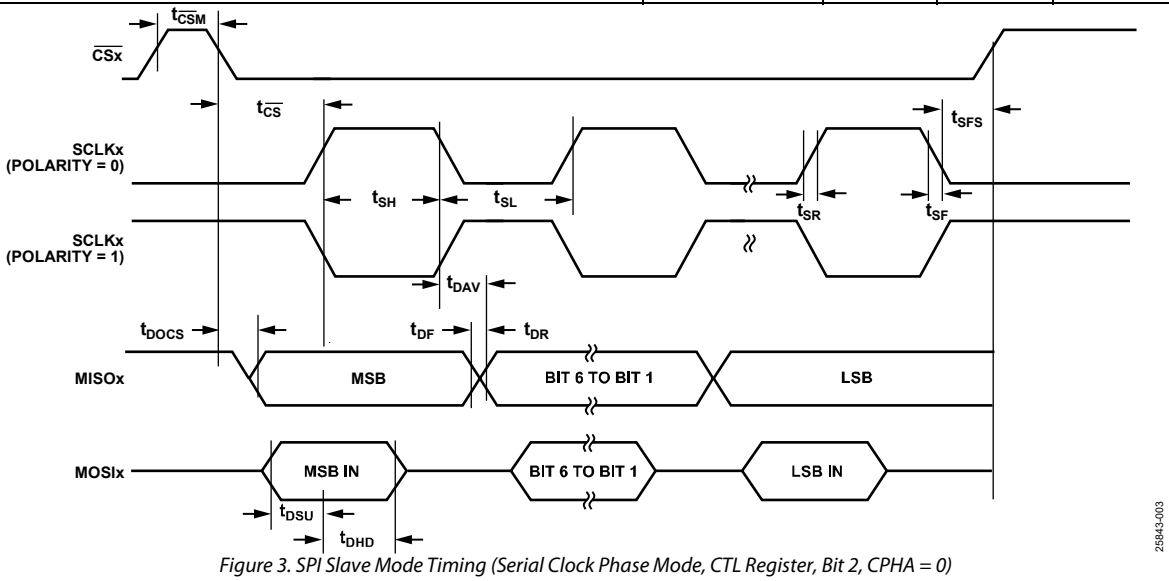


Figure 3. SPI Slave Mode Timing (Serial Clock Phase Mode, CTL Register, Bit 2, CPHA = 0)

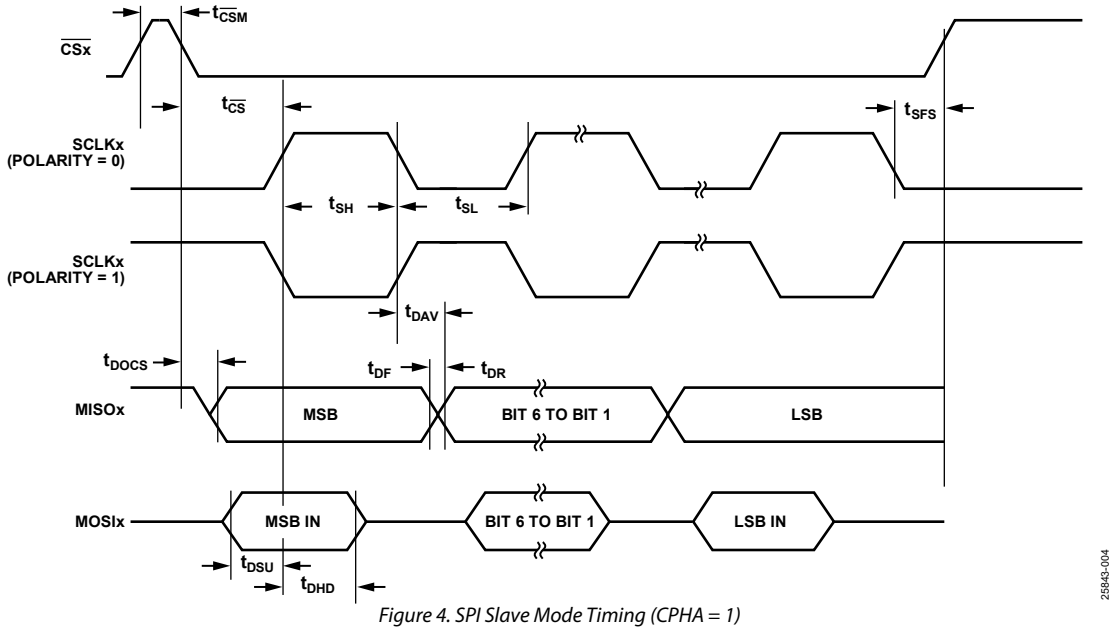


Figure 4. SPI Slave Mode Timing (CPHA = 1)

SPI Timing Specifications: Master Mode

SCLKx = 40 MHz, SPI SPI GPIOs (P0.3 to P0.0, P1.7 to P1.4) pin drive strength set to 12 mA. IOVDD1 ≥ 1.2 V. DIV is the SPI clock divider, in the SPI baud rate selection register (see the ADuCM420 hardware reference manual for more information). t_{HCLK} is the time period of HCLK set up by the user.

