

## 18-BIT, 500-kHz, UNIPOLAR INPUT, MICROPOWER SAMPLING ANALOG-TO-DIGITAL CONVERTER WITH PARALLEL INTERFACE

### FEATURES

- 500-kHz Sample Rate
- 18-Bit NMC Ensured Over Temperature
- Zero Latency
- Low Power: 110 mW at 500 kHz
- Unipolar Input Range
- Onboard Reference Buffer
- High-Speed Parallel Interface
- Wide Digital Supply
- 8-/16-/18-Bit Bus Transfer
- 48-Pin TQFP Package

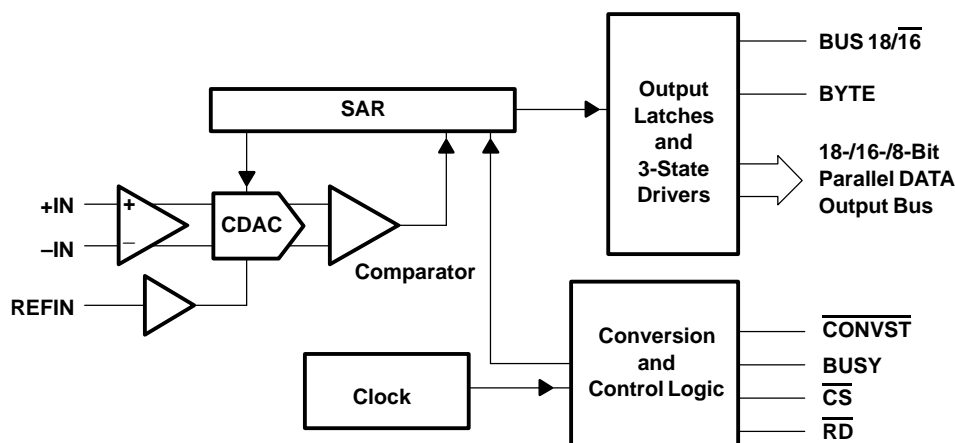
### APPLICATIONS

- Medical Instruments
- Optical Networking
- Transducer Interface
- High Accuracy Data Acquisition Systems
- Magnetometers

### DESCRIPTION

The ADS8383 is an 18-bit, 500 kHz A/D converter. The device includes a 18-bit capacitor-based SAR A/D converter with inherent sample and hold. The ADS8383 offers a full 18-bit interface, a 16-bit option where data is read using two read cycles or an 8-bit bus option using three read cycles.

The ADS8383 is available in a 48-lead TQFP package and is characterized over the industrial  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  temperature range.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

**ORDERING INFORMATION**

MODEL	MAXIMUM INTEGRAL LINEARITY (LSB)	MAXIMUM DIFFERENTIAL LINEARITY (LSB)	NO MISSING CODES RESOLUTION (BIT)	PACKAGE TYPE	PACKAGE DESIGNATOR	TEMPERATURE RANGE	ORDERING INFORMATION	TRANSPORT MEDIA QUANTITY
ADS8383I	±10	-2~7	17	48 Pin TQFP	PFB	-40°C to 85°C	ADS8383IPFBT	Tape and reel 250
							ADS8383IPFBR	Tape and reel 1000
ADS8383IB	±7	-1~2.5	18	48 Pin TQFP	PFB	-40°C to 85°C	ADS8383IBPFBT	Tape and reel 250
							ADS8383IBPFBR	Tape and reel 1000

NOTE: For the most current specifications and package information, refer to our website at www.ti.com.

**ABSOLUTE MAXIMUM RATINGS**

over operating free-air temperature range unless otherwise noted<sup>(1)</sup>

		UNIT
Voltage	+IN to AGND	+VA + 0.1 V
	-IN to AGND	0.5 V
Voltage range	+VA to AGND	-0.3 V to 7 V
	+VBD to BDGND	-0.3 V to 7 V
	+VA to +VBD	-0.3 V to 2.5 V
Digital input voltage to BDGND		-0.3 V to +VBD + 0.3 V
Digital output voltage to BDGND		-0.3 V to +VBD + 0.3 V
Operating free-air temperature range, T <sub>A</sub>		-40°C to 85°C
Storage temperature range, T <sub>stg</sub>		-65°C to 150°C
Junction temperature (T <sub>J</sub> max)		150°C
TQFP package	Power dissipation	(T <sub>J</sub> Max - T <sub>A</sub> )/θ <sub>JA</sub>
	θ <sub>JA</sub> thermal impedance	86°C/W
Lead temperature, soldering	Vapor phase (60 sec)	215°C
	Infrared (15 sec)	220°C

(1) 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 under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

**SPECIFICATIONS**
 $T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $+V_A = 5\text{ V}$ ,  $+V_{BD} = 3\text{ V}$  or  $5\text{ V}$ ,  $V_{\text{ref}} = 4.096\text{ V}$ ,  $f_{\text{SAMPLE}} = 500\text{ kHz}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT	
<b>Analog Input</b>							
Full-scale input voltage (see Note 1)		+IN – –IN	0		$V_{\text{ref}}$	V	
Absolute input voltage		+IN	–0.2		$V_{\text{ref}} + 0.2$	V	
		–IN	–0.2		0.2		
Input capacitance				45		pF	
Input leakage current				1		nA	
<b>System Performance</b>							
Resolution				18		Bits	
No missing codes		ADS8383I	(+IN – –IN) < 0.5 FS		18	Bits	
			(+IN – –IN) ≥ 0.5 FS		17		
		ADS8383IB			18		
Integral linearity (see Notes 2 and 3)		ADS8383I	(+IN – –IN) < 0.125 FS		–4	LSB (18 bit)	
			(+IN – –IN) < 0.5 FS		–6		
			(+IN – –IN) ≥ 0.5 FS		–10		
		ADS8383IB	–7	–2/3	7		
Differential linearity		ADS8383I	(+IN – –IN) < 0.125 FS		–1	LSB (18 bit)	
			(+IN – –IN) < 0.5 FS		–1		
			(+IN – –IN) ≥ 0.5 FS		–2		
		ADS8383IB	–1	–1/1.4	2.5		
Offset error (see Note 4)		ADS8383I	–1	±0.5	1	mV	
		ADS8383IB	–0.75	±0.25	0.75		
Gain error (see Note 4)		ADS8383I	$V_{\text{ref}} = 4.096\text{ V}$		–0.1	0.1	%FS
		ADS8383IB	$V_{\text{ref}} = 4.096\text{ V}$		–0.06	0.06	%FS
Noise				60		μV RMS	
Power supply rejection ratio		At 3FFFFh output code		75		dB	
<b>Sampling Dynamics</b>							
Conversion time					1.5	μs	
Acquisition time			0.4			μs	
Throughput rate					500	kHz	
Aperture delay				4		ns	
Aperture jitter				15		ps	
Step response				150		ns	
Over voltage recovery				150		ns	

(1) Ideal input span, does not include gain or offset error.

(2) LSB means least significant bit

(3) This is endpoint INL, not best fit.

(4) Measured relative to an ideal full-scale input (+IN – –IN) of 4.096 V

**SPECIFICATIONS (CONTINUED)**

T<sub>A</sub> = -40°C to 85°C, +V<sub>A</sub> = +5 V, +V<sub>BD</sub> = 3 V or 5 V, V<sub>ref</sub> = 4.096 V, f<sub>SAMPLE</sub> = 500 kHz (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Dynamic Characteristics</b>						
Total harmonic distortion (THD) (see Note 1)	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 1 kHz			-110	dB
	ADS8383IB				-112	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 10 kHz			-98	
	ADS8383IB				-108	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 50 kHz			-98	
	ADS8383IB				-99	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 100 kHz			-90	
	ADS8383IB				-91	
Signal to noise ratio (SNR) (see Note 1)	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 1 kHz			87	dB
	ADS8383IB				88	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 10 kHz			87	
	ADS8383IB				87	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 50 kHz			87	
	ADS8383IB				87	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 100 kHz			87	
	ADS8383IB				87	
Signal to noise + distortion (SINAD) (see Note 1)	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 1 kHz			86	dB
	ADS8383IB				87	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 10 kHz			86	
	ADS8383IB				86	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 50 kHz			86	
	ADS8383IB				86	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 100 kHz			85	
	ADS8383IB				85	
Spurious free dynamic range (SFDR) (see Note 1)	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 1 kHz			110	dB
	ADS8383IB				112	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 10 kHz			98	
	ADS8383IB				108	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 50 kHz			98	
	ADS8383IB				98	
	ADS8383I	V <sub>IN</sub> = 4 V <sub>pp</sub> at 100 kHz			90	
	ADS8383IB				94	
-3dB Small signal bandwidth				3		MHz
<b>Voltage Reference Input</b>						
Reference voltage at REFIN, V <sub>ref</sub>			2.5	4.096	4.2	V
Reference resistance (see Note 2)			500			kΩ
Reference current drain		f <sub>S</sub> = 500 kHz			1	mA
<b>Bias Input</b>						
Bias input range			2	2.048	2.1	V
Bias input drift					±5	%FS
Bias input current, sink			-150	-100		μA

(1) Calculated on the first nine harmonics of the input frequency

(2) Can vary ±20%

**SPECIFICATIONS (CONTINUED)**
 $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ ,  $+VA = +5\text{ V}$ ,  $+VBD = 3\text{ V}$  or  $5\text{ V}$ ,  $V_{\text{ref}} = 4.096\text{ V}$ ,  $f_{\text{SAMPLE}} = 500\text{ kHz}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Digital Input/Output</b>						
Logic family			CMOS			
Logic level	$V_{IH}$	$I_{IH} = 5\ \mu\text{A}$	$+VBD - 1$	$+VBD + 0.3$		V
	$V_{IL}$	$I_{IL} = 5\ \mu\text{A}$	$-0.3$	0.8		
	$V_{OH}$	$I_{OH} = 2\text{ TTL loads}$	$+VBD - 0.6$			
	$V_{OL}$	$I_{OL} = 2\text{ TTL loads}$	0.4			
Data format			Straight Binary			
<b>Power Supply Requirements</b>						
Power supply voltage	$+VBD$ (see Notes 1 and 2)		2.95	3.3	5.25	V
	$+VA$ (see Note 2)		4.75	5	5.25	V
Supply current, 500-kHz sample rate (see Note 3)			22		26	mA
Power dissipation, 500-kHz sample rate (see Note 3)			110		130	mW
<b>Temperature Range</b>						
Operating free-air			$-40$	85		$^\circ\text{C}$

(1) The difference between  $+VA$  and  $+VBD$  should be no less than 2.3 V, i.e. if  $+VA$  is 5.5 V,  $+VBD$  should be at least 2.95 V.

(2)  $+VBD \geq +VA - 2.3\text{ V}$

(3) This includes only  $+VA$  current.  $+VBD$  current is typical 1 mA with 5 pF load capacitance on all output pins.

**TIMING CHARACTERISTICS**

All specifications typical at –40°C to 85°C, +VA = +VBD = 5 V (see Notes 1, 2, and 3)

PARAMETER		MIN	TYP	MAX	UNIT
t <sub>CONV</sub>	Conversion time			1.5	μs
t <sub>ACQ</sub>	Acquisition time	0.4			μs
t <sub>pd1</sub>	CONVST low to conversion started (BUSY high)	10		50	ns
t <sub>pd2</sub>	Propagation delay time, End of conversion to BUSY low	10		20	ns
t <sub>w1</sub>	Pulse duration, CONVST low	40			ns
t <sub>su1</sub>	Setup time, CS low to CONVST low	20			ns
t <sub>w2</sub>	Pulse duration, CONVST high	20			ns
	CONVST falling edge jitter			10	ps
t <sub>w3</sub>	Pulse duration, BUSY signal low	Min(t <sub>ACQ</sub> )		1	μs
t <sub>w4</sub>	Pulse duration, BUSY signal high			1.52	μs
t <sub>h1</sub>	Hold time, First data bus data transition (RD low, or CS low for read cycle, or BYTE or BUS18/16 input changes) after CONVST low	40			ns
t <sub>d1</sub>	Delay time, CS low to RD low	0			ns
t <sub>su2</sub>	Setup time, RD high to CS high	0			ns
t <sub>w5</sub>	Pulse duration, RD low time	50			ns
t <sub>en</sub>	Enable time, RD low (or CS low for read cycle) to data valid			20	ns
t <sub>d2</sub>	Delay time, data hold from RD high	5			ns
t <sub>d3</sub>	Delay time, BUS18/16 or BYTE rising edge or falling edge to data valid	10		20	ns
t <sub>w6</sub>	RD high	20			ns
t <sub>h2</sub>	Hold time, last RD (or CS for read cycle) rising edge to CONVST falling edge	125			ns
t <sub>pd4</sub>	Propagation delay time, BUSY falling edge to next RD (or CS for read cycle) falling edge	Max(t <sub>d5</sub> )			ns
t <sub>d4</sub>	Delay time, BYTE edge to BUS18/16 edge skew	0			ns
t <sub>su3</sub>	Setup time, BYTE or BUS18/16 rising edge to RD falling edge	10			ns
t <sub>h3</sub>	Hold time, BYTE or BUS18/16 falling edge to RD falling edge	10			ns
t <sub>dis</sub>	Disable time, RD High (CS high for read cycle) to 3-stated data bus			20	ns
t <sub>d5</sub>	Delay time, BUSY low to MSB data valid			30	ns
t <sub>su4</sub>	Setup time, BYTE or BUS18/16 change before BUSY falling edge	10		20	μs

(1) All input signals are specified with t<sub>r</sub> = t<sub>f</sub> = 5 ns (10% to 90% of +VBD) and timed from a voltage level of (V<sub>IL</sub> + V<sub>IH</sub>)/2.

