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## FEATURES

**Flexible LVDS interface allows word, byte, or nibble load**  
**Single-carrier W-CDMA ACLR = 82 dBc at 122.88 MHz IF**  
**Analog output: adjustable 8.7 mA to 31.7 mA**  
**Integrated 1x/2x/4x/8x interpolator/complex modulator**  
**allows carrier placement anywhere in the DAC bandwidth**  
**Gain, dc offset, and phase adjustment for sideband suppression**  
**Multiple chip synchronization interfaces**  
**High performance, low noise PLL clock multiplier**  
**Digital inverse sinc filter**  
**Low power: 1.5 W at 1.2 GSPS, 800 mW at 500 MSPS, full operating conditions**  
**72-lead, exposed paddle LFCSP**

## ENHANCED PRODUCT FEATURES

**Supports defense and aerospace applications (AQEC standard)**  
**Military temperature range (such as -55°C to +105°C)**  
**Controlled manufacturing baseline**  
**One assembly/test site**  
**One fabrication site**  
**Enhanced product change notification**  
**Qualification data available on request**

## APPLICATIONS

**Wireless infrastructure**  
**W-CDMA, CDMA2000, TD-SCDMA, WiMAX, GSM, LTE**  
**Digital high or low IF synthesis**  
**Transmit diversity**  
**Wideband communications: LMDS/MMDS, point-to-point**

## GENERAL DESCRIPTION

The **AD9122-EP** is a dual, 16-bit, high dynamic range digital-to-analog converter (DAC) that provides a sample rate of 1130 MSPS, permitting multicarrier generation up to the Nyquist frequency.

The **AD9122-EP** TxDAC+® includes features optimized for direct conversion transmit applications, including complex digital modulation, and gain and offset compensation. The DAC outputs are optimized to interface seamlessly with analog quadrature modulators, such as the ADL537x F-MOD series from Analog Devices, Inc. A 4-wire serial port interface provides for programming/readback of many internal parameters. Full-scale output current can be programmed over a range of 8.7 mA to 31.7 mA. The **AD9122-EP** comes in a 72-lead LFCSP. Additional application and technical information can be found in the **AD9122** data sheet.

## PRODUCT HIGHLIGHTS

1. Ultralow noise and intermodulation distortion (IMD) enable high quality synthesis of wideband signals from baseband to high intermediate frequencies (IF).
2. Proprietary DAC output switching technique enhances dynamic performance.
3. Current outputs are easily configured for various single-ended or differential circuit topologies.
4. Flexible LVDS digital interface allows the standard 32-wire bus to be reduced to one-half or one-quarter of the width.

## COMPANION PRODUCTS

**IQ Modulators: ADL5370, ADL537x family**  
**IQ Modulators with PLL and VCO: ADRF6701, ADRF670x family**  
**Clock Drivers: AD9516, AD951x family**  
**Voltage Regulator Design Tool: ADIsimPower**  
**Additional companion products on the [AD9122 product page](#)**

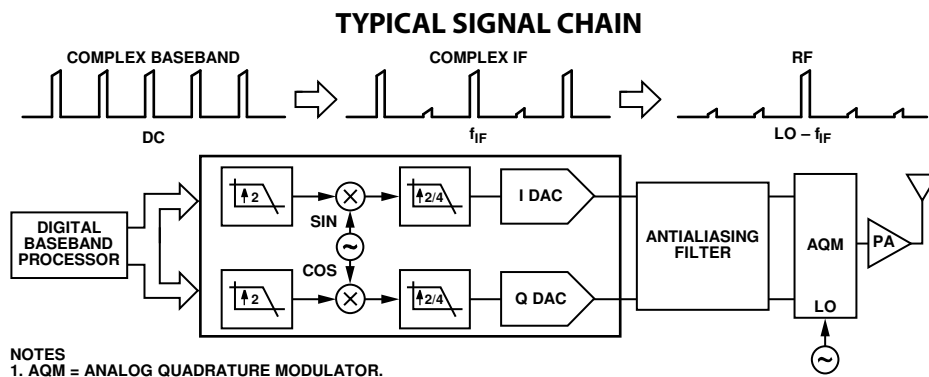


Figure 1.

