

Ultra High-Speed 12-Bit A/D Converter

HAS-1204

FEATURES 12-Bit Resolution 500kHz Word Rates Internal Track-and-Hold Single 40-Pin DIP

APPLICATIONS Medical Instrumentation Radar Systems Test Systems Waveform Analysis Fast Fourier Transforms



GENERAL DESCRIPTION

The HAS-1204 A/D Converter is a *complete* 12-bit hybrid A/D converter in a single 40-pin metal DIP. In this context, "complete" means the unit includes a track-and-hold (T/H) amplifier, encoder, and all the necessary timing circuits. It is a remarkable, self-contained device ready to perform the conversion function without the need for external circuits.

The maximum conversion time of the HAS-1204 is 2.0 microseconds, including the acquisition time of the internal T/H. The large-signal bandwidth of the T/H is 4MHz and the small-signal bandwidth is 7MHz. This combination of characteristics assures that the HAS-1204 will operate at word rates from dc through 500kHz, digitizing analog signals containing frequency components to 250kHz with minimum attenuation or distortion.

Integrating the T/H, encoder, and timing circuits into a single package allows optimum matching of T/H-encoder parameters to obtain the best possible performance. It also lowers the overall power dissipation to 2.2 watts, making the HAS-1204 an ideal choice for designers who face space and/or power restrictions for their designs.



HAS-1204 Block Diagram

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SPECIFICATIONS (typical @ + 25°C with nominal power supplies unless otherwise noted)