(2) See timing diagrams.

(3) All timing are measured with 20 pF equivalent loads on all data bits and BUSY pins.

## TIMING CHARACTERISTICS

All specifications typical at  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $+V_A = 5\text{ V}$ ,  $+V_{BD} = 3\text{ V}$  (see Notes 1, 2, and 3)

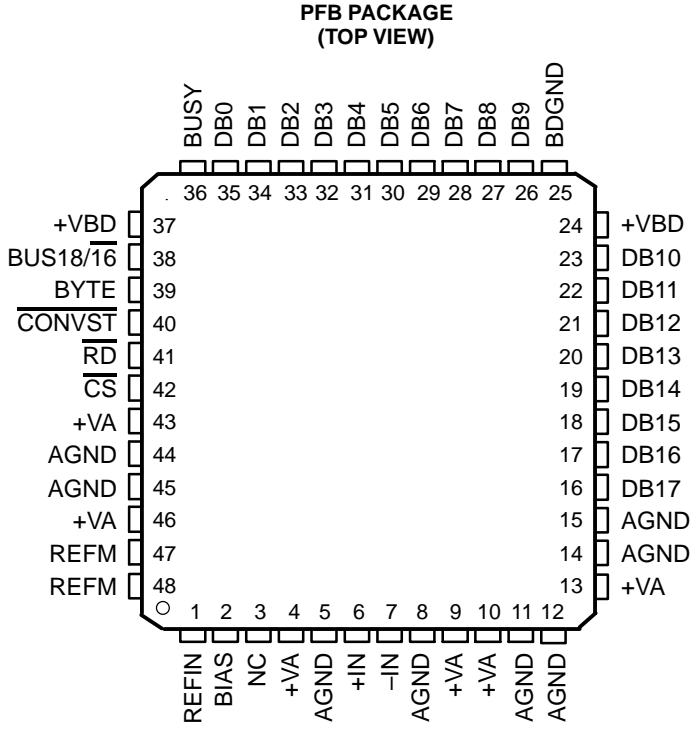
PARAMETER		MIN	TYP	MAX	UNIT
$t_{\text{CONV}}$	Conversion time			1.5	$\mu\text{s}$
$t_{\text{ACQ}}$	Acquisition time	0.4			$\mu\text{s}$
$t_{\text{pd1}}$	$\overline{\text{CONVST}}$ low to conversion started (BUSY high)	10		50	ns
$t_{\text{pd2}}$	Propagation delay time, end of conversion to BUSY low	10		20	ns
$t_{\text{w1}}$	Pulse duration, $\overline{\text{CONVST}}$ low	40			ns
$t_{\text{su1}}$	Setup time, $\overline{\text{CS}}$ low to $\overline{\text{CONVST}}$ low	20			ns
$t_{\text{w2}}$	Pulse duration, $\overline{\text{CONVST}}$ high	20			ns
	$\overline{\text{CONVST}}$ falling edge jitter			10	ps
$t_{\text{w3}}$	Pulse duration, BUSY signal low	$\text{Min}(t_{\text{ACQ}})$		1	$\mu\text{s}$
$t_{\text{w4}}$	Pulse duration, BUSY signal high			1.52	$\mu\text{s}$
$t_{\text{h1}}$	Hold time, first data bus transition ( $\overline{\text{RD}}$ low, or $\overline{\text{CS}}$ low for read cycle, or BYTE or BUS 18/16 input changes) after $\overline{\text{CONVST}}$ low	40			ns
$t_{\text{d1}}$	Delay time, $\overline{\text{CS}}$ low to $\overline{\text{RD}}$ low	0			ns
$t_{\text{su2}}$	Setup time, $\overline{\text{RD}}$ high to $\overline{\text{CS}}$ high	0			ns
$t_{\text{w5}}$	Pulse duration, $\overline{\text{RD}}$ low	50			ns
$t_{\text{en}}$	Enable time, $\overline{\text{RD}}$ low (or $\overline{\text{CS}}$ low for read cycle) to data valid			30	ns
$t_{\text{d2}}$	Delay time, data hold from $\overline{\text{RD}}$ high	10			ns
$t_{\text{d3}}$	Delay time, BUS18/16 or BYTE rising edge or falling edge to data valid	10		30	ns
$t_{\text{w6}}$	Pulse duration, $\overline{\text{RD}}$ high time	20			ns
$t_{\text{h2}}$	Hold time, last $\overline{\text{RD}}$ (or $\overline{\text{CS}}$ for read cycle) rising edge to $\overline{\text{CONVST}}$ falling edge	125			ns
$t_{\text{pd4}}$	Propagation delay time, BUSY falling edge to next $\overline{\text{RD}}$ (or $\overline{\text{CS}}$ for read cycle) falling edge	$\text{Max}(t_{\text{d5}})$			ns
$t_{\text{d4}}$	Delay time, BYTE edge to BUS18/16 edge skew	0			ns
$t_{\text{su3}}$	Setup time, BYTE or BUS18/16 rising edge to $\overline{\text{RD}}$ falling edge	10			ns
$t_{\text{h3}}$	Hold time, BYTE or BUS18/16 falling edge to $\overline{\text{RD}}$ falling edge	10			ns
$t_{\text{dis}}$	Disable time, $\overline{\text{RD}}$ High ( $\overline{\text{CS}}$ high for read cycle) to 3-stated data bus			30	ns
$t_{\text{d5}}$	Delay time, BUSY low to MSB data valid delay time			40	ns
$t_{\text{su4}}$	Setup time, BYTE or BUS18/16 change before BUSY falling edge	10		30	$\mu\text{s}$

(1) All input signals are specified with  $t_r = t_f = 5\text{ ns}$  (10% to 90% of  $+V_{BD}$ ) and timed from a voltage level of  $(V_{IL} + V_{IH})/2$ .

(2) See timing diagrams.

(3) All timing are measured with 10 pF equivalent loads on all data bits and BUSY pins.

**PIN ASSIGNMENTS**



NC – No connection.



**TERMINAL FUNCTIONS**

NAME	NO.	I/O	DESCRIPTION						
AGND	5, 8, 11, 12, 14, 15, 44, 45	–	Analog ground						
BDGND	25	–	Digital ground for bus interface digital supply						
BIAS	2	I	Bias to internal circuit						
BUSY	36	O	Status output. High when a conversion is in progress.						
BUS18/16	38	I	Bus size select input. Used for selecting 18-bit or 16-bit wide bus transfer. 0: Data bits output on the 18-bit data bus pins DB[17:0]. 1: Last two data bits D[1:0] from 18-bit wide bus output on: a) the low byte pins DB[9:2] if BYTE = 0 b) the high byte pins DB[17:10] if BYTE = 1						
BYTE	39	I	Byte select input. Used for 8-bit bus reading. 0: No fold back 1: Low byte D[9:2] of the 16 most significant bits is folded back to high byte of the 16 most significant pins DB[17:10].						
CONVST	40	I	Convert start						
CS	42	I	Chip select						
Data Bus			8-Bit Bus			16-Bit Bus		18-Bit Bus	
			BYTE = 0	BYTE = 1	BYTE = 1	BYTE = 0	BYTE = 0	BYTE = 0	
			BUS18/16 = 0	BUS18/16 = 0	BUS18/16 = 1	BUS18/16 = 0	BUS18/16 = 1	BUS18/16 = 0	
DB17	16	O	D17 (MSB)	D9	All ones	D17 (MSB)	All ones	D17 (MSB)	
DB16	17	O	D16	D8	All ones	D16	All ones	D16	
DB15	18	O	D15	D7	All ones	D15	All ones	D15	
DB14	19	O	D14	D6	All ones	D14	All ones	D14	
DB13	20	O	D13	D5	All ones	D13	All ones	D13	
DB12	21	O	D12	D4	All ones	D12	All ones	D12	
DB11	22	O	D11	D3	D1	D11	All ones	D11	
DB10	23	O	D10	D2	D0(LSB)	D10	All ones	D10	
DB9	26	O	D9	All ones	All ones	D9	All ones	D9	
DB8	27	O	D8	All ones	All ones	D8	All ones	D8	
DB7	28	O	D7	All ones	All ones	D7	All ones	D7	
DB6	29	O	D6	All ones	All ones	D6	All ones	D6	
DB5	30	O	D5	All ones	All ones	D5	All ones	D5	
DB4	31	O	D4	All ones	All ones	D4	All ones	D4	
DB3	32	O	D3	All ones	All ones	D3	D1	D3	
DB2	33	O	D2	All ones	All ones	D2	D0 (LSB)	D2	
DB1	34	O	D1	All ones	All ones	D1	All ones	D1	
DB0	35	O	D0 (LSB)	All ones	All ones	D0 (LSB)	All ones	D0 (LSB)	
–IN	7	I	Inverting input channel						
+IN	6	I	Noninverting input channel						
NC	3	–	No connection						
REFIN	1	I	Reference input.						
REFM	47, 48	I	Reference ground.						
RD	41	I	Synchronization pulse for the parallel output.						
+VA	4, 9, 10, 13, 43, 46	–	Analog power supplies, 5-V dc						
+VBD	24, 37	–	Digital power supply for bus						