### Rev. 0

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**REVISION HISTORY**

**8/12—Revision 0: Initial Version**

# FUNCTIONAL BLOCK DIAGRAM

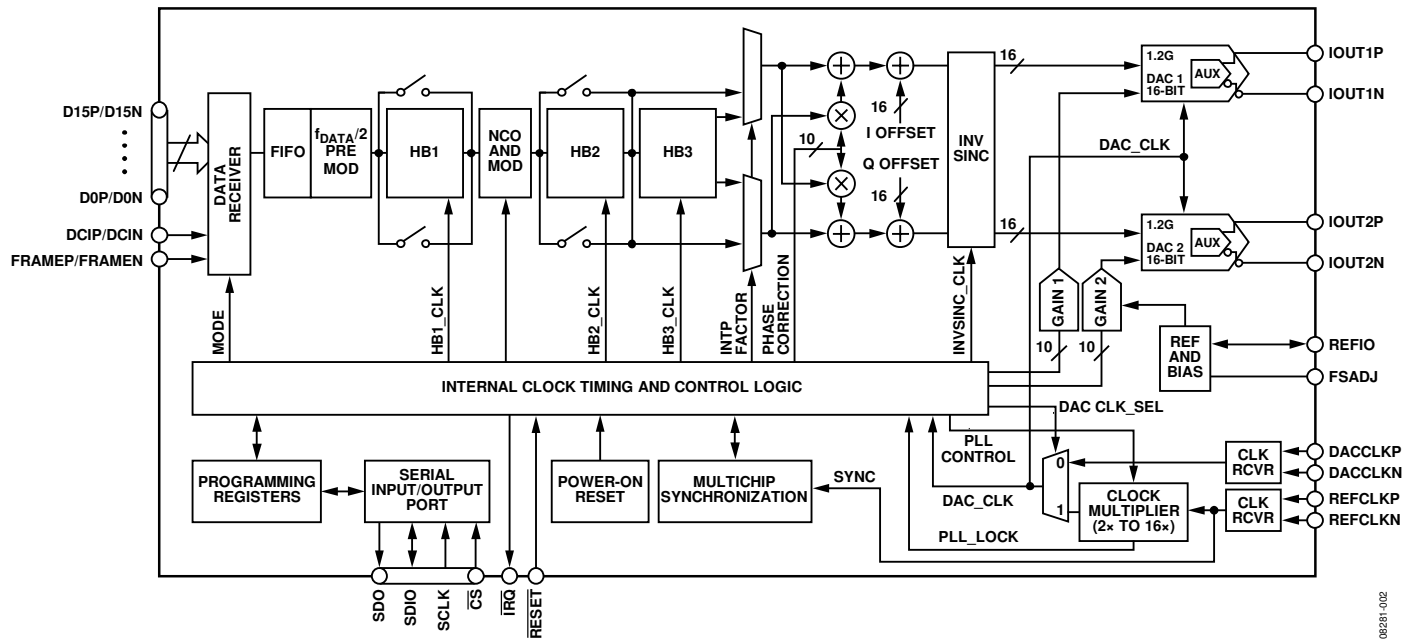


Figure 2.

06291-012

## SPECIFICATIONS

### DC SPECIFICATIONS

$T_{MIN}$  to  $T_{MAX}$ , AVDD33 = 3.3 V, DVDD18 = 1.8 V, CVDD18 = 1.8 V,  $I_{FS}$  = 20 mA, maximum sample rate, unless otherwise noted.

Table 1.

