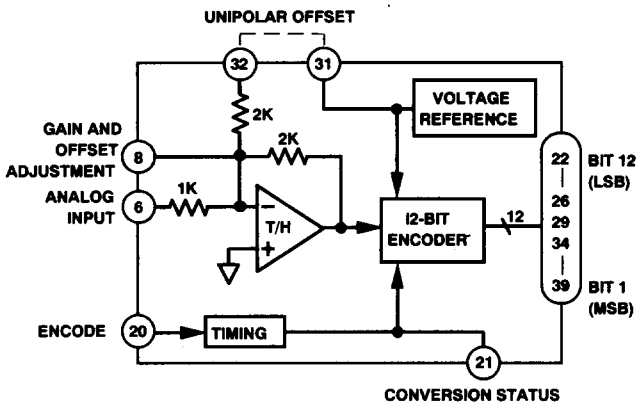
12-Bit, 1 MSPS A/D Converter

AD9003A

FEATURES
12-Bit Resolution
1 MSPS Word Rates
T/H and Timing Included
Low Power: 1.4 W

APPLICATIONS
Radar Systems
Digital Oscilloscopes
Analytical Instrumentation
High Resolution Imaging

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The AD9003A is a complete 12-bit, 1 MSPS analog-to-digital converter (ADC) which combines low cost and high performance in a single 40-pin board. The AD9003A is a pin-compatible replacement for the industry standard AD9003 hybrid. A monolithic encoder and a discrete track-and-hold are assembled in low cost surface mount technology to create a low power sampling ADC.

This high speed unit is capable of converting analog signals to the Nyquist limit at word rates through 1 MSPS. Its 1 μs conversion interval includes acquisition time for the internal T/H, making it a true 1 MSPS converter.

Unlike the original AD9003, output data is latched for the entire period. A conversion status signal simplifies transferring output data into external latches.

REV. 0

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AD9003A—SPECIFICATIONS (typical with nominal supplies, unless otherwise noted)

Parameter (Conditions)	Temperature	Test Level	AD9003A Min	AD9003A Typ	AD9003A Max	Units
RESOLUTION			12			Bits
LSB Weight				1.22		mV
STATIC ACCURACY						
Gain Error	+25°C	I		±0.15	±0.35	% FS
	Full	IV			±0.45	% FS
Bipolar Offset	+25°C	I		±8	±30	mV
	Full	IV			±40	mV
Unipolar Offset	+25°C	I		±8	±30	mV
	Full	IV			±40	mV
Differential Nonlinearity	+25°C	I		±0.7	±1.0	LSB
Integral Nonlinearity (Best Fit)	+25°C	I		±0.8	±1.5	LSB
	Full	IV			±1.5	LSB
No Missing Codes	Full	VI		Guaranteed		
DYNAMIC CHARACTERISTICS (Conversion Rate = 1.0 MSPS)[1]						
Harmonic Distortion[2]						
DC to 100 kHz	+25°C	I	74	82		dB
	Full	IV	72			dB
100 kHz to 500 kHz	+25°C	V		70		dB
Conversion Time (t_C)[3]	+25°C	I		475	560	ns
Effective Aperture Delay Time (t_A)	+25°C	IV	3	18	30	ns
Aperture Uncertainty (Jitter)	+25°C	V		20		ps, rms
Signal-to-Noise Ratio[4]	Full	VI	65	70		dB
Transient Response[5]	+25°C	V		350		ns
Overvoltage Recovery Time[6]	+25°C	V		700		ns
Two-Tone Intermodulation[7]	+25°C	V		87		dB
ANALOG INPUT						
Voltage Range (Full Scale)[8]	Full			5		V, p-p
Input Impedance	+25°C	I	990	1000	1010	Ω
	Full	IV	990	1000	1010	Ω
Input Bandwidth						
Small Signal, −3 dB[9]	+25°C	V		4.4		MHz
Large Signal, −3 dB[10]	+25°C	V		4.0		MHz
TEMPERATURE DRIFT						
Offset Temperature Coefficient						
Bipolar	Full	IV		±10	±35	ppm/°C
Unipolar	Full	IV		±10	±35	ppm/°C
Gain Temperature Coefficient	Full	IV		±15	±40	ppm/°C
Differential Linearity Tempco	Full	IV		±1.5	±3.5	ppm/°C
DIGITAL INPUTS						
Logic Compatibility	Full			TTL		
Logic "1" Voltage	Full	IV	+2.0		V_{CC}	V
Logic "0" Voltage	Full	IV	−0.5		+0.8	V
Encode Command[11]						
Input Current						
Logic "1"	Full	VI			1	μA
Logic "0"	Full	VI			−1.0	μA
Width	Full	IV	15			ns
Rate	Full	VI	dc		1.0	MSPS
Rise/Fall Times	Full	IV			10	ns
DIGITAL OUTPUTS						
Logic Compatibility	Full			TTL/CMOS		
Logic "1" Voltage	Full	VI	+2.4			V
Logic "0" Voltage	Full	VI			+0.4	V
Output Drive	Full			1 Standard TTL Load		
Format				Parallel		
Coding						
Unipolar Mode				Complementary Binary		
Bipolar Mode				Complementary Offset Binary		

