12-Bit, 170/210 MSPS 3.3 V A/D Converter

AD9430

FEATURES

SNR = 65 dB @ f_{IN} = 70 MHz @ 210 MSPS
ENOB of 10.6 @ f_{IN} = 70 MHz @ 210 MSPS (–0.5 dBFS)
SFDR = 80 dBc @ f_{IN} = 70 MHz @ 210 MSPS (–0.5 dBFS)
Excellent linearity:
DNL = ±0.3 LSB (typical)
INL = ±0.5 LSB (typical)
2 output data options:
Demultiplexed 3.3 V CMOS outputs each @ 105 MSPS
Interleaved or parallel data output option
LVDS at 210 MSPS
700 MHz full-power analog bandwidth
On-chip reference and track-and-hold
Power dissipation = 1.3 W typical @ 210 MSPS
1.5 V input voltage range
3.3 V supply operation
Output data format option
Data sync input and data clock output provided
Clock duty cycle stabilizer

APPLICATIONS

Wireless and wired broadband communications
Cable reverse path
Communications test equipment
Radar and satellite subsystems
Power amplifier linearization

GENERAL DESCRIPTION

The AD9430 is a 12-bit monolithic sampling analog-to-digital converter optimized for high performance, low power, and ease of use. The product operates up to a 210 MSPS conversion rate and is optimized for outstanding dynamic performance in wideband carrier and broadband systems. All necessary functions, including a track-and-hold (T/H) and reference, are included on the chip to provide a complete conversion solution.

The ADC requires a 3.3 V power supply and a differential ENCODE clock for full performance operation. The digital outputs are TTL/CMOS or LVDS compatible and support either twos complement or offset binary format. Separate output power supply pins support interfacing with 3.3 V or 2.5 V CMOS logic.

FUNCTIONAL BLOCK DIAGRAM

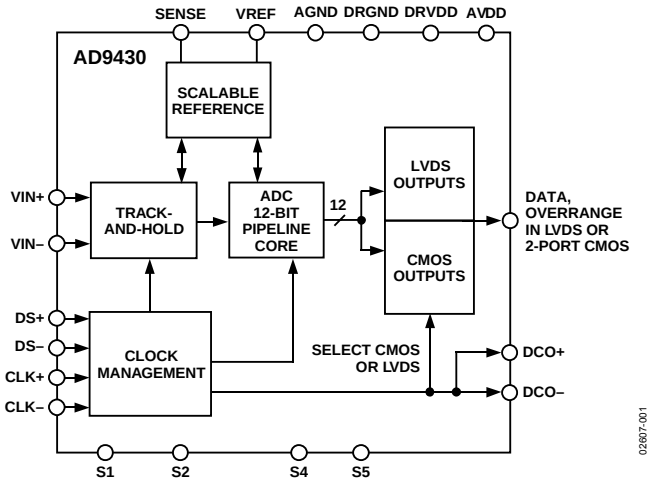

Figure 1. Functional Block Diagram

Two output buses support demultiplexed data up to 105 MSPS rates in CMOS mode. A data sync input is supported for proper output data port alignment in CMOS mode, and a data clock output is available for proper output data timing. In LVDS mode, the chip provides data at the ENCODE clock rate.

Fabricated on an advanced BiCMOS process, the AD9430 is available in a 100-lead, surface-mount plastic package (100 e-PAD TQFP) specified over the industrial temperature range (–40°C to +85°C).

PRODUCT HIGHLIGHTS

1. High performance.
   Maintains 65 dB SNR @ 210 MSPS with a 65 MHz input.
2. Low power.
   Consumes only 1.3 W @ 210 MSPS.
3. Ease of use.
   LVDS output data and output clock signal allow interface to current FPGA technology. The on-chip reference and sample/hold provide flexibility in system design. Use of a single 3.3 V supply simplifies system power supply design.
4. Out of range (OR).
   The OR output bit indicates when the input signal is beyond the selected input range.
5. Pin compatible with 10-bit AD9411 (LVDS only).

Rev. C

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REVISION HISTORY

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7/03—Rev. A to Rev. B

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3/03—Rev. 0 to Rev. A

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5/02—Revision 0: Initial Version

DC SPECIFICATIONS

AVDD = 3.3 V, DRVDD = 3.3 V, T_{MIN} = −40°C, T_{MAX} = +85°C, f_{IN} = −0.5 dBFS, internal reference, full scale = 1.536 V, LVDS output mode, unless otherwise noted.

Table 1.

			AD9430-170			AD9430-210			
Parameter	**Temp**	**Test Level**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
RESOLUTION				12					Bits
ACCURACY									
No Missing Codes	Full	VI		Guaranteed			Guaranteed		
Offset Error	25°C	I	−3		+3	−3		+3	mV
Gain Error	25°C	I	−5		+5	−5		+5	% FS
Differential Nonlinearity (DNL)	25°C	I	−1	± 0.3	+1	−1	± 0.3	+1	LSB
	Full	VI	−1	± 0.3	+1.5	−1	± 0.3	+1.5	LSB
Integral Nonlinearity (INL)	25°C	I	−1.5	± 0.5	+1.5	−1.75	± 0.3	+1.75	LSB
	Full	VI	−2.25	± 0.5	+2.25	−2.5	± 0.3	+2.5	LSB
TEMPERATURE DRIFT									
Offset Error	Full	V		58			58		µV/°C
Gain Error	Full	V		0.02			0.02		%/°C
Reference Out (VREF)	Full	V		+0.12/−0.24			+0.12/−0.24		mV/°C
REFERENCE									
Reference Out (VREF)	25°C	I	1.15	1.235	1.3	1.15	1.235	1.3	V
Output Current[1]	25°C	IV			3.0			3.0	mA
I_{VREF} Input Current[2]	25°C	I			20			20	mA
I_{SENSE} Input Current	25°C	I		1.6	5.0		1.6	5.0	mA
ANALOG INPUTS (VIN+, VIN−)[3]									
Differential Input Voltage Range (S5 = GND)	Full	V		1.536			1.536		V
Differential Input Voltage Range (S5 = AVDD)	Full	V		0.766			0.766		V
Input Common-Mode Voltage	Full	VI	2.65	2.8	2.9	2.65	2.8	2.9	V
Input Resistance	Full	VI	2.2	3	3.8	2.2	3	3.8	kΩ
Input Capacitance	25°C	V		5			5		pF
POWER SUPPLY (LVDS Mode)									
AVDD	Full	IV	3.1	3.3	3.6	3.2	3.3	3.6	V
DRVDD	Full	IV	3.0	3.3	3.6	3.0	3.3	3.6	V
Supply Currents:									
I_{ANALOG}(AVDD = 3.3 V)[4]	Full	VI		335	372		390	450	mA
$I_{DIGITAL}$ (DRVDD = 3.3 V)	Full	VI		55	62		55	62	mA
Power Dissipation	Full	VI		1.29	1.43		1.5	1.7	W
Power Supply Rejection	25°C	V		−7.5			−7.5		mV/V
POWER SUPPLY (CMOS Mode)									
AVDD	Full	IV	3.1	3.3	3.6	3.2	3.3	3.6	V
DRVDD	Full	IV	3.0	3.3	3.6	3.0	3.3	3.6	V
Supply Currents:									
I_{AVDD}(AVDD = 3.3 V)[5]	Full	IV		335	372		390	450	mA
I_{DRVDD} (DRVDD = 3.3 V)	Full	IV		24	30		30	30	mA
Power Dissipation	Full	IV		1.1			1.3		W
Power Supply Rejection	25°C	V		−7.5			−7.5		mV/V

[1] Internal reference mode; SENSE = Floats.
[2] External reference mode; SENSE = DRVDD, VREF driven by external 1.23 V reference.
[3] S5 (Pin 1) = GND. See Analog Input section. S5 = GND in all dc, ac tests unless otherwise specified.
[4] I_{AVDD} and I_{DRVDD} are measured with an analog input of 10.3 MHz, −0.5 dBFS, sine wave, rated ENCODE rate, and in LVDS output mode. See Typical Performance Characteristics and Application Notes sections for I_{DRVDD}. Power consumption is measured with a dc input at rated ENCODE rate in LVDS output mode.
[5] I_{AVDD} and I_{DRVDD} are measured with an analog input of 10.3 MHz, −0.5 dBFS, sine wave, rated ENCODE rate, and in CMOS output mode. See Typical Performance Characteristics and Application Notes sections for I_{DRVDD}. Power consumption is measured with a dc input at rated ENCODE rate in CMOS output mode.

AC SPECIFICATIONS

AVDD = 3.3 V, DRVDD = 3.3 V, T_{MIN} = −40°C, T_{MAX} = +85°C, f_{IN} = −0.5 dBFS, internal reference, full scale = 1.536 V, LVDS output mode, unless otherwise noted.

Table 2[1].

				AD9430-170			AD9430-210			
Parameter		**Temp**	**Test Level**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
SNR										
Analog Input @ −0.5 dBFS	10 MHz	25°C	I	63.5	65		62.5	64.5		dB
	70 MHz	25°C	I	63	65		62.5	64.5		dB
	100 MHz	25°C	V		65			64.5		dB
	240 MHz	25°C	V		61			61		dB
SINAD										
Analog Input @ −0.5 dBFS	10 MHz	25°C	I	63.5	65		62.5	64.5		dB
	70 MHz	25°C	I	63	65		62.5	64.5		dB
	100 MHz	25°C	V		65			64.5		dB
	240 MHz	25°C	V		60			60		dB
EFFECTIVE NUMBER OF BITS (ENOB)										
	10 MHz	25°C	I	10.2	10.6		10.2	10.5		Bits
	70 MHz	25°C	I	10.2	10.6		10.2	10.5		Bits
	100 MHz	25°C	V		10.6			10.5		Bits
	240 MHz	25°C	V		9.8			9.8		Bits
WORST HARMONIC (2nd or 3rd)										
Analog Input @ −0.5 dBFS 10 MHz	10 MHz	25°C	I		−85	−75		−84	−74	dBc
	70 MHz	25°C	I		−85	−75		−84	−74	dBc
	100 MHz	25°C	V		−77			−77		dBc
	240 MHz	25°C	V		−63			−63		dBc
WORST HARMONIC (4th or Higher)										
Analog Input @ −0.5 dBFS 10 MHz	10 MHz	25°C	I		−87	−78		−87	−77	dBc
	70 MHz	25°C	I		−87	−78		−87	−77	dBc
	100 MHz	25°C	V		−77			−77		dBc
	240 MHz	25°C	V		−63			−63		dBc
TWO-TONE IMD[2]										
F1, F2 @ −7 dBFS		25°C	V		−75			−75		dBc
ANALOG INPUT BANDWIDTH		25°C	V		700			700		MHz

[1] All ac specifications tested by driving CLK+ and CLK− differentially.
[2] F1 = 28.3 MHz, F2 = 29.3 MHz.

DIGITAL SPECIFICATIONS

AVDD = 3.3 V, DRVDD = 3.3 V, T_{MIN} = −40°C, T_{MAX} = +85°C, unless otherwise noted.

Table 3.

Parameter	Temp	Test Level	AD9430-170 Min	AD9430-170 Typ	AD9430-170 Max	AD9430-210 Min	AD9430-210 Typ	AD9430-210 Max	Unit
ENCODE AND DS INPUTS (CLK+, CLK–, DS+, DS–)[1]									
Differential Input Voltage[2]	Full	IV	0.2			0.2			V
Common-Mode Voltage[3]	Full	VI	1.375	1.5	1.575	1.375	1.5	1.575	V
Input Resistance	Full	VI	3.2	5.5	6.5	3.2	5.5	6.5	kΩ
Input Capacitance	25°C	V		4			4		pF
LOGIC INPUTS (S1, S2, S4, S5)									
Logic 1 Voltage	Full	IV	2.0			2.0			V
Logic 0 Voltage	Full	IV			0.8			0.8	V
Logic 1 Input Current	Full	VI			190			190	µA
Logic 0 Input Current	Full	VI			10			10	µA
Input Resistance	25°C	V		30			30		kΩ
Input Capacitance	25°C	V		4			4		pF
LOGIC OUTPUTS (CMOS Mode)									
Logic 1 Voltage[4]	Full	IV	DRVDD −0.05			DRVDD −0.05			V
Logic 0 Voltage	Full	IV			0.05			0.05	V
LOGIC OUTPUTS (LVDS Mode), [5]									
V_{OD} Differential Output Voltage	Full	VI	247		454	247		454	mV
V_{OS} Output Offset Voltage	Full	VI	1.125		1.375	1.125		1.375	V
Output Coding			Twos complement or binary			Twos complement or binary			

[1] ENCODE and DS inputs identical on-chip. See Equivalent Circuits section.
[2] All ac specifications tested by driving CLK+ and CLK– differentially, |(CLK+) – (CLK–)| > 200 mV.
[3] ENCODE inputs' common mode can be externally set, such that 0.9 V < ENC± < 2.6 V.
[4] Digital output logic levels: DRVDD = 3.3 V, C_{LOAD} = 5 pF.
[5] LVDS R_{TERM} = 100 Ω, LVDS output current set resistor (R_{SET}) = 3.74 kΩ (1% tolerance).

SWITCHING SPECIFICATIONS

AVDD = 3.3 V, DRVDD = 3.3 V, T_{MIN} = −40°C, T_{MAX} = +85°C, unless otherwise noted.)

Table 4.

		Test	AD9430-170			AD9430-210			
Parameter (Conditions)	**Temp**	**Level**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Unit**
Maximum Conversion Rate[1]	Full	VI	170			210			MSPS
Minimum Conversion Rate	Full	V			40			40	MSPS
CLK+ Pulse Width High (t_{EH})	Full	IV	2		12.5	2		12.5	ns
CLK+ Pulse Width Low (t_{EL})	Full	IV	2		12.5	2		12.5	ns
DS Input Setup Time (t_{SDS})[2]	Full	IV	−0.5			−0.5			ns
DS Input Hold Time (t_{HDS})	Full	IV	1.75			1.75			ns
OUTPUT (CMOS Mode)									
Valid Time (t_V)	Full	IV	2			2			ns
Propagation Delay (t_{PD})	Full	IV		3.8	5		3.8	5	ns
Rise Time (tR) (20% to 80%)	25°C	V		1			1		ns
Fall Time (tF) (20% to 80%)	25°C	V		1			1		ns
DCO Propagation Delay (tCPD)	Full	IV		3.8	5		3.8	5	ns
Data to DCO Skew ($t_{PD} – t_{CPD}$)	Full	IV	−0.5	0	+0.5	−0.5	0	+0.5	ns
Interleaved Mode (A, B Latency)	Full	IV		14, 14			14, 14		Cycles
Parallel Mode (A, B Latency)	Full	IV		15, 14			15, 14		Cycles
OUTPUT (LVDS Mode)									
Valid Time (t_V)	Full	VI	2.0			2.0			ns
Propagation Delay (t_{PD})	Full	VI		3.2	4.3		3.2	4.3	ns
Rise Time (t_R) (20% to 80%)	25°C	V		0.5			0.5		ns
Fall Time (t_F) (20% to 80%)	25°C	V		0.5			0.5		ns
DCO Propagation Delay (t_{CPD})	Full	VI	1.8	2.7	3.8	1.8	2.7	3.8	ns
Data to DCO Skew ($t_{PD} – t_{CPD}$)	Full	IV	0.2	0.5	0.8	0.2	0.5	0.8	ns
Latency	Full	IV		14			14		Cycles
Aperture Delay (t_A)	25°C	V		1.2			1.2		ns
Aperture Uncertainty (Jitter, t_J)	25°C	V		0.25			0.25		ps rms
Out of Range Recovery Time (CMOS and LVDS)	25°C	V			1			1	Cycles

[1] All ac specifications tested by driving CLK+ and CLK– differentially.
[2] DS inputs used in CMOS mode only.