TIMING DIAGRAMS

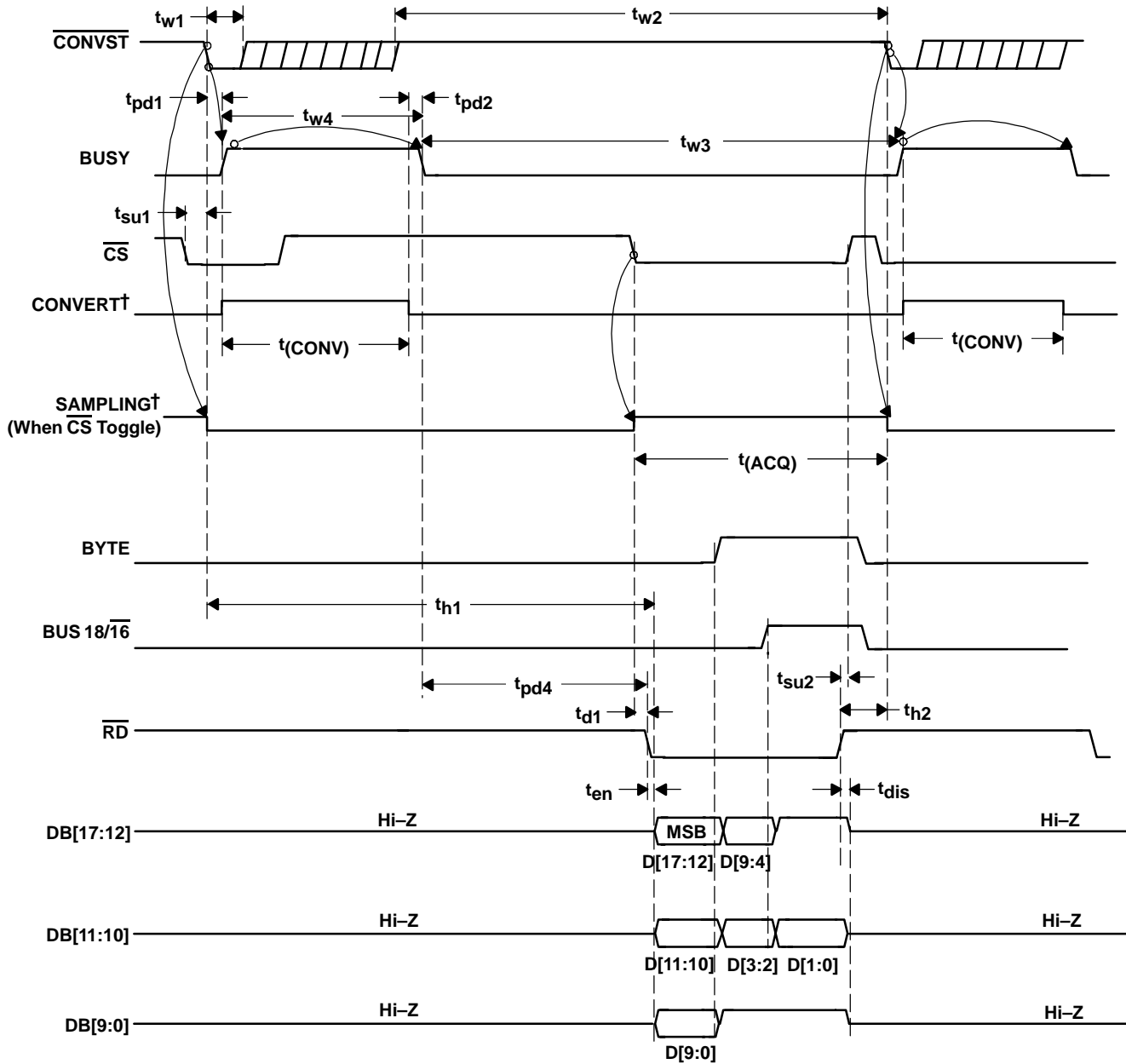
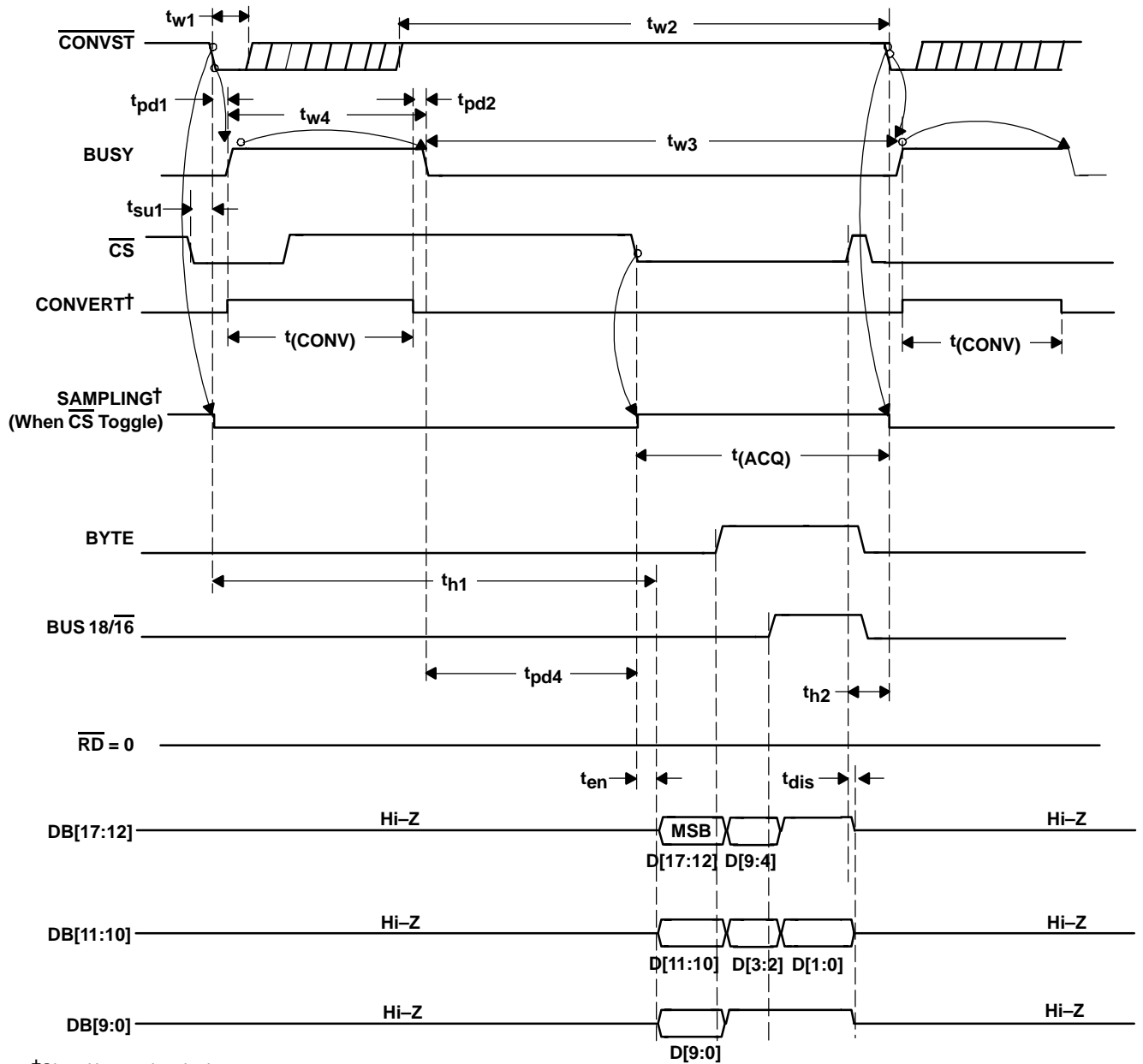


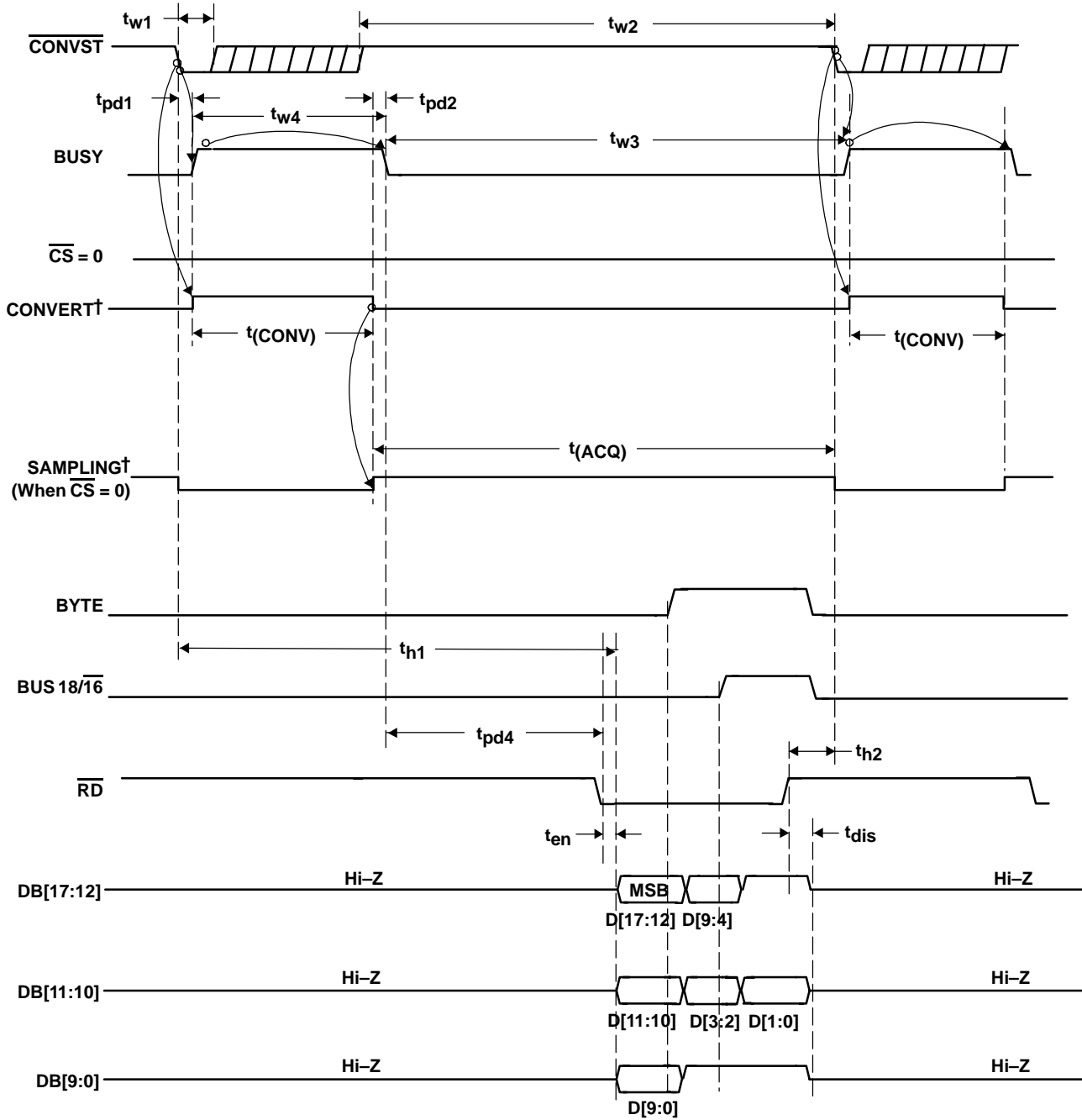
Figure 1. Timing for Conversion and Acquisition Cycles With  $\overline{\text{CS}}$  and  $\overline{\text{RD}}$  Toggling



$^\dagger$ Signal internal to device

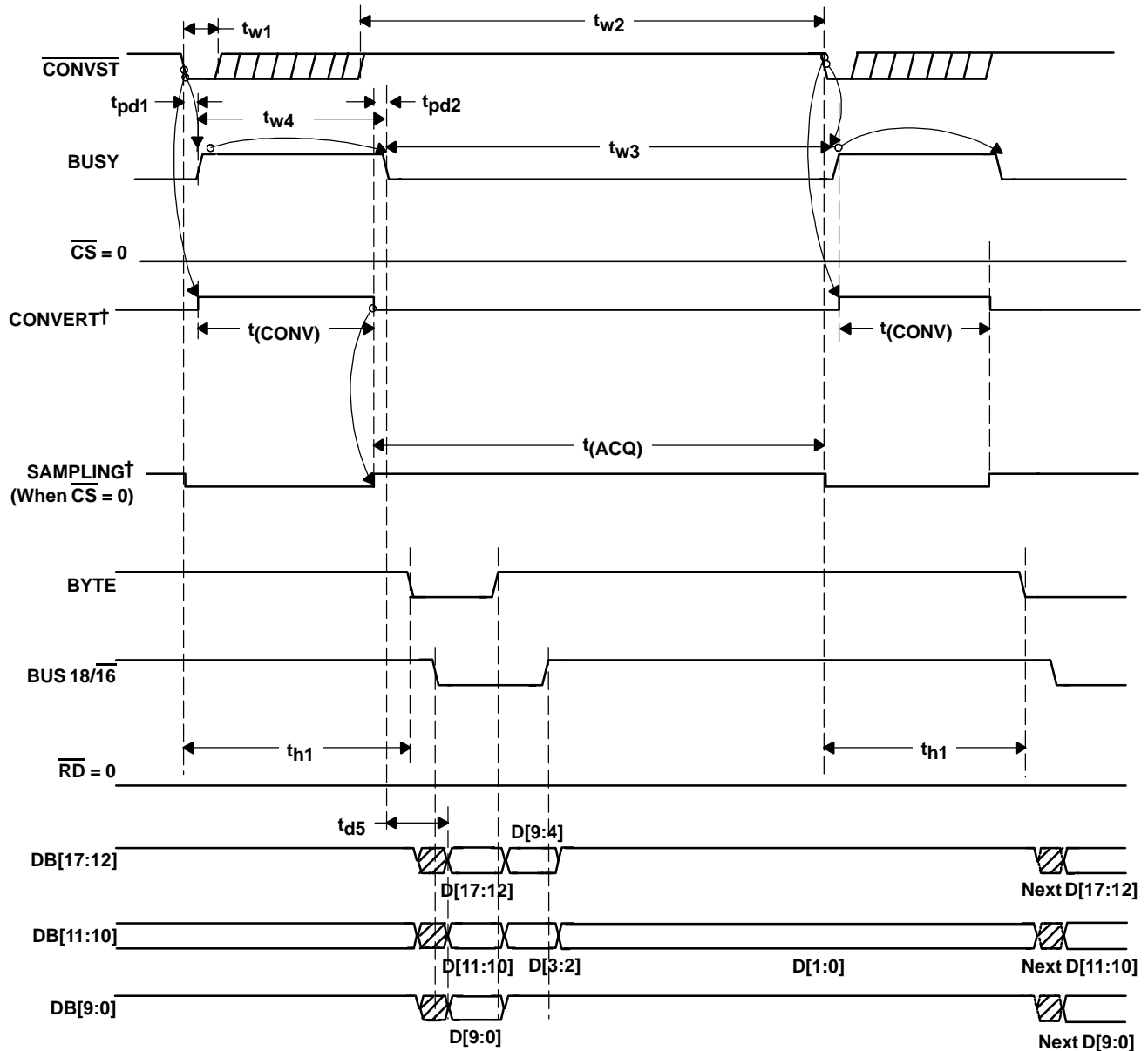
NOTE:  $\overline{\text{RD}}$  cannot be tied to  $\text{BDGND}$ . Three read cycles are required at power on.