Table 7. SPI Master Mode Timing (CPHA = 0 and 1)

Parameter	Description	Min	Typ	Max	Unit
t_{SL}	SCLKx low pulse width		(DIV + 1) × t_{HCLK}/2		ns
t_{SH}	SCLKx high pulse width		(DIV + 1) × t_{HCLK}/2		ns
t_{DAV}	Data output valid after SCLKx edge	0			ns
t_{DSU}	Data input setup time before SCLKx edge	5			ns
t_{DHD}	Data input hold time after SCLKx edge	5			ns
t_{DF}	Data output fall time		5		ns
t_{DR}	Data output rise time		5		ns
t_{SR}	SCLKx rise time		5		ns
t_{SF}	SCLKx fall time		5		ns

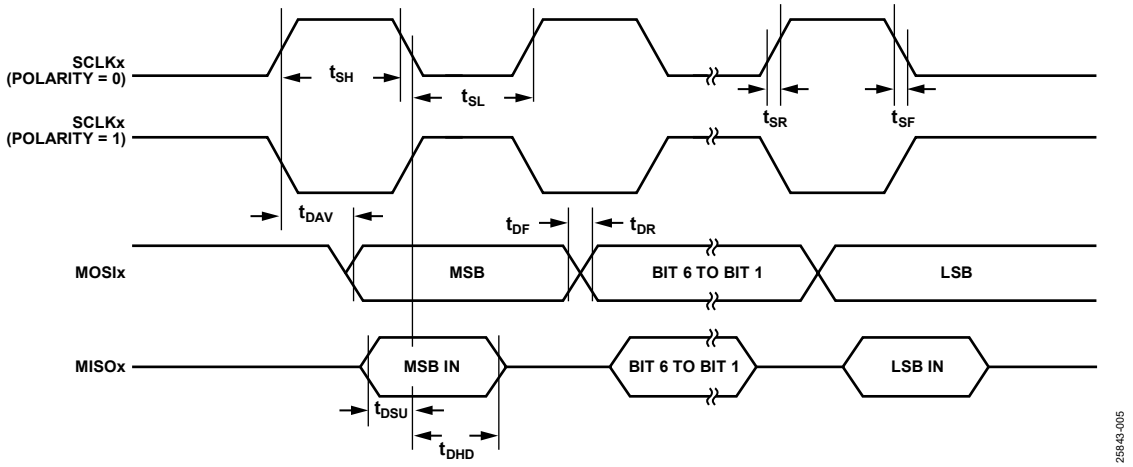


Figure 5. SPI Master Mode Timing (CPHA = 1)

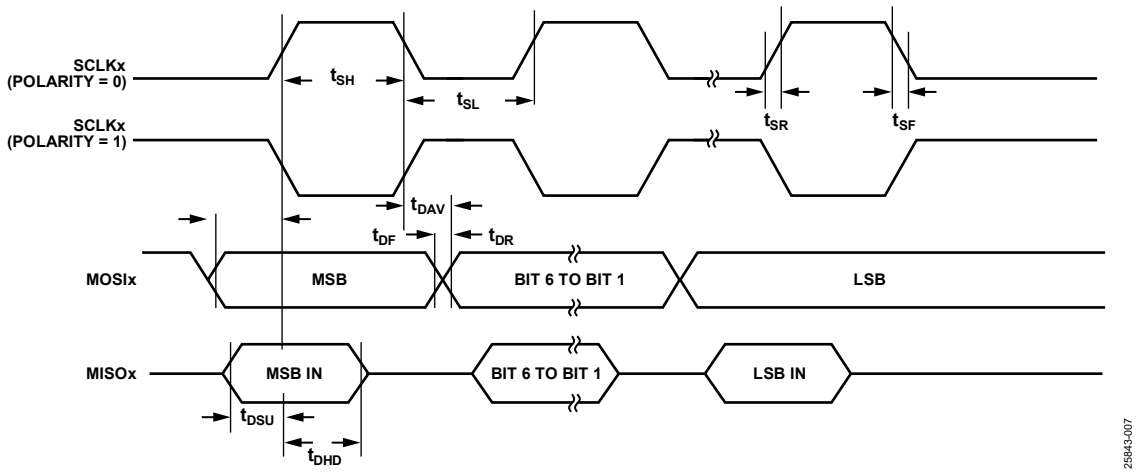


Figure 6. SPI Master Mode Timing (CPHA = 0)

Table 8. MDIO vs. Management Data Clock (MDC) Timing

Parameter[1]	Description	Min	Typ	Max	Unit
Maximum MCK Clock Speed	Push/pull mode			10	MHz
	Open-drain mode, pull-up resistance (R_{PULLUP}) = 312 Ω			4	MHz
t_{SETUP}	MDIO setup before MCK edge (push/pull mode)	5			ns
	Open-drain mode, R_{PULLUP} = 312 Ω	10			ns
t_{HOLD}	MDIO valid after MCK edge (push/pull mode)	7			ns
	Open-drain mode, R_{PULLUP} = 312 Ω	10			ns
t_{DELAY}	Data output after MCK edge (push/pull mode)			26	ns
	Open-drain mode, R_{PULLUP} = 312 Ω			100	

[1] In Figure 7, CFP is C formfactor pluggable. V_{IH} is the voltage input high level, and V_{IL} is voltage input low level.

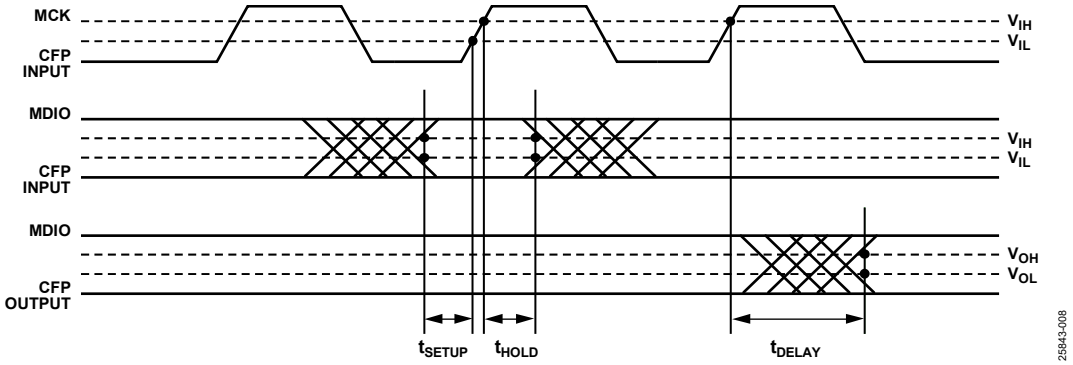


Figure 7. MDIO Timing

ABSOLUTE MAXIMUM RATINGS

Table 9.