Parameter	Min	Typ	Max	Unit
RESOLUTION		16		Bits
ACCURACY				
Differential Nonlinearity (DNL)		±2.1		LSB
Integral Nonlinearity (INL)		±3.7		LSB
MAIN DAC OUTPUTS				
Offset Error	−0.001	0	+0.001	% FSR
Gain Error (with Internal Reference)	−4.6	±2	+4.6	% FSR
Full-Scale Output Current <sup>1</sup>	8.66	19.6	31.66	mA
Output Compliance Range	−1.0		+1.0	V
Power Supply Rejection Ratio, AVDD33	−0.3		+0.3	% FSR/V
Output Resistance		10		MΩ
Gain DAC Monotonicity		Guaranteed		
Settling Time to Within ±0.5 LSB		20		ns
MAIN DAC TEMPERATURE DRIFT				
Offset		0.04		ppm/°C
Gain		100		ppm/°C
Reference Voltage		30		ppm/°C
REFERENCE				
Internal Reference Voltage		1.2		V
Output Resistance		5		kΩ
ANALOG SUPPLY VOLTAGES				
AVDD33	3.13	3.3	3.47	V
CVDD18	1.71	1.8	1.89	V
DIGITAL SUPPLY VOLTAGES				
DVDD18	1.71	1.8	1.89	V
IOVDD	1.71	1.8/3.3	3.47	V
POWER CONSUMPTION				
2× Mode, $f_{DAC}$ = 491.22 MSPS, IF = 10 MHz, PLL Off		834		mW
2× Mode, $f_{DAC}$ = 491.22 MSPS, IF = 10 MHz, PLL On		913		mW
8× Mode, $f_{DAC}$ = 800 MSPS, IF = 10 MHz, PLL Off		1135	1259	mW
AVDD33		55	57	mA
CVDD18		85	90	mA
DVDD18		444	505	mA
Power-Down Mode (Register 0x01 = 0xF0)		6.5	18.8	mW
POWER-UP TIME		260		ms
OPERATING RANGE	−55	+25	+105	°C

<sup>1</sup> Based on a 10 kΩ external resistor between FSADJ and AVSS.

**DIGITAL SPECIFICATIONS**

$T_{MIN}$  to  $T_{MAX}$ , AVDD33 = 3.3 V, IOVDD = 3.3 V, DVDD18 = 1.8 V, CVDD18 = 1.8 V,  $I_{FS}$  = 20 mA, maximum sample rate, unless otherwise noted.

**Table 2.**

Parameter	Test Conditions/Comments	Min	Typ	Max	Unit
<b>CMOS INPUT LOGIC LEVEL</b>					
Input $V_{IN}$ Logic High	IOVDD = 1.8 V	1.2			V
	IOVDD = 2.5 V	1.6			V
	IOVDD = 3.3 V	2.0			V
Input $V_{IN}$ Logic Low	IOVDD = 1.8 V			0.6	V
	IOVDD = 2.5 V, 3.3 V			0.8	V
<b>CMOS OUTPUT LOGIC LEVEL</b>					
Output $V_{OUT}$ Logic High	IOVDD = 1.8 V	1.4			V
	IOVDD = 2.5 V	1.8			V
	IOVDD = 3.3 V	2.4			V
Output $V_{OUT}$ Logic Low	IOVDD = 1.8 V, 2.5 V, 3.3 V			0.4	V
<b>LVDS RECEIVER INPUTS<sup>1</sup></b>					
Input Voltage Range, $V_{IA}$ or $V_{IB}$	Applies to data, DCI, and FRAME inputs	825		1675	mV
Input Differential Threshold, $V_{IDTH}$		-100		+100	mV
Input Differential Hysteresis, $V_{IDTHH}$ to $V_{IDTHL}$			20		mV
Receiver Differential Input Impedance, $R_{IN}$		80		120	$\Omega$
LVDS Input Rate	See Table 5				
<b>DAC CLOCK INPUT (DACCLKP, DACCLKN)</b>					
Differential Peak-to-Peak Voltage	Self-biased input, ac-coupled	100	500	2000	mV
Common-Mode Voltage			1.25		V
Maximum Clock Rate		1230			MHz
<b>REFCLK INPUT (REFCLKP, REFCLKN)</b>					
Differential Peak-to-Peak Voltage	1 GHz $\leq$ $f_{VCO}$ $\leq$ 2.1 GHz See the Multichip Synchronization section of the AD9122 data sheet for conditions	100	500	2000	mV
Common-Mode Voltage			1.25		V
REFCLK Frequency (PLL Mode)		15.625		600	MHz
REFCLK Frequency (SYNC Mode)		0		600	MHz
<b>SERIAL PORT INTERFACE</b>					
Maximum Clock Rate (SCLK)		40			MHz
Minimum Pulse Width High ( $t_{PWH}$ )				12.5	ns
Minimum Pulse Width Low ( $t_{PWL}$ )				12.5	ns
Setup Time, SDIO to SCLK ( $t_{DS}$ )		2.1			ns
Hold Time, SDIO to SCLK ( $t_{DH}$ )		0.75			ns
Data Valid, SDO to SCLK ( $t_{DV}$ )		2.85			ns
Setup Time, $\overline{CS}$ to SCLK ( $t_{DCSB}$ )			1.4		ns