**Figure 2. Timing for Conversion and Acquisition Cycles With  $\overline{\text{CS}}$  Toggling,  $\overline{\text{RD}}$  Held at  $\text{BDGND}$  After Power-On Initialization**



†Signal internal to device

Figure 3. Timing for Conversion and Acquisition Cycles With  $\overline{\text{CS}}$  Tied to BDGND,  $\overline{\text{RD}}$  Toggling



$^\dagger$ Signal internal to device

NOTE:  $\overline{\text{RD}}$  cannot be tied to BDGND. Three read cycles are required at power on.

**Figure 4. Timing for Conversion and Acquisition Cycles With  $\overline{\text{CS}}$  and  $\overline{\text{RD}}$  Held at BDGND After Power-On Initialization - Auto Read**

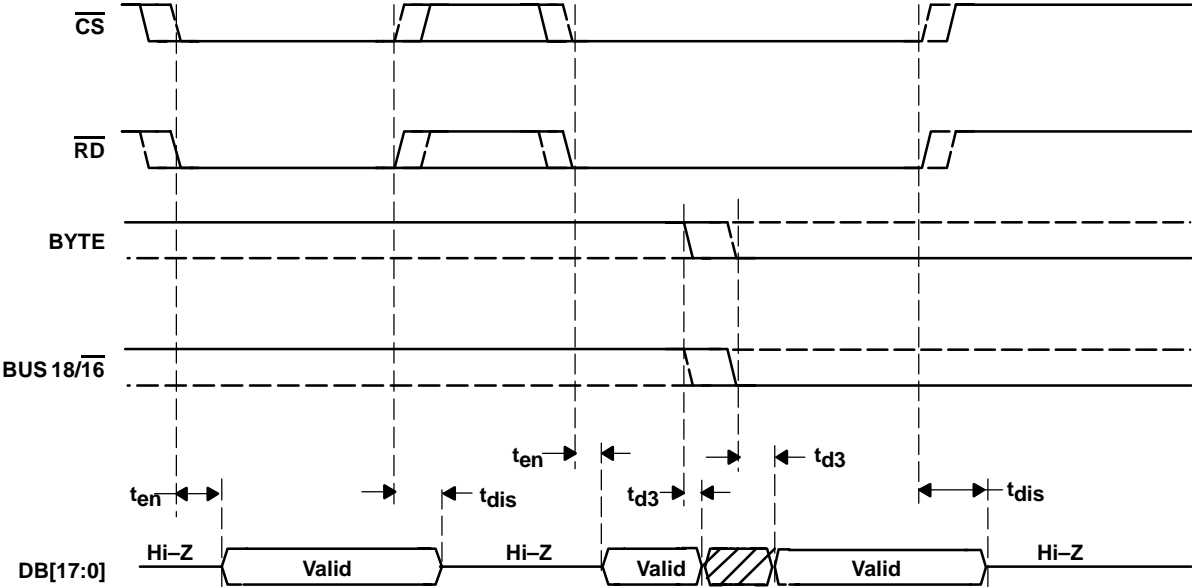


Figure 5. Detailed Timing for Read Cycles

TYPICAL CHARACTERISTICS†

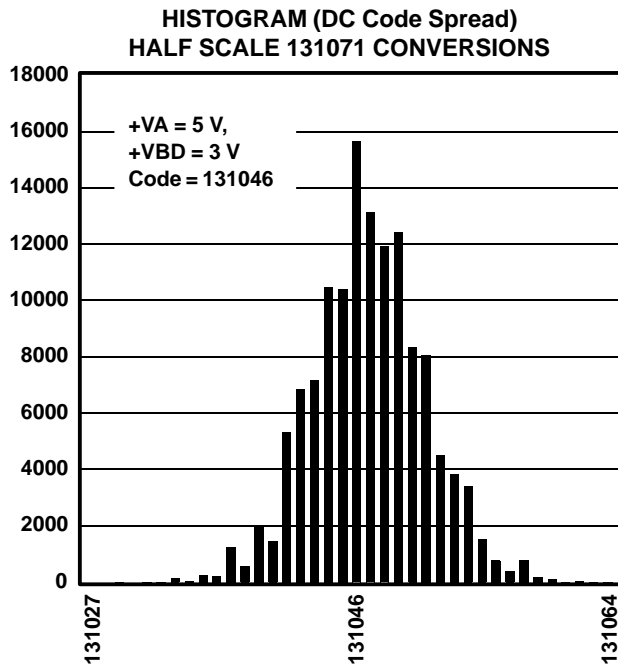


Figure 6

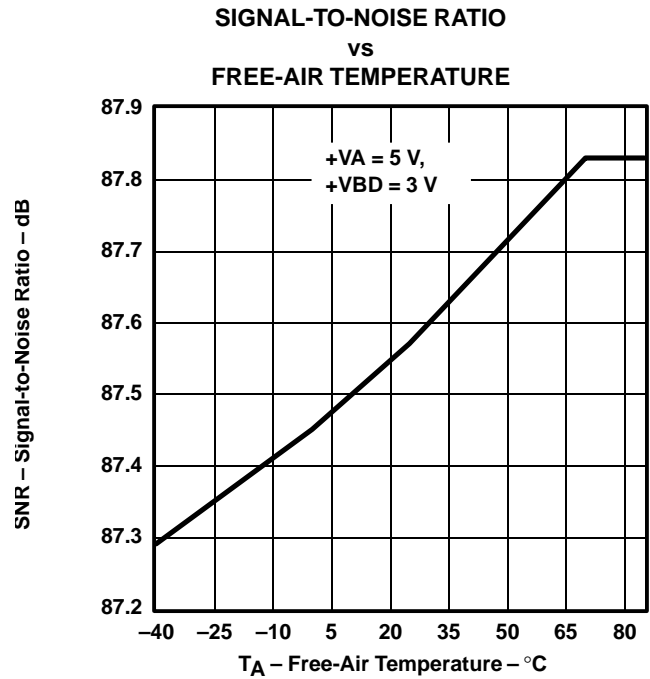


Figure 7

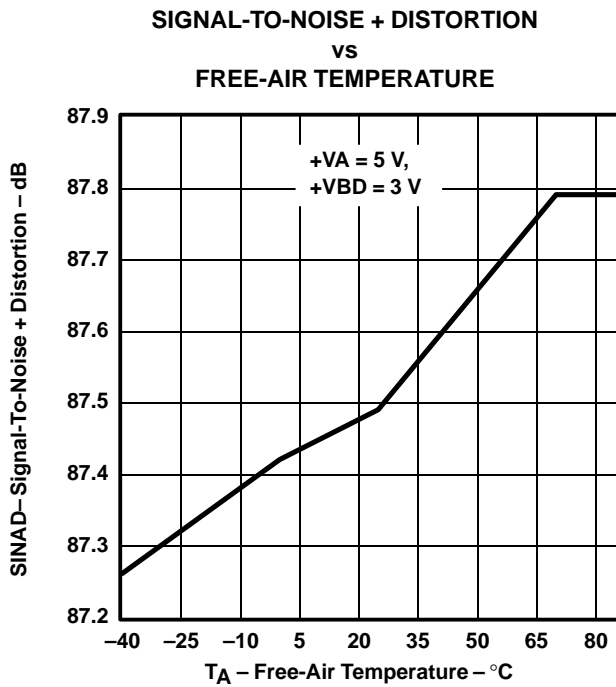


Figure 8

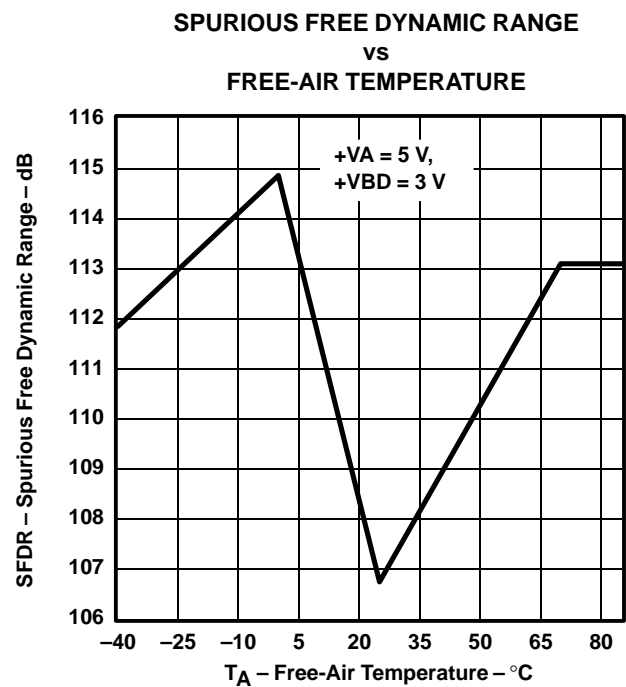


Figure 9

† At  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ , +VA = 5 V, +VBD = 5 V, REFIN = 4.096 V and  $f_{\text{sample}} = 500$  kHz (unless otherwise noted)

TOTAL HARMONIC DISTORTION  
vs  
FREE-AIR TEMPERATURE

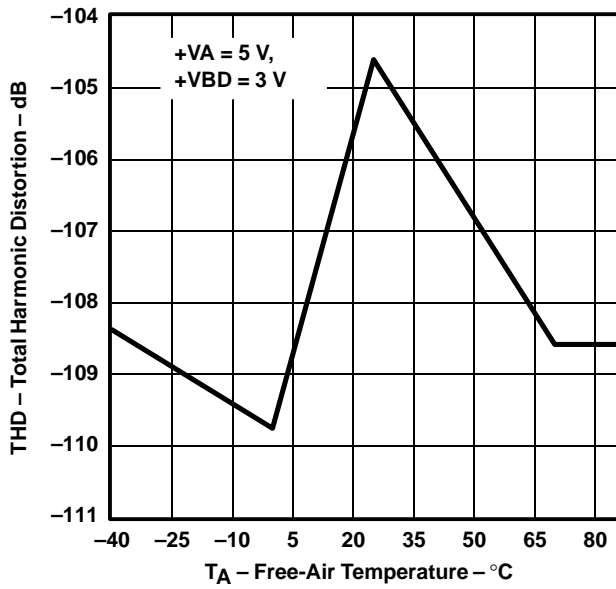


Figure 10

EFFECTIVE NUMBER OF BITS  
vs  
FREE-AIR TEMPERATURE

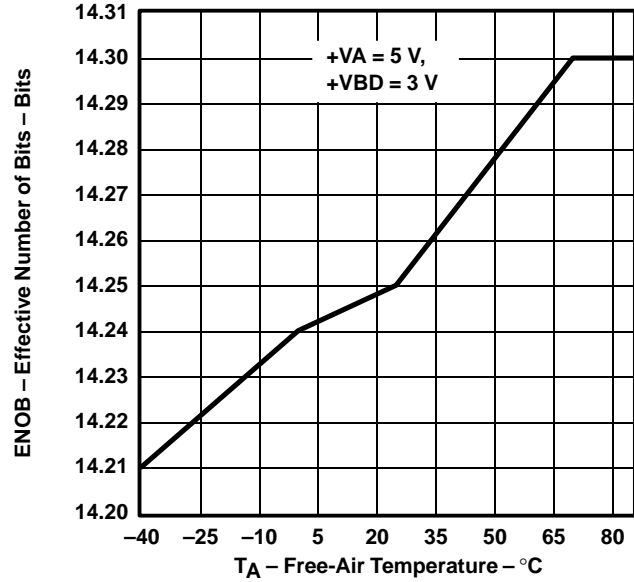


Figure 11

SIGNAL-TO-NOISE RATIO  
vs  
INPUT FREQUENCY

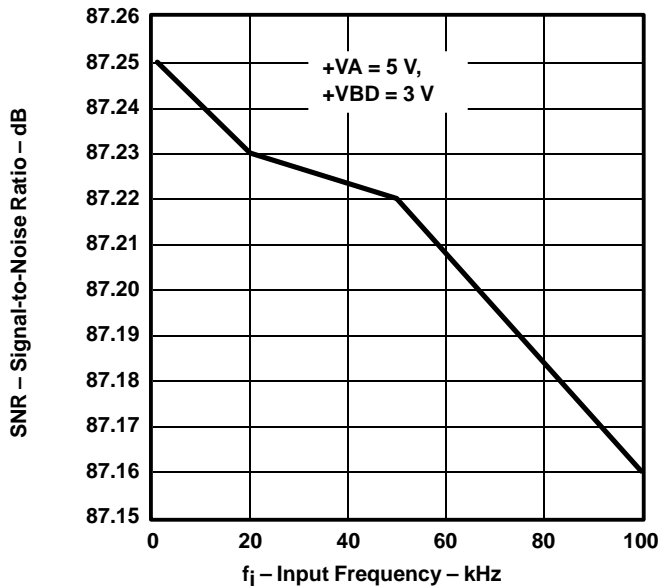


Figure 12

SIGNAL-TO-NOISE + DISTORTION  
vs  
INPUT FREQUENCY

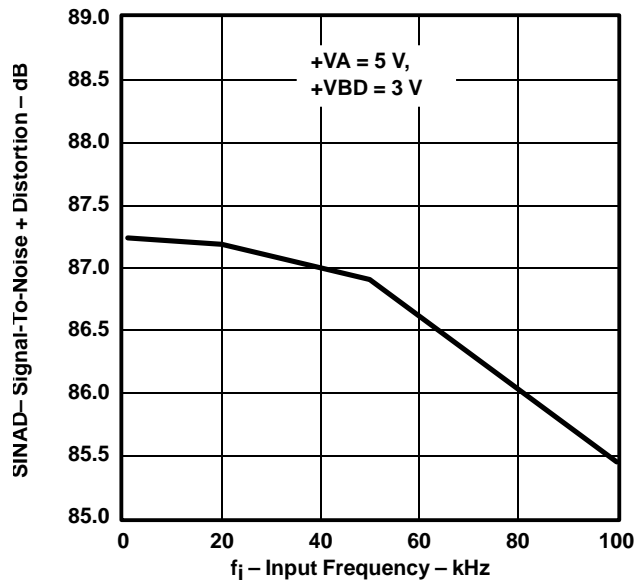


Figure 13

† At -40°C to 85°C, +VA = 5 V, +VBD = 5 V, REFIN = 4.096 V and  $f_{\text{sample}} = 500$  kHz (unless otherwise noted)