Parameter (Conditions)	Temperature	Test Level	AD9003A Min	Typ	Max	Units
POWER REQUIREMENTS						
$+V_S$ Voltage	Full	IV	+14.5	+15.0	+15.5	V
$+V_S$ Current	Full	VI		18	24	mA
$-V_S$ Voltage	Full	IV	−14.5	−15.0	−15.5	V
$-V_S$ Current	Full	VI		60	76	mA
V_{CC} Voltage	Full	IV	+4.75	+5.0	+5.25	V
V_{CC} Current	Full	VI		49	62	mA
Power Dissipation	Full	VI		1.4	1.9	W
PSRR[12]	+25°C	V		45		dB

NOTES
[1]Converting faster than 1.0 MSPS is possible; however, acquisition time is reduced, which may increase distortion of high frequency analog signals.
[2]Harmonic distortion is expressed in dB below full scale (FS) in terms of spurious signals generated at 1.0 MSPS encode rate and single tone analog input in range shown.
[3]Measured from leading edge of encode command to trailing (rising) edge of conversion status signal (See Timing Diagram).
[4]RMS signal to rms noise ratio; analog input 1 dB below FS @ 100 kHz; 1.0 MSPS encode rate.
[5]For full-scale step input, 12-bit accuracy attained in specified time.
[6]Recovers to 12-bit accuracy in specified time after 1.4 × FS input overvoltage.
[7]Intermodulation measured in dB below FS at 1.0 MSPS encode rate with input frequencies of 75 kHz and 105 kHz; each 7 dB below FS.
[8]Voltage Range = ±2.5 V, or 0 V to −5.0 V.
[9]With analog input 40 dB below FS.
[10]With FS analog input. (Large-signal BW flat within 0.5 dB, dc to 500 kHz.)
[11]Transition from Logic "0" to Logic "1" initiates conversion.
[12]Power Supply Rejection Ratio (PSRR) is sensitivity of offset to V_{CC}. This is parameter which is most sensitive to variations in supply voltage.
Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS [1]

Supply Voltages
$\pm V_S$ . . . . . ±18 V
V_{CC} . . . . . −0.5 V to +6.5 V
Analog Input . . . . . −5.5 V to +3.5 V
Digital Input . . . . . −0.5 V to V_{CC}
Operating Temperature Range (Ambient) . . . . . 0°C to +70°C
Storage Temperature . . . . . −40°C to +85°C
Lead Soldering Temperature (10 sec) . . . . . +300°C

NOTE
[1]Absolute maximum ratings are limiting values to be applied individually, and beyond which the serviceability of the circuit may be impaired. Functional operability is not necessarily implied. Exposure to absolute maximum rating conditions for an extended period of time 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 – Periodically sample tested.
IV – Parameter is guaranteed by design and characterization testing.
V – Parameter is a typical value only.
VI – All devices are 100% production tested at +25°C; 100% production tested at temperature extremes for extended temperature devices; sample tested at temperature extremes for commercial/industrial devices.

PIN DESIGNATIONS

(As viewed from bottom)

Pin	Function	Pin	Function
40	GROUND	1	+5 V
39	BIT 1 (MSB)	2	REFERENCE BYPASS[1]
38	BIT 2	3	GROUND
37	BIT 3	4	GROUND
36	BIT 4	5	−15 V
35	BIT 5	6	ANALOG INPUT
34	BIT 6	7	NC
33	+5 V	8	GAIN & OFFSET ADJUST
32	UNIPOLAR OFFSET[1, 2]	9	GROUND
31	UNIPOLAR OFFSET[1, 2]	10	GROUND
30	+15 V	11	GROUND
29	BIT 7	12	GROUND
28	INTERNAL GND[3]	13	GROUND
27	INTERNAL GND[3]	14	GROUND
26	BIT 8	15	GROUND
25	BIT 9	16	GROUND
24	BIT 10	17	+5 V
23	BIT 11	18	GROUND
22	BIT 12 (LSB)	19	−15 V
21	CONVERSION STATUS	20	ENCODE COMMAND