Model	Units	HAS-1204BM	HAS-1204SM	OUTLINE DIMENSIONS
RESOLUTION (FS = Full Scale)	Bits (%FS)	12 (0.024)	*	Dimensions shown in inches and (mm)
LSB WEIGHT				Dimensions snown in menes and (mm).
5V Input Range	mV	1.22	*	0.19 (4.83)
10V Input Range	mV	2.44	*	. Max
ACCURACY				+ []
Linearity@dc	%FS $\pm 1/2LSB$	0.0125	*	0.24 (6.09)
Monotonicity		Guaranteed	*	
Nonlinearity vs. Temperature	ppm/°C	3	<u>.</u>	
Gain Error	%FS(max)	0.1(0.7)	1	0.125 (3.175) 2.0.010 (2.54) 2.0.0540 (0) 8077041 410
Gain vs. Temperature	ppm/°C	35		19 PLACES
DYNAMIC CHARACTERISTICS				1 11 120
In-Band Harmonics'	dB balant FS	75		
(dc to bokHz) (60kHz to 120kHz)	dB below FS	75	*	x
(120 kHz to 200 kHz)	dB below FS	70	*	WW =
Conversion Rate	kHz	500	*	880 083
Conversion Time	μs, max	2.0	*	6 [23
Aperture Uncertainty (Jitter)	ps	60	*	
Aperture Time (Delay)	ns(min/max)	10(4/18)	*	
Signal to Noise Ratio (SNR) ²	dB	69	*	
Transient Response ³	ns	400	*	0.126 (2.126)
Overvoltage Recovery"	ns	900	*	±0.010 1900 (48.260) ± 0.006
Input Bandwidth		-		2.145 (54.483) MAX
Small Signal, - 3dB ⁻	MHZ		1	
Large Signal, - 3dB ⁻	MHZ	4		HAS-1204 PIN DESIGNATIONS
(37 SkHz: 52 SkHz)	dB below FS	85	*	(As viewed from bottom)
ANALOCINIDUT	dib telow 1 5	05		(As viewed from bottom)
ANALOGINPUI Voltage Banges	VES	010 - 5:010 - 10	1 A. C. A.	
voltage Ranges	v, F3	-5;010 - 10		
Overvoltage	V. max	2×FS	*	40 ANALOG GROUND 1 ENCODE COMMAND
Impedance	, , max	2.1.10	÷	39 10V RANGE 2 DATA READY
5V Ranges	$\Omega(\max)$	$1,000(\pm 10)$	* · .	38 5V RANGE 3 ANALOG GROUND
10V Ranges	Ω(max)	$2,000(\pm 20)$	* *	37 GAIN ADJUST 4 +5V 36 -15V 5 -15V
Offset ⁸	1 A A A A A A A A A A A A A A A A A A A		1 A.M. 1	35 + 15V 6 DIGITAL GROUND
Initial-10V Input	mV(max)	10(60)	. * - 514	34 +5V 7 BIT1(MSB)
vs. Temperature (Unipolar)	FS ppm/°C	15		33 DIGITAL GROUND 8 BIT 2 32 FACTORY USE ONLY 9 BIT 3
vs. Temperature (Bipolar)	FS ppm/°C	50	· • · · · · · · · · ·	31 FACTORY USE ONLY 10 BIT 4
ENCODE COMMAND INPUT ⁹				30 – 15V 11 BIT5 29 BIPOLAR OFFSET 12 BIT6
Logic Levels, TTL-Compatible	v	"0" = 0 to $+0.4$		28 D/A OUTPUT 13 +5V
formation and	LOTTL Lands	$n_1 = +2.4 \text{ to } +5$		27 ANALOG GROUND 14 DIGITAL GROUND
Bise and Fall Times	LS IIL Loads	2	1.000	25 ANALOG GROUND 16 BIT 8
Width	ns, max	10		24 ANALOG GROUND 17 BIT 9
Min	ns	90	*	23 ANALOG GROUND 18 BIT 10
Max	ns	160	*	21 SERIAL OUT 20 BIT 12 (LSB)
Frequency	kHz	dc to 500	*	
DIGITAL OUTPUT ¹⁰				
Format	Data Bits	12 Parallel: NRZ	*	
	Data Ready	1:RZ	*	NOTES
Logic Levels, TTL-Compatible	V	"0" = 0 to $+0.4$	*	*Specification same as HAS-1204BM
		"1" = $+2.4$ to $+5$	•	generated at 500kHz encode rate at analog input frequencies
Drive	TTL Loads	1 Standard	*	shown in ().
Coding				*RMS signal to rms noise ratio with 50kHz analog input and encode rate of 500kHz; input signal at -1.0dB
Unipolar Mode		Complementary	*	³ For full-scale step input, 12-bit accuracy attained in specified time.
22 10 100 0		Binary (CBN)		⁴ Recovers to specified performance in specified time after 2×FS
Bipolar Mode		Complementary	•	input voltage.
		Offset Binary		With FS analog input. (Large-signal bandwidth flat within 0.5dB,
		(COB)		dc to 1MHz).
POWER REQUIREMENTS				Each input frequency applied at a level 7dB below full scale.
$+15V \pm 0.5V$	mA (max)	54(76)	1	⁹ Transition from digital "0" to digital "1" initiates encoding.
$-15V \pm 0.5V$ + $5V \pm 0.5V$	mA (max)	40(55)		¹⁰ Use trailing edge of Data Ready pulse to strobe digital outputs into
$+5V \pm 0.5V$ Power Dissipation ¹¹	mA (max)	160(177)	÷	external circuits (See Figure 2).
TEMPEDATUDEDANOPI2	w (max)	2.2(2.03)		$^{12}T = Case temperature.$
Operating	°C	- 25 10 1 95	- 55 - 1 100	¹³ Maximum junction temperature = 150°C. Operating unit requires
Storage	°C	-2510 + 85 -6510 ± 150	*	Soo cubic teet per minute (CPPM) moving air.
THERMAL RECIETANICE 13	0	0510 + 150	0	specifications subject to change without notice.
Inexmal RESISTANCE				
(Free Air)	°C/W	25	¥	
Iunction to Case, Bic	°C/W	16	*	
y				



THEORY OF OPERATION/TIMING Refer to the block diagram of the HAS-1204.

Analog input signals to be digitized are applied to either Pin 38 (5V RANGE) or Pin 39 (10V RANGE), depending upon their amplitude. These signals are inputs to the internal track-and-hold (T/H) which is normally operating in the "track" mode as a buffer amplifier, following all changes in analog as they occur.

An external strap, shown between Pin 28 and Pin 29, is used if operating the converter in the bipolar mode; it is important to keep this strap as short as possible. For unipolar operation, connect Pin 29 to ground.

