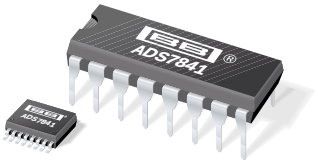
ADS7841



SBAS084B – JULY 2001

12-Bit, 4-Channel Serial Output Sampling ANALOG-TO-DIGITAL CONVERTER

FEATURES

- SINGLE SUPPLY: 2.7V to 5V
- 4-CHANNEL SINGLE-ENDED OR 2-CHANNEL DIFFERENTIAL INPUT
- UP TO 200kHz CONVERSION RATE
- ±1LSB MAX INL AND DNL
- NO MISSING CODES
- 72dB SINAD
- SERIAL INTERFACE
- DIP-16 OR SSOP-16 PACKAGE
- ALTERNATE SOURCE FOR MAX1247
- ADS7841ES: +125°C Version

APPLICATIONS

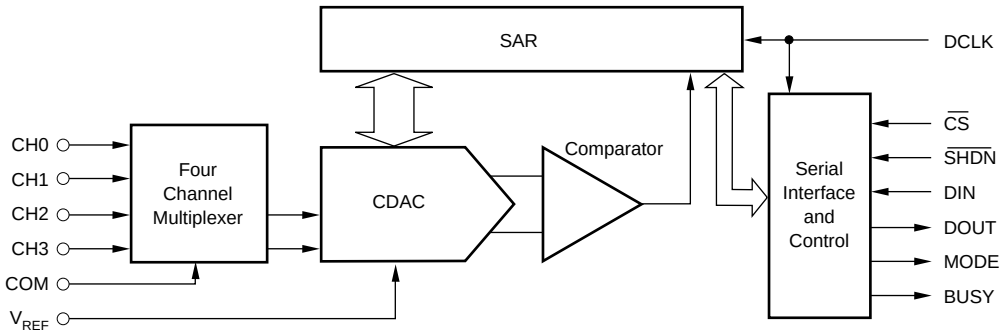
- DATA ACQUISITION
- TEST AND MEASUREMENT
- INDUSTRIAL PROCESS CONTROL
- PERSONAL DIGITAL ASSISTANTS
- BATTERY-POWERED SYSTEMS

DESCRIPTION

The ADS7841 is a 4-channel, 12-bit sampling Analog-to-Digital Converter (ADC) with a synchronous serial interface. The resolution is programmable to either 8 bits or 12 bits. Typical power dissipation is 2mW at a 200kHz throughput rate and a +5V supply. The reference voltage (V_{REF}) can be varied between 100mV and V_{CC}, providing a corresponding input voltage range of 0V to V_{REF}. The device includes a shutdown mode which reduces power dissipation to under 15µW. The ADS7841 is tested down to 2.7V operation.

Low power, high speed, and on-board multiplexer make the ADS7841 ideal for battery-operated systems such as personal digital assistants, portable multi-channel data loggers, and measurement equipment. The serial interface also provides low-cost isolation for remote data acquisition. The ADS7841 is available in a DIP-16 or a SSOP-16 package and is specified over the –40°C to +125°C(1) temperature range.

NOTE: (1) ES grade only.



ABSOLUTE MAXIMUM RATINGS[1]

$+V_{CC}$ to GND	–0.3V to +6V
Analog Inputs to GND	–0.3V to $+V_{CC}$ + 0.3V
Digital Inputs to GND	–0.3V to +6V
Power Dissipation	250mW
Maximum Junction Temperature	+150°C
Operating Temperature Range	–40°C to +125°C[2]
Storage Temperature Range	–65°C to +150°C
Lead Temperature (soldering, 10s)	+300°C

NOTES: (1) Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability. (2) ADS7841ES 0nly. All other grades are: –40°C to +85°C.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