EFFECTIVE NUMBER OF BITS  
vs  
INPUT FREQUENCY

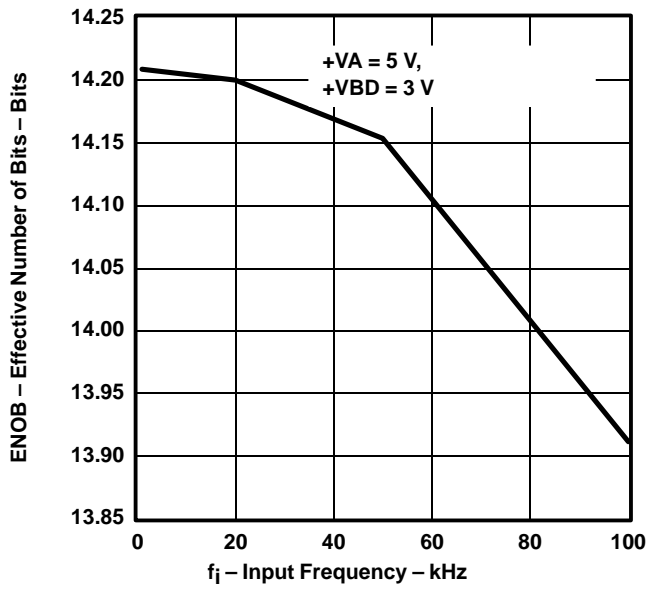


Figure 14

SPURIOUS FREE DYNAMIC RANGE  
vs  
INPUT FREQUENCY

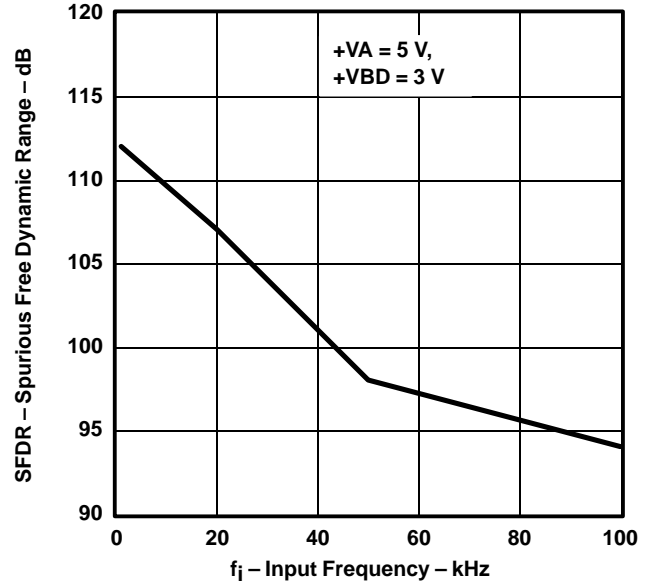


Figure 15

TOTAL HARMONIC DISTORTION  
vs  
INPUT FREQUENCY

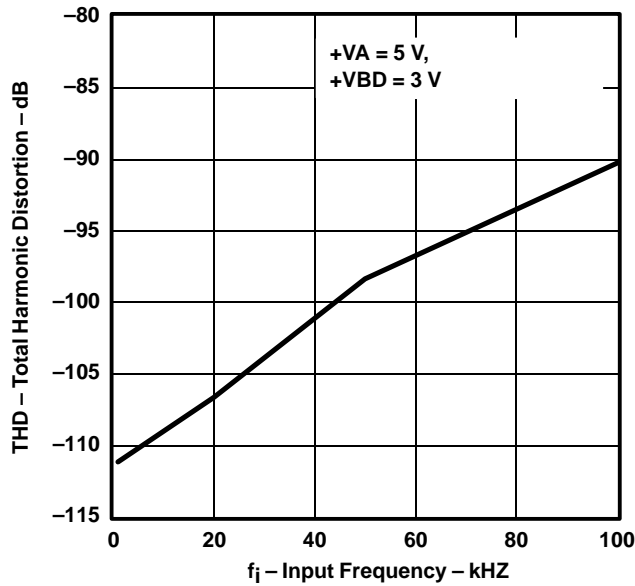


Figure 16

SUPPLY CURRENT  
vs  
SAMPLE RATE

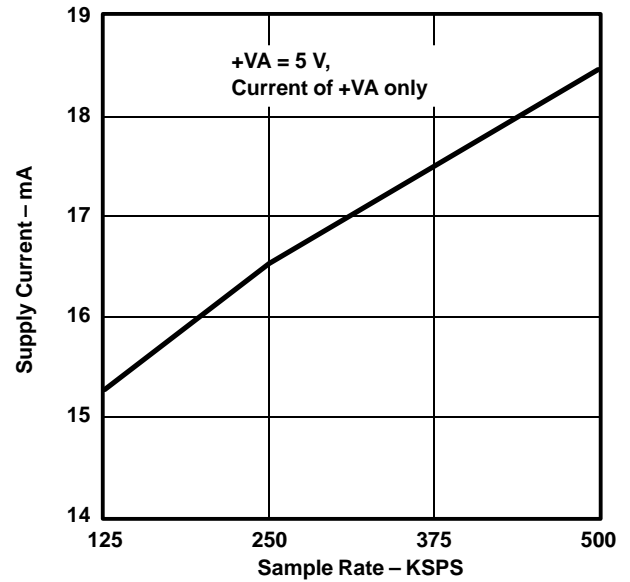


Figure 17

† At -40°C to 85°C, +VA = 5 V, +VBD = 5 V, REFIN = 4.096 V and  $f_{\text{sample}} = 500$  kHz (unless otherwise noted)

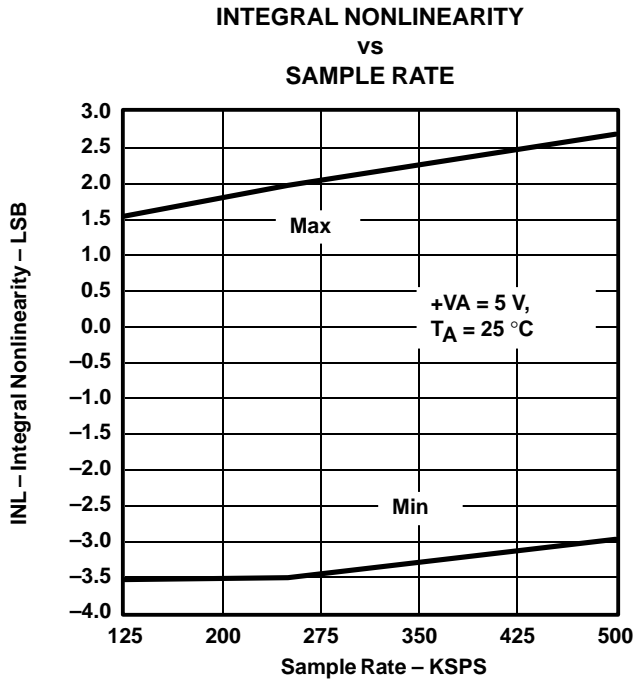


Figure 18

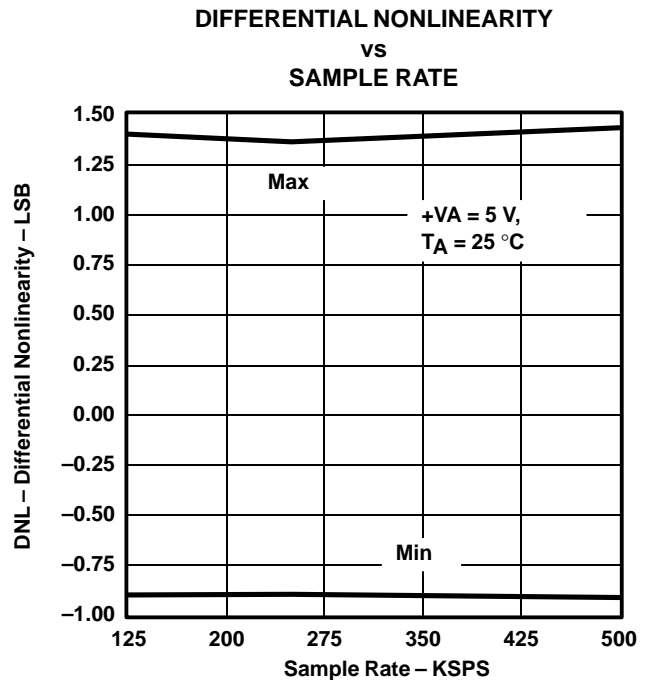


Figure 19

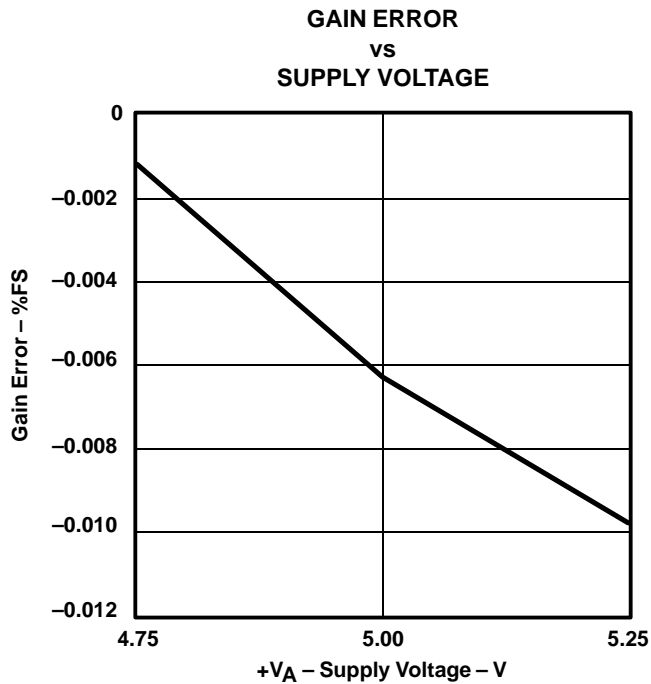


Figure 20

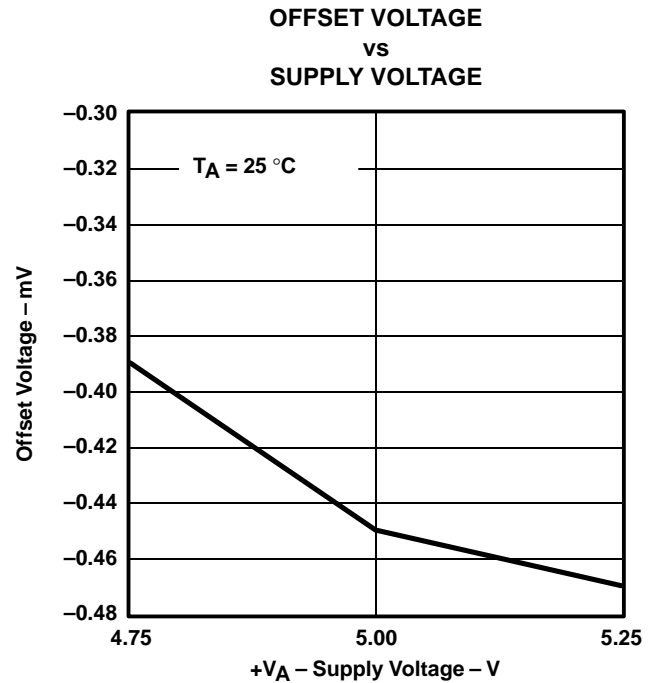


Figure 21

† At -40°C to 85°C, +VA = 5 V, +VBD = 5 V, REFIN = 4.096 V and  $f_{\text{sample}} = 500 \text{ kHz}$  (unless otherwise noted)

