



12-Bit, 20Msps, 3.3V, Low-Power ADC with Internal Reference

MAX1422

General Description

The MAX1422 3.3V, 12-bit analog-to-digital converter (ADC) features a fully differential input, pipelined, 12-stage ADC architecture with wideband track-and-hold (T/H) and digital error correction incorporating a fully-differential signal path. The MAX1422 is optimized for low-power, high dynamic performance applications in imaging and digital communications. The converter operates from a single 3.3V supply, consuming only 137mW while delivering a 67dB (typ) signal-to-noise ratio (SNR) at a 5MHz input frequency and a 20Msps sampling frequency. The fully-differential input stage has a small signal -3dB bandwidth of 400MHz and may be operated with single-ended inputs.

An internal 2.048V precision bandgap reference sets the ADCs full-scale range. A flexible reference structure accommodates an internally or externally applied buffered or unbuffered reference for applications requiring increased accuracy or a different input voltage range.

In addition to low operating power, the MAX1422 features two power-down modes, a reference power-down, and a shutdown mode. In reference power-down, the internal bandgap reference is deactivated, resulting in a 2mA (typ) supply current reduction. For idle periods, a full shutdown mode is available to maximize power savings.

The MAX1422 provides parallel, offset binary, CMOS-compatible three-state outputs.

The MAX1422 is available in a 7mm × 7mm × 1.4mm, 48-pin TQFP package and is specified over the commercial (0°C to +70°C) and extended industrial (-40°C to +85°C) temperature ranges.

Pin-compatible higher-speed versions of the MAX1422 are also available. Please refer to the MAX1421 data sheet for 40Msps and the MAX1420 data sheet for 60Msps.

Applications

- Medical Ultrasound Imaging
- CCD Pixel Processing
- Data Acquisition
- Radar
- IF and Baseband Digitization

Functional Diagram appears at end of data sheet.

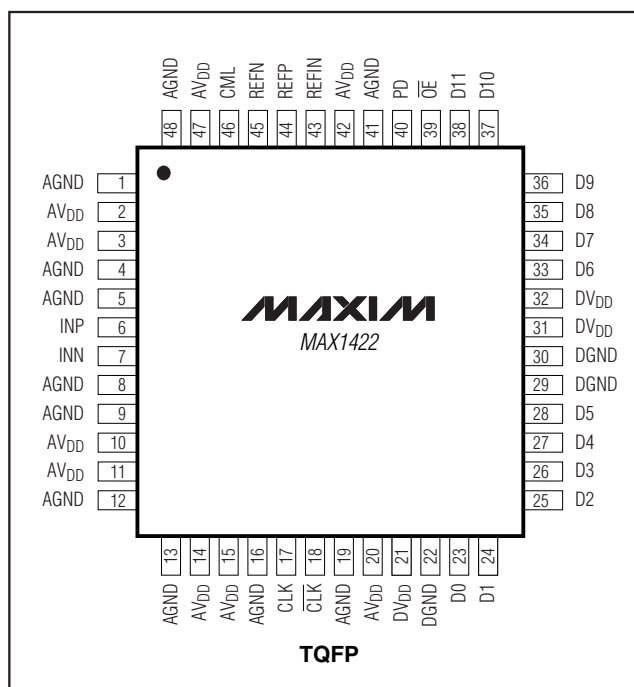
Features

- ◆ Single 3.3V Power Supply
- ◆ 67dB SNR at $f_{IN} = 5\text{MHz}$
- ◆ Internal 2.048V Precision Bandgap Reference
- ◆ Differential Wideband Input T/H Amplifier
- ◆ Power-Down Modes
 - 130mW (Reference Shutdown Mode)
 - 10μW (Shutdown Mode)
- ◆ Space-Saving 48-Pin TQFP Package

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX1422CCM	0°C to +70°C	48 TQFP
MAX1422ECM	-40°C to +85°C	48 TQFP

Pin Configuration



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ABSOLUTE MAXIMUM RATINGS

AVDD, DVDD to AGND-0.3V to +4V
 DVDD, AVDD to DGND-0.3V to +4V
 DGND to AGND-0.3V to +0.3V
 INP, INN, REFP, REFN, REFIN,
 CML, CLK, $\overline{\text{CLK}}$,(AGND - 0.3V) to (AVDD + 0.3V)
 D0–D11, $\overline{\text{OE}}$, PD(DGND - 0.3V) to (DVDD + 0.3V)
 Continuous Power Dissipation (TA = +70°C)

48-Pin TQFP (derate 21.7mW/°C above +70°C)1739mW
 Operating Temperature Ranges
 MAX1422CCM0°C to +70°C
 MAX1422ECM-40°C to +85°C
 Maximum Junction Temperature+150°C
 Storage Temperature Range-65°C to +150°C
 Lead Temperature (soldering, 10s)+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(VAVDD = VD VDD = 3.3V, AGND = DGND = 0, VIN = ±1.024V, differential input voltage at -0.5dBFS, internal reference, fCLK = 20MHz (50% duty cycle); digital output load CL = 10pF, ≥+25°C guaranteed by production test, <+25°C guaranteed by design and characterization. Typical values are at TA = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC ACCURACY						
Resolution	RES			12		Bits
Differential Nonlinearity	DNL	TA = +25°C, no missing codes	-1		1	LSB
		TA = TMIN to TMAX		±0.5		
Integral Nonlinearity	INL	TA = TMIN to TMAX		±2		LSB
Mid-scale Offset	MSO		-3	±.75	3	%FSR
Mid-scale Offset Temperature Coefficient	MSOTC			3 × 10 ⁻⁴		%/°C
Gain Error	GE	Internal reference (Note 1)	-5	±0.1	5	%FSR
		External reference applied to REFIN, (Note 2)	-5	±0.2	5	
		External reference applied to REFP, CML, and REFN (Note 3)	-1.5		1.5	
Gain Error Temperature Coefficient	GETC	External reference applied to REFP, CML, and REFN (Note 3)		15 × 10 ⁻⁶		%/°C
DYNAMIC PERFORMANCE (fCLK = 20MHz, 4096-point FFT)						
Signal-to-Noise Ratio	SNR	fIN = 5MHz, TA = +25°C	63	67		dB
Spurious-Free Dynamic Range	SFDR	fIN = 5MHz, TA = +25°C	64	74		dBc
Total Harmonic Distortion	THD	fIN = 5MHz, TA = +25°C		-72	-63	dBc
Signal-to-Noise and Distortion	SINAD	fIN = 5MHz, TA = +25°C	60	65		dB
Effective Number of Bits	ENOB	fIN = 5MHz		10.5		Bits
Two-Tone Intermodulation Distortion	IMD	fIN1 = 7.028MHz, fIN2 = 8.093MHz (Note 4)		-77		dBc
Differential Gain	DG			±1		%
Differential Phase	DP			±0.25		Degrees
ANALOG INPUTS (INP, INN, CML)						
Input Resistance	RIN	Either input to ground		61		kΩ
Input Capacitance	CIN	Either input to ground		4		pF
Common-Mode Input Level (Note 5)	VCML			VAVDD × 0.5		V

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ELECTRICAL CHARACTERISTICS (continued)