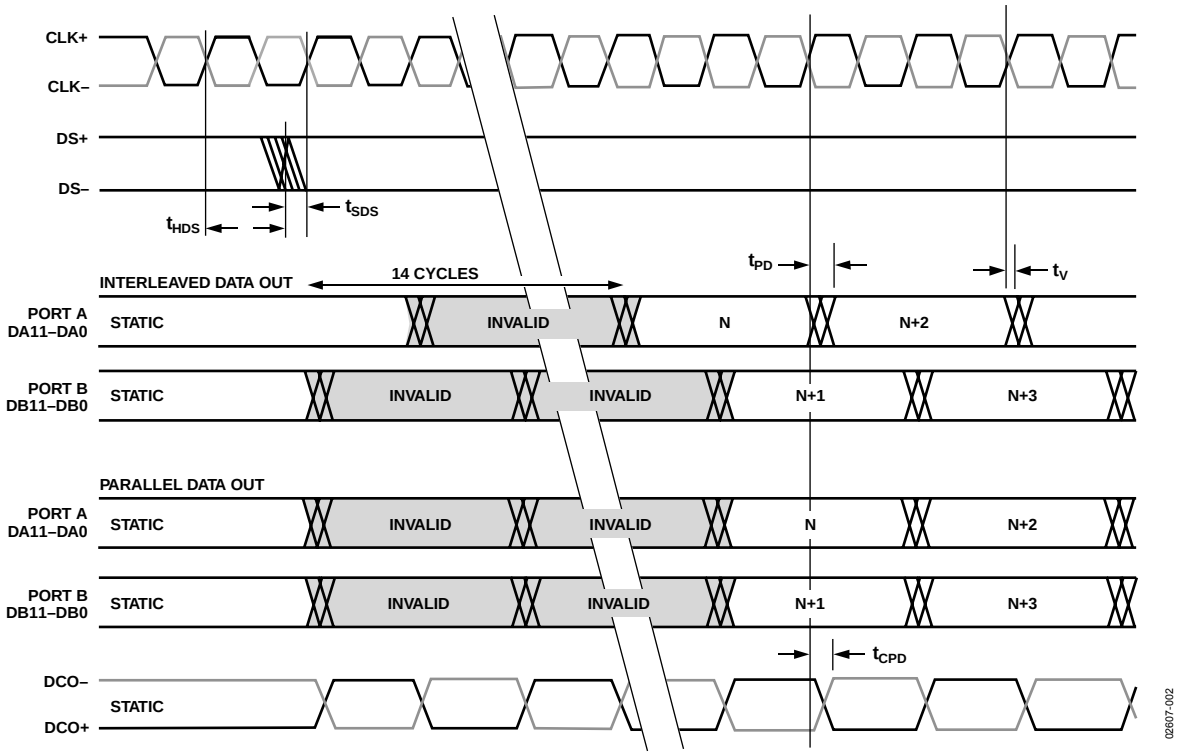


Figure 2. CMOS Timing Diagram

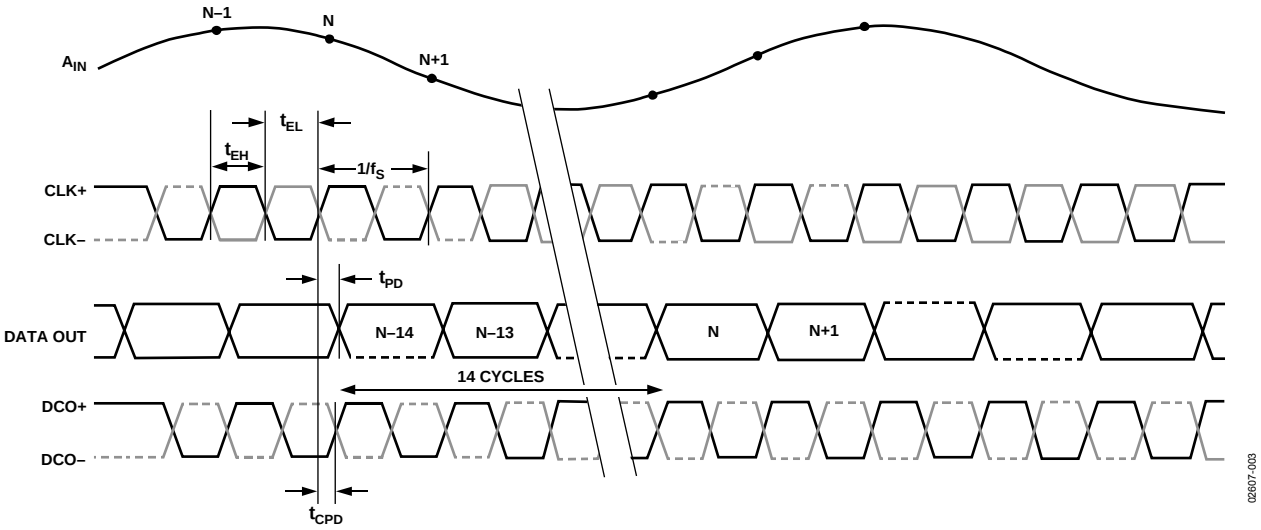


Figure 3. LVDS Timing Diagram

ABSOLUTE MAXIMUM RATINGS

Table 5.

Parameter	Rating
AVDD, DRVDD	4 V
Analog Inputs	−0.5 V to AVDD + 0.5 V
Digital Inputs	−0.5 V to DRVDD + 0.5 V
REFIN Inputs	−0.5 V to AVDD + 0.5 V
Digital Output Current	20 mA
Operating Temperature	−55°C to +125°C
Storage Temperature	−65°C to +150°C
Maximum Junction Temperature	150°C
Maximum Case Temperature	150°C
θ_{JA}[1]	25°C/W, 32°C/W

[1] Typical θ_{JA} = 32°C/W (heat slug not soldered); typical θ_{JA} = 25°C/W (heat slug soldered) for multilayer board in still air with solid ground plane.

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 listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

EXPLANATION OF TEST LEVELS

Test Level

I. 100% production tested.

II. 100% production tested at 25°C and sample tested at specified temperatures.

III. Sample tested only.

IV. Parameter is guaranteed by design and characterization testing.

V. Parameter is a typical value only.

VI. 100% production tested at 25°C; guaranteed by design and characterization testing for industrial temperature range; 100% production tested at temperature extremes for military devices.

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although this product features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

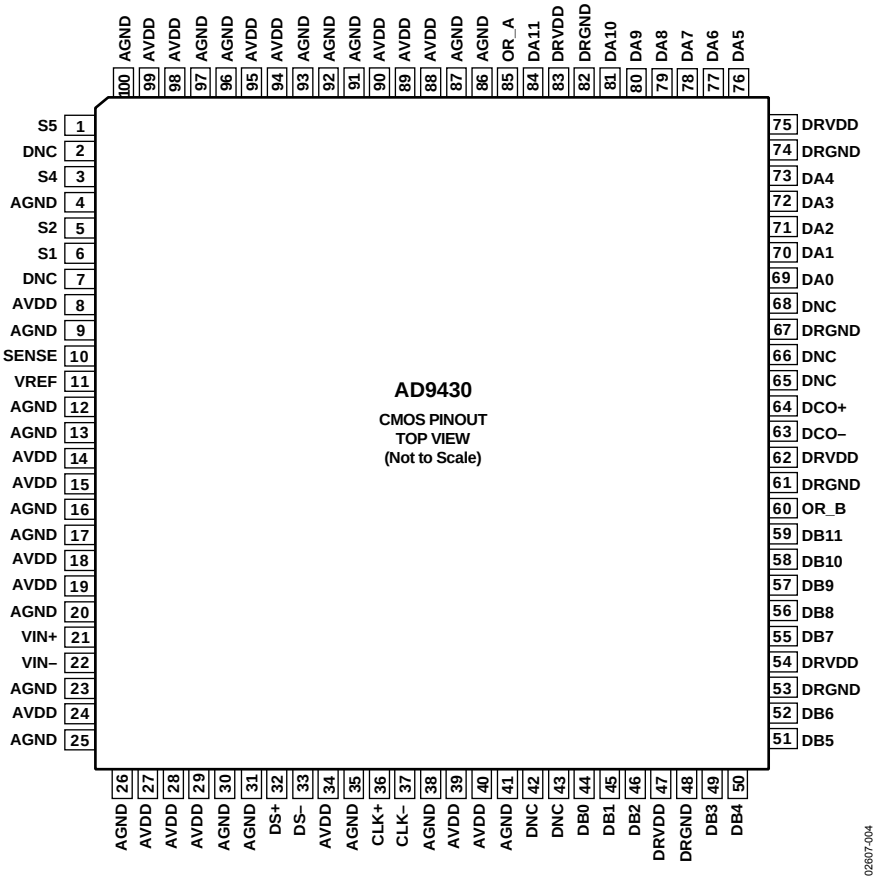


Figure 4. CMOS Dual-Mode Pinout

Table 6. Pin Function Descriptions (CMOS Mode)

Pin Number	Mnemonic	Function
1	S5	Full-Scale Adjust Pin. AVDD sets f_S = 0.768 V p-p differential, GND sets f_S = 1.536 V p-p differential.
2, 7, 42, 43, 65, 66, 68	DNC	Do Not Connect.
3	S4	Interleaved, Parallel Select Pin. High = interleaved.
4, 9, 12, 13, 16, 17, 20, 23, 25, 26, 30, 31, 35, 38, 41, 86, 87, 91, 92, 93, 96, 97, 100	AGND[1]	Analog Ground.
5	S2	Output Mode Select. Low = dual-port CMOS, high = LVDS.
6	S1	Data Format Select. Low = binary, high = twos complement for both CMOS and LVDS mode.
8, 14, 15, 18, 19, 24, 27, 28, 29, 34, 39, 40, 88, 89, 90, 94, 95, 98, 99	AVDD	3.3 V Analog Supply.
10	SENSE	Reference Mode Select Pin. Float for internal reference operation.
11	VREF	1.235 V Reference I/O—Function Dependent on SENSE.
21	VIN+	Analog Input—True.
22	VIN–	Analog Input—Complement.
32	DS+	Data Sync (Input)—True. Tie low if not used.
33	DS–	Data Sync (Input)—Complement. Tie high if not used.
36	CLK+	Clock Input—True.
37	CLK–	Clock Input—Complement.
44	DB0	B Port Output Data Bit (LSB).
45	DB1	B Port Output Data Bit.
46	DB2	B Port Output Data Bit.
47, 54, 62, 75, 83	DRVDD	3.3 V Digital Output Supply (3.0 V to 3.6 V).
48, 53, 61, 67, 74, 82	DRGND	Digital Output Ground.
49	DB3	B Port Output Data Bit.
50	DB4	B Port Output Data Bit.
51	DB5	B Port Output Data Bit.
52	DB6	B Port Output Data Bit.
55	DB7	B Port Output Data Bit.
56	DB8	B Port Output Data Bit.
57	DB9	B Port Output Data Bit.
58	DB10	B Port Output Data Bit.
59	DB11	B Port Output Data Bit (MSB).
60	OR_B	B Port Overrange.
63	DCO–	Data Clock Output—Complement.
64	DCO+	Data Clock Output—True.
69	DA0	A Port Output Data Bit (LSB).
70	DA1	A Port Output Data Bit.
71	DA2	A Port Output Data Bit.
72	DA3	A Port Output Data Bit.
73	DA4	A Port Output Data Bit.
76	DA5	A Port Output Data Bit.
77	DA6	A Port Output Data Bit.
78	DA7	A Port Output Data Bit.
79	DA8	A Port Output Data Bit.
80	DA9	A Port Output Data Bit.
81	DA10	A Port Output Data Bit.
84	DA11	A Port Output Data Bit (MSB).
85	OR_A	A Port Overrange.

[1] AGND and DRGND should be tied together to a common ground plane.

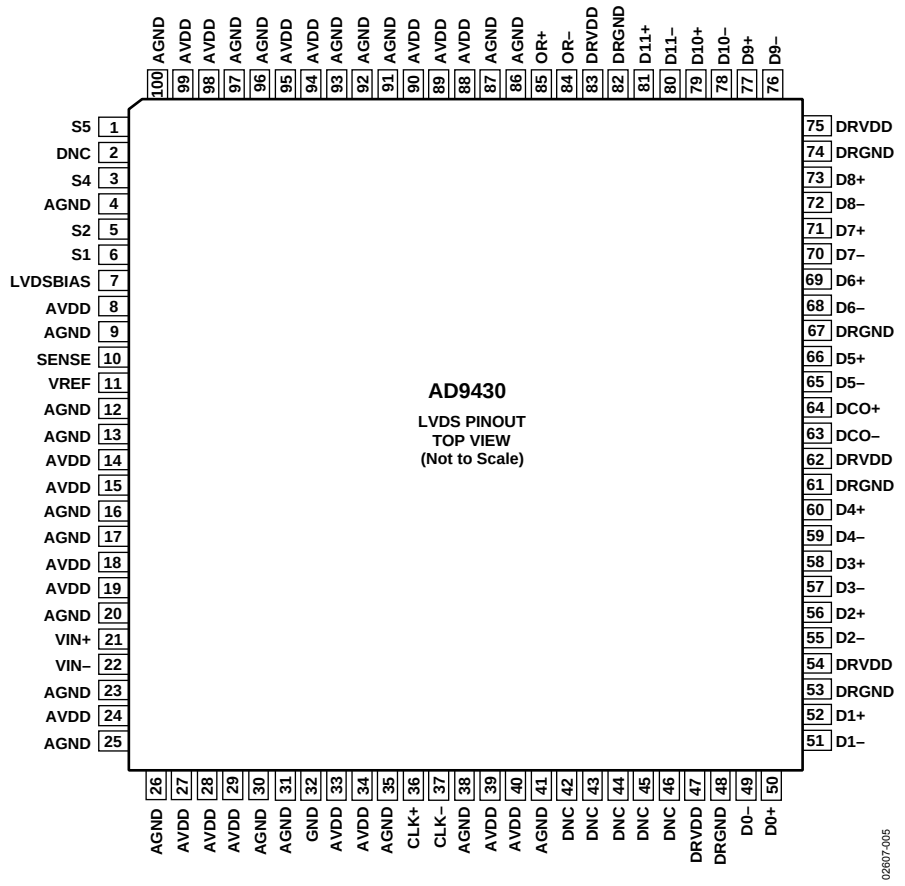


Figure 5. LVDS Mode Pinout

Table 7. Pin Function Descriptions (LVDS Mode)

Pin Number	Mnemonic	Function
1	S5	Full-Scale Adjust Pin. AVDD sets f_S = 0.768 V p-p differential, GND sets f_S = 1.536 V p-p differential.
2, 42 to 46	DNC	Do Not Connect.
3	S4	Control Pin for CMOS Mode. Tie low when operating in LVDS mode.
4, 9, 12, 13, 16, 17, 20, 23, 25, 26, 30, 31, 35, 38, 41, 86, 87, 91, 92, 93, 96, 97, 100	AGND[1]	Analog Ground.
5	S2	Output Mode Select. GND = dual-port CMOS; AVDD = LVDS.
6	S1	Data Format Select. GND = binary, AVDD = twos complement.
7	LVDSBIAS	Set Pin for LVDS Output Current. Place 3.74 kW resistor terminated to ground.
8, 14, 15, 18, 19, 24, 27, 28, 29, 33, 34, 39, 40, 88, 89, 90, 94, 95, 98, 99	AVDD	3.3 V Analog Supply.
10	SENSE	Reference Mode Select Pin. Float for internal reference operation.
11	VREF	1.235 V Reference I/O—Function Dependent on SENSE.
21	VIN+	Analog Input—True.
22	VIN–	Analog Input—Complement.
32	GND	Data Sync (Input)—Not Used in LVDS Mode. Tie to GND.
36	CLK+	Clock Input—True (LVPECL Levels).
37	CLK–	Clock Input—Complement (LVPECL Levels).
47, 54, 62, 75, 83	DRVDD	3.3 V Digital Output Supply (3.0 V to 3.6 V).
48, 53, 61, 67, 74, 82	DRGND	Digital Output Ground.
49	D0–	D0 Complement Output Bit (LSB).
50	D0+	D0 True Output Bit (LSB).
51	D1–	D1 Complement Output Bit.
52	D1+	D1 True Output Bit.
55	D2–	D2 Complement Output Bit.
56	D2+	D2 True Output Bit.
57	D3–	D3 Complement Output Bit.
58	D3+	D3 True Output Bit.
59	D4–	D4 Complement Output Bit.
60	D4+	D4 True Output Bit.
63	DCO–	Data Clock Output—Complement.
64	DCO+	Data Clock Output—True.
65	D5–	D5 Complement Output Bit.
66	D5+	D5 True Output Bit.
68	D6–	D6 Complement Output Bit.
69	D6+	D6 True Output Bit.
70	D7–	D7 Complement Output Bit.
71	D7+	D7 True Output Bit.
72	D8–	D8 Complement Output Bit.
73	D8+	D8 True Output Bit.
76	D9–	D9 Complement Output Bit.
77	D9+	D9 True Output Bit.
78	D10–	D10 Complement Output Bit.
79	D10+	D10 True Output Bit.
80	D11–	D11 Complement Output Bit.
81	D11+	D11 True Output Bit.
84	OR–	Overrange Complement Output Bit.
85	OR+	Overrange True Output Bit.

[1] AGND and DRGND should be tied together to a common ground plane.

TERMINOLOGY

Analog Bandwidth
The analog input frequency at which the spectral power of the fundamental frequency (as determined by the FFT analysis) is reduced by 3 dB.

Aperture Delay
The delay between the 50% point of the rising edge of the ENCODE command and the instant at which the analog input is sampled.

Aperture Uncertainty (Jitter)
The sample-to-sample variation in aperture delay.

Crosstalk
Coupling onto one channel being driven by a low level (–40 dBFS) signal when the adjacent interfering channel is driven by a full-scale signal.

Differential Analog Input Resistance, Differential Analog Input Capacitance, and Differential Analog Input Impedance
The real and complex impedances measured at each analog input port. The resistance is measured statically and the capacitance and differential input impedances are measured with a network analyzer.

Differential Analog Input Voltage Range
The peak-to-peak differential voltage that must be applied to the converter to generate a full-scale response. Peak differential voltage is computed by observing the voltage on a single pin and subtracting the voltage from the other pin, which is 180° out of phase. Peak-to-peak differential is computed by rotating the input's phase 180° and again taking the peak measurement. The difference is then computed between both peak measurements.

Differential Nonlinearity
The deviation of any code width from an ideal 1 LSB step.

Effective Number of Bits (ENOB)
Calculated from the measured SNR based on the equation

$$ENOB = \frac{SNR_{MEASURED} - 1.76dB}{6.02}$$

ENCODE Pulse Width/Duty Cycle
Pulse width high is the minimum amount of time the ENCODE pulse (clock pulse) should be left in Logic 1 state to achieve rated performance; pulse width low is the minimum time the ENCODE pulse should be left in low state. See timing implications of changing t_{EH} in the Application Notes, Encode Input section. At a given clock rate, these specifications define an acceptable ENCODE duty cycle.

Full-Scale Input Power
Expressed in dBm. Computed using the following equation:

$$Power_{FULLSCALE} = 10\log\left(\frac{V^2{}_{FULLSCALE\ RMS}}{\frac{Z_{INPUT}}{0.001}}\right)$$

Gain Error
The difference between the measured and ideal full-scale input voltage range of the ADC.

Harmonic Distortion, Second
The ratio of the rms signal amplitude to the rms value of the second harmonic component, reported in dBc.

Harmonic Distortion, Third
The ratio of the rms signal amplitude to the rms value of the third harmonic component, reported in dBc.

Integral Nonlinearity
The deviation of the transfer function from a reference line measured in fractions of 1 LSB using a "best straight line" determined by a least square curve fit.

Minimum Conversion Rate
The ENCODE rate at which the SNR of the lowest analog signal frequency drops by no more than 3 dB below the guaranteed limit.

Maximum Conversion Rate
The ENCODE rate at which parametric testing is performed.

Output Propagation Delay
The delay between a differential crossing of CLK+ and CLK– and the time when all output data bits are within valid logic levels.

Noise (for Any Range within the ADC)
Calculated as follows:

$$V_{NOISE} = \sqrt{Z \times 0.001 \times 10\left(\frac{FS_{dBM} - SNR_{dBc} - Signal_{dBFS}}{10}\right)}$$

where *Z* is the input impedance, *FS* is the full scale of the device for the frequency in question, *SNR* is the value of the particular input level, and *Signal* is the signal level within the ADC, reported in dB below full scale. This value includes input levels both thermal and quantization noise.