<sup>1</sup> LVDS receiver is compliant with the IEEE 1596 reduced range link, unless otherwise noted.

**DIGITAL INPUT DATA TIMING SPECIFICATIONS****Table 3.**

Parameter	Value	Unit
<b>LATENCY (DACCLK CYCLES)</b>		
1× Interpolation (With or Without Modulation)	64	Cycles
2× Interpolation (With or Without Modulation)	135	Cycles
4× Interpolation (With or Without Modulation)	292	Cycles
8× Interpolation (With or Without Modulation)	608	Cycles
Inverse Sinc	20	Cycles
Fine Modulation	8	Cycles

## AC SPECIFICATIONS

$T_{MIN}$  to  $T_{MAX}$ , AVDD33 = 3.3 V, DVDD18 = 1.8 V, CVDD18 = 1.8 V,  $I_{FS}$  = 20 mA, maximum sample rate, unless otherwise noted.

Table 4.

Parameter	Min	Typ	Max	Unit
SPURIOUS-FREE DYNAMIC RANGE (SFDR)				
$f_{DAC} = 100$ MSPS, $f_{OUT} = 20$ MHz		78		dBc
$f_{DAC} = 200$ MSPS, $f_{OUT} = 50$ MHz		80		dBc
$f_{DAC} = 400$ MSPS, $f_{OUT} = 70$ MHz		69		dBc
$f_{DAC} = 800$ MSPS, $f_{OUT} = 70$ MHz		72		dBc
TWO-TONE INTERMODULATION DISTORTION (IMD)				
$f_{DAC} = 200$ MSPS, $f_{OUT} = 50$ MHz		84		dBc
$f_{DAC} = 400$ MSPS, $f_{OUT} = 60$ MHz		86		dBc
$f_{DAC} = 400$ MSPS, $f_{OUT} = 80$ MHz		84		dBc
$f_{DAC} = 800$ MSPS, $f_{OUT} = 100$ MHz		81		dBc
NOISE SPECTRAL DENSITY (NSD), EIGHT-TONE, 500 kHz TONE SPACING				
$f_{DAC} = 200$ MSPS, $f_{OUT} = 80$ MHz		-162		dBm/Hz
$f_{DAC} = 400$ MSPS, $f_{OUT} = 80$ MHz		-163		dBm/Hz
$f_{DAC} = 800$ MSPS, $f_{OUT} = 80$ MHz		-164		dBm/Hz
W-CDMA ADJACENT CHANNEL LEAKAGE RATIO (ACLR), SINGLE-CARRIER				
$f_{DAC} = 491.52$ MSPS, $f_{OUT} = 10$ MHz		84		dBc
$f_{DAC} = 491.52$ MSPS, $f_{OUT} = 122.88$ MHz		82		dBc
$f_{DAC} = 983.04$ MSPS, $f_{OUT} = 122.88$ MHz		83		dBc
W-CDMA SECOND ACLR, SINGLE-CARRIER				
$f_{DAC} = 491.52$ MSPS, $f_{OUT} = 10$ MHz		88		dBc
$f_{DAC} = 491.52$ MSPS, $f_{OUT} = 122.88$ MHz		86		dBc
$f_{DAC} = 983.04$ MSPS, $f_{OUT} = 122.88$ MHz		88		dBc