($V_{AVDD} = V_{DVDD} = 3.3V$, $AGND = DGND = 0$, $V_{IN} = \pm 1.024V$, differential input voltage at -0.5dBFS, internal reference, $f_{CLK} = 20MHz$ (50% duty cycle); digital output load $C_L = 10pF$, $\geq +25^\circ C$ guaranteed by production test, $< +25^\circ C$ guaranteed by design and characterization. Typical values are at $T_A = +25^\circ C$.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Common-Mode Input Voltage Range (Note 5)	V_{CMVR}			$V_{CML} \pm 5\%$		V
Differential Input Range	V_{IN}	$V_{INP} - V_{INN}$ (Note 6)		$\pm V_{DIFF}$		V
Small-Signal Bandwidth	BW_{-3dB}	(Note 7)		400		MHz
Large-Signal Bandwidth	$FPBW_{-3dB}$	(Note 7)		150		MHz
Overvoltage Recovery	OVR	$1.5 \times FS$ input		1		Clock cycles
INTERNAL REFERENCE (V_{REFIN} bypassed with 0.22 μF in parallel with 1nF)						
Common-Mode Reference Voltage	V_{CML}	At CML		$V_{AVDD} \times 0.5$		V
Positive Reference Voltage	V_{REFP}	At REFP		$V_{CML} + 0.512$		V
Negative Reference Voltage	V_{REFN}	At REFN		$V_{CML} - 0.512$		V
Differential Reference Voltage	V_{DIFF}	(Note 6)		$1.024 \pm 5\%$		V
Differential Reference Temperature Coefficient	REFTC			± 100		ppm/ $^\circ C$
EXTERNAL REFERENCE ($V_{REFIN} = 2.048V$)						
REFIN Input Resistance	R_{IN}	(Note 8)	5			k Ω
REFIN Input Capacitance	C_{IN}			10		pF
REFIN Reference Input Voltage Range	V_{REFIN}			$2.048 \pm 10\%$		V
Differential Reference Voltage Range	V_{DIFF}	(Note 6)	$0.92 \times V_{REFIN}/2$	$V_{REFIN}/2$	$1.08 \times V_{REFIN}/2$	V
EXTERNAL REFERENCE ($V_{REFIN} = 0$, reference voltage applied to REFP, REFN, and CML)						
REFP, REFN, CML Input Current	I_{IN}		-200		200	μA
REFP, REFN, CML Input Capacitance	C_{IN}			15		pF
Differential Reference Voltage Range	V_{DIFF}	(Note 6)		$1.024 \pm 10\%$		V
CML Input Voltage Range	V_{CML}			$1.65 \pm 10\%$		V
REFP Input Voltage Range	V_{REFP}			$V_{CML} + V_{DIFF}/2$		V
REFN Input Voltage Range	V_{REFN}			$V_{CML} - V_{DIFF}/2$		V
DIGITAL INPUTS (CLK, $\overline{CLK}$, PD, OE)						
Input Logic High	V_{IH}		$0.7 \times V_{DVDD}$			V
Input Logic Low	V_{IL}			$0.3 \times V_{DVD}$		V

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ELECTRICAL CHARACTERISTICS (continued)

($V_{AVDD} = V_{DVDD} = 3.3V$, $AGND = DGND = 0$, $V_{IN} = \pm 1.024V$, differential input voltage at -0.5dBFS, internal reference, $f_{CLK} = 20MHz$ (50% duty cycle); digital output load $C_L = 10pF$, $\geq +25^\circ C$ guaranteed by production test, $< +25^\circ C$ guaranteed by design and characterization. Typical values are at $T_A = +25^\circ C$.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Current		CLK, $\overline{CLK}$		± 330		μA
		PD	-20		20	
		$\overline{OE}$	-20		20	
Input Capacitance				10		pF
DIGITAL OUTPUTS (D0–D11)						
Output Logic High	V_{OH}	$I_{OH} = 200\mu A$	$V_{DVDD} - 0.5$		V_{DVDD}	V
Output Logic Low	V_{OL}	$I_{OL} = -200\mu A$	0		0.5	V
Three-State Leakage			-10		10	μA
Three-State Capacitance				2		pF
POWER REQUIREMENTS						
Analog Supply Voltage	V_{AVDD}		3.138	3.3	3.465	V
Digital Supply Voltage	V_{DVDD}		2.7	3.3	3.63	V
Analog Supply Current	I_{AVDD}			39	46	mA
Analog Supply Current with Internal Reference in Shutdown		$V_{REFIN} = 0$		37	44	mA
Analog Shutdown Current		$PD = DVDD$			20	μA
Digital Supply Current	I_{DVDD}			3		mA
Digital Shutdown Current		$PD = DVDD$			20	μA
Power Dissipation	P_{DISS}	Analog power dissipation		137	152	mW
Power-Supply Rejection Ratio	PSRR	(Note 9)		± 1		mV/V
TIMING CHARACTERISTICS						
Maximum Clock Frequency	f_{CLK}	Figure 6	20			MHz
Clock High	t_{CH}	Figure 6, clock period 50ns		25		ns
Clock Low	t_{CL}	Figure 6, clock period 50ns		25		ns
Pipeline Delay (Latency)		Figure 6		7		Clock cycles
Aperture Delay	t_{AD}	Figure 10		2		ns
Aperture Jitter	t_{AJ}	Figure 10		2		ps
Data Output Delay	t_{OD}	Figure 6	5	10	14	ns
Bus Enable Time	t_{BE}	Figure 5		5		ns
Bus Disable Time	t_{BD}	Figure 5		5		ns

Note 1: Internal reference, REFIN bypassed to AGND with a combination of 0.22 μF in parallel with 1nF capacitor.

Note 2: External 2.048V reference applied to REFIN.

Note 3: Internal reference disabled. $V_{REFIN} = 0$, $V_{REFP} = 2.162V$, $V_{CML} = 1.65V$, and $V_{REFN} = 1.138V$.

Note 4: IMD is measured with respect to either of the fundamental tones.

Note 5: Specifies the common-mode range of the differential input signal supplied to the MAX1422.

Note 6: $V_{DIFF} = V_{REFP} - V_{REFN}$.

Note 7: Input bandwidth is measured at a 3dB level.

Note 8: V_{REFIN} is internally biased to 2.048V through a 10k Ω resistor.

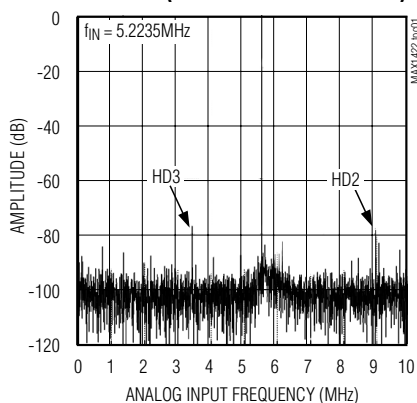
Note 9: Measured as the ratio of the change in mid-scale offset voltage for a $\pm 5\%$ change in V_{AVDD} , using the internal reference.