Power Supply Rejection Ratio
The ratio of a change in input offset voltage to a change in power supply voltage.

Signal-to-Noise-and-Distortion (SINAD)
The ratio of the rms signal amplitude (set 1 dB below full scale) to the rms value of the sum of all other spectral components, including harmonics but excluding dc.

Signal-to-Noise Ratio (without Harmonics)
The ratio of the rms signal amplitude (set at 1 dB below full scale) to the rms value of the sum of all other spectral components, excluding the first five harmonics and dc.

Spurious-Free Dynamic Range (SFDR)
The ratio of the rms signal amplitude to the rms value of the peak spurious spectral component. The peak spurious component may or may not be a harmonic. May be reported in dBc (i.e., degrades as signal level is lowered) or dBFS (always related back to converter full scale).

Two-Tone Intermodulation Distortion Rejection
The ratio of the rms value of either input tone to the rms value of the worst third-order intermodulation product; reported in dBc.

Two-Tone SFDR
The ratio of the rms value of either input tone to the rms value of the peak spurious component. The peak spurious component may or may not be an IMD product. May be reported in dBc (i.e., degrades as signal level is lowered) or in dBFS (always related back to converter full scale).

Worst Other Spur
The ratio of the rms signal amplitude to the rms value of the worst spurious component (excluding the second and third harmonic) reported in dBc.

Transient Response Time
The time it takes for the ADC to reacquire the analog input after a transient from 10% above negative full scale to 10% below positive full scale.

Out-of-Range Recovery Time
The time it takes for the ADC to reacquire the analog input after a transient from 10% above positive full scale to 10% above negative full scale, or from 10% below negative full scale to 10% below positive full scale.

EQUIVALENT CIRCUITS

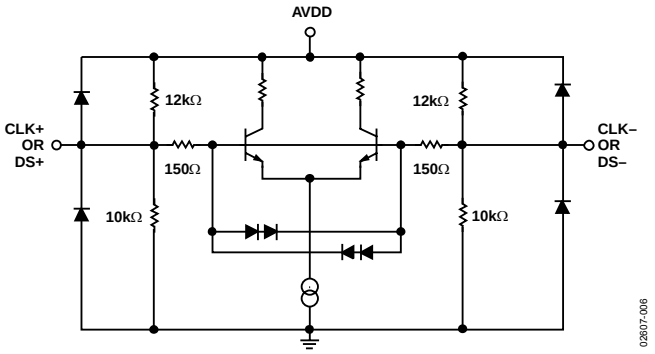


Figure 6. ENCODE and DS Inputs

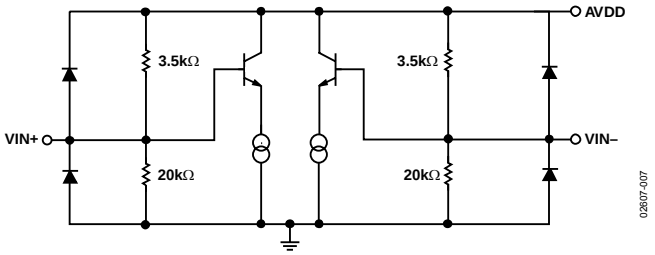


Figure 7. Analog Inputs

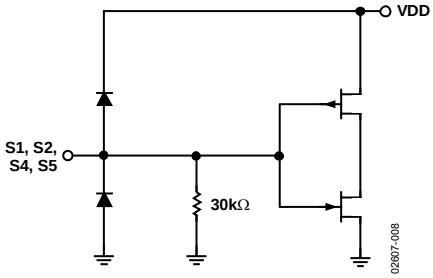


Figure 8. S1-S5 Inputs

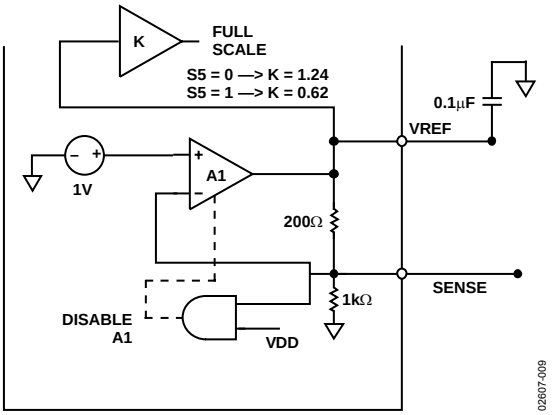


Figure 9. VREF, SENSE I/O

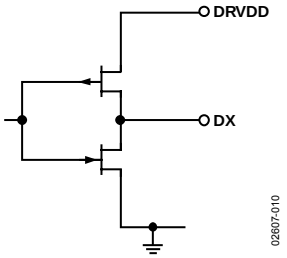


Figure 10. Data Outputs (CMOS Mode)

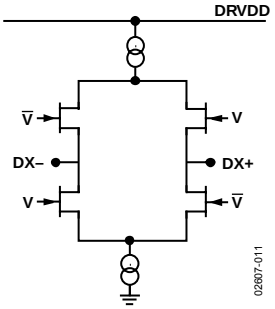


Figure 11. Data Outputs (LVDS Mode)

TYPICAL PERFORMANCE CHARACTERISTICS

Charts at 170 MSPS, 210 MSPS for –170, –210 grades, respectively. AVDD, DRVDD = 3.3 V, T = 25C, A_{IN} differential drive, Full scale = 1.536 V, internal reference unless otherwise noted.

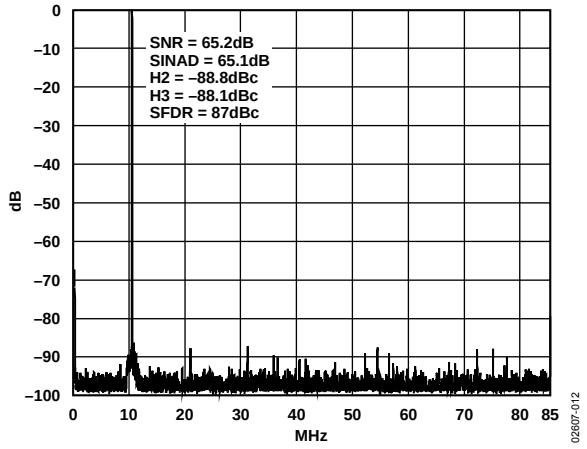


Figure 12. FFT: f_s = 170 MSPS, A_{IN} = 10.3 MHz @ –0.5 dBFS, LVDS Mode

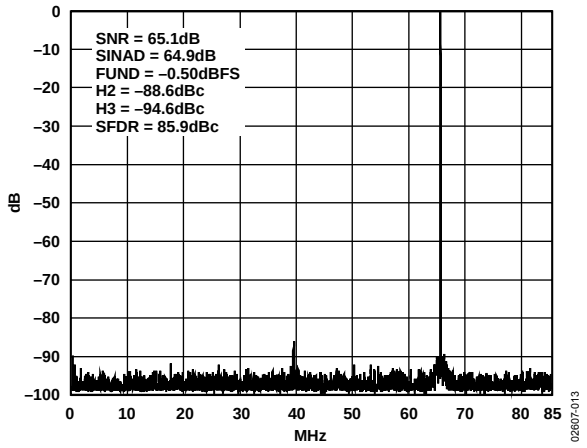


Figure 13. FFT: f_s = 170 MSPS, A_{IN} = 65 MHz @ –0.5 dBFS, LVDS Mode

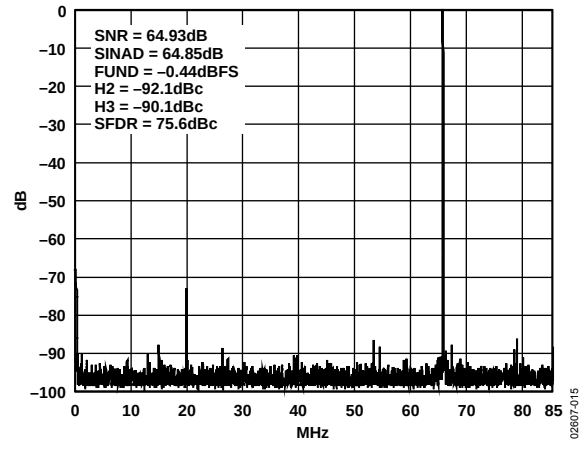


Figure 14. FFT: f_s = 170 MSPS, A_{IN} = 65 MHz @ –0.5 dBFS, CMOS Mode

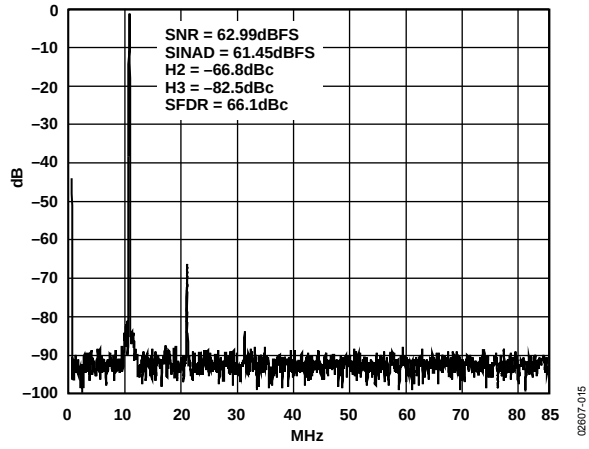


Figure 15. FFT: f_s = 170 MSPS, A_{IN} = 10.3, MHz @ –0.5 dBFS, Single-Ended Input, Full Scale = 0.76 V, LVDS Mode

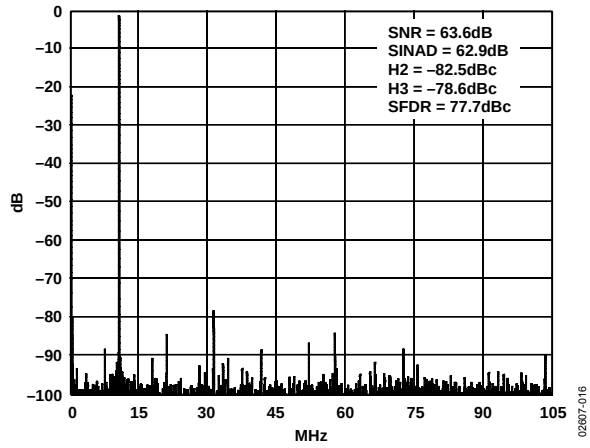


Figure 16. FFT: f_s = 210 MSPS, A_{IN} = 10.3 MHZ @ –0.5 dBFS, LVDS Mode

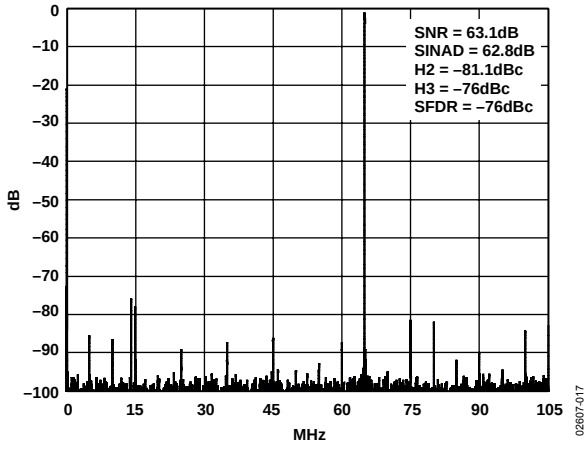


Figure 17. FFT: f_s = 210 MSPS, A_{IN} = 65 MHz @ –0.5 dBFS, CMOS Mode

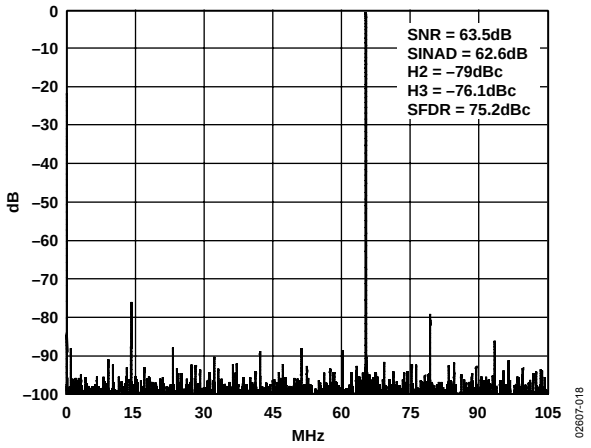


Figure 18. FFT: f_s = 210 MSPS, A_{IN} = 65 MHz @ –0.5 dBFS, LVDS Mode

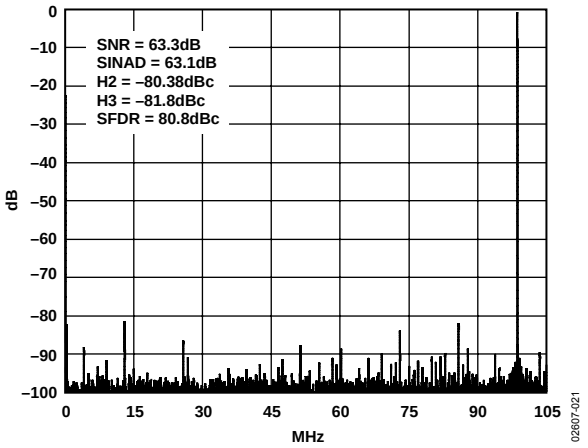


Figure 21. FFT: f_s = 213 MSP, A_{IN} = 100 MHz @ –0.5 dBFS, LVDS Mode

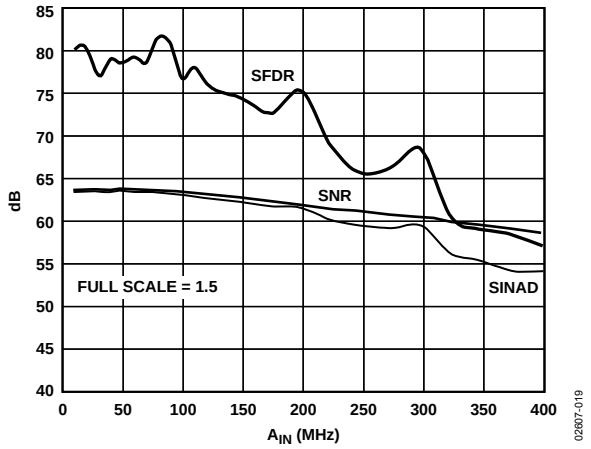


Figure 19. SNR, SINAD, and SFDR vs. A_{IN} Frequency, f_S = 210 MSPS, A_{IN} @ –0.5 dBFS, LVDS Mode

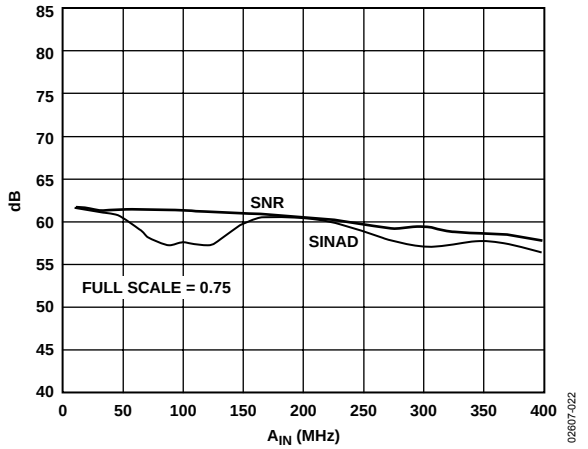


Figure 22. SNR, and SINAD vs. A_{IN} Frequency; f_s = 210 MSPS, A_{IN} @ –0.5 dBFS, LVDS Mode, Full Scale = 0.76 V

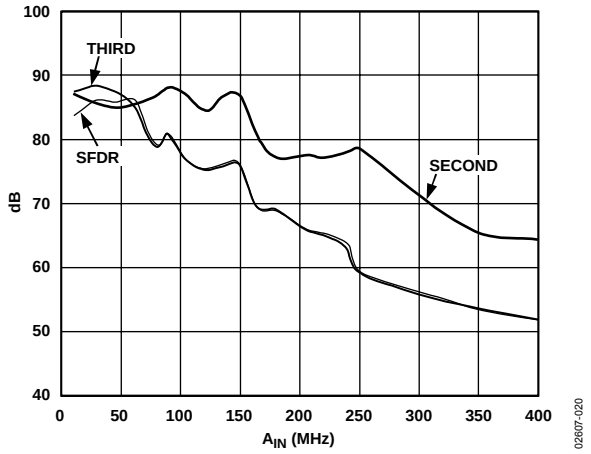


Figure 20. Harmonic Distortion (Second and Third) and SFDR vs. A_{IN} Frequency

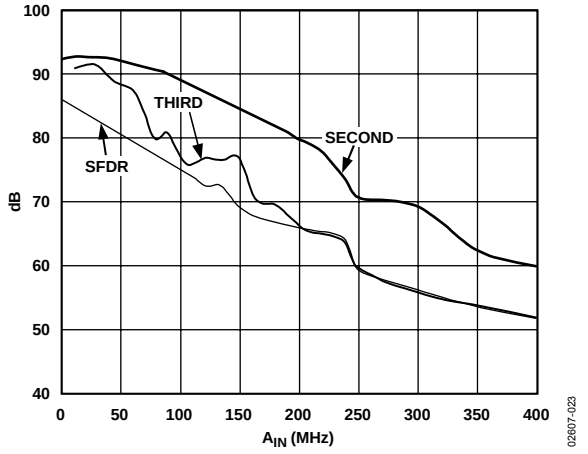


Figure 23. Harmonic Distortion (Second and Third) and SFDR vs. A_{IN} Frequency, f_s = 170 MSPS, CMOS Mode

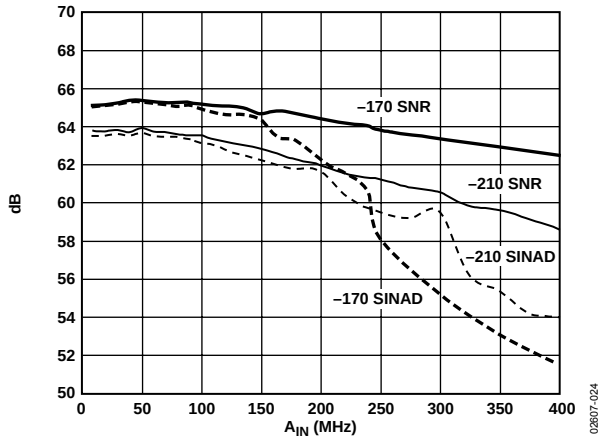


Figure 24. SNR, and SINAD vs. A_{IN} Frequency; f_s = 170, 210 MSPS, A_{IN} @ –0.5 dBFS, LVDS Mode