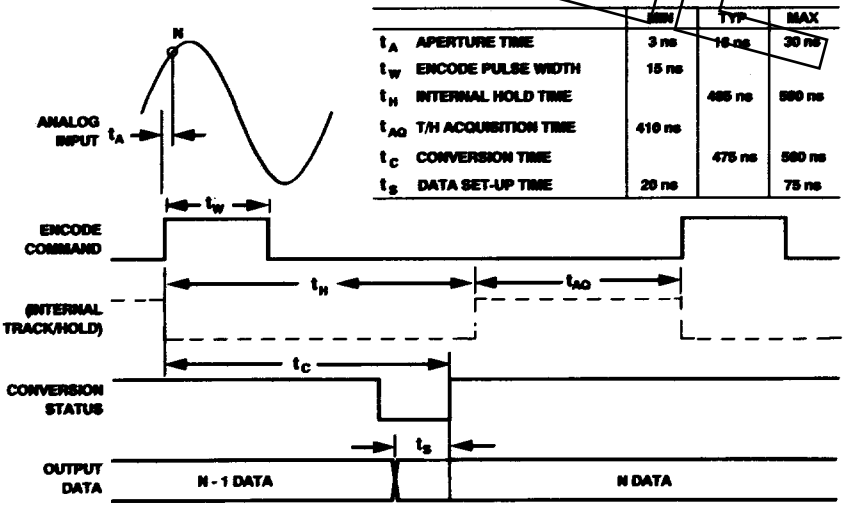
NOTES

1. Pins 2 and 31 must be bypassed to ground with 0.1 μF for optimum performance.
2. For unipolar operation, connect Pins 31 and 32; for bipolar operation, ground Pin 32 and bypass Pin 31 to ground with 0.1 μF.
3. Pins 27 and 28 may be connected together to comply with original AD9003 pinouts.

AD9003A TIMING

The user-provided ENCODE command puts the track-and-hold (T/H) into the "hold" mode. Typically, the internal encoder requires 475 ns to make the 12-bit-accurate conversion of the analog input signal. The conversion status signal indicates when this process is complete and returns the T/H to the "track" mode of operation.

Process variations within the encoder typically result in a hold time of 485 ns, but this interval can be as long as 590 ns. Even assuming worst-case variations, there are still 410 ns of acquisition time at 1 MSPS (1/1,000) conversion rates. Higher encode rates are possible but may cause distortion in high frequency analog signals because of reduced acquisition time. Acquisition times less than the 410 ns cited here will not allow the T/H to acquire signals with sufficient accuracy to maintain the rated dynamic performance.



		MIN	TYP	MAX
t_A	APERTURE TIME	3 ns	15 ns	30 ns
t_W	ENCODE PULSE WIDTH	15 ns		
t_H	INTERNAL HOLD TIME		485 ns	590 ns
t_{AQ}	T/H ACQUISITION TIME	410 ns		
t_C	CONVERSION TIME		475 ns	590 ns
t_S	DATA SET-UP TIME	20 ns		75 ns

Figure 1. AD9003A Timing Diagram

SETTING GAIN AND OFFSET

Varying gain and offset for the AD9003A enhances performance of the unit and increases its flexibility in applications. One suggested method of obtaining approximately ±5% variation in each is shown in Figure 2.

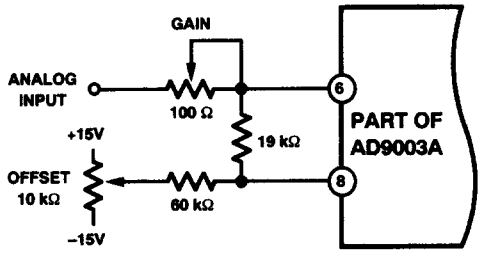


Figure 2. AD9003A Gain and Offset

The AD9003A can be operated in a unipolar mode or a bipolar mode; strap options and adjustments of the external controls shown in Figure 2 determine which is used. When calibrating for either mode, apply an encode command at the word rate frequency of the system to Pin 20.

Connect a precision voltage source between the ANALOG INPUT connection shown in Figure 2 and ground. Set its output for the voltage shown in Table I as being equal to −FS +1/2 LSB for the input range to be used (− 0.6 mV for unipolar operation and +2.4994 V for bipolar operation if using the full-scale 5 volt input range of the AD9003A).

Adjust the OFFSET control for a digital output which "dithers" between 0000 0000 0000 and 0000 0000 0001.

To set gain, readjust the output of the voltage reference source to the value shown in Table I as being equal to +FS −1.5 LSB for the input range to be used (−4.9982 V for unipolar operation; −2.4982 V for bipolar operation with the full-scale 5 volt range).

Adjust the GAIN control for a digital output which "dithers" between 1111 1111 1110 and 1111 1111 1111.

Table I.