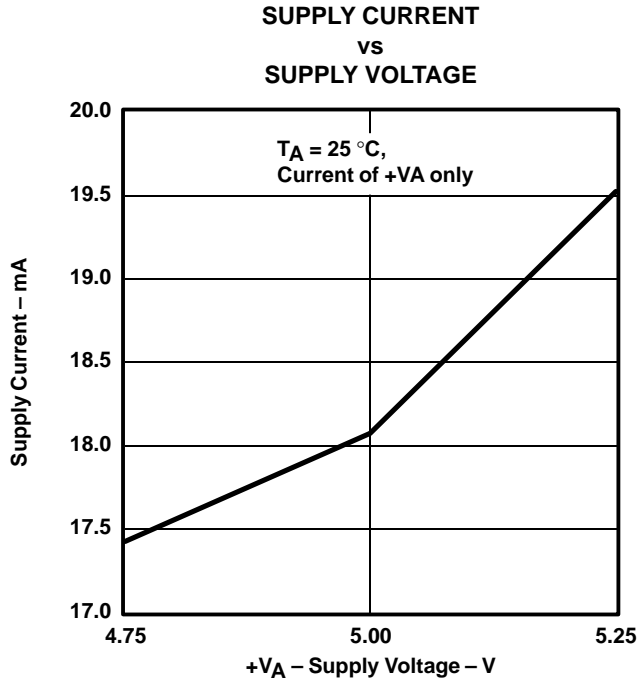


Figure 22

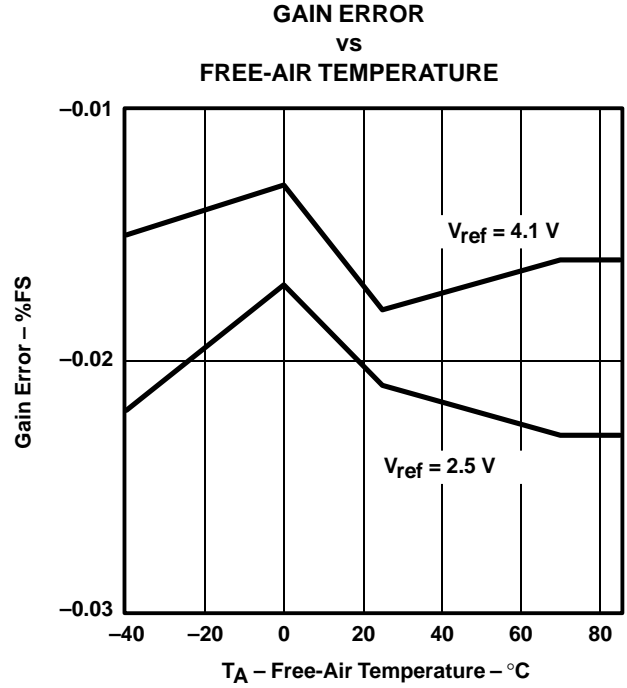


Figure 23

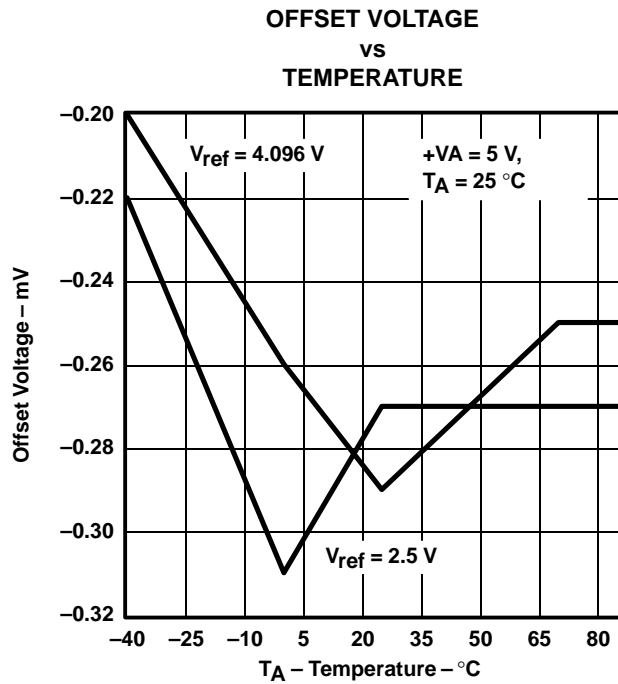


Figure 24

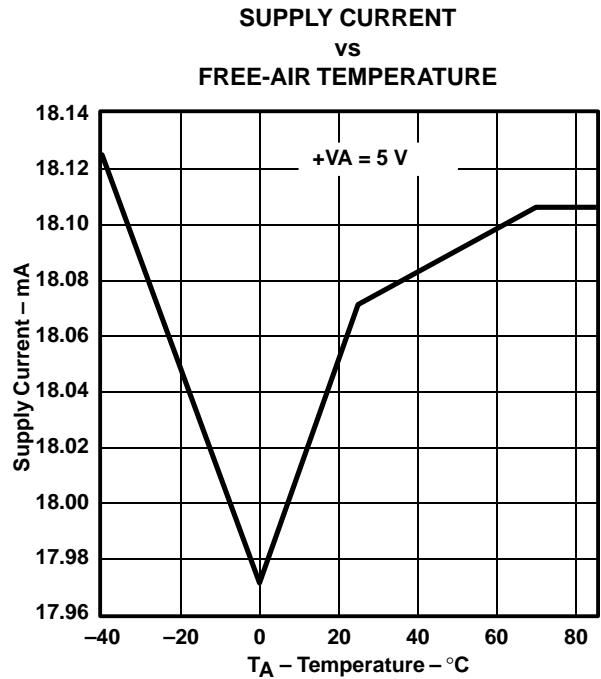
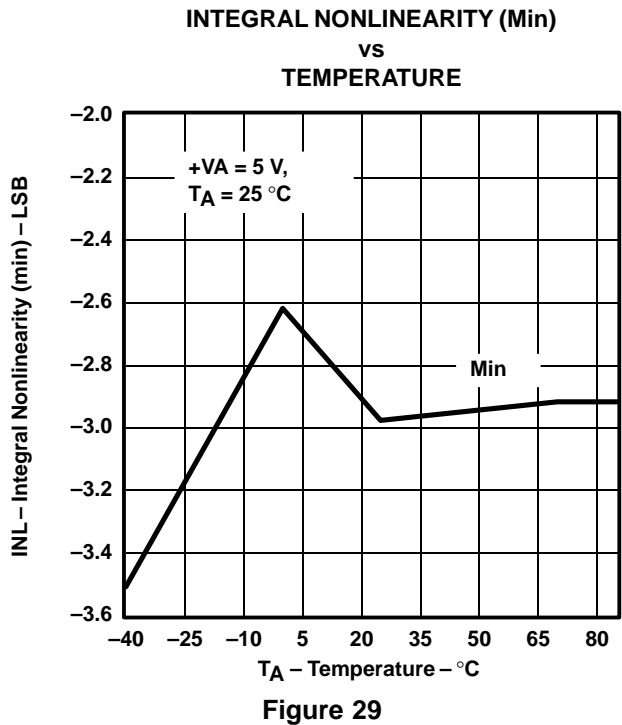
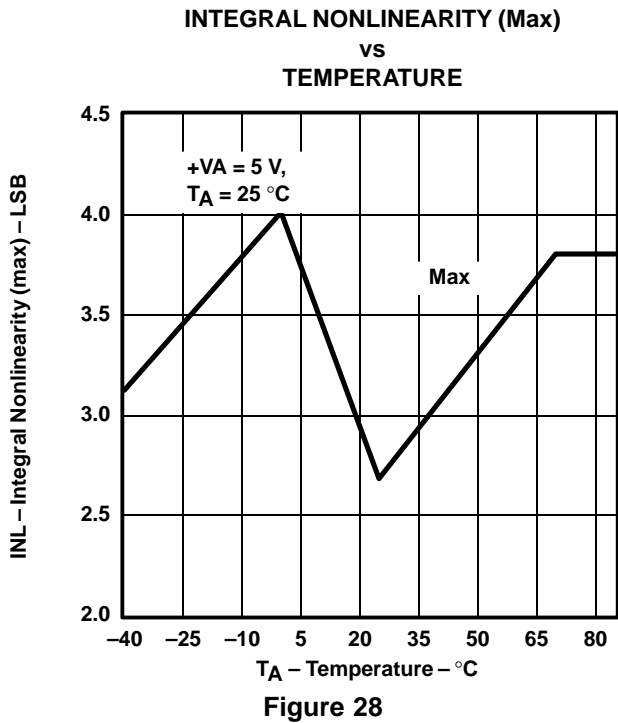
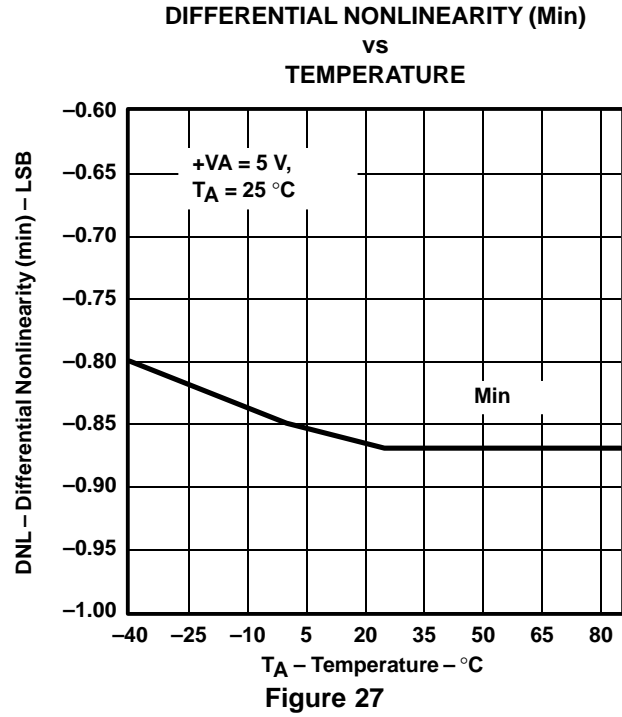
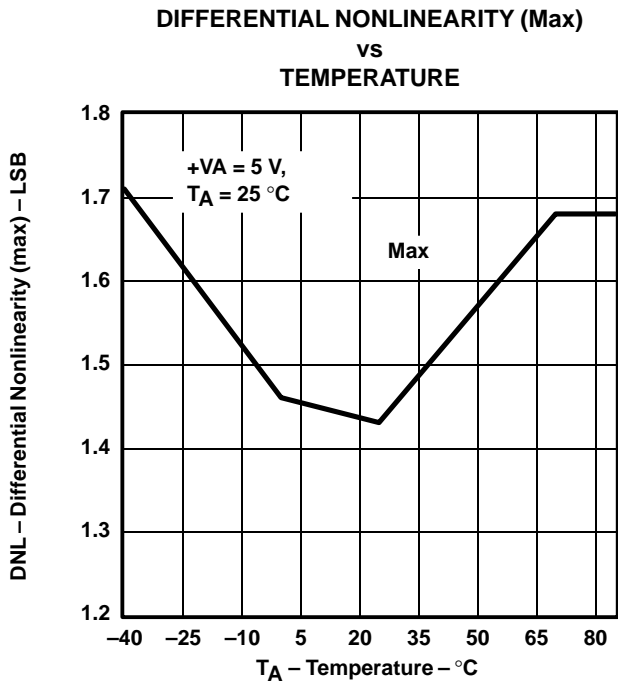


Figure 25

† At -40°C to 85°C, +VA = 5 V, +VBD = 5 V, REFIN = 4.096 V and  $f_{\text{sample}} = 500 \text{ kHz}$  (unless otherwise noted)



† At -40°C to 85°C, +VA = 5 V, +VBD = 5 V, REFIN = 4.096 V and  $f_{\text{sample}} = 500 \text{ kHz}$  (unless otherwise noted)