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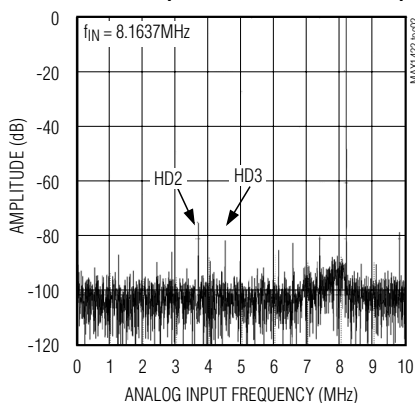
Typical Operating Characteristics

($V_{AVDD} = V_{DVDD} = 3.3V$, $AGND = DGND = 0$, $V_{IN} = \pm 1.024V$, differential input drive, $A_{IN} = -0.5dBFS$, $f_{CLK} = 20MHz$ (50% duty cycle) digital output load $C_L = 10pF$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

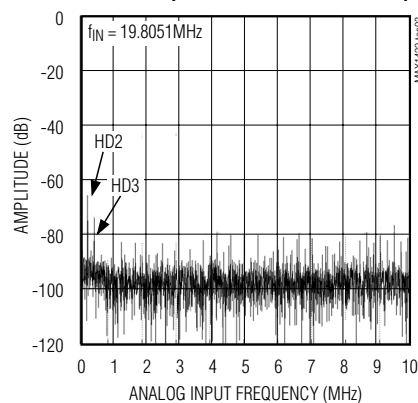
FFT PLOT (4096-POINT DATA RECORD)



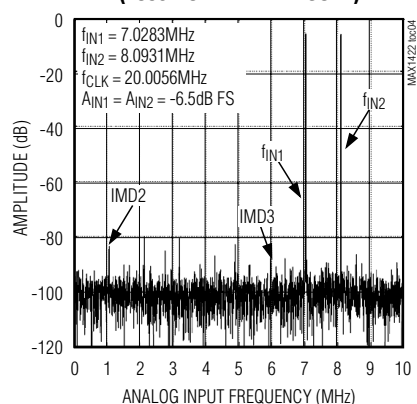
FFT PLOT (4096-POINT DATA RECORD)



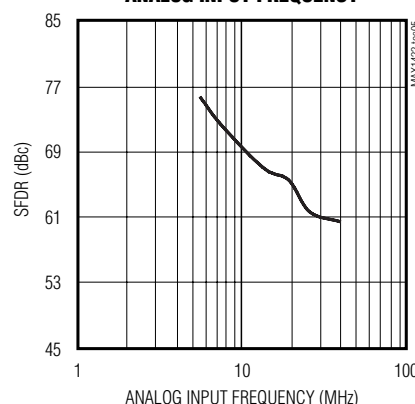
FFT PLOT (4096-POINT DATA RECORD)



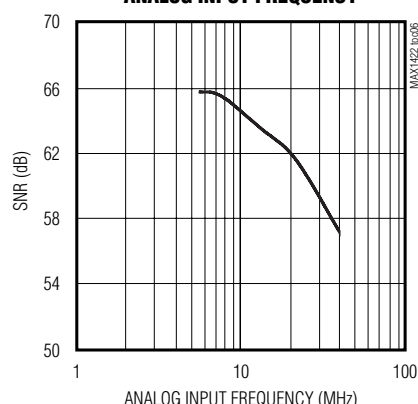
**TWO-TONE IMD PLOT
(4096-POINT DATA RECORD)**



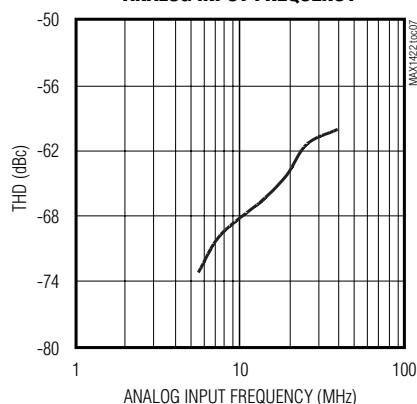
**SPURIOUS-FREE DYNAMIC RANGE vs.
ANALOG INPUT FREQUENCY**



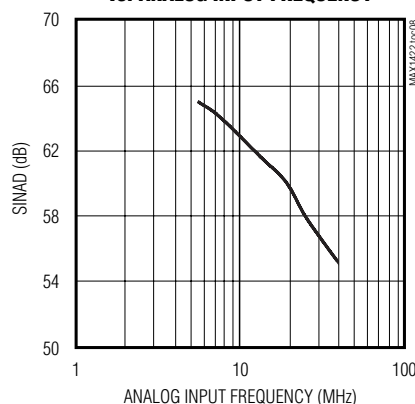
**SIGNAL-TO-NOISE RATIO vs.
ANALOG INPUT FREQUENCY**



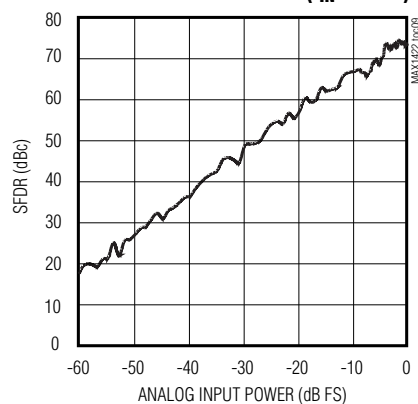
**TOTAL HARMONIC DISTORTION vs.
ANALOG INPUT FREQUENCY**



**SIGNAL-TO-NOISE PLUS DISTORTION
vs. ANALOG INPUT FREQUENCY**



**SPURIOUS-FREE DYNAMIC RANGE
vs. ANALOG INPUT POWER ($f_{IN} = 5MHz$)**

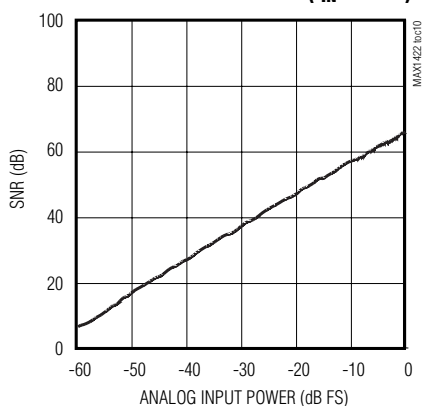


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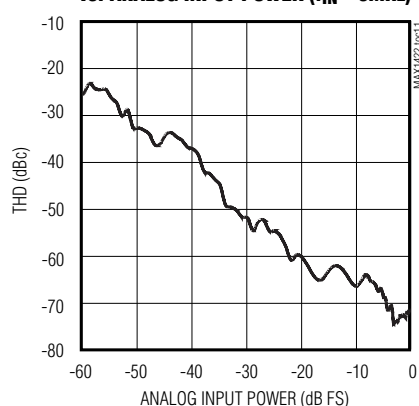
Typical Operating Characteristics (continued)

($V_{AVDD} = V_{DVDD} = 3.3V$, $AGND = DGND = 0$, $V_{IN} = \pm 1.024V$, differential input drive, $A_{IN} = -0.5dBFS$, $f_{CLK} = 20MHz$ (50% duty cycle) digital output load $C_L = 10pF$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

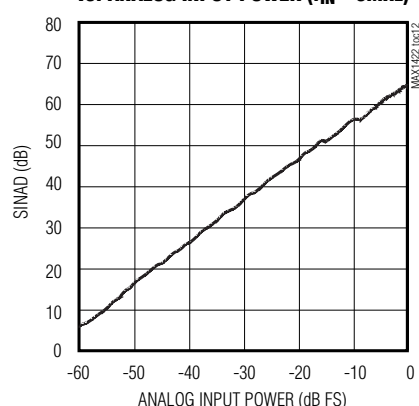
**SIGNAL-TO-NOISE RATIO
vs. ANALOG INPUT POWER ($f_{IN} = 5MHz$)**