Parameter	Rating
AVDD to AGND	−0.3 V to +3.63 V
IOVDD0 to IOGND	−0.3 V to +3.63 V
IOVDD1 to IOGND	−0.3 V to +1.98 V
DVDD to DGND	−0.3 V to +3.63 V
AVDD to IOVDD0	IOVDD0 ± 0.3 V
Analog Input Voltage to AGND (AVDD Range = 2.85 V to 3.6 V)	−0.3 V to AVDD + 0.3 V, must be ≤3.63 V
Digital Input Voltage to IOGND	−0.3 V to IOVDD0 + 0.3 V, must be ≤3.63 V
Digital Input Voltage to IOGND (P1.0 to P1.7 and P0.0 to P0.3 Only)[1]	−0.3 V to IOVDD1 + 0.3 V, must be ≤1.98 V
AGND to DGND	−0.3 V to +0.3 V
IOGND to DGND	−0.3 V to +0.3 V
Total Positive GPIO Pins Current	0 mA to 40 mA
Total Negative GPIO Pins Current	−40 mA to 0 mA
Temperature Ranges	
Storage	−65°C to +150°C
Operating	−40°C to +105°C
Reflow Profiles	
SnPb Assemblies (10 sec to 30 sec)	240°C
Pb-Free Assemblies (20 sec to 40 sec)	260°C
Junction Temperature	150°C

[1] When IOVDD1 is the selected power rail.

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

Thermal performance is directly linked to printed circuit board (PCB) design and operating environment. Careful attention to PCB thermal design is required.

θ_{JA} is the natural convection junction to ambient thermal resistance measured in a one cubic foot sealed enclosure. θ_{JC} is the junction to case thermal resistance.

Table 10. Thermal Resistance

Package Type	θ_{JA}[1]	θ_{JC}	Unit
CB-64-2	34	0.16	°C/W

[1] JEDEC 2S2P.

ELECTROSTATIC DISCHARGE (ESD) RATINGS

The following ESD information is provided for handling of ESD sensitive devices in an ESD protected area only.

Human body model (HBM) per ANSI/ESDA/JEDEC JS-001. Field induced charged device model (FICDM) per ANSI/ESDA/JEDEC JS-002.

ESD Ratings for ADuCM420

Table 11. ADuCM420, 64-Ball WLCSP

ESD Model	Withstand Threshold (kV)	Class
HBM	3	2
FICDM	0.5	C2A

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.