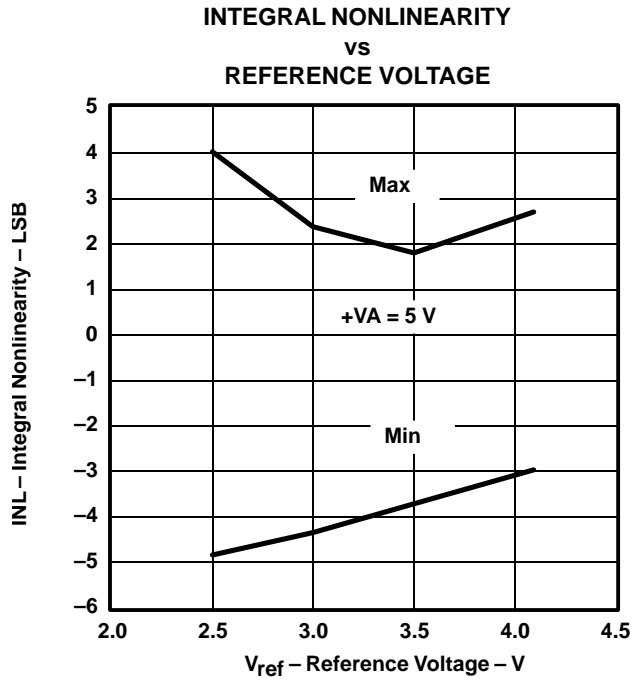


Figure 30

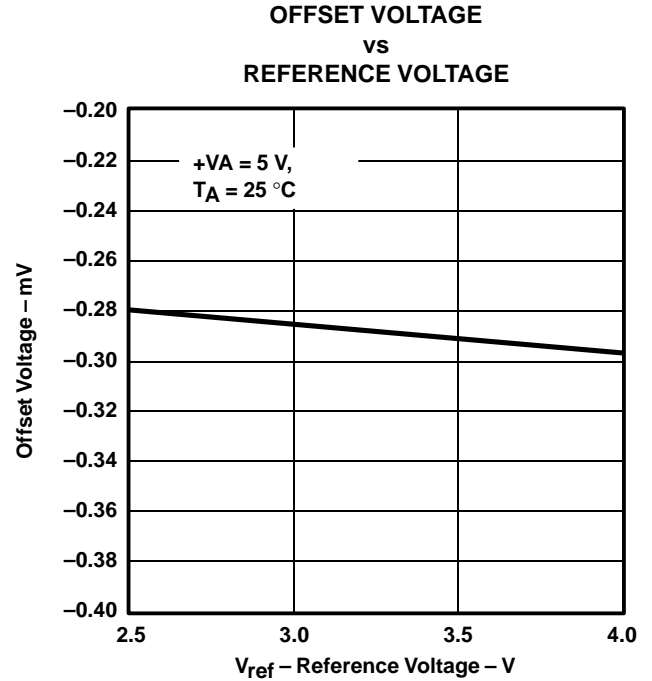


Figure 31

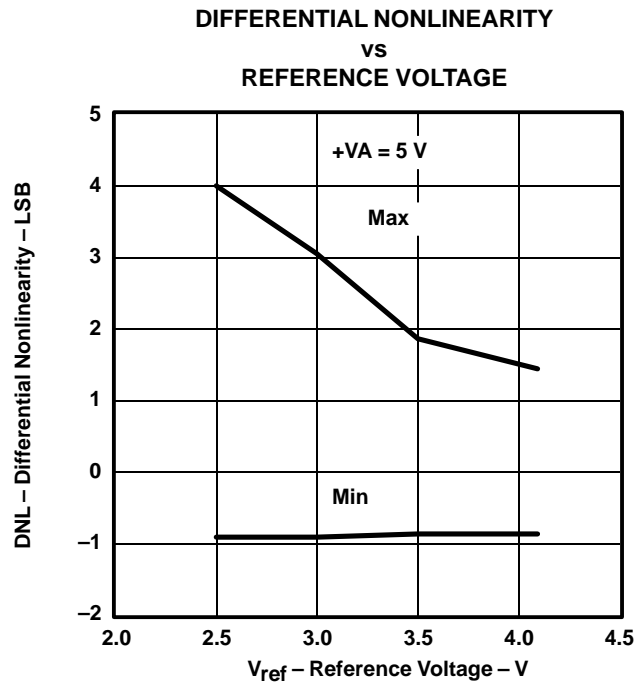
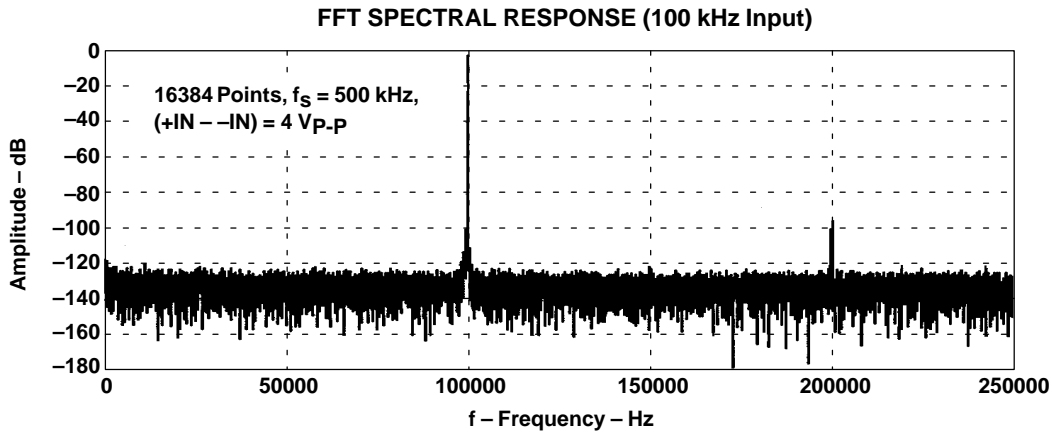
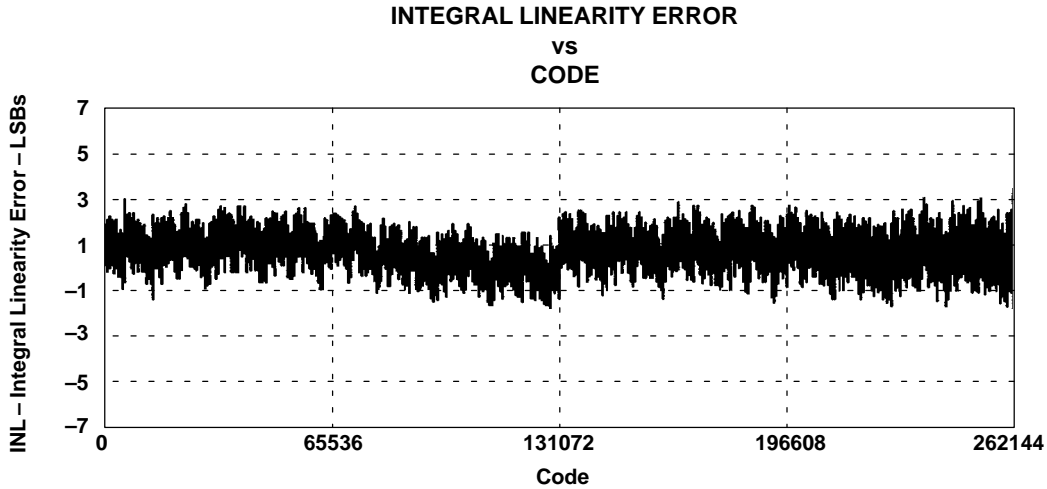
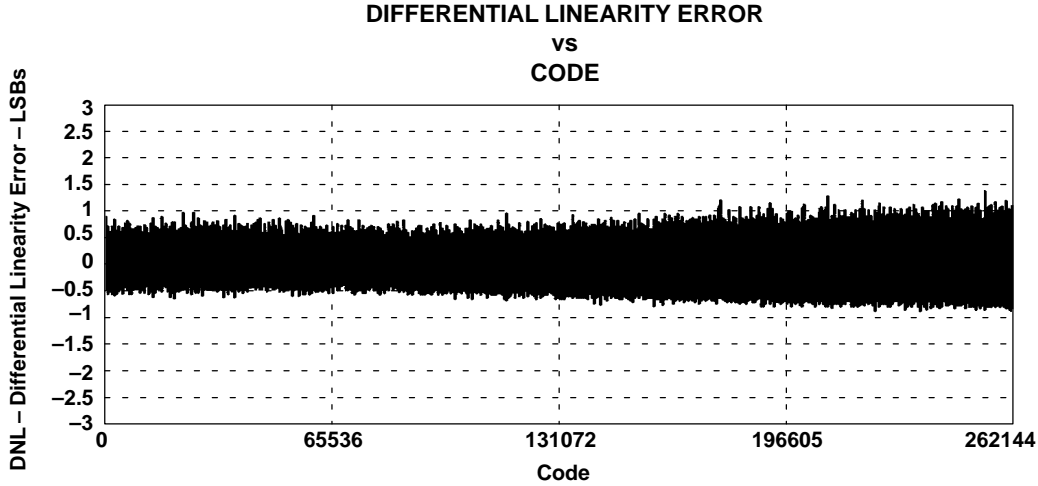
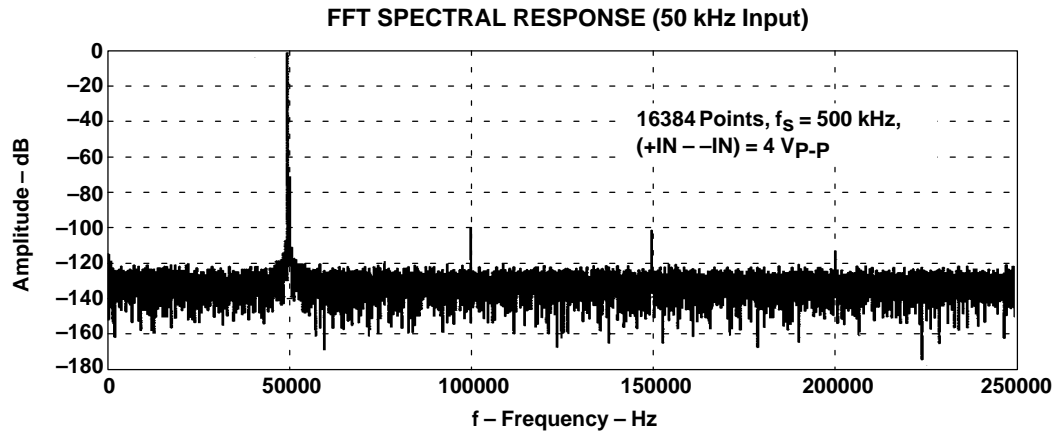


Figure 32

† At -40°C to 85°C, +VA = 5 V, +VBD = 5 V, REFIN = 4.096 V and f<sub>sample</sub> = 500 kHz (unless otherwise noted)



† At -40°C to 85°C, +VA = 5 V, +VBD = 5 V, REFIN = 4.096 V and  $f_{\text{sample}} = 500$  kHz (unless otherwise noted)



**Figure 36**

† At  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $+V_A = 5$  V,  $+V_{BD} = 5$  V,  $\text{REFIN} = 4.096$  V and  $f_{\text{sample}} = 500$  kHz (unless otherwise noted)

APPLICATION INFORMATION

MICROCONTROLLER INTERFACING

ADS8383 to 8-Bit Microcontroller Interface

Figure 37 shows a parallel interface between the ADS8383 and a typical microcontroller using the 8-bit data bus. The BUSY signal is used as a falling-edge interrupt to the microprocessor.

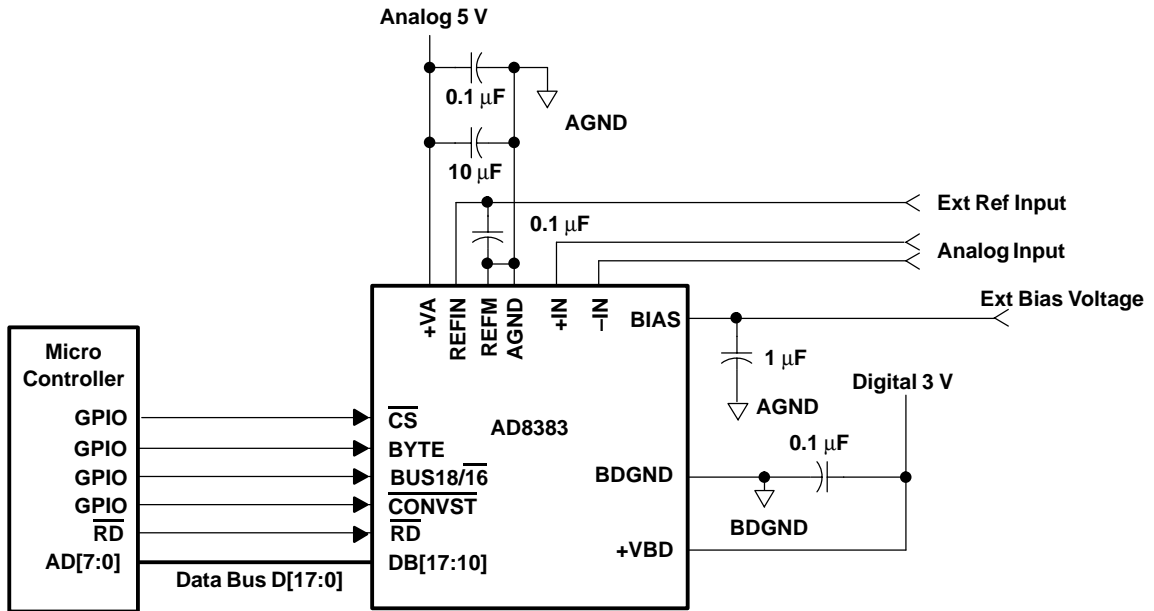


Figure 37. ADS8383 Application Circuitry



## PRINCIPLES OF OPERATION

The ADS8383 is a high-speed successive approximation register (SAR) analog-to-digital converter (ADC). The architecture is based on charge redistribution which inherently includes a sample/hold function. See Figure 37 for the application circuit for the ADS8383.