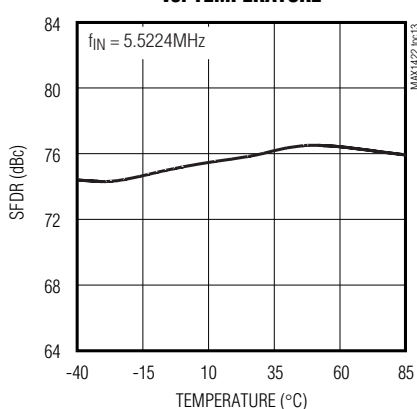
**TOTAL HARMONIC DISTORTION
vs. ANALOG INPUT POWER ($f_{IN} = 5MHz$)**



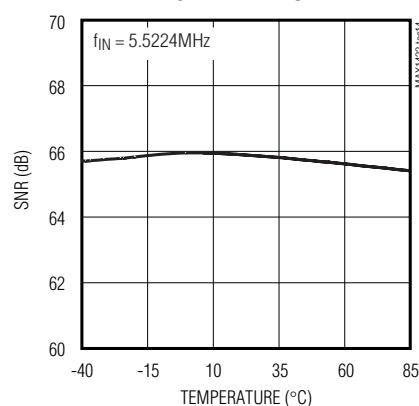
**SIGNAL-TO-NOISE PLUS DISTORTION
vs. ANALOG INPUT POWER ($f_{IN} = 5MHz$)**



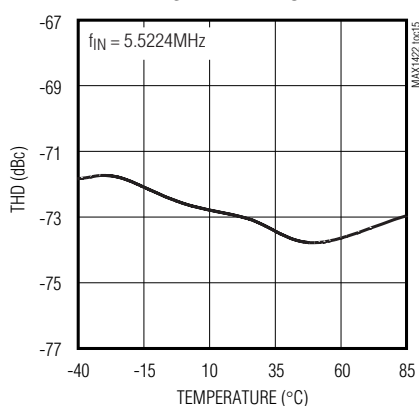
**SPURIOUS-FREE DYNAMIC RANGE
vs. TEMPERATURE**



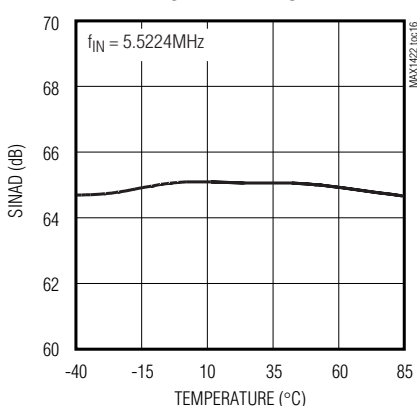
**SIGNAL-TO-NOISE RATIO
vs. TEMPERATURE**



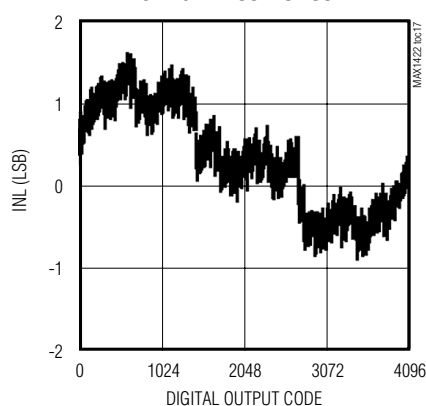
**TOTAL HARMONIC DISTORTION
vs. TEMPERATURE**



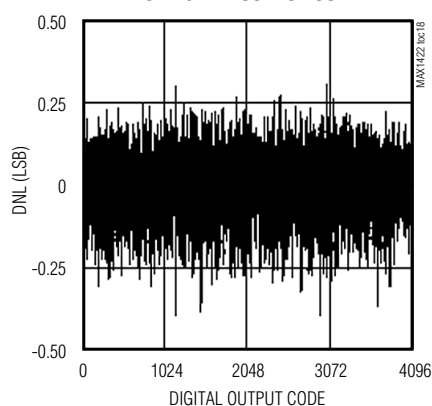
**SIGNAL-TO-NOISE PLUS DISTORTION
vs. TEMPERATURE**



**INTEGRAL NONLINEARITY
vs. DIGITAL OUTPUT CODE**



**DIFFERENTIAL NONLINEARITY
vs. DIGITAL OUTPUT CODE**



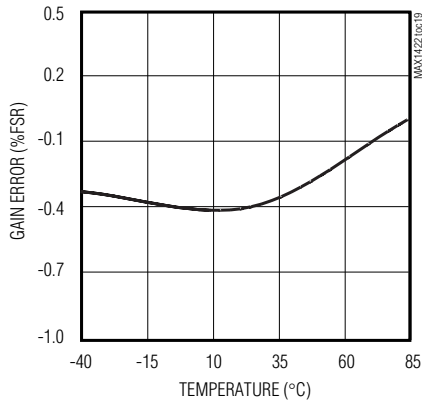
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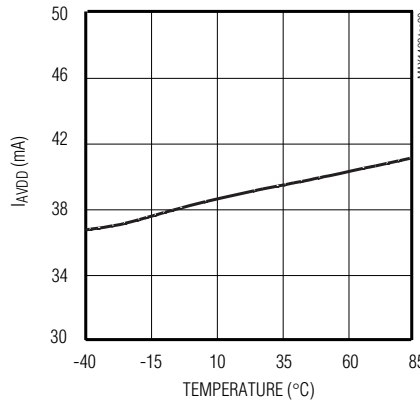
Typical Operating Characteristics (continued)

($V_{AVDD} = V_{DVDD} = 3.3V$, $AGND = DGND = 0$, $V_{IN} = \pm 1.024V$, differential input drive, $A_{IN} = -0.5dBFS$, $f_{CLK} = 20MHz$ (50% duty cycle) digital output load $C_L = 10pF$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ C$.)

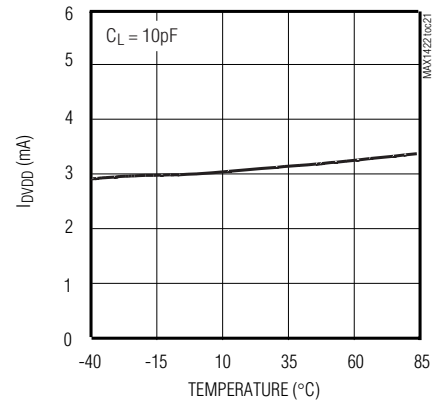
**GAIN ERROR vs. TEMPERATURE,
EXTERNAL REFERENCE ($V_{REFIN} = 2.048V$)**



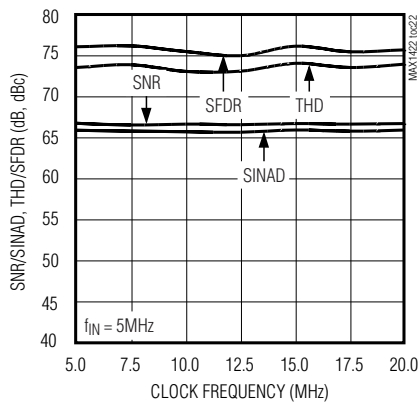
**ANALOG SUPPLY CURRENT
vs. TEMPERATURE**



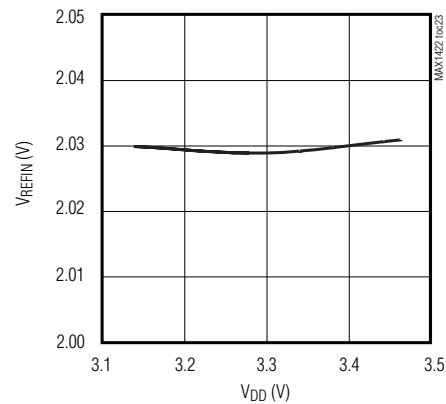
**DIGITAL SUPPLY CURRENT
vs. TEMPERATURE**