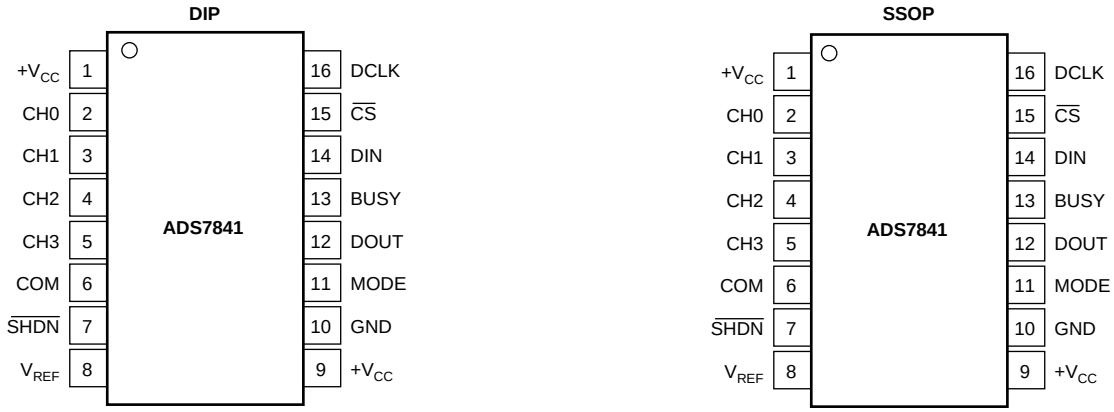
PACKAGE/ORDERING INFORMATION

PRODUCT	MINIMUM RELATIVE ACCURACY (LSB)	MAXIMUM GAIN ERROR (LSB)	SPECIFICATION TEMPERATURE RANGE	PACKAGE	PACKAGE DESIGNATOR	PACKAGE DRAWING NUMBER	ORDERING NUMBER[1]	TRANSPORT MEDIA
ADS7841E	±2	±4	–40°C to +85°C	SSOP-16	DBQ	322	ADS7841E	Rails
"	"	"	"	"	"	"	ADS7841E/2K5	Tape and Reel
ADS7841P	±2	"	–40°C to +85°C	DIP-16	N	180	ADS7841P	Rails
ADS7841EB	±1	±3	–40°C to +85°C	SSOP-16	DBQ	322	ADS7841EB	Rails
"	"	"	"	"	"	"	ADS7841EB/2K5	Tape and Reel
ADS7841PB	±1	"	–40°C to +85°C	DIP-16	N	180	ADS7841PB	Rails
ADS7841ES	±2	±4	–40°C to +125°C	SSOP-16	DBQ	322	ADS7841ES/2K5	Tape and Reel

NOTES: (1) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /2K5 indicates 2500 devices per reel). Ordering 2500 pieces of "ADS7841E/2K5" will get a single 2500-piece Tape and Reel.

PIN CONFIGURATIONS

Top View



PIN DESCRIPTIONS

PIN	NAME	DESCRIPTION
1	$+V_{CC}$	Power Supply, 2.7V to 5V
2	CH0	Analog Input Channel 0
3	CH1	Analog Input Channel 1
4	CH2	Analog Input Channel 2
5	CH3	Analog Input Channel 3
6	COM	Ground Reference for Analog Inputs. Sets zero code voltage in single-ended mode. Connect this pin to ground or ground reference point.
7	$\overline{SHDN}$	Shutdown. When LOW, the device enters a very low power shutdown mode.
8	V_{REF}	Voltage Reference Input
9	$+V_{CC}$	Power Supply, 2.7V to 5V
10	GND	Ground
11	MODE	Conversion Mode. When LOW, the device always performs a 12-bit conversion. When HIGH, the resolution is set by the MODE bit in the CONTROL byte.
12	DOUT	Serial Data Output. Data is shifted on the falling edge of DCLK. This output is high impedance when $\overline{CS}$ is HIGH.
13	BUSY	Busy Output. This output is high impedance when $\overline{CS}$ is HIGH.
14	DIN	Serial Data Input. If $\overline{CS}$ is LOW, data is latched on rising edge of DCLK.
15	$\overline{CS}$	Chip Select Input. Controls conversion timing and enables the serial input/output register.
16	DCLK	External Clock Input. This clock runs the SAR conversion process and synchronizes serial data I/O.

ELECTRICAL CHARACTERISTICS: +5V

At $T_A = T_{MIN}$ to T_{MAX}, $+V_{CC} = +5V$, $V_{REF} = +5V$, $f_{SAMPLE} = 200kHz$, and $f_{CLK} = 16 \bullet f_{SAMPLE} = 3.2MHz$, unless otherwise noted.