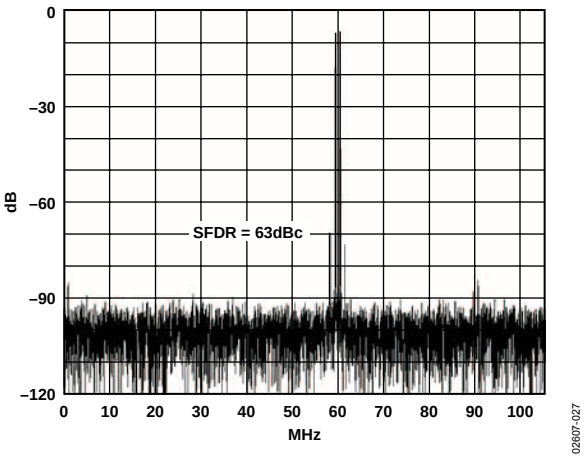


Figure 27. Two-Tone Intermodulation Distortion (59 MHz and 60 MHz), LVDS Mode, f_s = 210 MSPS

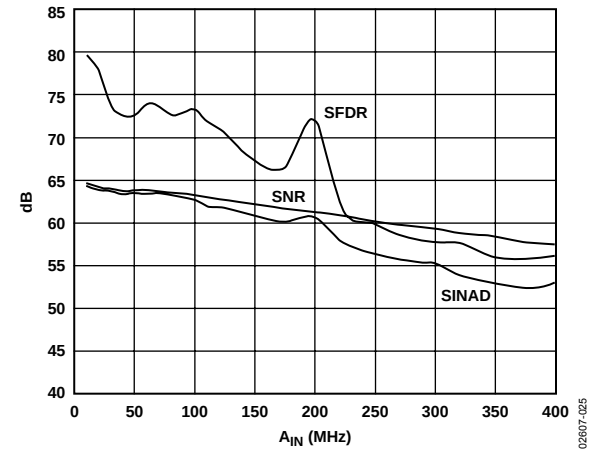


Figure 25. SNR, and SINAD, SFDR vs. A_{IN} Frequency; f_s = 210 MSPS, A_{IN} @ –0.5 dBFS, CMOS Mode

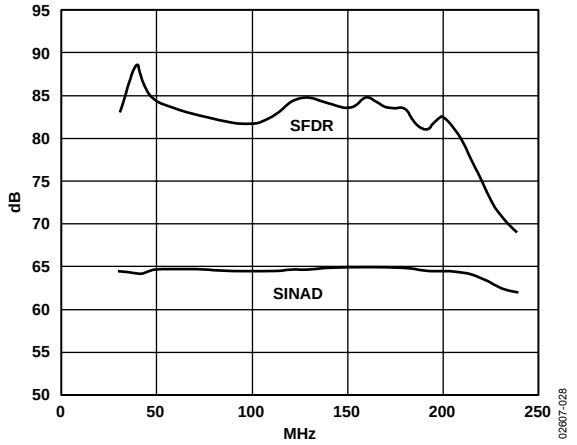


Figure 28. SINAD and SFDR vs. Clock Rate (A_{IN} = 10.3 MHz @ –0.5 dBFS, LVDS Mode), –170 Grade

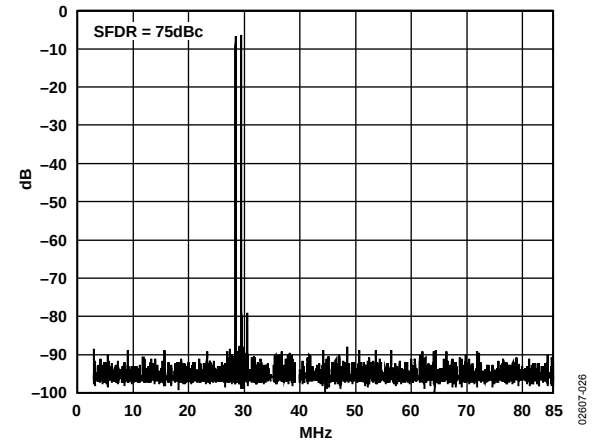


Figure 26. Two-Tone Intermodulation Distortion (28.3 MHz and 29.3 MHz; LVDS Mode, f_s = 170 MSPS)

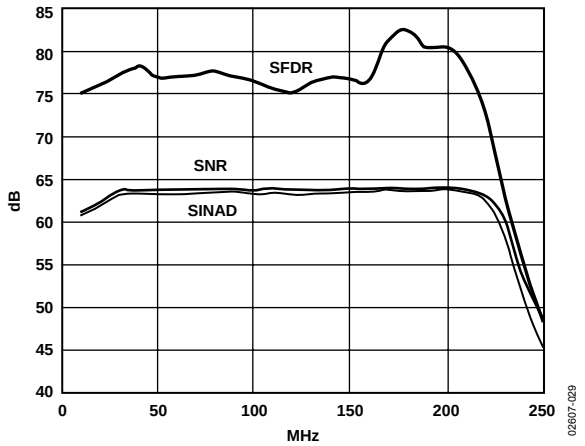


Figure 29. SNR, and SINAD, SFDR vs. Clock Rate (A_{IN} = 10.3 MHz, @ –0.5 dBFS), LVDS Mode, –210 Grade

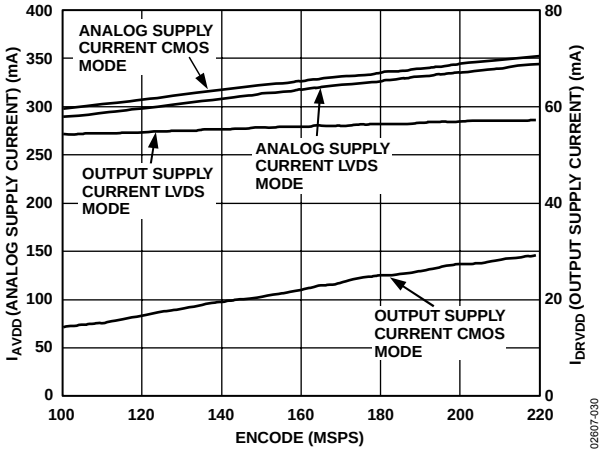


Figure 30. I_{AVDD} and I_{DRVDD} vs. Clock Rate (A_{IN} = 10.3 MHz @ –0.5 dBFS) 170 MSPS Grade, C_{LOAD} = 5pF

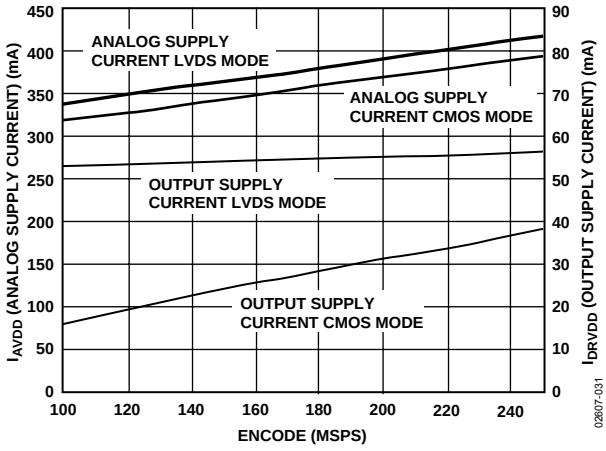


Figure 31. I_{AVDD} and I_{DRVDD} vs. Clock Rate (A_{IN} = 10.3 MHz @ –0.5 dBFS) 210 MSPS Grade, C_{LOAD} = 5 pF

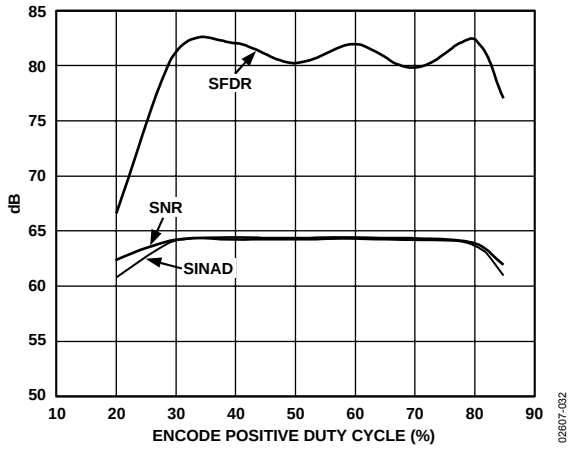


Figure 32. SINAD and SFDR vs. Clock Pulse Width High (A_{IN} = 10.3 MHz @ –0.5 dBFS, 170 MSPS, LVDS)

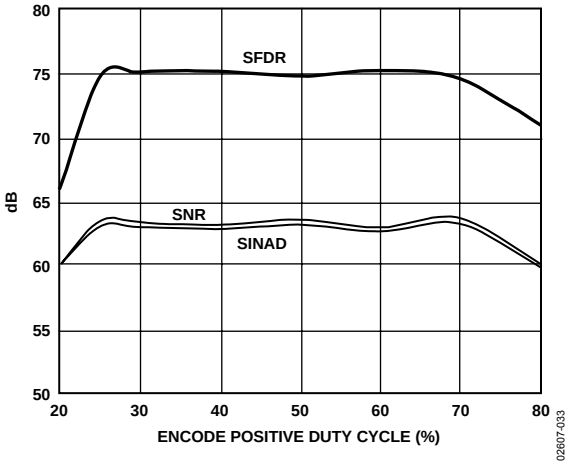


Figure 33. SNR, SINAD, and SFDR vs. ENCODE Pulse Width High, (A_{IN} = 10.3 MHz @ –0.5 dBFS, 210 MSPS, LVDS)

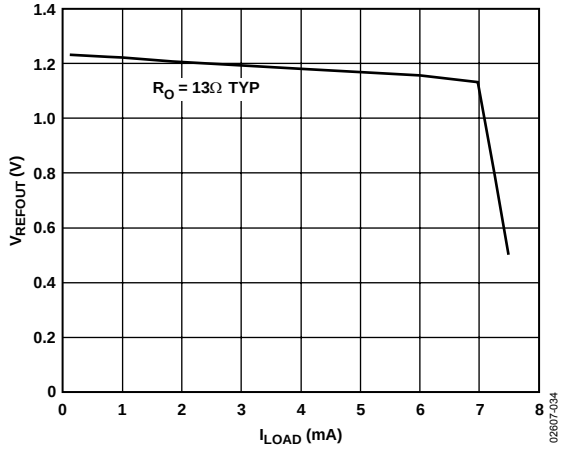


Figure 34. V_{REFOUT} vs. I_{LOAD}

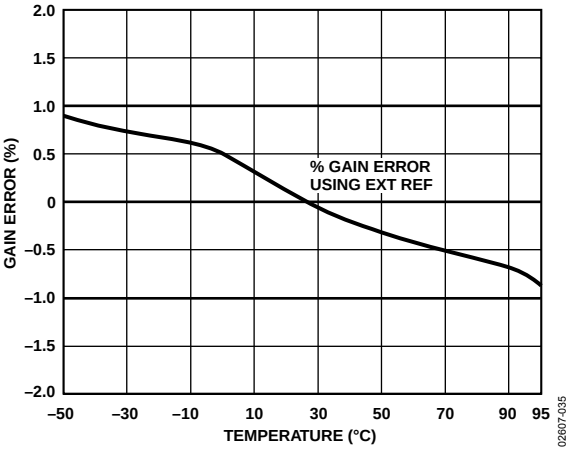


Figure 35. Full-Scale Gain Error vs. Temperature (A_{IN} = 10.3 MHz @ –0.5 dBFS, 170 MSPS/210 MSPS, LVDS)

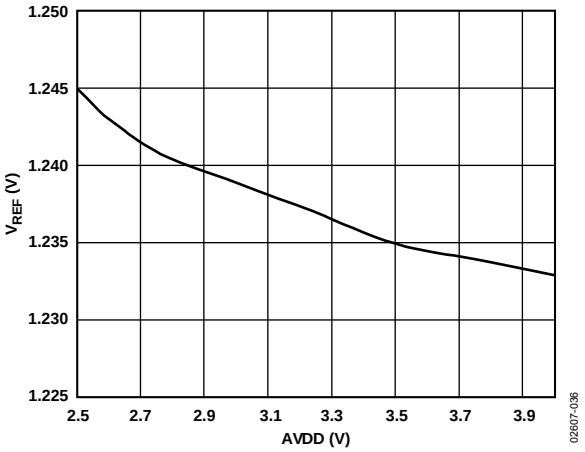


Figure 36. V_{REF} Output Voltage vs. AVDD

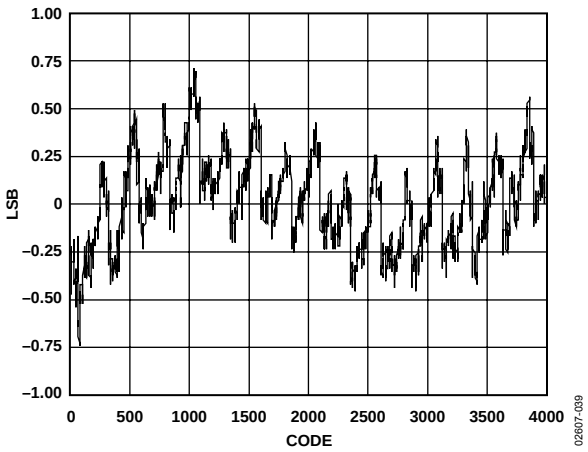


Figure 39. Typical INL Plot (A_{IN} = 10.3 MHz @ –0.5 dBFS, 170 MSPS, LVDS)

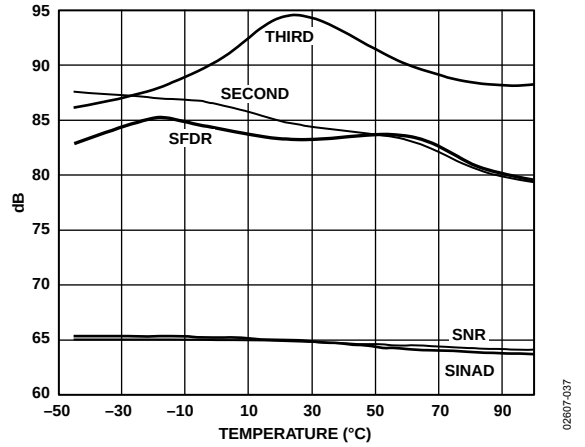


Figure 37. SNR, SINAD, SFDR vs. Temperature (A_{IN} = 10.3 MHz @ –0.5 dBFS, 170 MSPS)

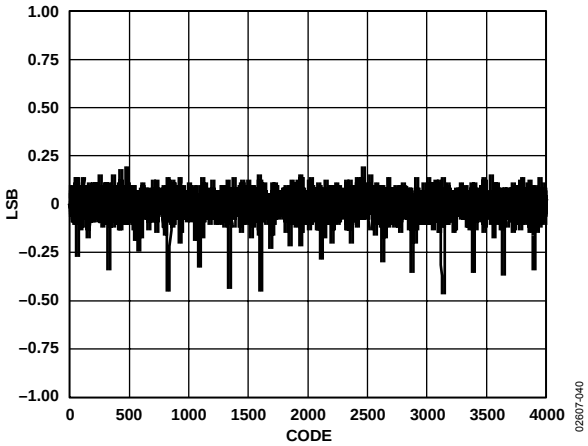


Figure 40. Typical DNL Plot (A_{IN} = 10.3 MHz @ –0.5 dBFS)

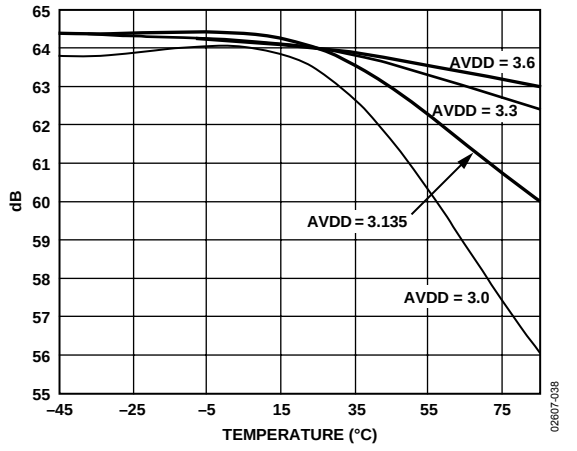


Figure 38. SINAD vs. Temperature, AVDD (A_{IN} = 70 MHz @ –0.5 dB, 210 MSPS, LVDS Mode)

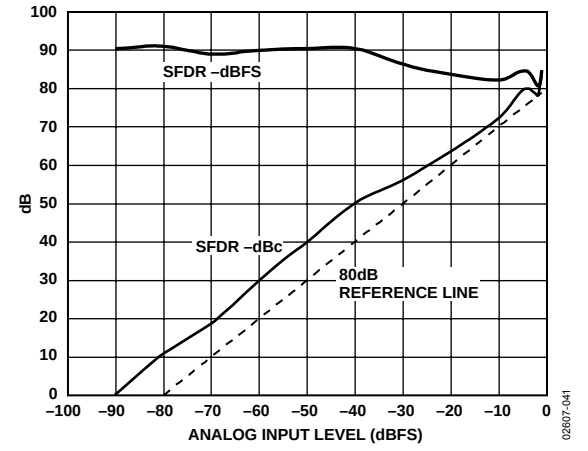


Figure 41. SFDR vs. A_{IN} Input Level, A_{IN} @ 10.3MHz,170 MSPS, LVDS Mode

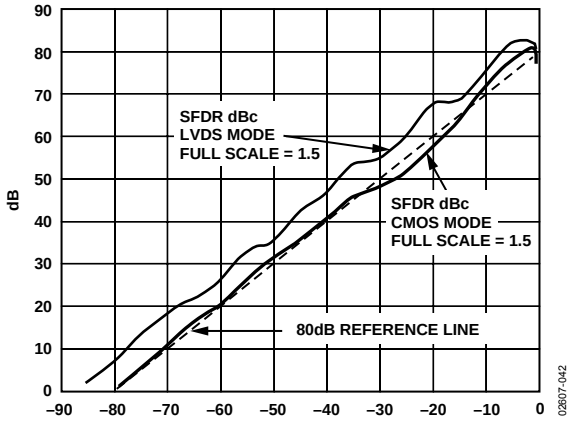


Figure 42. SFDR vs. A_{IN} Input Level, A_{IN} @ 10.3 MHz, 210 MSPS, LVDS/CMOS Modes