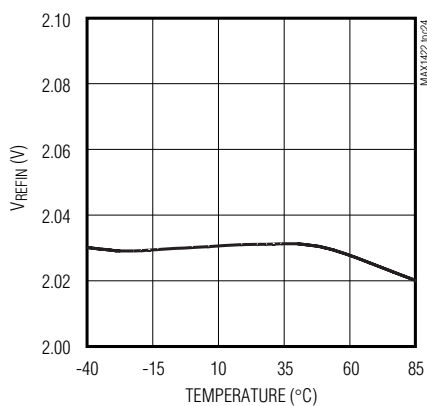
**SNR/SINAD, THD/SFDR
vs. CLOCK FREQUENCY**



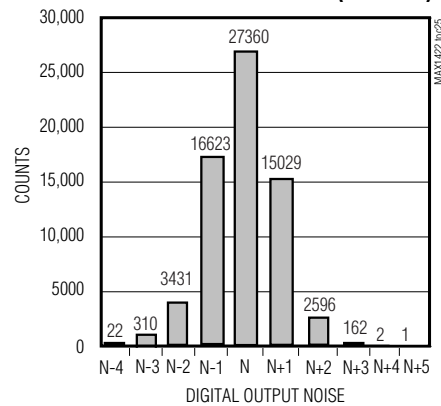
**INTERNAL REFERENCE VOLTAGE
vs. ANALOG SUPPLY VOLTAGE**



**INTERNAL REFERENCE VOLTAGE
vs. TEMPERATURE**



OUTPUT NOISE HISTOGRAM (DC-INPUT)



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Pin Description

PIN	NAME	FUNCTION
1, 4, 5, 8, 9, 12, 13, 16, 19, 41, 48	AGND	Analog Ground. Connect all return paths for analog signals to AGND.
2, 3, 10, 11, 14, 15, 20, 42, 47	AV _{DD}	Analog Supply Voltage. For optimum performance, bypass to the closest AGND with a parallel combination of a 0.1μF, and a 1nF capacitor. Connect a single 10μF and 1μF capacitor combination between AV _{DD} and AGND.
6	INP	Positive Analog Signal Input
7	INN	Negative Analog Signal Input
17	CLK	Clock Frequency Input. Clock frequency input ranges from 100kHz to 20MHz.
18	$\overline{\text{CLK}}$	Complementary Clock Frequency Input. This input is used for differential clock input. If the ADC is driven with a single-ended clock, bypass $\overline{\text{CLK}}$ with 0.1μF capacitor to AGND.
21, 31, 32	DV _{DD}	Digital Supply Voltage. For optimum performance, bypass to the closest DGND with a parallel combination of a 0.1μF and a 1nF capacitor. Connect a single 10μF and 1μF capacitor combination between DV _{DD} and DGND.
22, 29, 30	DGND	Digital Ground
23–28	D0–D5	Digital Data Outputs. Data bits D0 through D5, where D0 represents the LSB.
33–38	D6–D11	Digital Data Outputs. D6 through D11, where D11 represents the MSB.
39	$\overline{\text{OE}}$	Output Enable Input. A logic "1" on $\overline{\text{OE}}$ places the outputs D0–D11 into a high-impedance state. A logic "0" allows for the data bits to be read from the outputs.
40	PD	Shutdown Input. A logic "1" on PD places the ADC into shutdown mode.
43	REFIN	External Reference Input. Bypass to AGND with a capacitor combination of 0.22μF in parallel with 1nF. REFIN can be biased externally to adjust reference levels and calibrate full-scale errors. To disable the internal reference, connect REFIN to AGND.
44	REFP	Positive Reference I/O. Bypass to AGND with a capacitor combination of 0.22μF in parallel with 1nF. With the internal reference disabled (REFIN = AGND), REFP should be biased to $V_{\text{CML}} + V_{\text{DIFF}}/2$.
45	REFN	Negative Reference I/O. Bypass to AGND with a capacitor combination of 0.22μF in parallel with 1nF. With the internal reference disabled (REFIN = AGND), REFN should be biased to $V_{\text{CML}} - V_{\text{DIFF}}/2$.
46	CML	Common-Mode Level Input. Bypass to AGND with a capacitor combination of 0.22μF in parallel with 1nF. With the internal reference disabled (REFIN = AGND), CML accepts an external voltage of $1.65\text{V} \pm 10\%$.

Detailed Description

The MAX1422 uses a 12-stage, fully differential, pipelined architecture (Figure 1), that allows for high-speed conversion while minimizing power consumption. Each sample moves through a pipeline stage every half-clock cycle. Including the delay through the output latch, the latency is seven clock cycles.

A 2-bit (2-comparator) flash ADC converts the held-input voltage into a digital code. The following digital-

to-analog converter (DAC) converts the digitized result back into an analog voltage, which is then subtracted from the original held-input signal. The resulting error signal is then multiplied by two and the product is passed along to the next pipeline stage. This process is repeated until the signal has been processed by all 12 stages. Each stage provides a 1-bit resolution. Digital error correction compensates for ADC comparator offsets in each pipeline stage and ensures no missing codes.

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In unbuffered external reference mode, REFIN is connected to AGND, which deactivates the on-chip buffers of REFP, CML, and REFN. With their buffers shut down,

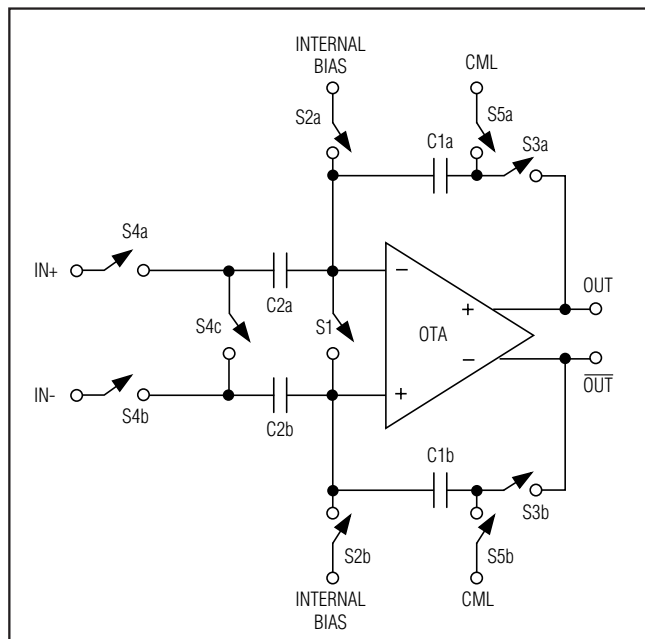


Figure 2. Internal T/H Circuit

12-Bit, 20Mps, 3.3V, Low-Power ADC with Internal Reference

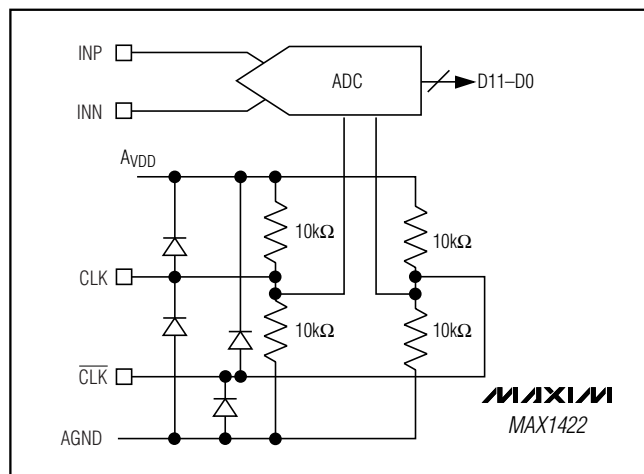


Figure 4. Simplified Clock Input Circuit

log portion of the MAX1421, thereby degrading its dynamic performance. The use of digital buffers (e.g. 74LVCH16244) on the digital outputs of the ADCs can further isolate the digital outputs from heavy capacitive loads. To further improve the MAX1422 dynamic performance, add small 100Ω series resistors to the digital output paths, close to the ADC. Figure 5 displays the timing relationship between output enable and data output.