Table 5. Maximum Rate (MSPS) with DVDD and CVDD Supply Regulation

Bus Width	Interpolation Factor	$f_{INTERFACE}$ (MSPS)			$f_{DAC}$ (MSPS)		
		DVDD18, CVDD18 =			DVDD18, CVDD18 =		
		1.8 V $\pm$ 5%	1.8 V $\pm$ 2%	1.9 V $\pm$ 2%	1.8 V $\pm$ 5%	1.8 V $\pm$ 2%	1.9 V $\pm$ 2%
Nibble (4 Bits)	1x	1000	1100	1130	125	137.5	141.25
	2x	1000	1100	1130	250	275	282.5
	4x	1000	1100	1130	500	550	565
	8x	1000	1100	1130	1000	1100	1130
Byte (8 Bits)	1x	1000	1100	1130	250	275	282.5
	2x	1000	1100	1130	500	550	565
	4x	1000	1100	1130	1000	1100	1130
	8x	500	550	565	1000	1100	1130
Word (16 Bits)	1x	1000	1100	1130	500	550	565
	2x (HB1)	800	900	900	800	900	900
	2x (HB2)	1000	1100	1130	1000	1100	1130
	4x	500	550	565	1000	1100	1130
	8x	250	275	282.5	1000	1100	1130

The setup ( $t_s$ ) and hold ( $t_H$ ) times, with respect to the edges, are shown in Figure 3. The minimum setup and hold times are shown in Table 6.

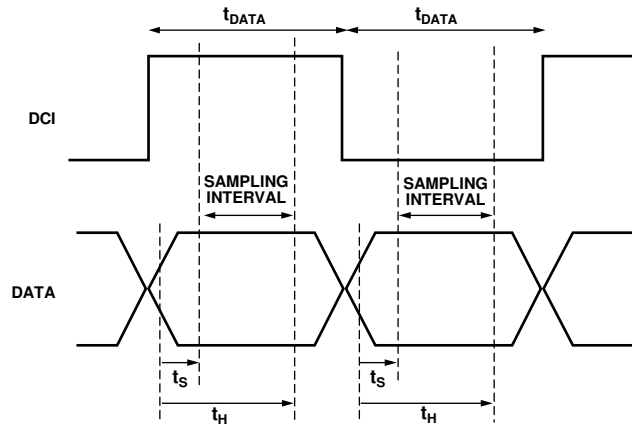


Figure 3. Timing Diagram for Input Data Port

Table 6. Data to DCI Setup and Hold Times

DCI Delay Register 0x16, Bits[1:0]	Minimum Setup Time, $t_s$ (ns)	Minimum Hold Time, $t_H$ (ns)	Sampling Interval (ns)
00	-0.01	0.65	0.64
01	-0.19	0.95	0.76
10	-0.38	1.22	0.84
11	-0.44	1.38	0.94

The data interface timing can be verified by using the sample error detection (SED) circuitry. See the Interface Timing Validation section in the [AD9122](#) data sheet for more information.



## ABSOLUTE MAXIMUM RATINGS

Table 7.

Parameter	Rating
AVDD33 to AVSS, EPAD, CVSS, DVSS	-0.3 V to +3.6 V
IOVDD to AVSS, EPAD, CVSS, DVSS	-0.3 V to +3.6 V
DVDD18, CVDD18 to AVSS, EPAD, CVSS, DVSS	-0.3 V to +2.1 V
AVSS to EPAD, CVSS, DVSS	-0.3 V to +0.3 V
EPAD to AVSS, CVSS, DVSS	-0.3 V to +0.3 V
CVSS to AVSS, EPAD, DVSS	-0.3 V to +0.3 V
DVSS to AVSS, EPAD, CVSS	-0.3 V to +0.3 V
FSADJ, REFIO, IOUT1P, IOUT1N, IOUT2P, IOUT2N to AVSS	-0.3 V to AVDD33 + 0.3 V
D[15:0]P, D[15:0]N, FRAMEP, FRAMEN, DCIP, DCIN to EPAD, DVSS	-0.3 V to DVDD18 + 0.3 V
DACCLKP, DACCLKN, REFCLKP, REFCLKN to CVSS	-0.3 V to CVDD18 + 0.3 V
RESET, IRQ, CS, SCLK, SDIO, SDO to EPAD, DVSS	-0.3 V to IOVDD + 0.3 V
Junction Temperature	125°C
Storage Temperature Range	-65°C to +150°C