TYPICAL PERFORMANCE CHARACTERISTICS

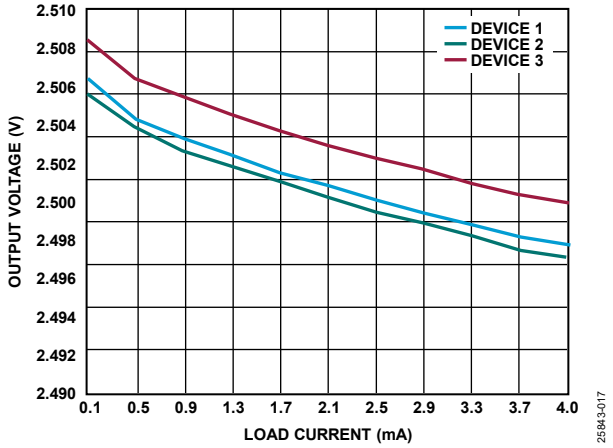


Figure 8. BUF0_VREF Load Regulation, 2.5 V Output Setting

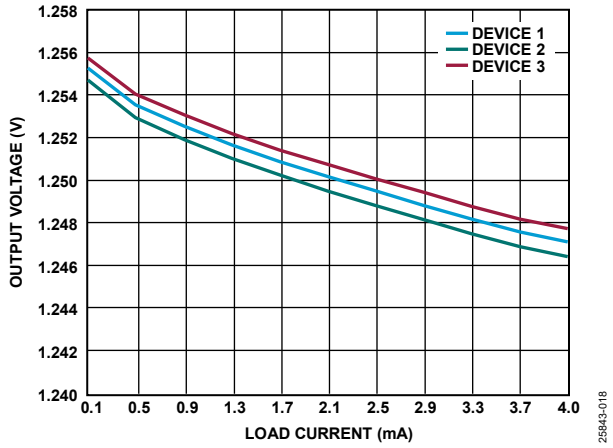


Figure 9. BUF0_VREF Load Regulation, 1.25 V Output Setting

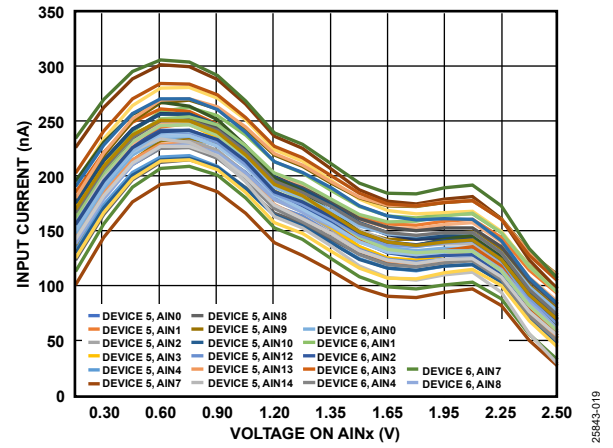


Figure 10. Input Current vs. Voltage on AINx, f_{SAMPLE} = 2 MSPS

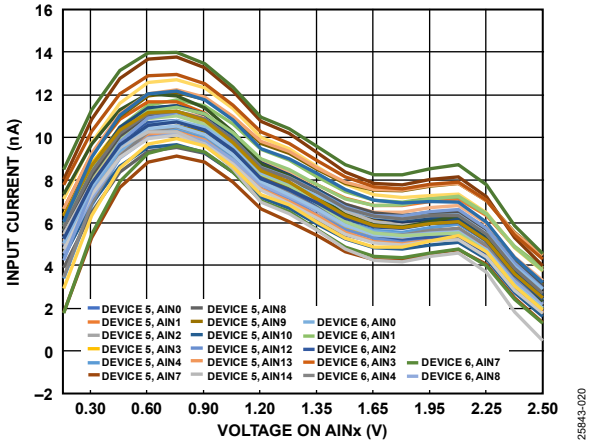


Figure 11. Input Current vs. Voltage on AINx, f_{SAMPLE} = 100 kSPS

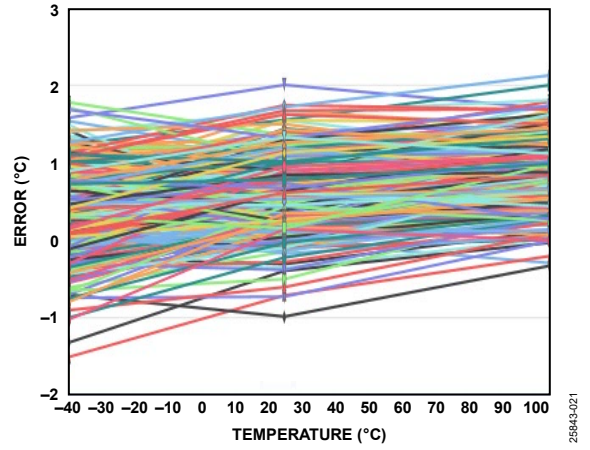


Figure 12. Temperature Sensor Accuracy, No Calibration, 240 Devices

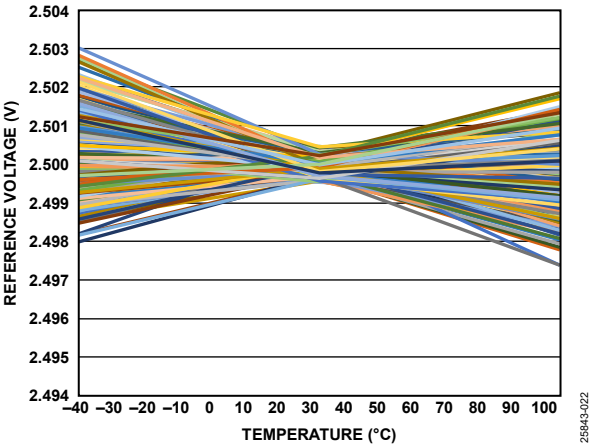


Figure 13. Reference Voltage Drift vs. Temperature, 250 Devices

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

Figure 14. Pin Configuration

Table 12. Pin Function Descriptions

Pin No.	Mnemonic	Type[1]	Description
A1	IOGND	S	Ground for Digital Inputs/Outputs.
A2	P2.0/ADCCONV/COMPDIN2/PLAI8	I/O	Digital Input/Output Port 2.0 (P2.0). External Input to Start ADC Conversions (ADCCONV). Comparator 2 Digital Input for Three-State (COMPDIN2). Input to PLA Element 8 (PLAI8).
A3	P2.1/DM/IRQ2/ECLKIN/COMPDIN3/PLAI9	I/O	Digital I/O Port 2.1 (P2.1). Download Mode Selection (DM). External Interrupt 2 (IRQ2). External Input Clock (ECLKIN). Comparator 3 Digital Input for Three-State (COMPDIN3). Input to PLA Element 9 (PLAI9).
A4	SWDIO	I/O	Serial Wire Bidirectional Data.
A5	VDAC7	AO	Voltage DAC 7 Output.
A6	VDAC6	AO	Voltage DAC 6 Output.
A7	VDAC5	AO	Voltage DAC 5 Output.
A8	VDAC3	AO	Voltage DAC 3 Output.

Pin No.	Mnemonic	Type[1]	Description
B1	P0.3/IRQ0/$\overline{CS0}$/PLACLK0/PLAI3	I/O	Digital Input/Output Port 0.3 (P0.3). External Interrupt 0 (IRQ0). SPI Channel 0 (SPI0) Chip Select ($\overline{CS0}$). PLA Clock 0 (PLACLK0). Input to PLA Element 3 (PLAI3). Ball B1 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
B2	P0.2/MOSI0/PLACLK1/PLAI2	I/O	Digital Input/Output Port 0.2 (P0.2). SPI0 Master Output, Slave Input (MOSI0). PLA Clock 1 (PLACLK1). Input to PLA Element 2 (PLAI2). Ball B2 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
B3	P2.3/BM/PLAI10	I/O	Digital Input/Output Port 2.3 (P2.3). An internal pull-up resistor is enabled at power-up on P2.3. Boot Mode (BM). This pin determines the start-up sequence after every reset. Input to PLA Element 10 (PLAI10).
B4	SWCLK	I	Serial Wire Debug Clock.
B5	$\overline{RESET}$	I	Reset Input (Active Low). An internal pull-up resistor is included with this pin.
B6	VDAC1	AO	Voltage DAC 1 Output.
B7	VREF	AO/AI	0.92 V Reference with 100 nF Capacitor.
B8	AVDD	S	3.3 V Analog Power Supply.
C1	IOVDD1	S	1.2 V or 1.8 V GPIO Supply.
C2	P0.1/MISO0/COMOUT1/PLAI1	I/O	Digital Input/Output Port 0.1 (P0.1). SPI0 Master Input, Slave Output (MISO0). Comparator 1 Output (COMOUT1) Input to PLA Element 1 (PLAI1). Ball C2 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
C3	P0.0/SCLK0/COMOUT0/PLAI0	I/O	Digital Input/Output Port 0.0 (P0.0). SPI0 Clock (SCLK0). Comparator 0 Output (COMOUT0). Input to PLA Element 0 (PLAI0). Ball C3 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
C4	P1.0/SIN1/COMOUT2/PLAI4	I/O	Digital Input/Output Port 1.0 (P1.0). UART Input 1 (SIN1). Comparator 2 Output (COMOUT2). Input to PLA Element 4 (PLAI4). Ball C4 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
C5	P2.2/POR/CLKOUT/SWO	I/O	Digital Input/Output Port 2.2 (P2.2). Reset Output (POR). This pin function is an output, and it is the default. Clock Output (CLKOUT). SWD Output (SWO).
C6	AIN14/COM3P/BUF0_VREF	AI/AO	Analog Input 14 (AIN14). Comparator 3 Emitter Voltage (V_E) Positive (COM3P). Buffered Reference Voltage source (BUF0_VREF).
C7	AIN2	AI	Analog Input 2.
C8	AIN4/VDAC0	AI	Analog Input 4 (AIN4). Voltage DAC 0 Output (VDAC0).
D1	DVDD_REG	AO	0.9 V Digital Regulator Supply with 0.47 µF Decoupling Capacitor. Do not use DVDD_REG to power external circuits.
D2	DGND	S	Digital Ground.