System Timing Requirements

Figure 6 depicts the relationship between the clock input, analog input, and data output. The MAX1422 samples the analog input signal on the rising edge of CLK (falling edge of $\overline{\text{CLK}}$), and output data is valid seven clock cycles (latency) later. Figure 6 also displays the relationship between the input clock parameters and the valid output data.

Applications Information

Figure 7 depicts a typical application circuit containing a single-ended to differential converter. The internal reference provides an $\text{AV}_{\text{DD}}/2$ output voltage for level-shifting purposes. The input is buffered and then split to a voltage follower and inverter. A lowpass filter at the input suppresses some of the wideband noise associated with high-speed op amps. Select the R_{ISO} and C_{IN} values to optimize the filter performance and to suit a particular application. For the application in Figure 7, a R_{ISO} of 50Ω is placed before the capacitive load to prevent ringing and oscillation. The 22pF C_{IN} capacitor acts as a small bypassing capacitor. Connecting C_{IN} from INN to INP may further improve dynamic performance.

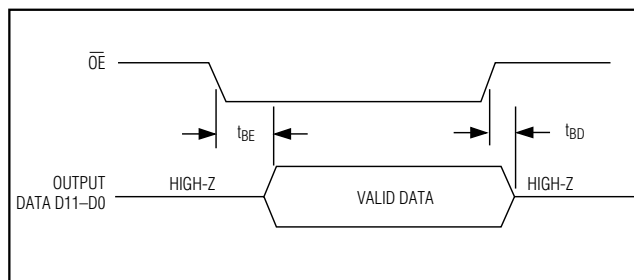


Figure 5. Output Enable Timing

Table 1. MAX1422 Output Code For Differential Inputs

DIFFERENTIAL INPUT VOLTAGE*	DIFFERENTIAL INPUT	OFFSET BINARY
$V_{\text{REF}} \times 2047/2048$	+FULL SCALE - 1LSB	1111 1111 1111
$V_{\text{REF}} \times 2046/2048$	+FULL SCALE - 2LSB	1111 1111 1110
$V_{\text{REF}} \times 1/2048$	+1 LSB	1000 0000 0001
0	Bipolar Zero	1000 0000 0000
$-V_{\text{REF}} \times 1/2048$	-1 LSB	0111 1111 1111
$-V_{\text{REF}} \times 2046/2048$	-FULL SCALE +1 LSB	0000 0000 0001
$-V_{\text{REF}} \times 2047/2048$	-FULL SCALE	0000 0000 0000

* $V_{\text{REF}} = V_{\text{REFP}} - V_{\text{REFN}}$

Using Transformer Coupling

An RF transformer (Figure 8) provides an excellent solution to convert a single-ended signal to a fully differential signal, required by the MAX1422 for optimum performance. Connecting the center tap of the transformer to CML provides an $\text{AV}_{\text{DD}}/2$ DC level shift to the input. Although a 1:1 transformer is shown, a 1:2 or 1:4 step-up transformer may be selected to reduce the drive requirements.

In general, the MAX1422 provides better SFDR and THD with fully differential input signals over single-ended input signals, especially for very high input frequencies. In differential input mode, even-order harmonics are suppressed and each of the inputs requires only half the signal swing compared to single-ended mode.

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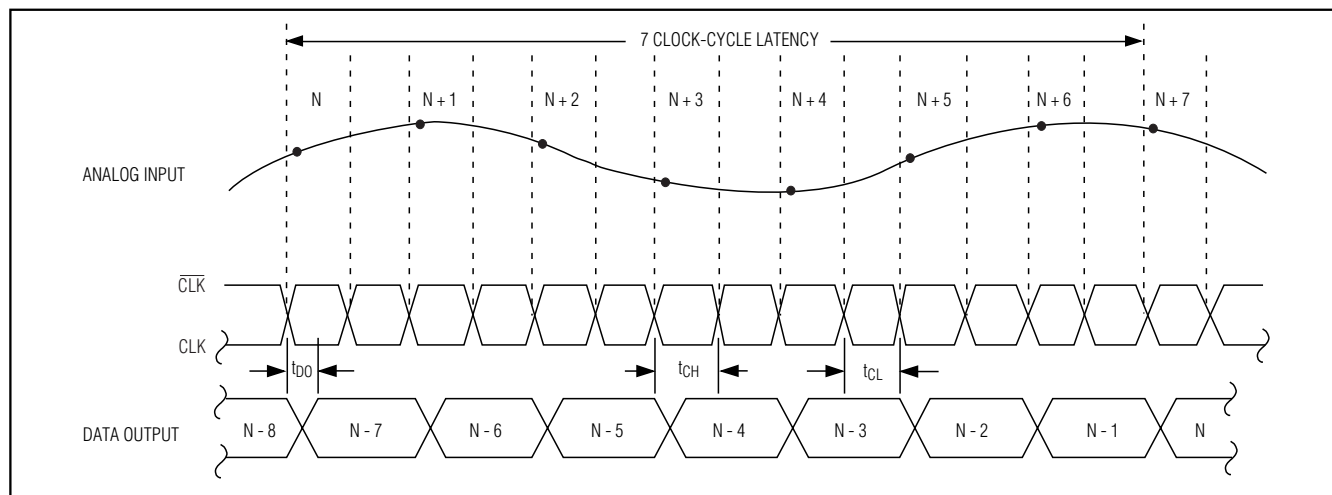


Figure 6. System and Output Timing Diagram

Single-Ended, AC-Coupled Input Signal

Figure 9 shows an AC-coupled, single-ended application, using a MAX4108 op amp. This configuration provides high-speed, high-bandwidth, low noise, and low distortion to maintain the integrity of the input signal.

Grounding, Bypassing and Board Layout

The MAX1422 requires high-speed board layout design techniques. Locate all bypass capacitors as close to the device as possible, preferably on the same side of the board as the ADC, using surface-mount devices for minimum inductance. Bypass REFP, REFN, REFIN, and CML with a parallel network of 0.22 μ F capacitors and 1nF to AGND. AVDD should be bypassed with a similar network of a 10 μ F bipolar capacitor in parallel with two ceramic capacitors of 1nF and 0.1 μ F. Follow the same rules to bypass the digital supply DVDD to DGND. Multilayer boards with separate ground and power planes produce the highest level of signal integrity. Consider the use of a split ground plane arrangement to match the physical location of the analog ground (AGND) and the digital output driver ground (DGND) on the ADCs package. The two ground planes should be joined at a single point such that the noisy digital ground currents do not interfere with the analog ground plane. Alternatively, all ground pins could share the

same ground plane if the ground plane is sufficiently isolated from any noisy, digital systems ground plane (e.g., downstream output buffer DSP ground plane). Route high-speed digital signal traces away from sensitive analog traces, and remove digital ground and power planes from underneath digital outputs. Keep all signal lines short and free of 90 degree turns.