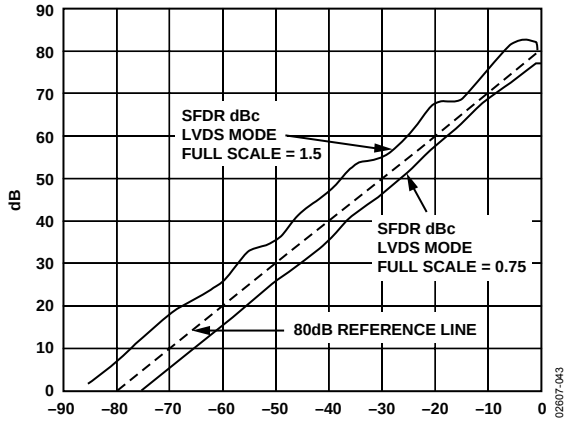


Figure 43. SFDR vs. A_{IN} Input Level, A_{IN} @ 10.3 MHz, 210 MSPS, LVDS Mode, Full Scale = 0.76 V/1.536 V

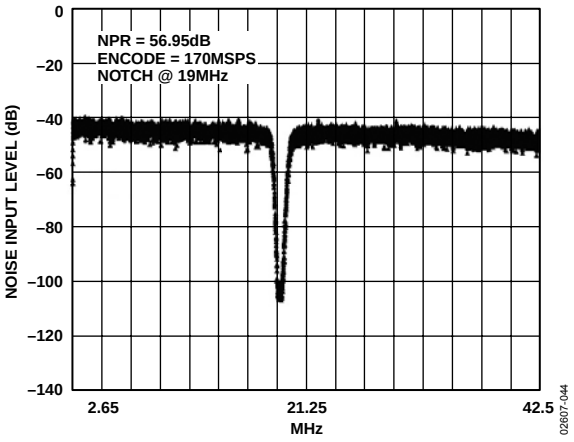


Figure 44. Noise Power Ratio Plot

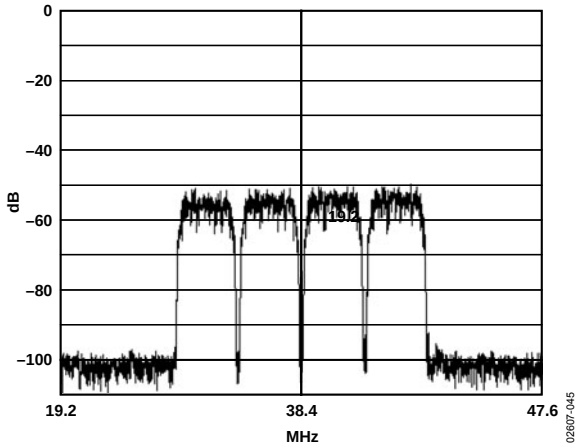


Figure 45. W-CDMA Four Channels Centered at 38.4 MHz, f_s = 153.6 MHz, LVDS Mode

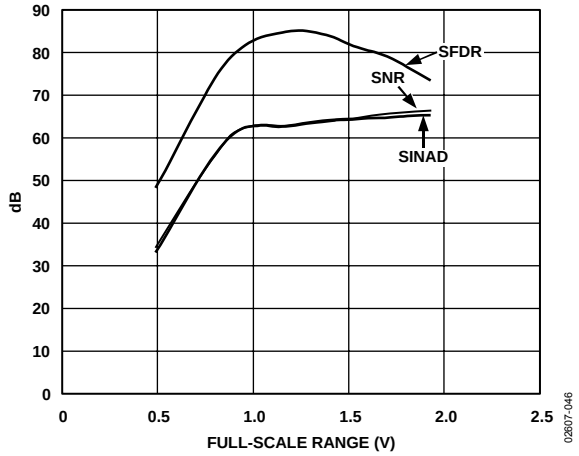


Figure 46. SNR, and SINAD. SFDR vs. Full-Scale Range, S5 = 0, Full-Scale Range Varied by Adjusting VREF, 170 MSPS

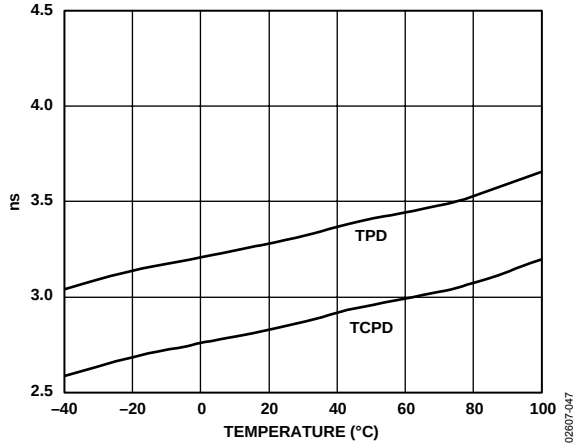


Figure 47. Propagation Delay vs. Temperature, LVDS Mode, 170 MSPS/210 MSPS

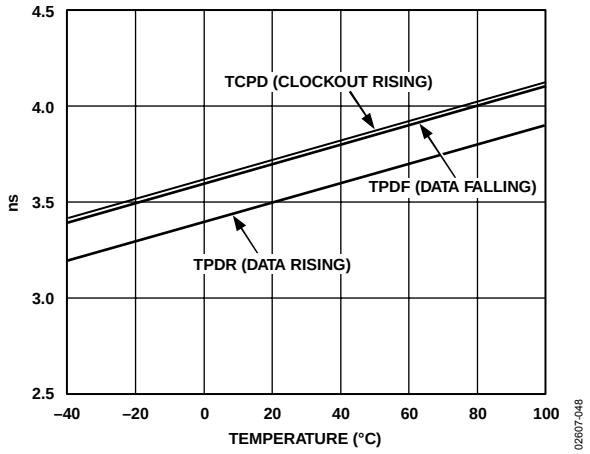


Figure 48. Propagation Delay vs. Temperature, CMOS Mode, 170 MSPS/210 MSPS

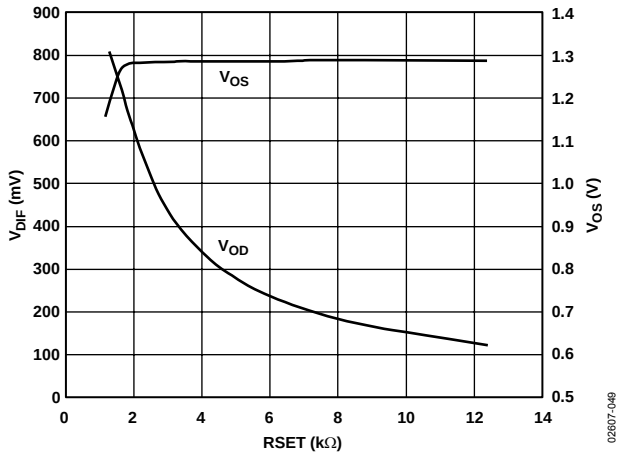


Figure 49. LVDS Output Swing, Common-Mode Voltage vs. RSET, Placed at LVDSBIAS, 170 MSPS/210 MSPS

APPLICATION NOTES

THEORY OF OPERATION

The AD9430 architecture is optimized for high speed and ease of use. The analog inputs drive an integrated high bandwidth track-and-hold circuit that samples the signal prior to quantization by the 12-bit core. For ease of use, the part includes an on-board reference and input logic that accepts TTL, CMOS, or LVPECL levels. The digital output's logic levels are user selectable as standard 3 V CMOS or LVDS (ANSI-644 compatible) via Pin S2.

ENCODE INPUT

Any high speed A/D converter is extremely sensitive to the quality of the sampling clock provided by the user. A track-and-hold circuit is essentially a mixer, and any noise, distortion, or timing jitter on the clock is combined with the desired signal at the A/D output. For that reason, considerable care has been taken in the design of the clock inputs of the AD9430, and the user is advised to give careful thought to the clock source.

The AD9430 has an internal clock duty cycle stabilization circuit that locks to the rising edge of CLK+ and optimizes timing internally. This allows for a wide range of input duty cycles at the input without degrading performance. Jitter in the rising edge of the input is still of paramount concern and is not reduced by the internal stabilization circuit. The duty cycle control loop does not function for clock rates less than 30 MHz nominally. The loop has a time constant associated with it that needs to be considered in applications where the clock rate can change dynamically, requiring a wait time of 1.5 µs to 5 µs after a dynamic clock frequency increase before valid data is available. This circuit is always on and cannot be disabled by the user.

The clock inputs are internally biased to 1.5 V (nominal) and support either differential or single-ended signals. For best dynamic performance, a differential signal is recommended. An MC100LVEL16 performs well in the circuit to drive the clock inputs, as illustrated in Figure 50. (For trace lengths > 2 inches, a standard LVPECL termination is recommended rather than the simple pull-down as shown.) Note that for this low voltage PECL device, the ac coupling is optional.

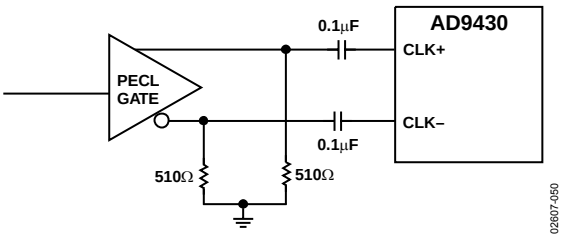


Figure 50. Driving Clock Inputs with LVEL16

Table 8. Output Select Coding

S1[1] (Data Format Select)	S2 (LVDS/CMOS Mode Select)[2]	S4 (I/P Select)	S5 (Full-Scale Select)[3]	Mode
1	X	X	X	Twos complement
0	X	X	X	Offset binary
X	0	1	X	Dual-mode CMOS interleaved
X	0	0	X	Dual-mode CMOS parallel
X	1	X	X	LVDS mode
X	X	X	1	Full scale = 0.768 V
X	X	X	0	Full scale = 1.536 V

[1] X = Don't care.
[2] S4 used in CMOS mode only (S2 = 0). S1 to S5 all have 30 kΩ-resistive pull-downs on-chip.
[3] S5 full-scale adjust (see Analog Inputs section).

In interleaved mode, output data on Port A is offset from output data changes on Port B by one-half output clock cycle:

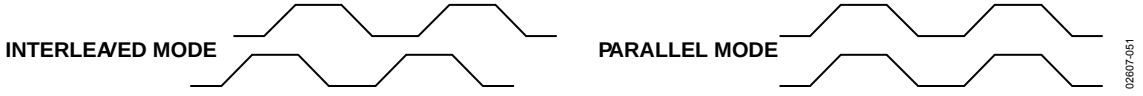


Figure 51.

ANALOG INPUT

The analog input to the AD9430 is a differential buffer. For best dynamic performance, impedances at VIN+ and VIN– should match. The analog input is optimized to provide superior wideband performance and requires that the analog inputs be driven differentially. SNR and SINAD performance degrades significantly if the analog input is driven with a single-ended signal.

A wideband transformer, such as Mini-Circuits' ADT1-1WT, can provide the differential analog inputs for applications that require a single-ended-to-differential conversion. Both analog inputs are self-biased by an on-chip resistor divider to a nominal 2.8 V. (See the Equivalent Circuits section.)

Special care was taken in the design of the analog input section of the AD9430 to prevent damage and corruption of data when the input is overdriven. The nominal differential input range is approximately 1.5 V p-p ~ (768 mV × 2). Note that the best performance is achieved with S5 = 0 (full-scale = 1.5). See Figure 43.

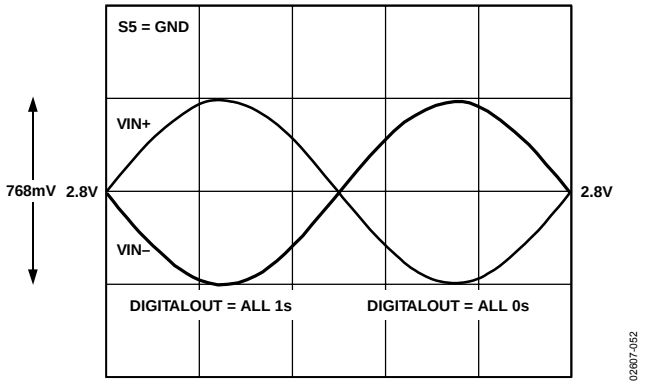


Figure 52. Differential Analog Input Range

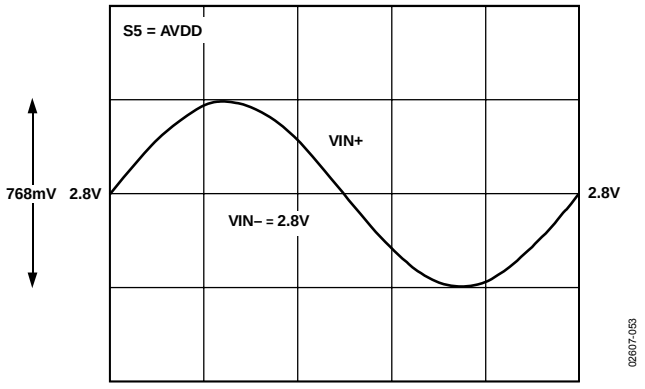


Figure 53. Single-Ended Analog Input Range

DS INPUTS (DS+, DS–)

In CMOS output mode, the data sync inputs (DS+, DS–) can be used in applications that require a given sample to appear at a specific output port (A or B) relative to a given external timing signal. The DS inputs can also be used to synchronize two or more ADCs in a system to maintain phasing between Ports A and B on separate ADCs (in effect, synchronizing multiple DCO outputs). When DS+ is held high (DS– low), the ADC data outputs and clock do not switch and are held static. Synchronization is accomplished by the assertion (falling edge) of DS+ within the timing constraints t_{SDS} and t_{HDS}, relative to a clock rising edge. (On initial synchronization, t_{HDS} is not relevant.) If DS+ falls within the required setup time (t_{SDS}) before a given clock rising edge N, the analog value at that point in time will be digitized and available at Port A, 14 cycles later in interleaved mode.

The very next sample, N + 1, is sampled by the next rising clock edge and available at Port B, 14 cycles after that clock edge. In dual parallel mode, Port A has a 15-cycle latency and Port B has a 14-cycle latency, but data is available at the same time. Driving each ADC's DS inputs by the same sync signals accomplishes this. An easy way to accomplish synchronization is by a one-time sync at power-on reset. Note that when running the AD9430 in LVDS mode, set DS+ to ground and DS– to 3.3 V, as the DS inputs are relevant only in CMOS output mode, simplifying the design for some applications as well as affording superior SNR/SINAD performance at higher encode/analog frequencies.

CMOS OUTPUTS

The off-chip drivers on the chip can be configured to provide CMOS compatible output levels via Pin S2. The CMOS digital outputs (S2 = 0) are TTL/CMOS compatible for lower power consumption. The outputs are biased from a separate supply (DRVDD), allowing easy interface to external logic. The outputs are CMOS devices that swing from ground to DRVDD (with no dc load). It is recommended to minimize the capacitive load the ADC drives by keeping the output traces short (< 1 inch, for a total C_{LOAD} < 5 pF). When operating in CMOS mode, it is also recommended to place low value (20 Ω) series damping resistors on the data lines to reduce switching transient effects on performance.

LVDS OUTPUTS

The off-chip drivers on the chip can be configured to provide LVDS compatible output levels via Pin S2. LVDS outputs are available when S2 = V_{DD} and a 3.74 kΩ RSET resistor is placed at Pin 7 (LVDSBIAS) to ground. The RSET resistor current is ratioed on-chip, setting the output current at each output equal to a nominal 3.5 mA (11 × IRSET). A 100 Ω differential termination resistor placed at the LVDS receiver inputs results

in a nominal 350 mV swing at the receiver. LVDS mode facilitates interfacing with LVDS receivers in custom ASICs and FPGAs that have LVDS capability for superior switching performance in noisy environments. Single point-to-point net topologies are recommended with a 100 Ω termination resistor as close to the receiver as possible. It is recommended to keep the trace length two inches maximum and to keep differential output trace lengths as equal as possible.

CLOCK OUTPUTS (DCO+, DCO–)

The input ENCODE is divided by two (in CMOS mode) and available off-chip at DCO+ and DCO–. These clocks can facilitate latching off-chip, providing a low skew clocking solution (see Figure 2). The on-chip clock buffers should not drive more than 5 pF of capacitance to limit switching transient effects on performance. Note that the output clocks are CMOS levels when CMOS mode is selected (S2 = 0) and are LVDS levels when in LVDS mode (S2 = V_{DD}), (requiring a 100 Ω differential termination at receiver in LVDS mode). The output clock in LVDS mode switches at the ENCODE rate.

VOLTAGE REFERENCE

A stable and accurate 1.23 V voltage reference is built into the AD9430 (VREF). The analog input full-scale range is linearly proportional to the voltage at VREF. Note that an external reference can be used by connecting the SENSE pin to VDD (disabling internal reference) and driving VREF with the external reference source. No appreciable degradation in performance occurs when VREF is adjusted ±5%. A 0.1 µF capacitor to ground is recommended at the VREF pin in internal and external reference applications. Float the SENSE pin for internal reference operation.