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

## THERMAL RESISTANCE

The exposed pad (EPAD) of the 72-lead LFCSP must be soldered to the ground plane (AVSS). The EPAD provides an electrical, thermal, and mechanical connection to the board.

Typical  $\theta_{JA}$ ,  $\theta_{JB}$ , and  $\theta_{JC}$  values are specified for a 4-layer board in still air. Airflow increases heat dissipation, effectively reducing  $\theta_{JA}$  and  $\theta_{JB}$ .

Table 8. Thermal Resistance

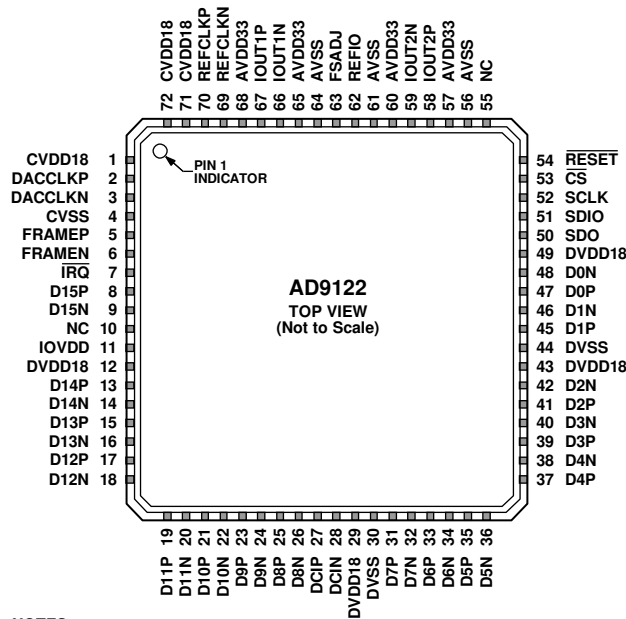
Package	$\theta_{JA}$	$\theta_{JB}$	$\theta_{JC}$	Unit	Conditions
72-Lead LFCSP	20.7	10.9	1.1	°C/W	EPAD soldered to ground plane

## 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



- NOTES**
1. EXPOSED PAD (EPAD) MUST BE SOLDERED TO THE GROUND PLANE (AVSS). THE EPAD PROVIDES AN ELECTRICAL, THERMAL, AND MECHANICAL CONNECTION TO THE BOARD.
  2. NC = NO CONNECT. DO NOT CONNECT TO THIS PIN.

Figure 4. Pin Configuration

Table 9. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	CVDD18	1.8 V Clock Supply. Supplies clock receivers, clock distribution, and PLL circuitry.
2	DACCLKP	DAC Clock Input, Positive.
3	DACCLKN	DAC Clock Input, Negative.
4	CVSS	Clock Supply Common.
5	FRAMEP	Frame Input, Positive. This pin must be tied to DVSS if not used.
6	FRAMEN	Frame Input, Negative. This pin must be tied to DVDD18 if not used.
7	IRQ	Interrupt Request. Open-drain, active low output. Connect an external pull-up to IOVDD through a 10 kΩ resistor.
8	D15P	Data Bit 15 (MSB), Positive.
9	D15N	Data Bit 15 (MSB), Negative.
10	NC	No Connect. Do not connect to this pin.
11	IOVDD	Supply Pin for Serial Port I/O Pins, RESET, and IRQ. 1.8 V to 3.3 V can be supplied to this pin.
12	DVDD18	1.8 V Digital Supply. Supplies power to digital core and digital data ports.
13	D14P	Data Bit 14, Positive.
14	D14N	Data Bit 14, Negative.
15	D13P	Data Bit 13, Positive.
16	D13N	Data Bit 13, Negative.
17	D12P	Data Bit 12, Positive.
18	D12N	Data Bit 12, Negative.
19	D11P	Data Bit 11, Positive.
20	D11N	Data Bit 11, Negative.
21	D10P	Data Bit 10, Positive.
22	D10N	Data Bit 10, Negative.
23	D9P	Data Bit 9, Positive.
24	D9N	Data Bit 9, Negative.