Static Parameter Definitions

Integral Nonlinearity (INL)

Integral nonlinearity is the deviation of the values on an actual transfer function from a straight line. This straight-line can be either a best straight-line fit or a line drawn between the endpoints of the transfer function, once offset and gain errors have been nullified. The static linearity parameters for the MAX1422 are measured using the best straight-line fit method.

Differential Nonlinearity (DNL)

Differential nonlinearity is the difference between an actual step-width and the ideal value of 1LSB. A DNL error specification of less than 1LSB guarantees no missing codes.

Dynamic Parameter Definitions

Aperture Jitter

Figure 10 depicts the aperture jitter (t_{AJ}), which is the sample-to-sample variation in the aperture delay.

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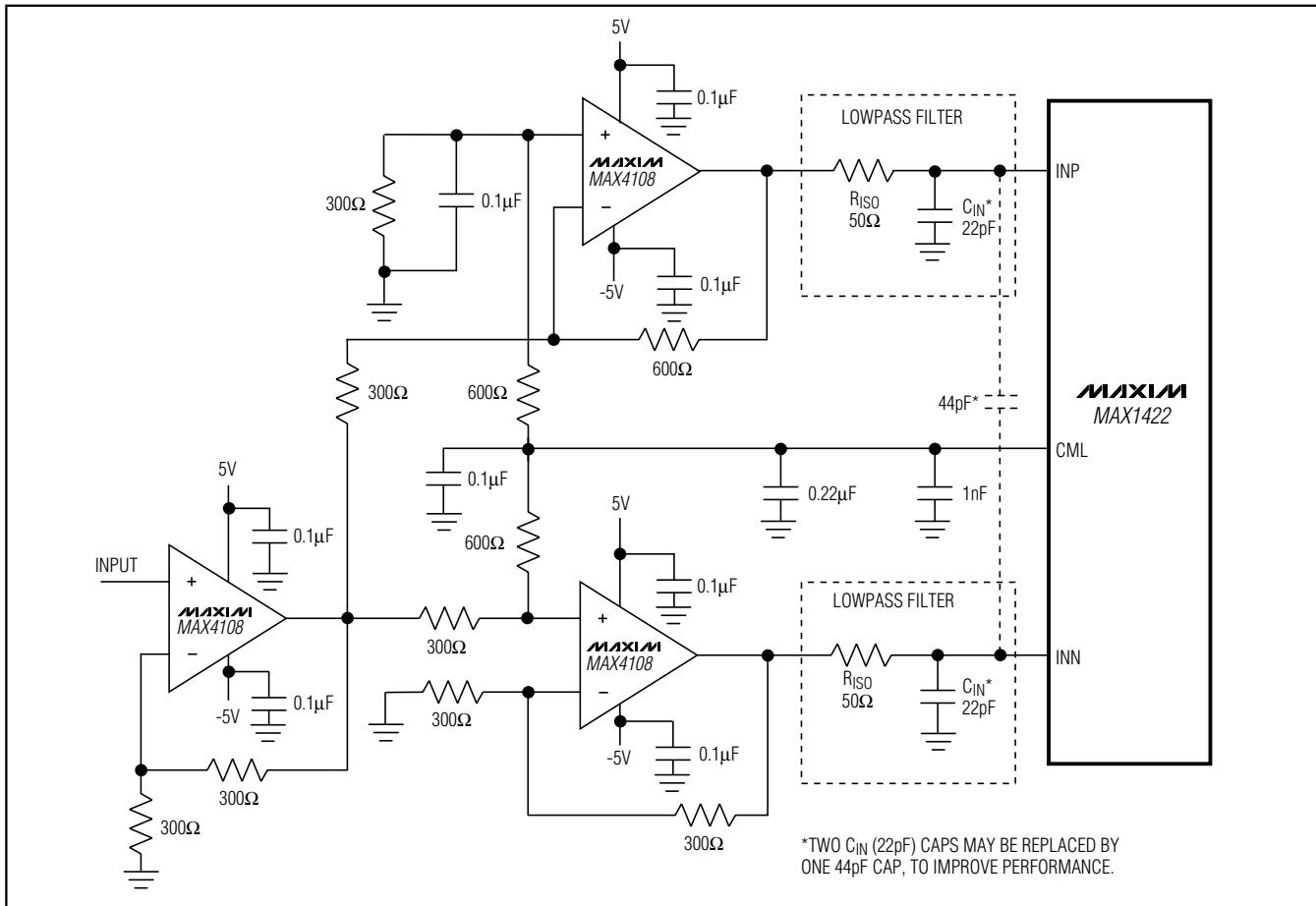


Figure 7. Typical Application Circuit for Single-Ended to Differential Conversion

Aperture Delay

Aperture delay (t_{AD}) is the time defined between the falling edge of the sampling clock and the instant when an actual sample is taken (Figure 10).

Signal-to-Noise Ratio (SNR)

For a waveform perfectly reconstructed from digital samples, the theoretical maximum SNR is the ratio of the full-scale analog input (RMS value) to the RMS quantization error (residual error). The ideal, theoretical, minimum analog-to-digital noise is caused by quantization error only and results directly from the ADCs resolution (N-Bits):

$$SNR_{(MAX)} = (6.02 \times N + 1.76)dB$$

In reality, there are other noise sources besides quantization noise e.g., thermal noise, reference noise, clock jitter, etc. SNR is computed by taking the ratio of the

RMS signal to the RMS noise, which includes all spectral components minus the fundamental, the first four harmonics, and the DC offset.

Signal-to-Noise Plus Distortion (SINAD)

SINAD is computed by taking the ratio of the RMS signal to all spectral components minus the fundamental and the DC offset.

Effective Number of Bits (ENOB)

ENOB specifies the dynamic performance of an ADC at a specific input frequency and sampling rate. An ideal ADCs error consists of quantization noise only. ENOB is computed from:

$$ENOB = \frac{SINAD - 1.76}{6.02}$$

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Total Harmonic Distortion (THD)

THD is typically the ratio of the RMS sum of the first four harmonics of the input signal to the fundamental itself. This is expressed as:

$$\left(\text{THD} = 20 \times \log_{10} \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + V_5^2}}{V_1} \right)$$

where V_1 is the fundamental amplitude, and V_2 through V_5 are the amplitudes of the 2nd- through 5th-order harmonics.