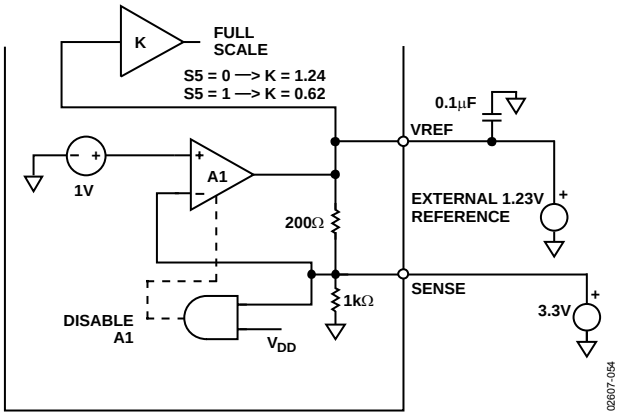


Figure 54. Using an External Reference

NOISE POWER RATIO TESTING (NPR)

NPR is a test that is commonly used to characterize the return path of cable systems where the signals are typically QAM signals with a "noise-like" frequency spectrum. NPR performance of the AD9430 was characterized in the lab yielding an effective NPR = 56.9 dB at an analog input of 19 MHz. This agrees with a theoretical maximum NPR of 57.1 dB for an 11-bit ADC at 13.6 dB backoff. The rms noise power of the signal inside the notch is compared with the rms noise level outside the notch using an FFT. Sufficiently long record lengths to guarantee a sufficient number of samples inside the notch are a requirement, as well as a high order band-stop filter that provides the required notch depth for testing.

EVALUATION BOARD, CMOS MODE

The AD9430 evaluation board offers an easy way to test the AD9430 in CMOS mode. It requires a clock source, an analog input signal, and a 3.3 V power supply. The clock source is buffered on the board to provide the clocks for the ADC, an on-board DAC, latches, and a data ready signal. The digital outputs and output clocks are available at two 40-pin connectors, P3 and P4. (See Figure 60.) The board has several different modes of operation and is shipped in the following configurations:

- Offset Binary
- Internal Voltage Reference
- CMOS Parallel Timing
- Full-Scale Adjust = Low

POWER CONNECTOR

Power is supplied to the board via a detachable 12-lead power strip (three 4-pin blocks). (AVDD, DRVDD, and VDL are the minimum required power connections).

Table 9. Power Connector, CMOS Mode

AVDD 3.3 V	Analog supply for ADC (350 mA)
DRVDD 3.3 V	Output supply for ADC (28 mA)
VDL 3.3 V	Supply for support logic and DAC (350 mA)
EXT_VREF	Optional external reference input
VCLK/V_XTAL	Supply for clock buffer/optional CRYSTAL
VAMP	Supply for optional amp

ANALOG INPUTS

The evaluation board accepts a 1.3 V p-p analog input signal centered at ground at SMB connector J4. This signal is terminated to ground through 50 Ω by R16. The input can be alternatively terminated at transformer T1 secondary by R13 and R14. T1 is a wideband RF transformer providing the single-ended-to-differential conversion, allowing the ADC to be driven differentially, minimizing even order harmonics. An optional second transformer, T2, can be placed following T1 if desired. This would provide some performance advantage (~1 dB to 2 dB) for high analog input frequencies (>100 MHz). If T2 is placed, two shorting traces at the pads would need to be cut. The analog signal is low-pass filtered by R41, C12 and R42, C13 at the ADC input.

GAIN

Full scale is set at E17, E18, and E19. Connecting E17 to E18 sets S5 low, full scale = 1.5 V differential; connecting E17 to E19 sets S5 high, full scale = 0.75 V differential.

ENCODE

The ENCODE clock is terminated to ground through 50 Ω at SMB connector J5. The input is ac-coupled to a high speed differential receiver (LVEL16) that provides the required low jitter, fast edge rates needed for optimum performance. J5 input should be > 0.5 V p-p. Power to the EL16 is set at jumper E47. Connecting E47 to E45 powers the buffer from AVDD; connecting E47 to E46 powers the buffer from VCLK/V_XTAL.

VOLTAGE REFERENCE

The AD9430 has an internal 1.23 V voltage reference. The ADC uses the internal reference as the default when jumpers E24–E27 and E25–E26 are left open. The full scale can be increased by placing optional resistor R3. The required value would vary with the process and needs to be tuned for the specific application. Full scale can similarly be reduced by placing R4; tuning is required here as well. An external reference can be used by shorting the SENSE pin to 3.3 V (place jumper E26–E25). E27–E24 jumper connects the ADC VREF pin to the EXT_VREF pin at the power connector.

DATA FORMAT SELECT

Data format select sets the output data format of the ADC. Setting DFS (E1 to E2) low sets the output format to be offset binary; setting DFS high (E1 to E3) sets the output to twos complement.

I/P TIMING SELECT

Output timing is set at E11, E12 and E13. E12 to E11 sets S4 low for parallel output timing mode. E11 to E13 sets S4 high for interleaved timing mode.

TIMING CONTROLS

Flexibility in latch clocking and output timing is accomplished by allowing for clock inversion at the timing controls section of the PCB. Each buffered clock is buffered by an XOR and can be inverted by moving the appropriate jumper for that clock.

CMOS DATA OUTPUTS

The ADC CMOS digital outputs are latched on the board by four LVT574s; the latch outputs are available at the two 40-pin connectors at Pins 11–33 on P23 (Channel A) and Pins 11–33 on P3 (Channel B). The latch output clocks (data ready) are available at Pin 37 on P23 (Channel A) and Pin 37 on P3 (Channel B). The data-ready clocks can be inverted at the timing controls section if needed

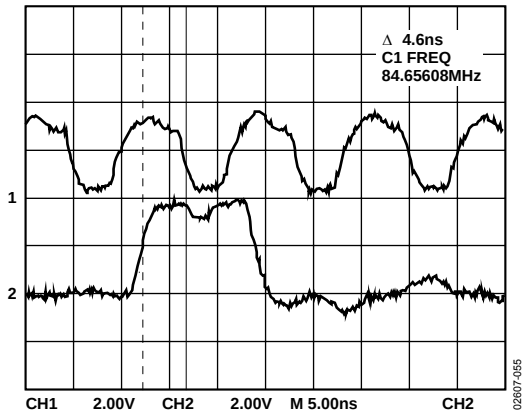


Figure 55. Data Output and Clock @ 80-Pin Connector

DAC OUTPUTS

Each channel is reconstructed by an on-board, dual-channel DAC, an AD9753. This DAC is intended to assist in debug—it should not be used to measure the performance of the ADC. It is a current output DAC with on-board 50 Ω termination resistors. Figure 56 is representative of the DAC output with a full-scale analog input. The scope setting is low bandwidth.

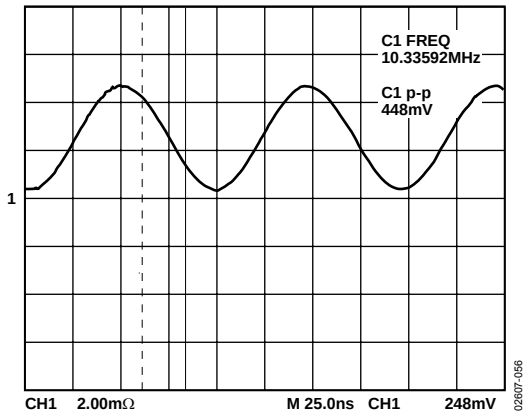


Figure 56. DAC Output

CRYSTAL OSCILLATOR

An optional crystal oscillator can be placed on the board to serve as a clock source for the PCB. Power to the oscillator is through the VCLK/VXTAL pin at the power connector. If an oscillator is used, ensure proper termination for best results. The board has been tested with a Valpey Fisher VF561 and a Vectron JN00158-163.84. Test results for the VF561 are shown in Figure 57.

OPTIONAL AMPLIFIER

The footprint for transformer T2 can be modified to accept a wideband differential amplifier (AD8350) for low frequency applications where gain is required. Note that Pin 2 would need to be lifted and left floating for operation. Input transformer T1 would need to be modified to a 4:1 for impedance matching and

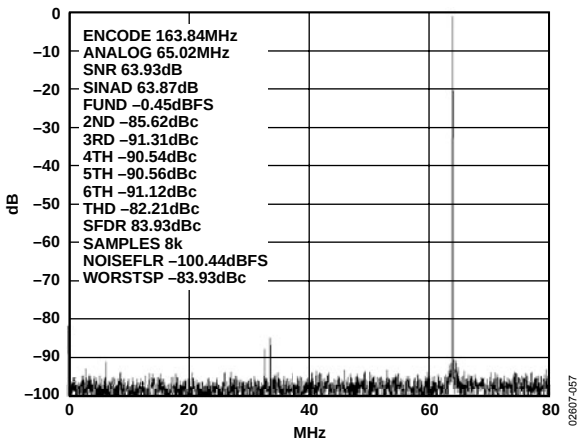


Figure 57. FFT—Using VF561 CRYSTAL as Clock Source

ADC input filtering would enhance performance. See the AD8350 data sheet. SNR/SINAD performance of 61 dB/60 dB is possible and would start to degrade at about 30 MHz.

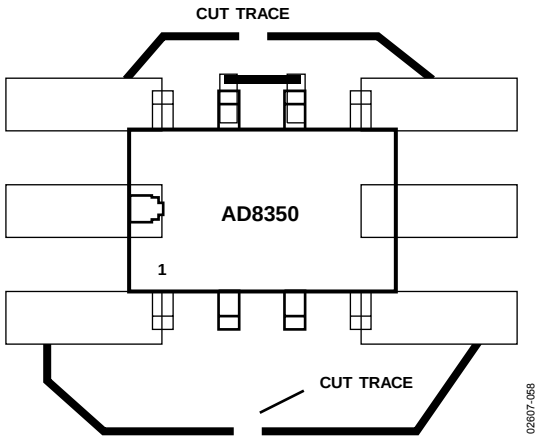


Figure 58. Using the AD8350 on the AD9430 PCB

TROUBLESHOOTING

If the board does not seem to be working correctly, try the following:

- Verify power at IC pins.
- Check that all jumpers are in the correct position for the desired mode of operation.
- Verify that VREF is at 1.23 V.
- Try running clock and analog inputs at low speeds (10 MSPS/1 MHz) and monitor latch, DAC, and ADC for toggling.

The AD9430 evaluation board is provided as a design example for customers of Analog Devices, Inc. ADI makes no warranties, express, statutory, or implied, regarding merchantability or fitness for a particular purpose.

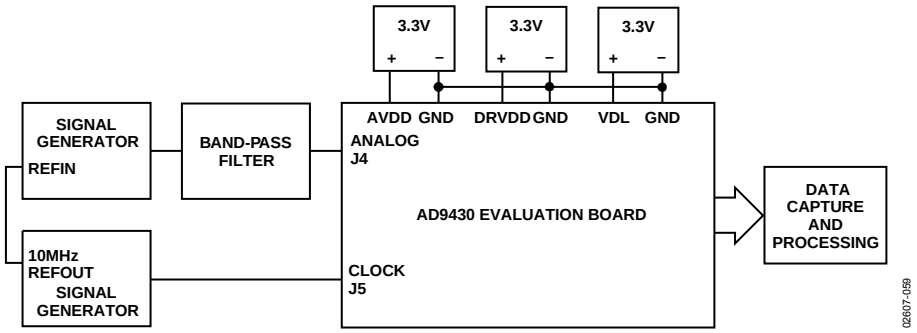


Figure 59. Evaluation Board Connections

Table 10. Evaluation Board Bill of Materials—CMOS

No.	Quantity	Reference Designator	Device	Package	Value	Comments
1	47	C1, C3–C11, C15–C17, C19–C29, C31–C48, C58–C62	Capacitor	0603	0.1 µF	C43, C47 Not placed
2	1	C2	Capacitor	0603	10 pF	Not placed
3	2	C12, C13	Capacitor	0603	20 pF	Not placed
4	1	C14	Capacitor	0603	0.01 µF	
5	1	C18	Capacitor	0603	1 µF	
6	7	C30, C49, C63–C67	Capacitor	CAPL	10 µF	C30 Not placed
7	9	E3, E1, E2	3-pin header/jumper			
		E19, E17, E18	3-pin header/jumper			
		E13, E11, E12	3-pin header/jumper			
		E26, E25, E27, E24	4-pin header			
		E46, E47, E45	3-pin header/jumper			
		E35, E33, E34	3-pin header/jumper			
		E32, E30, E31	3-pin header/jumper			
		E29, E23–E28	3-pin header/jumper			
		E22, E16–E21	3-pin header/jumper			
8	6	J1, J2, J3, J4, J5, J6	SMB	SMB		J2 Not placed
9	2	P3, P23[1]				
10	3	P4, P21, P22	4-pin power connector	Post	Z5.531.3425.0	Wieland
				Detachable Connector	25.602.5453.0	Wieland
11	8	R1, R5, R16, R25, R27, R28, R41, R42	Resistor	0603	50 Ω	R1, R13, R14 Not placed
12	3	R2, R3, R4	Resistor	0603	3.74 kΩ	R3, R4 Not placed
13	14	R6–R8, R10, R15, R21–R24, R33–R36, R38	Resistor	0603	100 Ω	R15, R21 to R24 Not placed
14	5	R9, R11, R12, R30, R37	Resistor	0603	0 Ω	
15	4	R17, R18, R19, R20	Resistor	0603	510 Ω	
16	1	R26	Resistor	0603	2 kΩ	
17	1	R29	Resistor	0603	390 Ω	
18	7	R31, R32, R39, R40, R43, R44, R45	Resistor	0603	1 kΩ	
19	4	RZ1, RZ2, RZ3, RZ4	Resistor pack 220 W	SO16RES	742C163221JTR	CTS
20	8	RZ5, RZ6, RZ7, RZ8, RZ9, RZ10, RZ11, RZ12	Resistor pack 22 W	SO16RES	742C163220JTR	CTS
21	2	T1, T2	Transformer	CD542	Mini-Circuits ADT1–1WT	T2 Not placed
22	1	U1	AD9430BSV	TQFP100	ADC	
23	1	U2	MC100LVEL16D	SO8NB	Clock buffer	
24	1	U3	74LVC86	SO14NB	XOR	
25	4	U4, U5, U6, U7	74LVT574	SO20	Latch	
26	1	U9	AD9753AST	LQFP48	DAC	
27	2	R13, R14	Resistors	0603	25 W	R13, R14 Not placed

[1] P3, P23 are implemented as one physical 80-pin connector SAMTEC TSW-140-08-L-D-RA.