Pin No.	Mnemonic	Type[1]	Description
D3	P1.2/SCL1/PWM0/PLAI6	I/O	Digital Input/Output Port 1.2 (P1.2). I²C Channel 1 (I²C1) Serial Clock (SCL1). PWM Output 0 (PWM0). Input to PLA Element 6 (PLAI6). Ball D3 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
D4	P1.3/SDA1/PWM1/PLAI7	I/O	Digital Input/Output Port 1.3 (P1.3). I²C1 Serial Data (SDA1). PWM Output 1 (PWM1). Input to PLA Element 7 (PLAI7). Ball D4 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
D5	P1.1/SOUT1/COMOUT3/PLAI5	I/O	Digital Input/Output Port 1.1 (P1.1). UART Output 1 (SOUT1). Comparator 3 Output (COMOUT3) Input to PLA Element 5 (PLAI5). Ball D5 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
D6	AIN3	AI	Analog Input 3.
D7	AIN0	AI	Analog Input 0.
D8	AIN10/COM1P	AI	Analog Input 10 (AIN10). Comparator 1 V_E Positive (COM1P).
E1	IOVDD0	S	3.3 V GPIO Supply.
E2	IOGND	S	Ground for Digital Inputs/Outputs.
E3	P1.4/SCLK1/PWM2/PLAO10	I/O	Digital Input/Output Port 1.4 (P1.4). SPI Channel 1 (SPI1) Clock (SCLK1). PWM Output 2 (PWM2). Output of PLA Element 10 (PLAO10). Ball E3 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
E4	P1.7/IRQ1/$\overline{CS1}$/PWM5/PLAO13	I/O	Digital Input/Output Port 1.7 (P1.7). External Interrupt 1 (IRQ1). SPI1 Chip Select ($\overline{CS1}$). PWM Output 5 (PWM5). Output of PLA Element 13 (PLAO13). Ball E4 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
E5	VDAC8/P5.0	AO/I/O	Voltage DAC 8 Output (VDAC8). Digital Input/Output Port 5.0 (P5.0).
E6	AIN12/COM2P	AI	Analog Input 12 (AIN12). Comparator 2 V_E Positive (COM2P).
E7	AGND	S	Analog Ground.
E8	AVDD_REG	AO	2.5 V Analog Regulator Supply with 0.47 µF Decoupling Capacitor. Do not use AVDD_REG to power external circuits.
F1	P1.5/MISO1/PWM3/PLAO11	I/O	Digital Input/Output Port 1.5 (P1.5). SPI1 Master Input, Slave Output (MISO1). PWM Output 3 (PWM3). Output of PLA Element 11 (PLAO11). Ball F1 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.