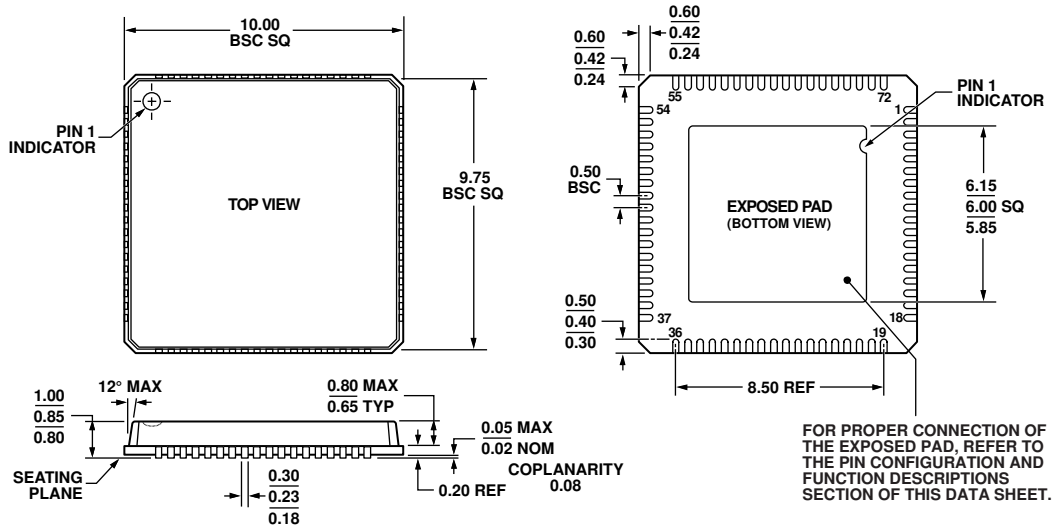
Pin No.	Mnemonic	Description
25	D8P	Data Bit 8, Positive.
26	D8N	Data Bit 8, Negative.
27	DCIP	Data Clock Input, Positive.
28	DCIN	Data Clock Input, Negative.
29	DVDD18	1.8 V Digital Supply. Supplies power to digital core and digital data ports.
30	DVSS	Digital Common.
31	D7P	Data Bit 7, Positive.
32	D7N	Data Bit 7, Negative.
33	D6P	Data Bit 6, Positive.
34	D6N	Data Bit 6, Negative.
35	D5P	Data Bit 5, Positive.
36	D5N	Data Bit 5, Negative.
37	D4P	Data Bit 4, Positive.
38	D4N	Data Bit 4, Negative.
39	D3P	Data Bit 3, Positive.
40	D3N	Data Bit 3, Negative.
41	D2P	Data Bit 2, Positive.
42	D2N	Data Bit 2, Negative.
43	DVDD18	1.8 V Digital Supply. Supplies power to digital core and digital data ports.
44	DVSS	Digital Common.
45	D1P	Data Bit 1, Positive.
46	D1N	Data Bit 1, Negative.
47	D0P	Data Bit 0 (LSB), Positive.
48	D0N	Data Bit 0 (LSB), Negative.
49	DVDD18	1.8 V Digital Supply. Supplies power to digital core and digital data ports.
50	SDO	Serial Port Data Output (CMOS Levels with Respect to IOVDD).
51	SDIO	Serial Port Data Input/Output (CMOS Levels with Respect to IOVDD).
52	SCLK	Serial Port Clock Input (CMOS Levels with Respect to IOVDD).
53	$\overline{\text{CS}}$	Serial Port Chip Select, Active Low (CMOS Levels with Respect to IOVDD).
54	$\overline{\text{RESET}}$	Reset, Active Low (CMOS Levels with Respect to IOVDD).
55	NC	No Connect. Do not connect to this pin.
56	AVSS	Analog Supply Common.
57	AVDD33	3.3 V Analog Supply.
58	IOUT2P	Q DAC Positive Current Output.
59	IOUT2N	Q DAC Negative Current Output.
60	AVDD33	3.3 V Analog Supply.
61	AVSS	Analog Supply Common.
62	REFIO	Voltage Reference. Nominally 1.2 V output. Should be decoupled to AVSS.
63	FSADJ	Full-Scale Current Output Adjust. Place a 10 k $\Omega$ resistor from this pin to AVSS.
64	AVSS	Analog Supply Common.
65	AVDD33	3.3 V Analog Supply.
66	IOUT1N	I DAC Negative Current Output.
67	IOUT1P	I DAC Positive Current Output.
68	AVDD33	3.3 V Analog Supply.
69	REFCLKN	PLL Reference Clock Input, Negative. This pin has a secondary function as a synchronization input.
70	REFCLKP	PLL Reference Clock Input, Positive. This pin has a secondary function as a synchronization input.
71	CVDD18	1.8 V Clock Supply. Supplies clock receivers, clock distribution, and PLL circuitry.
72	CVDD18	1.8 V Clock Supply. Supplies clock receivers, clock distribution, and PLL circuitry.
	EPAD	The exposed pad (EPAD) must be soldered to the ground plane (AVSS). The EPAD provides an electrical, thermal, and mechanical connection to the board.