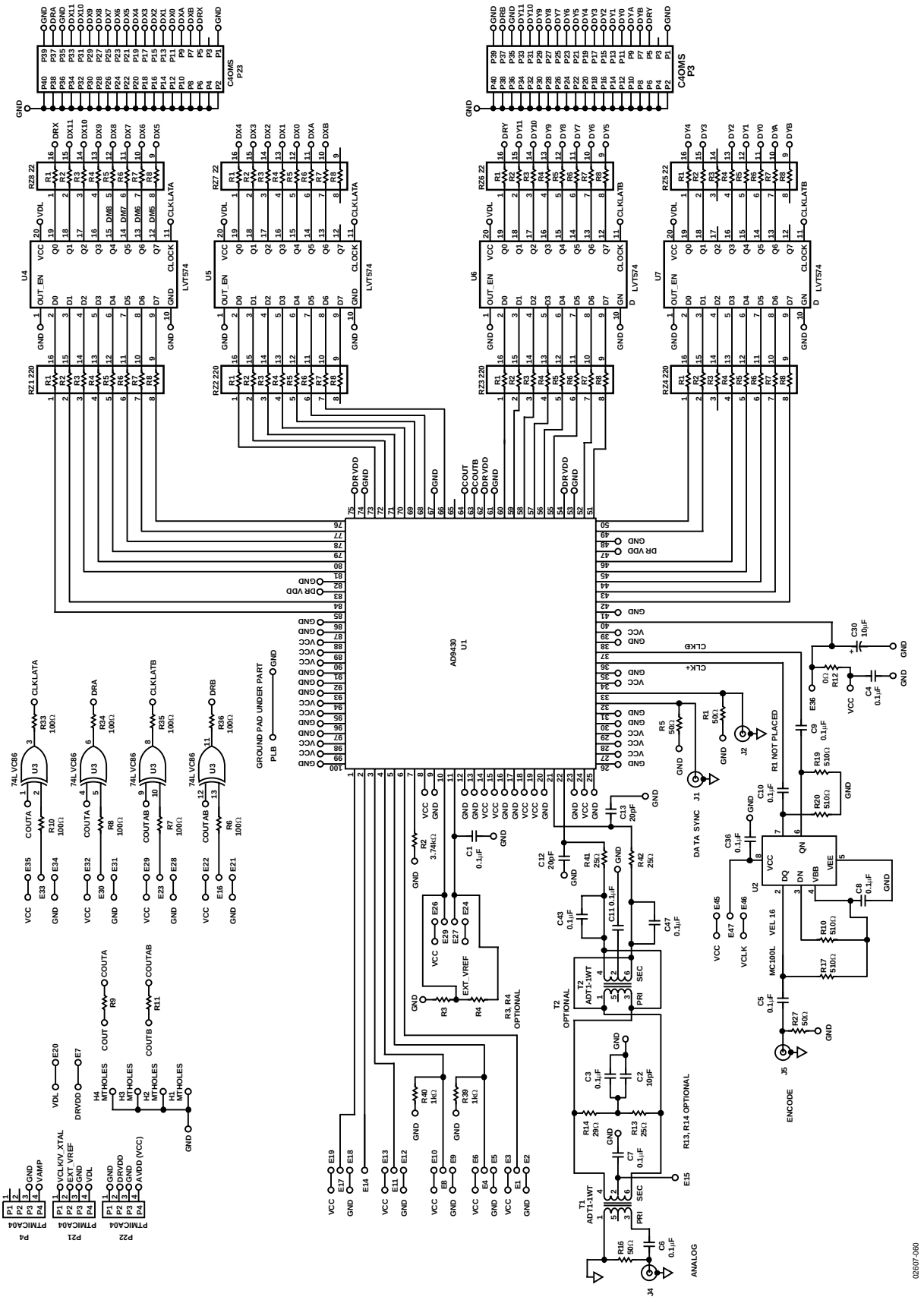


Figure 60. Evaluation Board Schematic—CMOS

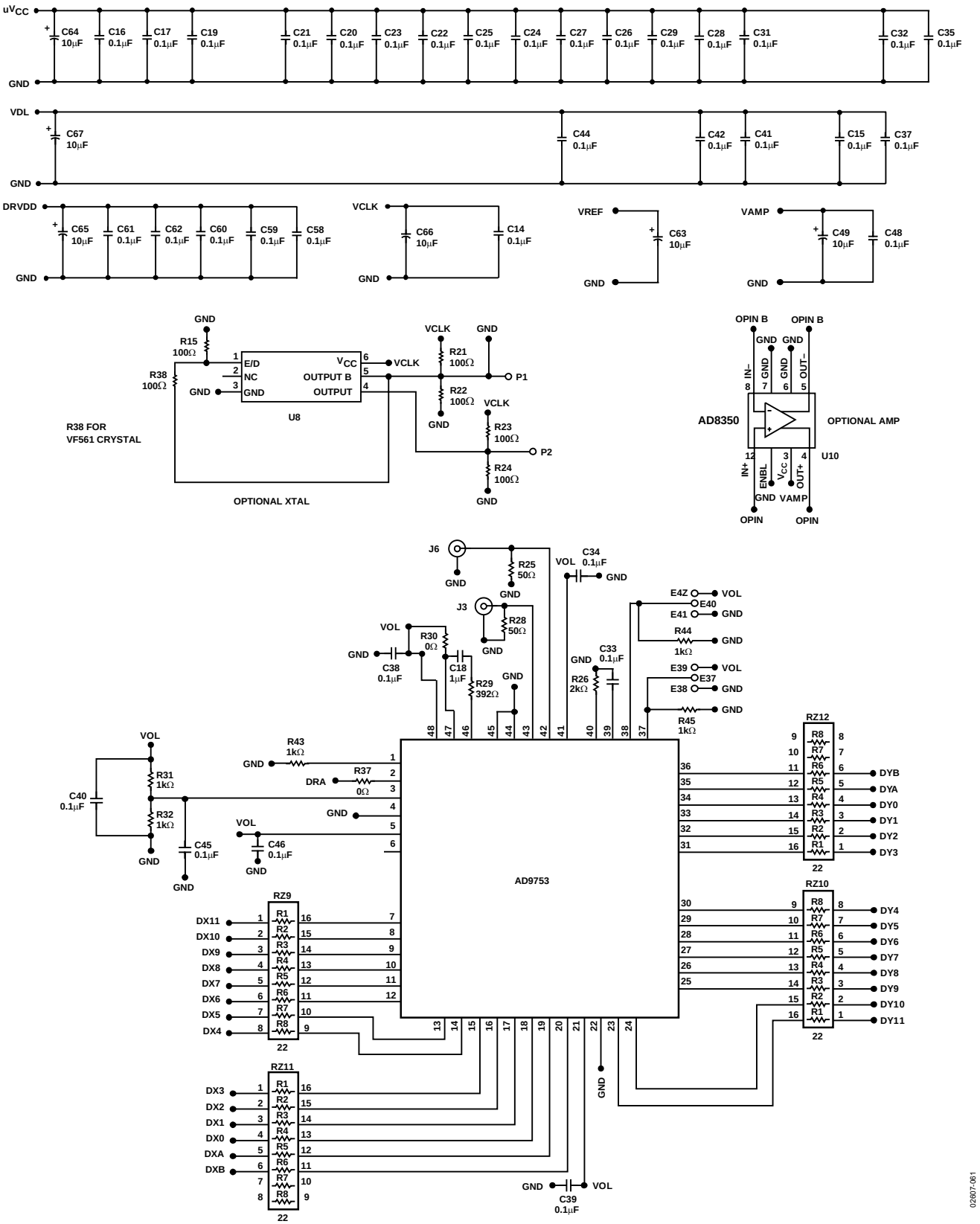


Figure 61. Evaluation Board Schematic—CMOS (continued)

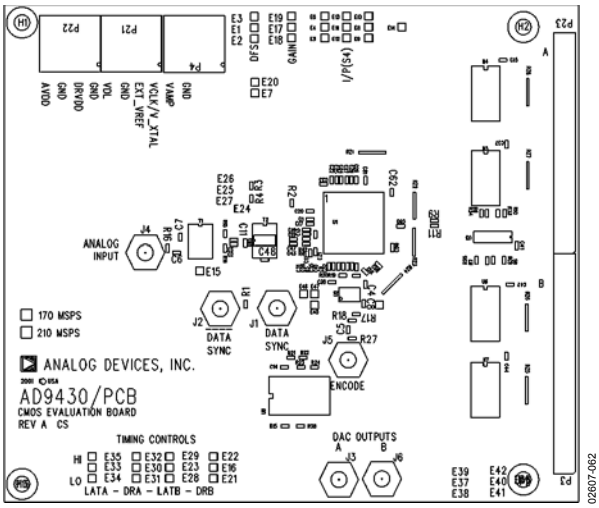


Figure 62. PCB Top Side Silkscreen

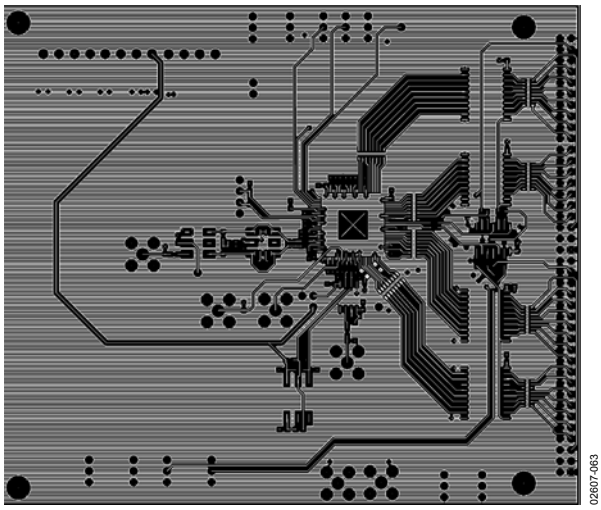


Figure 63. PCB Top Side Copper

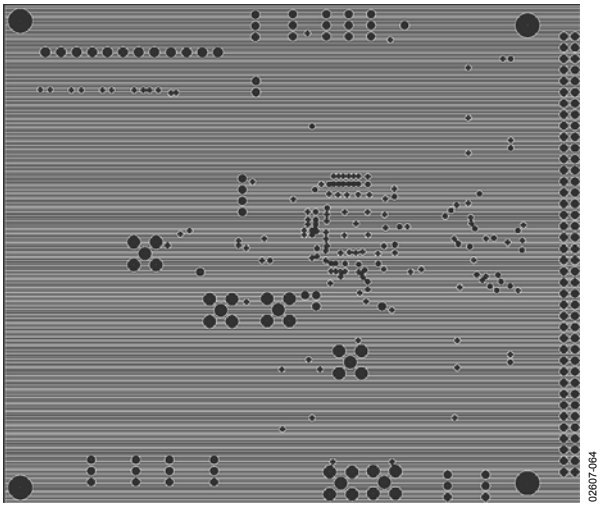


Figure 64. PCB Ground Layer

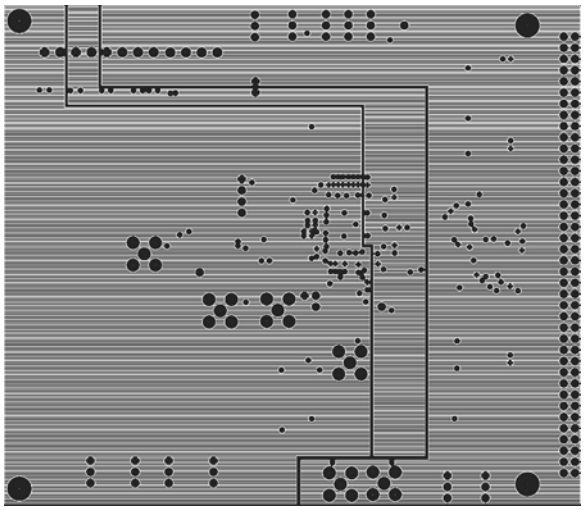


Figure 65. PCB Split Power Plane

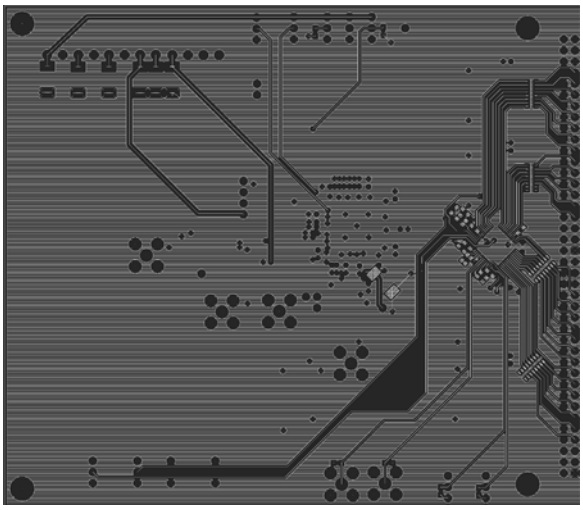


Figure 66. PCB Bottom Side Copper

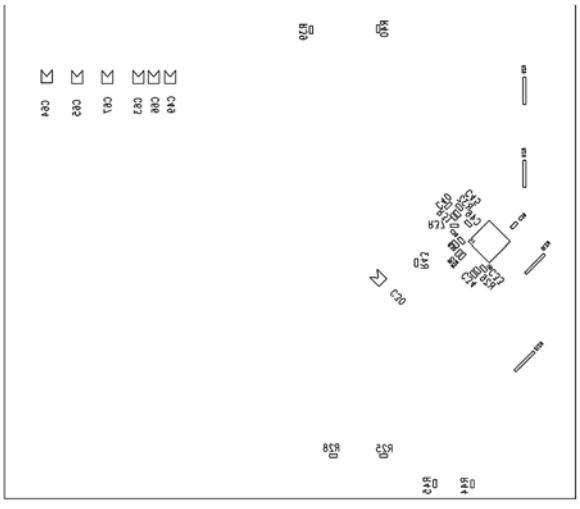


Figure 67. PCB Bottom Side Silkscreen

EVALUATION BOARD, LVDS MODE

The AD9430 evaluation board offers an easy way to test the AD9430 in LVDS mode. (The board is also compatible with the AD9411.) It requires a clock source, an analog input signal, and a 3.3 V power supply. The clock source is buffered on the board to provide the clocks for the ADC, latches, and a data-ready signal. The digital outputs and output clocks are available at a 40-pin connector, P23. The board has several different modes of operation and is shipped in the following configurations:

- Offset Binary
- Internal Voltage Reference
- Full-Scale Adjust = Low

POWER CONNECTOR

Power is supplied to the board via a detachable 8-lead power strip (two 4-pin blocks). Note for the following table that VCC, DRVDD, and VDL are the minimum required power connections, and LVEL16 clock buffer can be powered from VCC or VDL at E47 jumper.

Table 11. Power Connector, LVDS Mode

VCC 3.3 V	Analog supply for ADC (350 mA)
DRVDD 3.3 V	Output supply for ADC (50 mA)
VDL 3.3 V	Supply for support logic
EXT_VREF	Optional external reference input

ANALOG INPUTS

The evaluation board accepts a 1.3 V p-p analog input signal centered at ground at SMB connector J4. This signal is terminated to ground through 50 Ω by R16. The input can be alternatively terminated at T1 transformer secondary by R13 and R14. T1 is a wideband RF transformer providing the single-ended-to-differential conversion, allowing the ADC to be driven differentially, minimizing even-order harmonics. An optional second transformer, T2, can be placed following T1 if desired. This provides some performance advantage (~1 – 2dB) for high analog input frequencies (>100 MHz). If T2 is placed, two shorting traces at the pads need to be cut. The analog signal can be low-pass filtered by R41, C12 and R42, C13 at the ADC input. A wideband differential amplifier (AD8351) can be configured on the PCB for DC-coupled applications. Remove C6, C15, C30 to prevent transformer loading of the amp. See the PCB schematic for more information.

GAIN

Full scale is set at E17–E19, E17–E18 sets S5 low, full scale = 1.5 V differential; E17–E19 sets S5 high, full scale = 0.75 V differential. Best performance is obtained at 1.5 V full scale.

CLOCK

The CLOCK input is terminated to ground through a 50 Ω resistor at SMB connector J5. The input is ac-coupled to a high speed differential receiver (LVEL16) that provides the required low jitter, fast edge rates needed for optimum performance. J5 input should be > 0.5 V p-p. Power to the LVEL16 is set at Jumper E47. E47–E45 powers the buffer from AVDD; E47–E46 powers the buffer from VCLK/V_XTAL.

VOLTAGE REFERENCE

The AD9430 has an internal 1.23 V voltage reference. The ADC uses the internal reference as the default when jumpers E24–E27 and E25–E26 are left open. The full scale can be increased by placing optional resistor R3. The required value varies with the process and needs to be tuned for the specific application. Full scale can similarly be reduced by placing R4; tuning is required here as well. An external reference can be used by shorting the SENSE pin to 3.3 V (place jumper E26–E25). Jumper E27–E24 connects the ADC VREF pin to the EXT_VREF pin at the power connector.

DATA FORMAT SELECT

Data format select (DFS) sets the output data format of the ADC. Setting DFS low (E1–E2) sets the output format to be offset binary; setting DFS high (E1–E3) sets the output to twos complement.

DATA OUTPUTS

The ADC LVDS digital outputs are routed directly to the connector at the card edge. Resistor pads have been placed at the output connector to allow for termination if the connector receiving logic does not have the required differential termination for the data bits and DCO. Each output trace pair should be terminated differentially at the far end of the line with a single 100 ohm resistor.

CRYSTAL OSCILLATOR

An optional crystal oscillator can be placed on the board to serve as a clock source for the PCB. Power to the oscillator is through the VCLK/VXTAL pin at the power connector. If an oscillator is used, ensure proper termination for best results. The board has been tested with a Valpey Fisher VF561 and a Vectron JN00158-163.84.

Table 12. Evaluation Board Bill of Material—LVDS PCB

No.	Quantity	Reference Designator	Device	Package	Value	Comment
1	33	C1, C4–C11, C15–C17, C19–C32, C35, C36, C58–C62 C3, C18, C39, C40	Capacitors	0603	0.1 µF	C3, C18, C39, C40 Not placed
2	4	C33, C34, C37, C38	Capacitor	0402	0.1 µF	C33, C34, C37, C38 Not placed
3	4	C63–C66	Capacitor	TAJD CAPL	10 uF	
4	1	C2	Capacitor	0603	10 pF	C2 Not placed
5	2	C12, C13	Capacitor	0603	20 pF	C12, C13 Not placed
6	2	J4, J5	Jacks	SMB		
7	2	P21, P22	Power connectors Top	25.602.5453.0 Wieland		
8	2	P21, P22	Power connectors Posts	Z5.531.3425.0 Wieland		
9	1	P23	40-pin right-angle connector	Digi-Key S2131-20-ND		
10	16	R1, R6–R12, R15, R31–R37	Resistor	0402	100 Ω	R1, R6–R12, R15, R31–37 Not placed
11	1	R2	Resistor	0603	3.8 kΩ	
12	3	R5, R16, R27	Resistor	0603	50 Ω	
13	2	R17, R18	Resistor	0603	510 Ω	
14	2	R19, R20	Resistor	0603	150 Ω	
15	2	R29, R30	Resistor	0603	1 kΩ	
16	2	R41, R42	Resistor	0603	25 Ω	
17	2	R3, R4	Resistor	0603	3.8 kΩ	
18	2	R13, R14	Resistor	0603	25 Ω	R13, R14 Not placed
19	6	R22, R23, R24, R25, R26, R28	Resistor	0603	100 Ω	R22, R23, R24, R25, R26, R28 Not placed
20	5	R38, R39, R40, R45, R47	Resistor	0402	25 Ω	R38, R39, R40, R45, R47 Not placed
21	2	R43, R44	Resistor	0402	10 kΩ	R43, R44 Not placed
22	1	R46	Resistor	0402	1.2 kΩ	R46 Not placed
23	2	R48, R49	Resistor	0402	0 Ω	R48, R49 Not placed
24	2	R50, R51	Resistor	0402	1 kΩ	R50, R51 Not placed
25	1	T1 T2	RF transformer	Mini circuits ADT1-1WT		T2 Not placed
26	1	U2	RF amp	AD8351		
27	1	U9	Optional crystal oscillator	JN00158 or VF561		
28	1	U1	AD9430	TQFP-100		
29	1	U3	MC100LVEL16	SO8NB		