Pin No.	Mnemonic	Type[1]	Description
F2	P1.6/MOSI1/PWM4/PLAO12	I/O	Digital Input/Output Port 1.6 (P1.6). SPI1 Master Output, Slave Input (MOSI1). PWM Output 4 (PWM4). Output of PLA Element 12 (PLAO12). Ball F2 is a multilevel voltage input/output with 3.3 V, 1.8 V, or 1.2 V support. Note that 3.3 V is the default.
F3	P0.7/IRQ4/SDA2/COMPDIN1/PLAO5	I/O	Digital Input/Output Port 0.7 (P0.7). External Interrupt 4 (IRQ4). I^2C Channel 2 (I^2C2) Serial Data (SDA2). Comparator 1 Digital Input for Three-State (COMPDIN1). Output of PLA Element 5 (PLAO5).
F4	P3.2/PRTADDR2/PWMTRIP/PLAI14	I/O	Digital Input/Output Port 3.2 (P3.2). MDIO Port Address Bit 2 (PRTADDR2). PWM Trip (PWMTRIP). Input to PLA Element 14 (PLAI14).
F5	VDAC9/P5.1	AO/I/O	Voltage DAC 9 Output (VDAC9). Digital Input/Output Port 5.1 (P5.1).
F6	AIN8/COM0P	AI	Analog Input 8 (AIN8). Comparator 0 V_E Positive (COM0P).
F7	ADCREFN	AO/AI	Decoupling Capacitor Connection for ADC. Connect this pin to AGND.
F8	ADCREFP	AO/AI	Decoupling Capacitor Connection for ADC Reference Buffer with 4.7 µF Decoupling Capacitor.
G1	P0.4/SCL0/SIN0/PLAO2	I/O	Digital Input/Output Port 0.4 (P0.4). I^2C Channel 0 (I^2C0) Serial Clock (SCL0). UART 0 Input (SIN0). Output of PLA Element 2 (PLAO2).
G2	P0.5/SDA0/SOUT0/PLAO3	I/O	Digital Input/Output Port 0.5 (P0.5). I^2C0 Serial Data (SDA0). UART Output 0 (SOUT0). Output of PLA Element 3 (PLAO3).
G3	P0.6/IRQ3/SCL2/COMPDIN0/PLAO4	I/O	Digital Input/Output Port 0.6 (P0.6). External Interrupt 3 (IRQ3). I^2C2 Serial Clock (SCL2). Comparator 0 Digital Input for Three-State (COMPDIN0). Output of PLA Element 4 (PLAO4).
G4	P3.1/PRTADDR1/PWMSYNC/PLAI13	I/O	Digital Input/Output Port 3.1 (P3.1). MDIO Port Address Bit 1 (PRTADDR1). PWM Synchronization (PWMSYNC). Input to PLA Element 13 (PLAI13).
G5	VDAC11/P5.3	AO/I/O	Voltage DAC 11 Output (VDAC11). Digital Input/Output Port 5.1 (P5.3).
G6	AIN7/VDAC2	AI	Analog Input 7 (AIN7). Voltage DAC 2 Output (VDAC2).
G7	AIN1	AI	Analog Input 1.
G8	AIN9/COM0N	AI	Analog Input 9 (AIN9). Comparator 0 V_E Negative (COM0N).
H1	IOGND	S	Ground for Digital Inputs/Outputs.
H2	DVDD	S	1.8 V or 3.3 V Digital Power Supply.
H3	P3.6/MDIO	I/O	Digital Input/Output Port 3.6 (P3.6). MDIO Slave Data (MDIO).
H4	P3.5/MCK/SRDY1/PLAO27	I/O	Digital Input/Output Port 3.5 (P3.5). MDIO Slave Clock (MCK). SPI1 Ready (SRDY1). Output of PLA Element 27 (PLAO27).

Pin No.	Mnemonic	Type[1]	Description
H5	P3.0/PRTADDR0/SRDY0/PLAI12	I/O	Digital Input/Output Port 3.0 (P3.0). MDIO Port Address Bit 0 (PRTADDR0). SPI0 Ready (SRDY0). Input to PLA Element 12 (PLAI12).
H6	VDAC10/P5.2	AO/I/O	Voltage DAC 10 Output (VDAC10). Digital Input/Output Port 5.2 (P5.2).
H7	VDAC4	AO	Voltage DAC 4 Output.
H8	AIN13/COM2N	AI	Analog Input 13 (AIN13). Comparator 2 V_E Negative (COM2N).

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

THEORY OF OPERATION

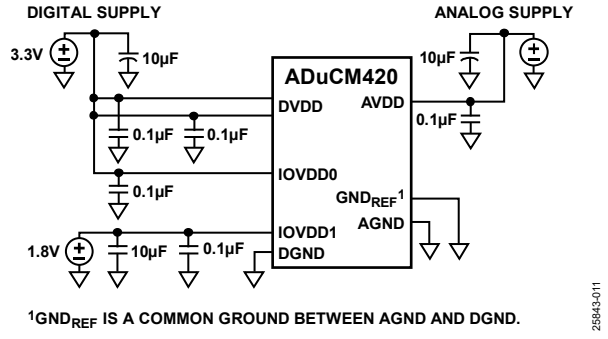
The ADuCM420 is an on-chip system. The ADuCM420 is mixed-signal microcontroller based on the Arm Cortex-M33 processor.

See the ADuCM420 hardware reference manual for full details on the operation of the ADuCM420, including, but not limited to, all register details and information about the various features and operation of the power management unit, the Arm Cortex-M33 processor, the ADC circuit, the flash controller, and the SPI, I^2C, and UART interfaces.

APPLICATIONS INFORMATION

POWER SUPPLIES

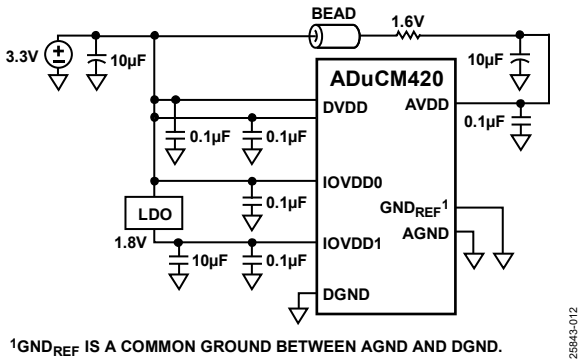
The ADuCM420 operational power supply voltage is 2.85 V to 3.6 V for AVDD and IOVDD0, 1.2 V or 1.8 V for IOVDD1, and 1.8 V to 3.6 V for DVDD. Separate analog (AVDD) and digital power supply pins (IOVDD1 and DVDD) allow AVDD to be kept relatively free of noisy digital signals often present in the system DVDD line. In this mode, the ADuCM420 can also operate with split supplies. That is, the device can use different voltage levels for each supply as long as the minimum and maximum specifications defined in Table 1 and Table 9 for each supply are adhered to. A typical split supply configuration is shown in Figure 15.



[1]GND_{REF} IS A COMMON GROUND BETWEEN AGND AND DGND.

Figure 15. External Multiple Supply Connections

As an alternative to providing two separate power supplies, the user can reduce noise on AVDD by placing a small series resistor and/or ferrite bead between AVDD and DVDD and then decoupling AVDD separately to ground. An example of this configuration is shown in Figure 16. With this configuration, other analog circuitry (such as op amps and voltage reference) can be powered from the AVDD supply line as well.



[1]GND_{REF} IS A COMMON GROUND BETWEEN AGND AND DGND.