The user determines the point at which the digitizing process is to be initiated by controlling the application of the TTL-compatible Encode Command pulse. Its positive-going leading edge switches the T/H to the "hold" mode of operation, "freezing" the analog input signal and beginning the digitizing process. As shown in the block diagram, the Encode Command applied to Pin 1 generates the required timing signals within the HAS-1204 A/D, making it unnecessary to add external circuits.

The held value of analog input is part of the input to a high-speed comparator within the converter. The other input is the analog output of the internal high-speed, high-accuracy D/A converter. The resulting output of the comparator is applied to the successive approximation register (SAR), also controlled by timing signals initiated by the encode command.

Digital outputs are available in both serial and parallel formats, as shown in Figure 1, HAS-1204 Timing.

Times shown in the timing diagram are typical times, unless noted otherwise. In the illustration, the Track/Hold signal is internal, not available to the user; it is included to help understand the operation of the converter. Timing intervals are measured from the leading edge of the Encode Command supplied by the user; this makes it easier to establish appropriate system timing.

Note the trailing edge of each clock pulse occurs after its corresponding serial output information has changed. If the serial output of the HAS-1204 converter is the desired signal, the trailing edges of clock pulses should be used as the stobes.

To assure the serial output data are fully established, the user is urged to incorporate a delay of approximately 30 nanoseconds between the trailing clock edge and the latch. This compensates for latch setup time, and slight variations in timing between the clock pulses and their associated data.

The portion of Figure 1 pertaining to Data Ready timing shows it returns to the digital "0" state 10 nanoseconds before the track-and-hold switches from "hold" to "track". The trailing edge of clock pulse #12 and the "track" transition are time-coincident, so this change in Data Ready occurs 10 nanoseconds before the trailing edge of the last clock pulse; and at the same time as the Bit 12 data change.

Time coincidence between the change of the Data Ready pulse and the arrival of Bit 12 (LSB) data might seem to preclude using the Data Ready pulse as a strobe. Despite that initial impression, the trailing (falling) edge of the Data Ready is recommended for strobing the parallel outputs into external circuits. This can be accomplished by using an inverter with a time delay (t_D) of the appropriate amount for the latch which is being used, as illustrated in Figure 2.

The timing relationships discussed above are generated internally because the clock pulses' rising edges control the switching. The 30-nanosecond width of each clock signal helps assure that its serial output data are firmly established by the time the clock's trailing edge arrives.







Figure 2. Output Strobe

APPLICATIONS INFORMATION

Figures 3 and 4 provide needed details on the adjustment of controls for setting the amount of offset and gain.

As noted in both illustrations, the OFFSET control must be set first for proper performance of the converter. Since the HAS-1204 is capable of operating in either a unipolar or bipolar mode, OFFSET ADJUST and GAIN ADJUST include information for both.







Figure 4. Gain Adust

However, careful adjustment of available controls is not the only way to help assure optimum performance. Like all high-speed, high-resolution components, the HAS-1204 is also sensitive to layout constraints. The use of a large, low-impedance ground plane is imperative.

In addition, bypass capacitors on the power supply leads are recommended. For most applications, electrolytic capacitors of 10-22 microfarads in parallel with ceramic capacitors of 0.01μ F to 0.1μ F will enhance the converter's effectiveness. These should be connected as closely as possible to the power supply pins entering the hybrid.

To prevent cross-coupling of analog and digital signals which may "mask" lower-order bits, analog and digital signal paths should be physically separated as much as possible. The user is urged to pay careful attention to both electrical and mechanical design to obtain best results.

ORDERING INFORMATION

Two versions of HAS-1204 A/D Converters are available as standard products; both are housed in 40-pin hermetically-sealed metal packages. With the exception of operating temperatures, the specifications are the same for both units. For a temperature range of -25° C to $+85^{\circ}$ C, specify the model HAS-1204BM; for a range of -55° C to $+100^{\circ}$ C, order model number HAS-1204SM. Units screened to military requirements are also available; contact the factory for details.

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