The conversion clock is generated internally. The conversion time of 1.6  $\mu\text{s}$  is capable of sustaining a 500-kHz throughput.

The analog input is provided to two input pins: +IN and –IN. When a conversion is initiated, the differential input on these pins is sampled on the internal capacitor array. While a conversion is in progress, both inputs are disconnected from any internal function.

### REFERENCE

The ADS8383 can operate with an external 4.096-V reference for a corresponding full-scale range of 4.096 V.

### BIASING THE ADS8383

The ADS8383 requires an external 2.048-V bandgap reference to generate the bias currents for internal circuitry. Figure 38 shows the internal circuitry used to generate the bias currents. The bias generation circuit also pumps 100  $\mu\text{A}$  (150  $\mu\text{A}$  max) out from the BIAS pin. The bandgap used should be capable of sinking 100  $\mu\text{A}$  (150  $\mu\text{A}$  max) while holding the voltage on the pin steady. Table 1 shows the specification of the bandgap used to drive the BIAS pin of the ADS8383.

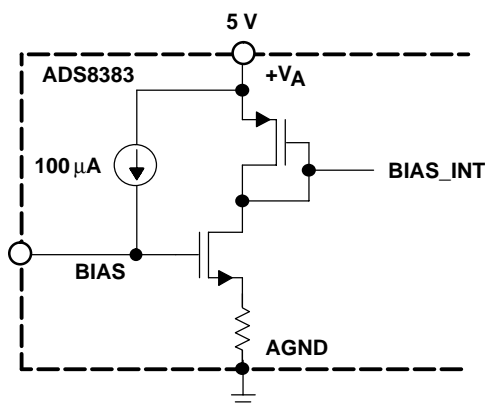


Figure 38. Bias Current Generation

Table 1. Bias Specifications

PARAMETER	MIN	TYP	MAX	UNITS
Output Voltage	2	2.048	2.1	V
$I_{\text{sink}}$		100	150	$\mu\text{A}$

Any common bandgap like REF3020 can be used to drive the BIAS pin of the ADS8383. Figure 39 shows how REF3020 can be used with the ADS8383. A 1  $\mu\text{F}$  decoupling capacitor is recommended between pins 2 and AGND of the ADS8383 for optimal performance.

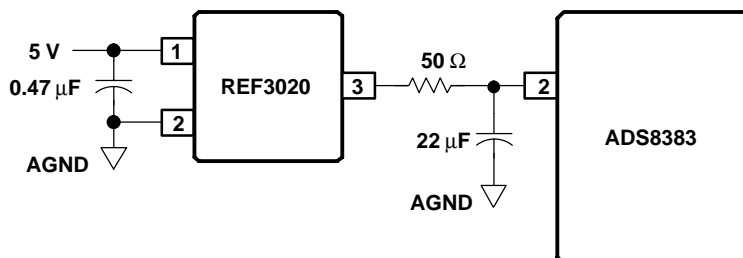


Figure 39. Using the REF3020 to Drive the ADS8383 BIAS Pin

## ANALOG INPUT

When the converter enters the hold mode, the voltage difference between the +IN and –IN inputs is captured on the internal capacitor array. The voltage on the –IN input is limited between –0.2 V and 0.2 V, allowing the input to reject small signals which are common to both the +IN and –IN inputs. The +IN input has a range of –0.2 V to  $V_{ref} + 0.2$  V. The input span (+IN – (–IN)) is limited to 0 V to  $V_{ref}$ .

The input current on the analog inputs depends upon a number of factors: sample rate, input voltage, and source impedance. Essentially, the current into the ADS8383 charges the internal capacitor array during the sample period. After this capacitance has been fully charged, there is no further input current. The source of the analog input voltage must be able to charge the input capacitance (45 pF) to an 18-bit settling level within the acquisition time (400 ns) of the device. When the converter goes into the hold mode, the input impedance is greater than 1 G $\Omega$ .

Care must be taken regarding the absolute analog input voltage. To maintain the linearity of the converter, the +IN and –IN inputs and the span (+IN – (–IN)) should be within the limits specified. Outside of these ranges, the converter's linearity may not meet specifications. To minimize noise, low bandwidth input signals with low-pass filters should be used.

Care should be taken to ensure that the output impedance of the sources driving the +IN and –IN inputs are matched. If this is not observed, the two inputs could have different settling times. This may result in offset error, gain error, and linearity error which changes with temperature and input voltage.

## DIGITAL INTERFACE

### Timing And Control

See the timing diagrams in the specifications section for detailed information on timing signals and their requirements.

The ADS8383 uses an internal oscillator generated clock which controls the conversion rate and in turn the throughput of the converter. No external clock input is required.

Conversions are initiated by bringing the  $\overline{\text{CONVST}}$  pin low for a minimum of 20 ns (after the 20 ns minimum requirement has been met, the  $\overline{\text{CONVST}}$  pin can be brought high), while  $\overline{\text{CS}}$  is low. The ADS8383 switches from the sample to the hold mode on the falling edge of the  $\overline{\text{CONVST}}$  command. A clean and low jitter falling edge of this signal is important to the performance of the converter. The BUSY output is brought high immediately following  $\overline{\text{CONVST}}$  going low. BUSY stays high through the conversion process and returns low when the conversion has ended.

Sampling starts with the falling edge of the BUSY signal when  $\overline{\text{CS}}$  is tied low or starts with the falling edge of  $\overline{\text{CS}}$  when BUSY is low.

Both  $\overline{\text{RD}}$  and  $\overline{\text{CS}}$  can be high during and before a conversion with one exception ( $\overline{\text{CS}}$  must be low when  $\overline{\text{CONVST}}$  goes low to initiate a conversion). Both the  $\overline{\text{RD}}$  and  $\overline{\text{CS}}$  pins are brought low in order to enable the parallel output bus with the conversion.

### Reading Data

The ADS8383 outputs full parallel data in straight binary format as shown in Table 2. The parallel output is active when  $\overline{\text{CS}}$  and  $\overline{\text{RD}}$  are both low. There is a minimal quiet zone requirement around the falling edge of  $\overline{\text{CONVST}}$ . This is 125 ns prior to the falling edge of  $\overline{\text{CONVST}}$  and 40 ns after the falling edge. No data read should be attempted within this zone. Any other combination of  $\overline{\text{CS}}$  and  $\overline{\text{RD}}$  sets the parallel output to 3-state. BYTE and BUS18/16 are used for multiword read operations. BYTE is used whenever lower bits on the bus are output on the higher byte of the bus. BUS18/16 is used whenever the last two bits on the 18-bit bus is output on either bytes of the higher 16-bit bus. Refer to Table 2 for ideal output codes.

**Table 2. Ideal Input Voltages and Output Codes**

DESCRIPTION	ANALOG VALUE	DIGITAL OUTPUT STRAIGHT BINARY	
FULL SCALE RANGE	$V_{ref}$		
Least significant bit (LSB)	$V_{ref}/262144$	BINARY CODE	HEX CODE
Full scale	$V_{ref} - 1 \text{ LSB}$	11 1111 1111 1111 1111	3FFFF
Midscale	$V_{ref}/2$	10 0000 0000 0000 0000	20000
Midscale – 1 LSB	$V_{ref}/2 - 1 \text{ LSB}$	01 1111 1111 1111 1111	1FFFF
Zero	0 V	00 0000 0000 0000 0000	00000

The output data is a full 18-bit word (D17–D0) on DB17–DB0 pins (MSB–LSB) if both  $\overline{\text{BUS18/16}}$  and  $\overline{\text{BYTE}}$  are low.

The result may also be read on a 16-bit bus by using only pins DB17–DB2. In this case two reads are necessary: the first as before, leaving both  $\overline{\text{BUS18/16}}$  and  $\overline{\text{BYTE}}$  low and reading the 16 most significant bits (D17–D2) on pins DB17–DB2, then bringing  $\overline{\text{BUS18/16}}$  high while holding  $\overline{\text{BYTE}}$  low. When  $\overline{\text{BUS18/16}}$  is high, the lower two bits (D1–D0) appear on pins DB3–DB2.

The result may also be read on an 8-bit bus for convenience. This is done by using only pins DB17–DB10. In this case three reads are necessary: the first as before, leaving both  $\overline{\text{BUS18/16}}$  and  $\overline{\text{BYTE}}$  low and reading the 8 most significant bits on pins DB17–DB10, then bringing  $\overline{\text{BYTE}}$  high while holding  $\overline{\text{BUS18/16}}$  low. When  $\overline{\text{BYTE}}$  is high, the medium bits (D9–D2) appear on pins DB17–DB10. The last read is done by bringing  $\overline{\text{BUS18/16}}$  high while holding  $\overline{\text{BYTE}}$  high. When  $\overline{\text{BUS18/16}}$  is high, the lower two bits (D1–D0) appear on pins DB11–DB10. The last read cycle is not necessary if only the first 16 most significant bits are of interest.

All of these multiword read operations can be performed with multiple active  $\overline{\text{RD}}$  (toggling) or with  $\overline{\text{RD}}$  held low for simplicity. This is referred to as the AUTO READ operation. Note that  $\overline{\text{RD}}$  may not be tied to BDGND permanently due to the requirement of power-on initialization.

**Table 3. Conversion Data Read Out**

BYTE	$\overline{\text{BUS18/16}}$	DATA READ OUT				
		DB17–DB12	DB11–DB10	DB9–DB4	DB3–DB2	DB1–DB0
High	High	All One's	D1–D0	All One's	All One's	All One's
Low	High	All One's	All One's	All One's	D1–D0	All One's
High	Low	D9–D4	D3–D2	All One's	All One's	All One's
Low	Low	D17–D12	D11–D10	D9–D4	D3–D2	D1–D0

**POWER-ON INITIALIZATION**

At first power on there are three read cycles required ( $\overline{\text{RD}}$  must be toggled three times). If conversion cycle is attempted before these initialization read cycles, the first three conversion cycles will not produce valid results. This is used to load factory trimming data for a specific device to assure high accuracy of the converter. Because of this requirement, the  $\overline{\text{RD}}$  pin cannot be tied permanently to BDGND. System designers can still achieve the AUTO READ function if the power-on requirement is satisfied.

**LAYOUT**

For optimum performance, care should be taken with the physical layout of the ADS8383 circuitry.

As the ADS8383 offers single-supply operation, it will often be used in close proximity with digital logic, microcontrollers, microprocessors, and digital signal processors. The more digital logic present in the design and the higher the switching speed, the more difficult it is to achieve good performance from the converter.

The basic SAR architecture is sensitive to glitches or sudden changes on the power supply, reference, ground connections and digital inputs that occur just prior to latching the output of the analog comparator. Thus, driving any single conversion for an n-bit SAR converter, there are at least n *windows* in which large external transient voltages can affect the conversion result. Such glitches might originate from switching power supplies, nearby digital logic, or high power devices.

The degree of error in the digital output depends on the reference voltage, layout, and the exact timing of the external event.

On average, the ADS8383 draws very little current from an external reference as the reference voltage is internally buffered. If the reference voltage is external and originates from an op amp, make sure that it can drive the bypass capacitor or capacitors without oscillation. A 0.1- $\mu$ F bypass capacitor is recommended from pin 1 (REFIN) directly to pin 48 (REFM). REFM and AGND should be shorted on the same ground plane under the device.

The AGND and BDGND pins should be connected to a clean ground point. In all cases, this should be the analog ground. Avoid connections which are too close to the grounding point of a microcontroller or digital signal processor. If required, run a ground trace directly from the converter to the power supply entry point. The ideal layout consists of an analog ground plane dedicated to the converter and associated analog circuitry.

As with the AGND connections, +VA should be connected to a 5-V power supply plane or trace that is separate from the connection for digital logic until they are connected at the power entry point. Power to the ADS8383 should be clean and well bypassed. A 0.1- $\mu$ F ceramic bypass capacitor should be placed as close to the device as possible. See Table 4 for the placement of the capacitor. In addition, a 1- $\mu$ F to 10- $\mu$ F capacitor is recommended. In some situations, additional bypassing may be required, such as a 100- $\mu$ F electrolytic capacitor or even a Pi filter made up of inductors and capacitors—all designed to essentially low-pass filter the 5-V supply, removing the high frequency noise.

**Table 4. Power Supply Decoupling Capacitor Placement**

POWER SUPPLY PLANE SUPPLY PINS	CONVERTER ANALOG SIDE	CONVERTER DIGITAL SIDE
Pin pairs that require shortest path to decoupling capacitors	(4,5), (8,9), (10,11), (13,15), (43,44), (45,46)	(24,25)
Pins that require no decoupling	12, 14	37

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