Figure 16. External Single-Supply Connections

In both Figure 15 and Figure 16, a large value (10 µF) reservoir capacitor is connected to DVDD, and a separate 10 µF capacitor is connected to AVDD. In addition, local small value (0.1 µF) capacitors are located at each AVDD, IOVDD0, IOVDD1, and DVDD pin of the chip. As per standard design practice, include all of these capacitors and ensure that the smaller capacitors are close to each supply pin with trace lengths as short as possible. Connect the ground terminal of each of these capacitors directly to the underlying ground plane.

Note that the analog and digital ground pins on the ADuCM420 must be referenced to the same system ground reference point at all times.

POWER-UP REQUIREMENTS

Figure 17 and Figure 18 show the power-up requirements for DVDD and AVDD. Figure 19 shows the power-up requirement for IOVDD0 if no external pull-up is applied to the P2.3/BM/PLAI10 pin.

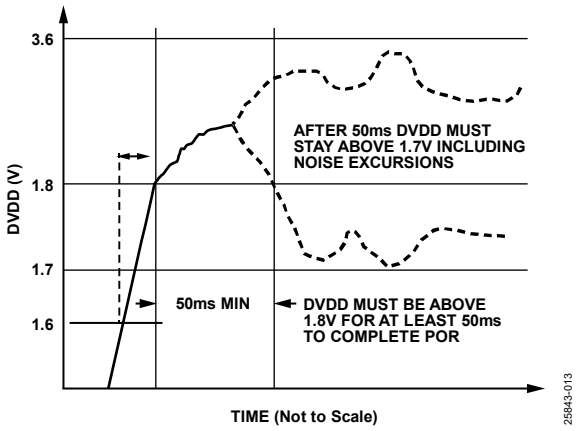
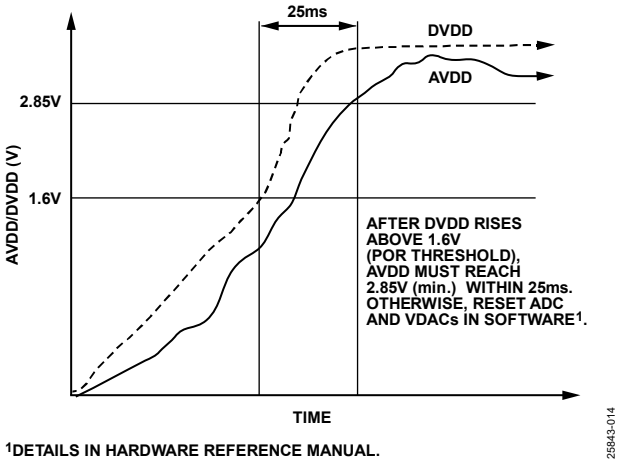


Figure 17. DVDD Power-Up Requirements



[1]DETAILS IN HARDWARE REFERENCE MANUAL.

Figure 18. AVDD Power-Up Requirements

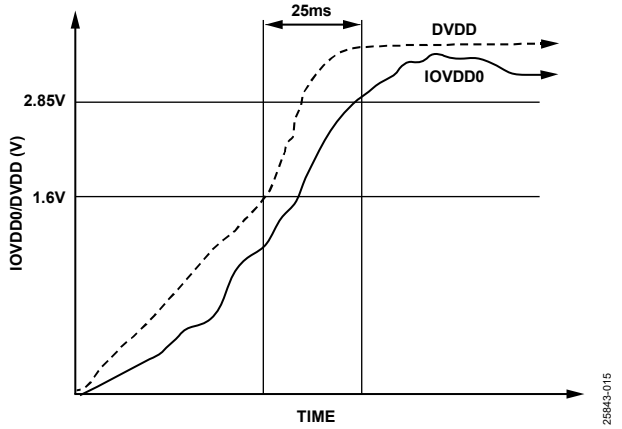


Figure 19. IOVDD0 Power-Up Requirement, No External Pull-Up

RECOMMENDED CIRCUIT AND COMPONENT VALUES

Figure 20 shows a typical connection diagram for the ADuCM420.

Adequately decouple the supplies and regulators with capacitors connected between the AVDD_REG, DVDD_REG, and IOVDDx balls and their associated ground balls (AGND and DGND). Table 12 indicates which ground balls are paired with which supply balls.

There are three digital supply balls, IOVDD0, IOVDD1, and DVDD. Decouple these balls with a 0.1 µF capacitor placed as near as possible to each of the three balls and their associated ground balls (IOGND and DGND). In addition, place a 10 µF capacitor near these balls.

For DVDD, to improve noise reduction, place a ferrite bead in series with a 10 µF capacitor to DGND.

Similarly, the analog supply pin (AVDD) requires a 0.1 µF capacitor placed as near as possible to each ball and its associated AGND ball. Also, place a 10 µF capacitor near these balls.

The ADC reference requires a 4.7 µF capacitor be placed between ADCREFP and ADCREFN and located as near as possible to each ball. ADCREFN must be connected directly to AGND. The ADuCM420 contains two internal regulators. These regulators require external decoupling capacitors. The DVDD_REG and AVDD_REG balls each require a 0.47 µF capacitor to DGND and AGND, respectively. Take care in the layout to ensure that currents flowing from the ground end of each decoupling capacitor to its associated ground ball share as little track as possible with other ground currents on the PCB.