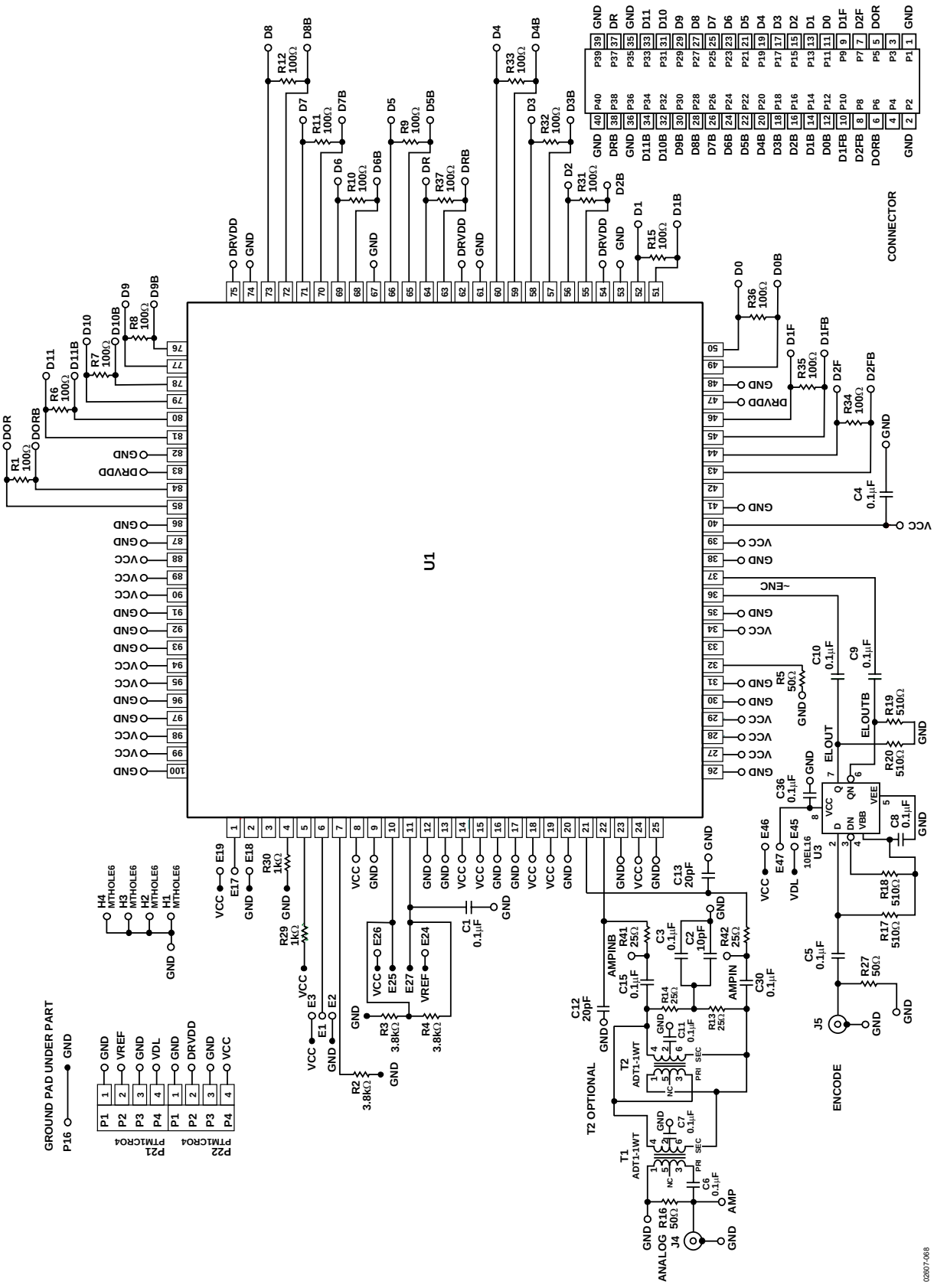
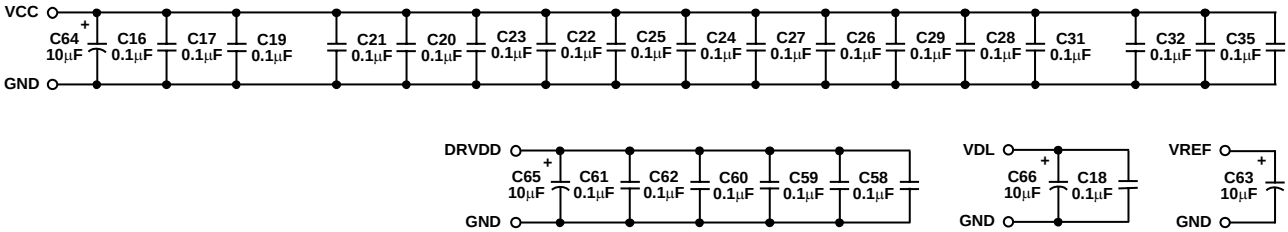
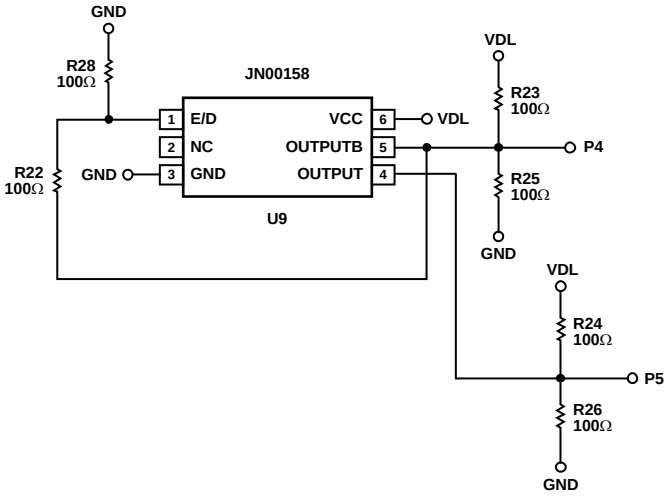


Figure 68. Evaluation Board Schematic—LVDS

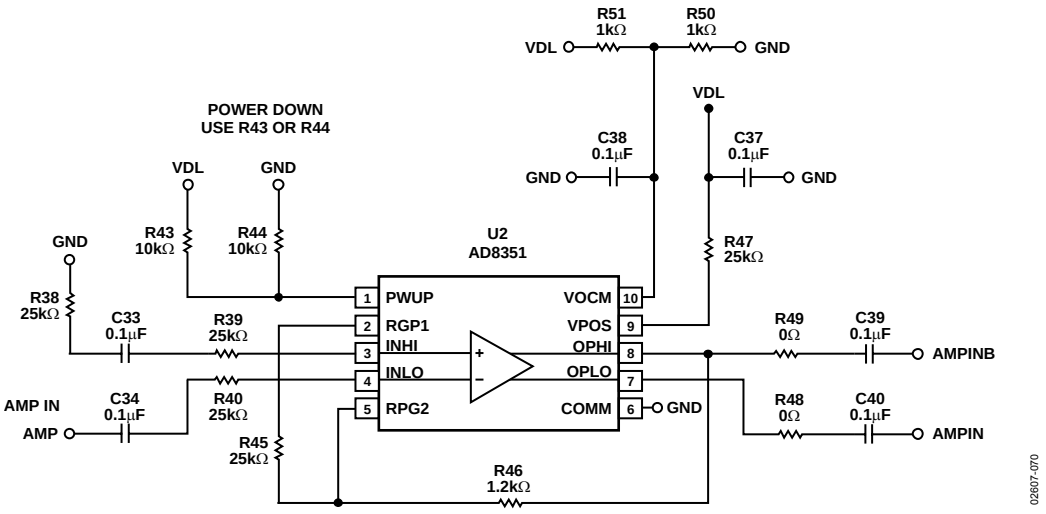


TO USE VF561 CRYSTAL



02607-069

Figure 69. Evaluation Board Schematic—LVDS (continued)



02607-070

Figure 70. Evaluation Board Schematic—LVDS (continued)

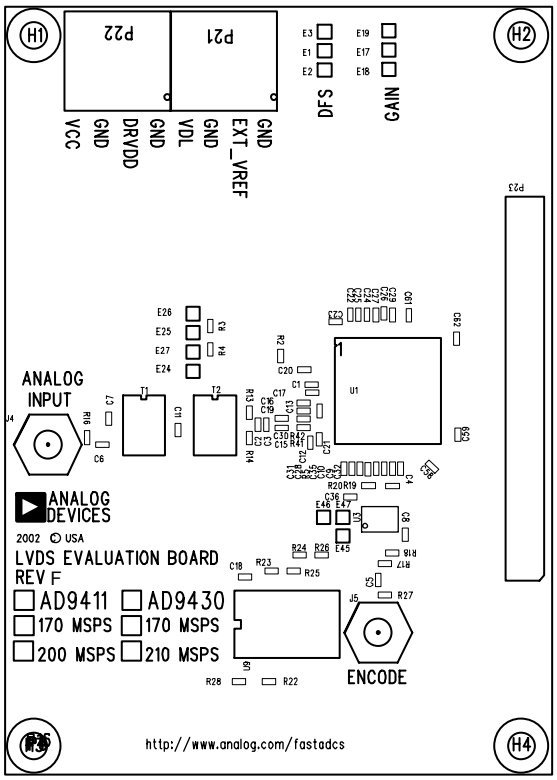


Figure 71. PCB Top Side Silkscreen—LVDS

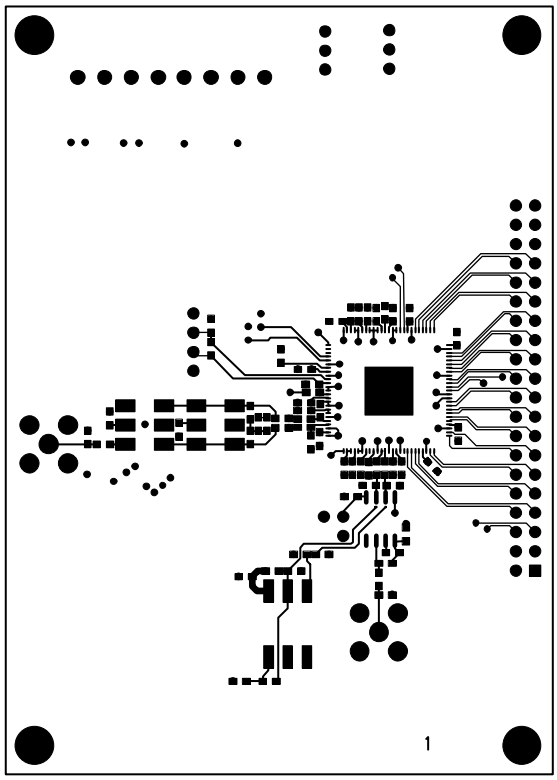


Figure 72. PCB Top Side Copper—LVDS

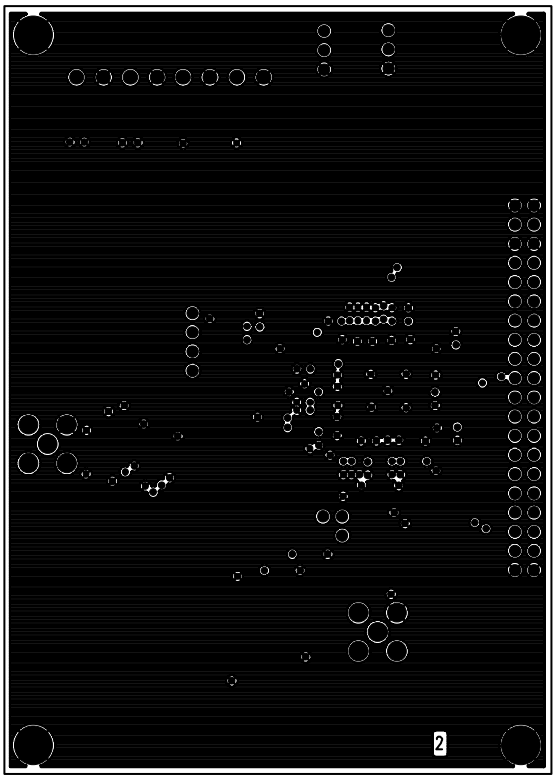


Figure 73. PCB Ground Layer—LVDS

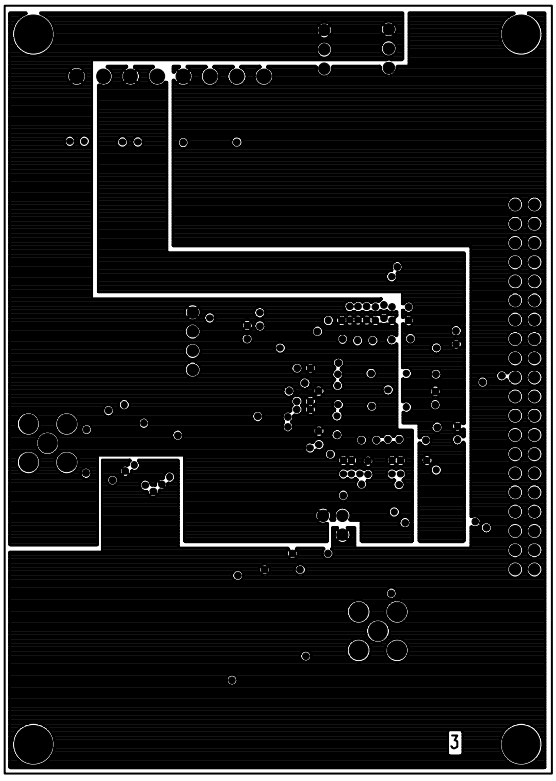


Figure 74. PCB Split Power Plane—LVDS

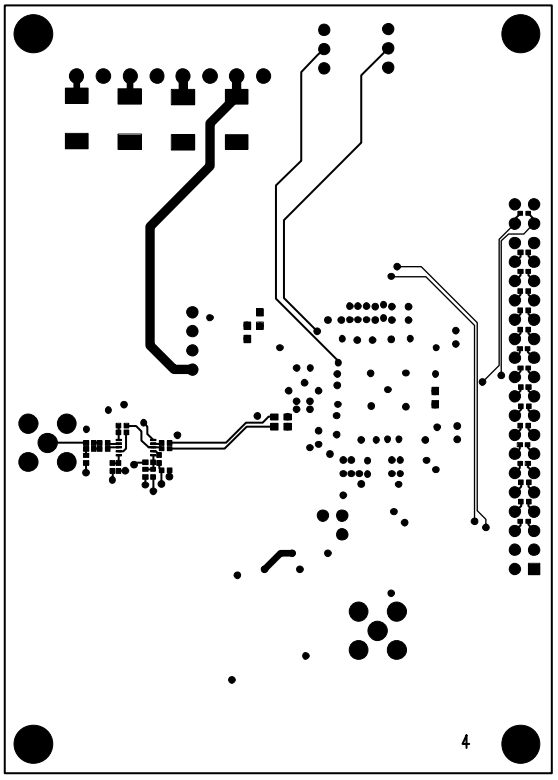


Figure 75. PCB Bottom Side Copper—LVDS

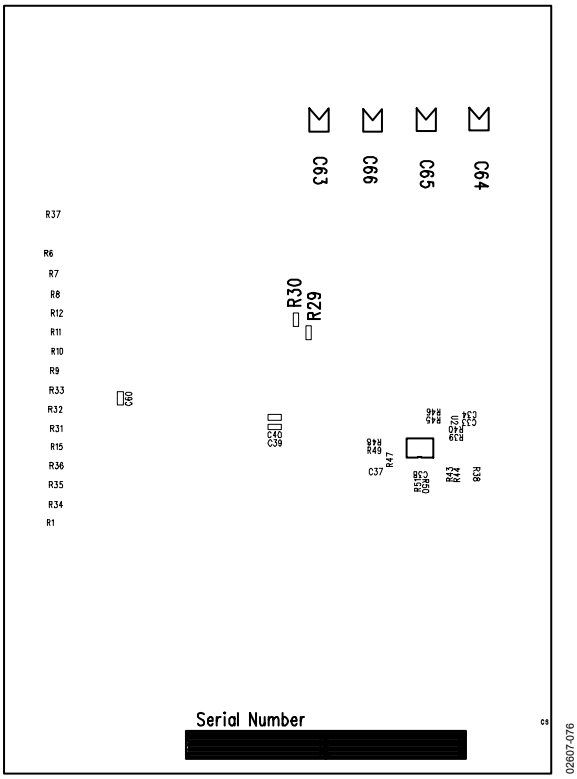
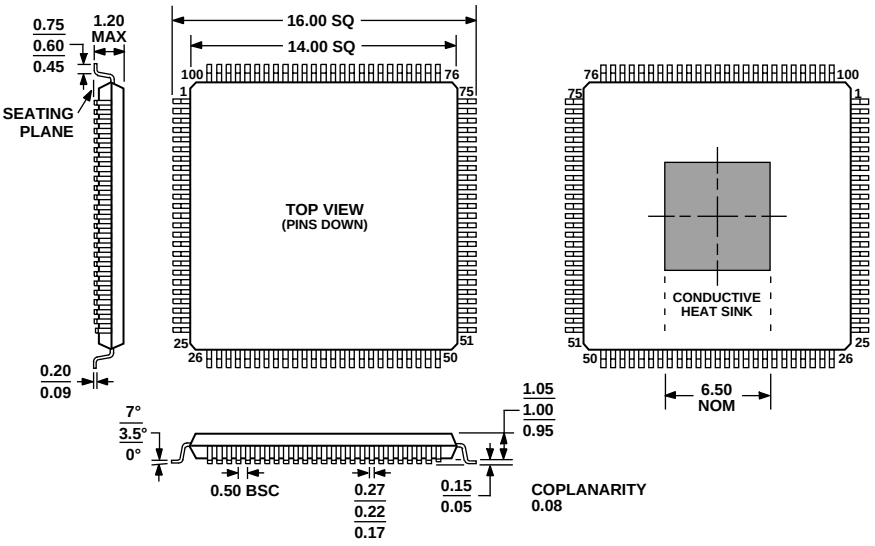


Figure 76. PCB Bottom Side Silkscreen—LVD

S

OUTLINE DIMENSIONS



COMPLIANT TO JEDEC STANDARDS MS-026AED-HD

NOTES
1. CENTER FIGURES ARE TYPICAL UNLESS OTHERWISE NOTED.
2. THE AD9411 HAS A CONDUCTIVE HEAT SLUG TO HELP DISSIPATE HEAT AND ENSURE RELIABLE OPERATION OF THE DEVICE OVER THE FULL INDUSTRIAL TEMPERATURE RANGE. THE SLUG IS EXPOSED ON THE BOTTOM OF THE PACKAGE AND ELECTRICALLY CONNECTED TO CHIP GROUND. IT IS RECOMMENDED THAT NO PCB SIGNAL TRACES OR VIAS BE LOCATED UNDER THE PACKAGE THAT COULD COME IN CONTACT WITH THE CONDUCTIVE SLUG. ATTACHING THE SLUG TO A GROUND PLANE WILL REDUCE THE JUNCTION TEMPERATURE OF THE DEVICE WHICH MAY BE BENEFICIAL IN HIGH TEMPERATURE ENVIRONMENTS.

Figure 77.100-Lead Thin Quad Flat Package, Exposed Pad [TQFP/EP]

(SV-100-1)

Dimensions shown in millimeters

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
AD9430BSV-170	–40°C to +85°C	100-Lead Thin Quad Flat Package, Exposed Pad [TQFP/EP]	SV-100-1
AD9430BSVZ-170[1]	–40°C to +85°C	100-Lead Thin Quad Flat Package, Exposed Pad [TQFP/EP]	SV-100-1
AD9430BSV-210	–40°C to +85°C	100-Lead Thin Quad Flat Package, Exposed Pad [TQFP/EP]	SV-100-1
AD9430BSVZ-210	–40°C to +85°C	100-Lead Thin Quad Flat Package, Exposed Pad [TQFP/EP]	SV-100-1
AD9430-CMOS/PCB		Evaluation Board (CMOS Mode) Shipped with –210 Grade	
AD9430-LVDS/PCB		Evaluation Board (LVDS Mode) Shipped with –210 Grade	

[1] Z = PB-free part.