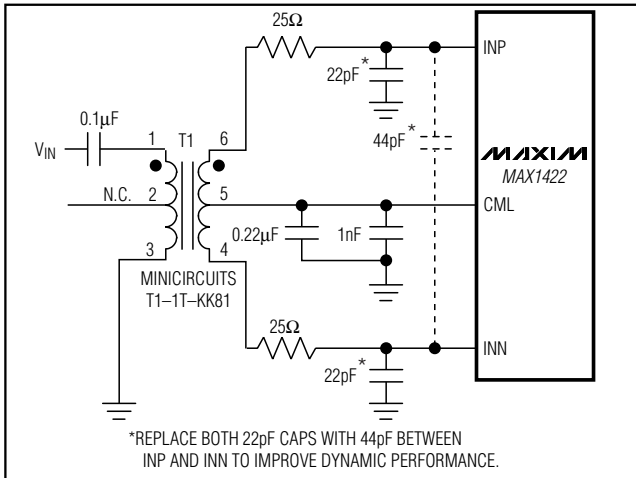


Figure 8. Using a Transformer for AC-Coupling

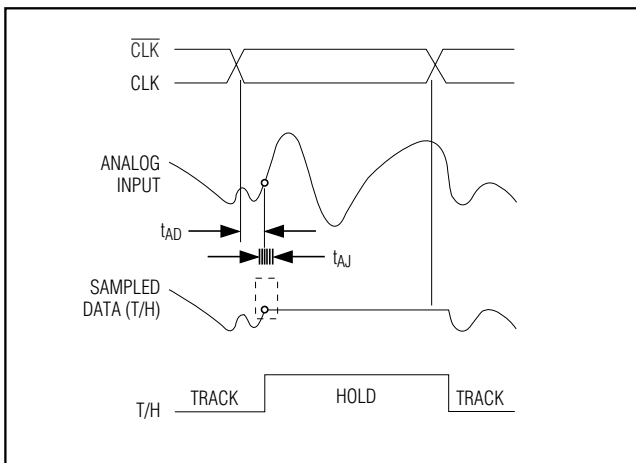


Figure 10. T/H Aperture Timing

Spurious-Free Dynamic Range (SFDR)

SFDR is the ratio expressed in decibels of the RMS amplitude of the fundamental (maximum signal component) to the RMS value of the next largest spurious component, excluding DC offset.

Intermodulation Distortion (IMD)

The two-tone IMD is the ratio expressed in decibels of either input tone to the worst 3rd-order (or higher) intermodulation products. The individual input tone levels are at -6.5dB full scale.

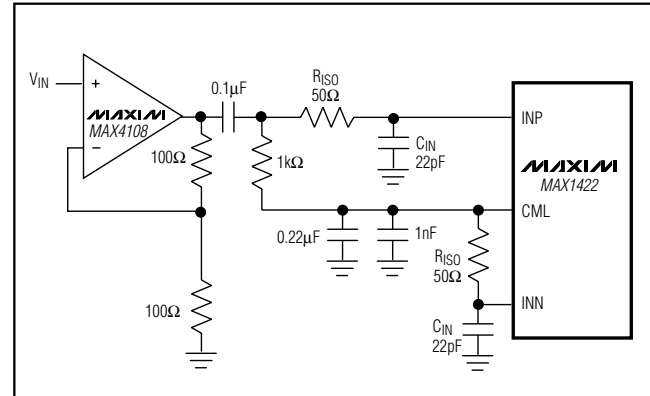
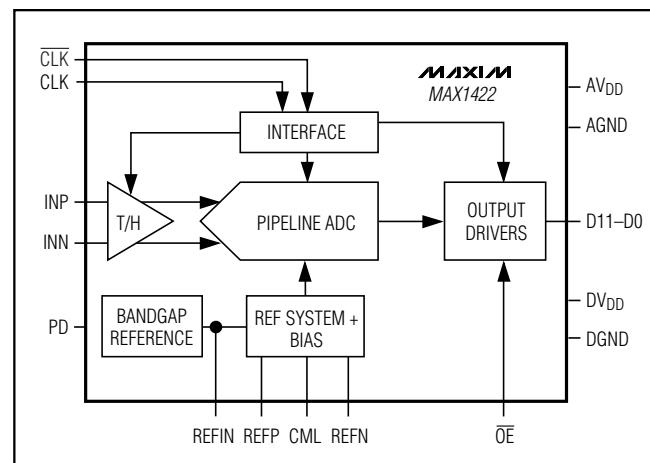


Figure 9. Single-Ended AC-Coupled Input

Functional Diagram

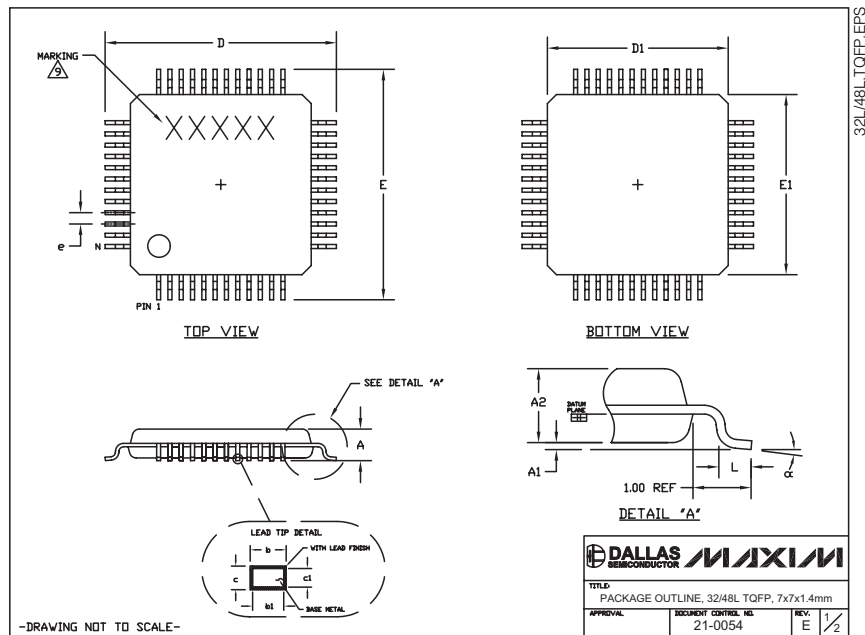


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Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to www.maxim-ic.com/packages.)

MAX1422



NOTES:

1. ALL DIMENSIONING AND TOLERANCING CONFORM TO ANSI Y14.5-1982.
2. DATUM PLANE $\square\square\square$ IS LOCATED AT MOLD PARTING LINE AND COINCIDENT WITH LEAD, WHERE LEAD EXITS PLASTIC BODY AT BOTTOM OF PARTING LINE.
3. DIMENSIONS D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE MOLD PROTRUSION IS 0.25 MM ON D1 AND E1 DIMENSIONS.
4. THE TOP OF PACKAGE IS SMALLER THAN THE BOTTOM OF PACKAGE BY 0.15 MILLIMETERS.
5. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 MM TOTAL IN EXCESS OF THE b DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. ALL DIMENSIONS ARE IN MILLIMETERS.
7. THIS OUTLINE CONFORMS TO JEDEC PUBLICATION 95, REGISTRATION MS-026.
8. LEADS SHALL BE COPLANAR WITHIN .004 INCH.
9. MARKING SHOWN IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
10. NUMBER OF LEADS ARE SHOWN FOR REFERENCE ONLY.

	JEDEC VARIATION			
	BBA		BBC	
	MIN.	MAX.	MIN.	MAX.
A	--	1.60	--	1.60
A1	0.05	0.15	0.05	0.15
A2	1.35	1.45	1.35	1.45
D	8.90	9.10	8.90	9.10
D1	6.90	7.10	6.90	7.10
E	8.90	9.10	8.90	9.10
E1	6.90	7.10	6.90	7.10
e	0.8	BSC.	0.5	BSC.
L	0.45	0.75	0.45	0.75
b	0.30	0.45	0.17	0.27
b1	0.30	0.40	0.17	0.23
c	0.09	0.20	0.09	0.20
cl	0.09	0.16	0.09	0.16
N	32		48	
alpha	0°	7°	0°	7°

-DRAWING NOT TO SCALE-

 DALLAS SEMICONDUCTOR			
TITLE: PACKAGE OUTLINE, 32/48L TQFP, 7x7x1.4mm			
APPROVAL:	DOCUMENT CONTROL NO. 21-0054	REV. E	2/2

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