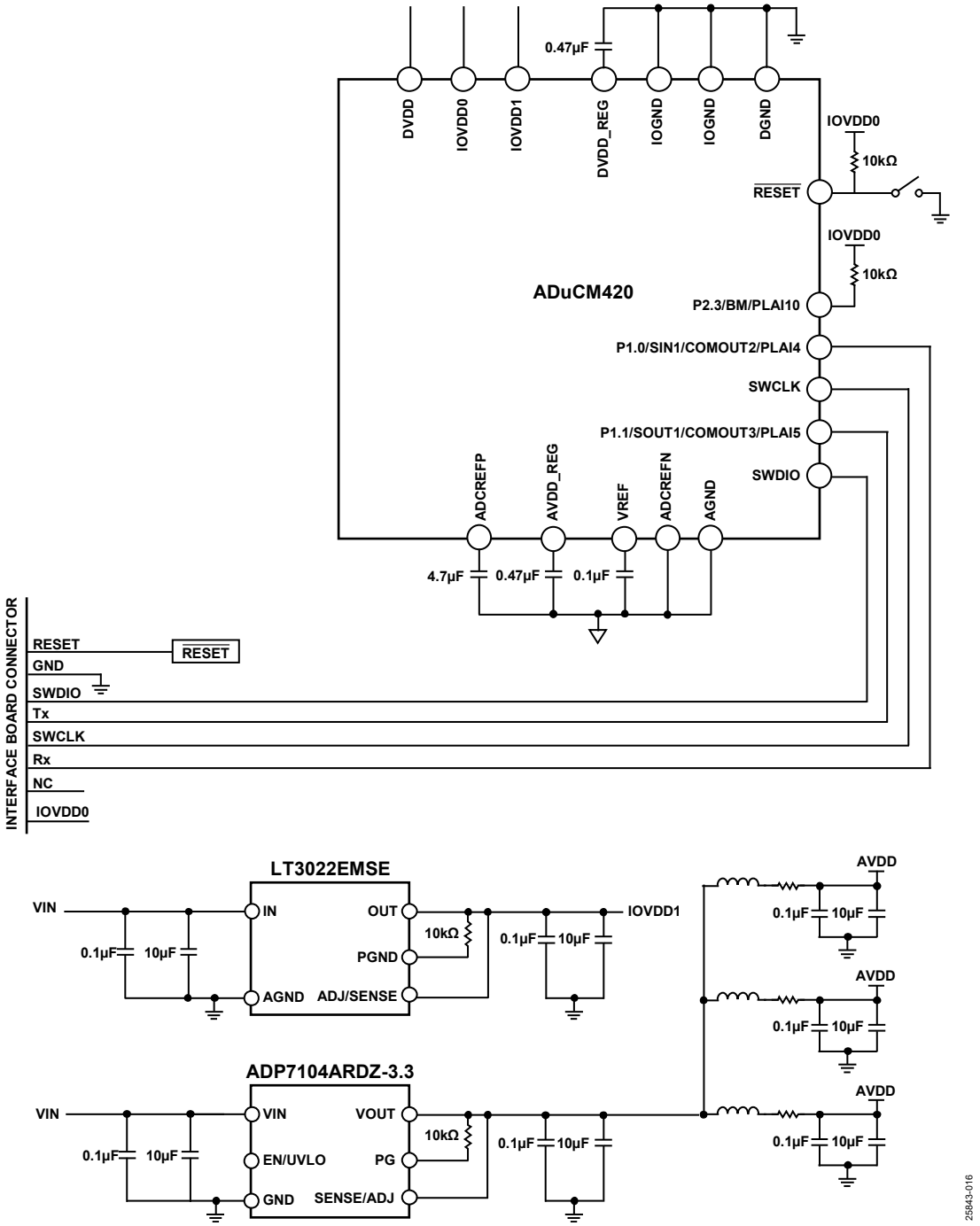


Figure 20. Recommended Circuit and Component Values (ADuCM420, LT3022EMSE, and ADP7104ARDZ-3.3)

OUTLINE DIMENSIONS

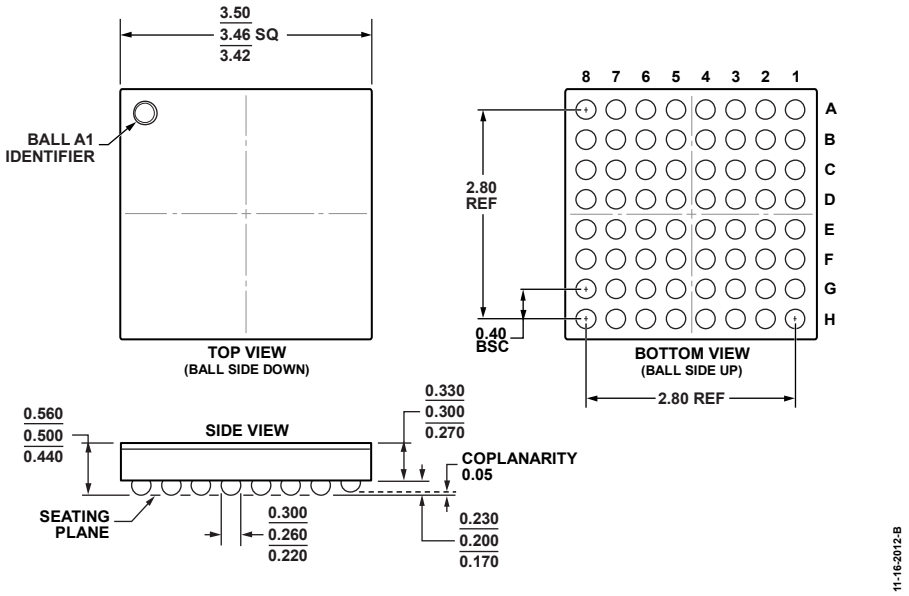


Figure 21. 64-Ball Wafer Level Chip Scale Package [WLCSP]
(CB-64-2)
Dimensions shown in millimeters

ORDERING GUIDE

Model[1]	Temperature Range	Package Description	Package Option
ADUCM420BCBZ-RL	−40°C to +105°C	64-Ball Wafer Level Chip Scale Package [WLCSP]	CB-64-2
ADUCM420BCBZ-RL7	−40°C to +105°C	64-Ball Wafer Level Chip Scale Package [WLCSP]	CB-64-2
EVAL-ADuCM420QSP1Z		WLCSP Evaluation Board and Quick Start Development System	

[1] Z = RoHS Compliant Part.

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