Table 22A is unique to the AD9122-EP. Refer to the Digital Datapath section of the [AD9122](#) data sheet for further information. All other tables, which have been omitted, can be found in the [AD9122](#) data sheet.

**Table 22A. Summary of Data Rates and Bandwidths vs. Interpolation Modes (DVDD18, CVDD18 = 1.9 V ± 2%)**

Bus Width	Filter Modes			f <sub>BUS</sub> (Mbps)	f <sub>DATA</sub> (Mbps)	Real Signal Bandwidth (MHz)	f <sub>DAC</sub> (MHz)
	HB3	HB2	HB1				
Nibble (4 Bits)	0	0	0	1130	141.25	69	141.25
	0	0	1	1130	141.25	55	282.5
	0	1	0	1130	141.25	34.5	282.5
	0	1	1	1130	141.25	55	565
	1	1	0	1130	141.25	34.5	565
	1	1	1	1130	141.25	55	1130
Byte (8 Bits)	0	0	0	1130	282.5	188	282.5
	0	0	1	1130	282.5	110	565
	0	1	0	1130	282.5	69	565
	0	1	1	1130	282.5	110	1130
	1	1	0	1130	282.5	69	1130
	1	1	1	565	141.25	55	1130
Word (16 Bits)	0	0	0	1130	565	275	565
	0	0	1	900	450	180	900
	0	1	0	1130	565	138	1130
	0	1	1	565	282.5	110	1130
	1	1	0	565	282.5	69	1130
	1	1	1	282.5	141.25	55	1130

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MO-220-VNND-4

Figure 5. 72-Lead Lead Frame Chip Scale Package [LFCSP\_VQ]  
 10 mm × 10 mm Body, Very Thin Quad  
 (CP-72-7)  
 Dimensions shown in millimeters

052809-A

ORDERING GUIDE

Model <sup>1</sup>	Temperature Range	Package Description	Package Option
AD9122SCPZ-EP	-55°C to +105°C	72-Lead Lead Frame Chip Scale Package [LFCSP_VQ]	CP-72-7
AD9122SCPZ-EP-RL	-55°C to +105°C	72-Lead Lead Frame Chip Scale Package [LFCSP_VQ]	CP-72-7

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