For UNIPOLAR Input	Apply Reference	And Adjust	For "Dither" Between
0 V to −5 V	−0.6 mV	OFFSET	0000 0000 0000 and 0000 0000 0001
0 V to −5 V	−4.9982 V	GAIN	1111 1111 1110 and 1111 1111 1111
For BIPOLAR Input	**Apply Reference**	**And Adjust**	**For "Dither" Between**
±2.5 V	+2.4994 V	OFFSET	0000 0000 0000 and 0000 0000 0001
±2.5 V	−2.4982 V	GAIN	1111 1111 1110 and 1111 1111 1111

Figures 3 and 4 provide additional information about the switching points of the LSB when adjusting for either unipolar or bipolar operation using the full-scale 5 volt input. Other input ranges less than the standard 5 volt range can also be used; for these, the switching points of the LSB would be changed correspondingly.

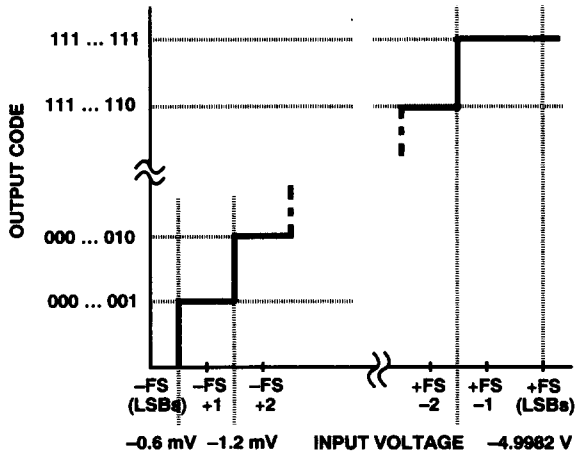


Figure 3. AD9003A Unipolar Adjustment

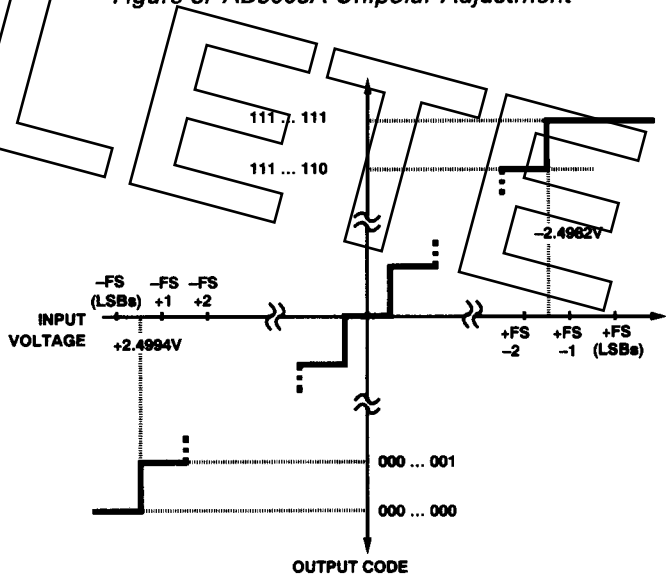
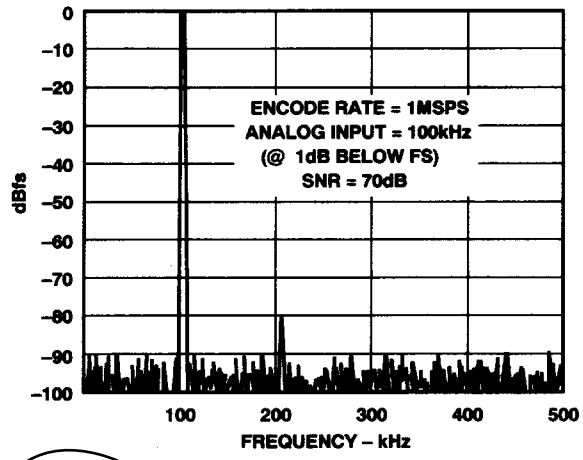
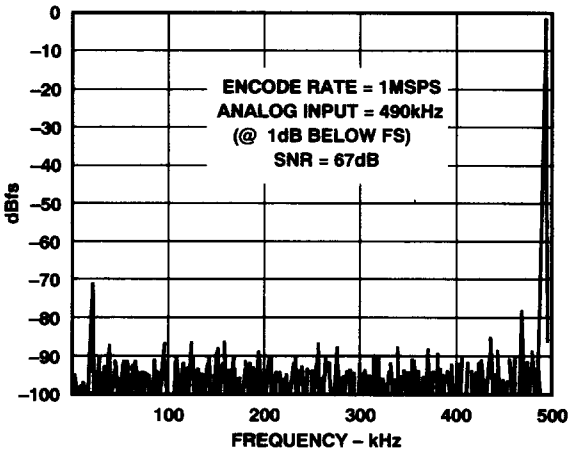


Figure 4. AD9003A Bipolar Adjustment



AD9003A Fast Fourier Transform (FFT)



AD9003A Fast Fourier Transform (FFT)

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).