PARAMETER	CONDITIONS	ADS7841E, P			ADS7841EB, PB			ADS7841ES			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
ANALOG INPUT											
Full-Scale Input Span	Positive Input - Negative Input	0		V_{REF}	*		*	*		*	V
Absolute Input Range	Positive Input	–0.2		$+V_{CC}$ +0.2	*		*	*		*	V
	Negative Input	–0.2		+1.25	*		*	*		*	V
Capacitance			25			*			*		pF
Leakage Current				200			200			200	nA
SYSTEM PERFORMANCE											
Resolution			12			*			*		Bits
No Missing Codes		12			12			11			Bits
Integral Linearity Error				±2			±1			2	LSB[1]
Differential Linearity Error			±0.8			±0.5	±1		±0.8		LSB
Offset Error				±3			*			*	LSB
Offset Error Match			0.15	1.0		*	*		*	*	LSB
Gain Error				±4			±3			±4	LSB
Gain Error Match			0.1	1.0		*	*		*	*	LSB
Noise			30			*			*		µVrms
Power-Supply Rejection			70			*			*		dB
SAMPLING DYNAMICS											
Conversion Time				12			*			*	Clk Cycles
Acquisition Time		3			*			*			Clk Cycles
Throughput Rate				200			*			*	kHz
Multiplexer Settling Time			500			*			*		ns
Aperture Delay			30			*			*		ns
Aperture Jitter			100			*			*		ps
DYNAMIC CHARACTERISTICS											
Total Harmonic Distortion[2]	V_{IN} = 5Vp-p at 10kHz		–78	–72		–80	–76		–78	–72	dB
Signal-to-(Noise + Distortion)	V_{IN} = 5Vp-p at 10kHz	68	71		70	72		68	71		dB
Spurious-Free Dynamic Range	V_{IN} = 5Vp-p at 10kHz	72	79		76	81		72	79		dB
Channel-to-Channel Isolation	V_{IN} = 5Vp-p at 50kHz		120			*			120		dB
REFERENCE INPUT											
Range		0.1		$+V_{CC}$	*		*	*		*	V
Resistance	DCLK Static		5			*			*		GΩ
Input Current			40	100		*	*		*	*	µA
	f_{SAMPLE} = 12.5kHz		2.5			*			*		µA
	DCLK Static		0.001	3		*	*		*	*	µA
DIGITAL INPUT/OUTPUT											
Logic Family			CMOS			*			*		
Logic Levels											
V_{IH}	$\lvert I_{IH} \rvert \leq +5\mu A$	3.0		5.5	*		*	*		*	V
V_{IL}	$\lvert I_{IL} \rvert \leq +5\mu A$	–0.3		+0.8	*		*	*		*	V
V_{OH}	$I_{OH} = -250\mu A$	3.5			*			*			V
V_{OL}	$I_{OL} = 250\mu A$			0.4			*			*	V
Data Format			Straight Binary			*			*		
PWR SUPPLY REQUIREMENTS											
$+V_{CC}$	Specified Performance	4.75		5.25	*		*	*		*	V
Quiescent Current			550	900			*			*	µA
	f_{SAMPLE} = 12.5kHz		300			*			*		µA
	Power-Down Mode[3], $\overline{CS} = +V_{CC}$			3			*			*	µA
Power Dissipation				4.5			*			*	mW
TEMPERATURE RANGE											
Specified Performance		–40		+85	*		*	*		+125	°C

* Same specifications as ADS7841E, P.

NOTE: (1) LSB means Least Significant Bit. With V_{REF} equal to +5.0V, one LSB is 1.22mV. (2) First five harmonics of the test frequency. (3) Auto power-down mode (PD1 = PD0 = 0) active or $\overline{SHDN}$ = GND.

ELECTRICAL CHARACTERISTICS: +2.7V

At T_A = –40°C to +85°C, $+V_{CC}$ = +2.7V, V_{REF} = +2.5V, f_{SAMPLE} = 125kHz, and f_{CLK} = 16 • f_{SAMPLE} = 2MHz, unless otherwise noted.

PARAMETER	CONDITIONS	ADS7841E, P			ADS7841EB, PB			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
ANALOG INPUT								
Full-Scale Input Span	Positive Input - Negative Input	0		V_{REF}	*		*	V
Absolute Input Range	Positive Input	–0.2		$+V_{CC}$ +0.2	*		*	V
	Negative Input	–0.2		+0.2	*		*	V
Capacitance			25			*		pF
Leakage Current			±1			*		µA
SYSTEM PERFORMANCE								
Resolution			12			*		Bits
No Missing Codes		12			12			Bits
Integral Linearity Error				±2			±1	LSB[1]
Differential Linearity Error			±0.8			±0.5	±1	LSB
Offset Error				±3			*	LSB
Offset Error Match			0.15	1.0		*	*	LSB
Gain Error				±4			±3	LSB
Gain Error Match			0.1	1.0		*	*	LSB
Noise			30			*		µVrms
Power-Supply Rejection			70			*		dB
SAMPLING DYNAMICS								
Conversion Time				12			*	Clk Cycles
Acquisition Time		3			*			Clk Cycles
Throughput Rate				125			*	kHz
Multiplexer Settling Time			500			*		ns
Aperture Delay			30			*		ns
Aperture Jitter			100			*		ps
DYNAMIC CHARACTERISTICS								
Total Harmonic Distortion[2]	V_{IN} = 2.5Vp-p at 10kHz		–77	–72		–79	–76	dB
Signal-to-(Noise + Distortion)	V_{IN} = 2.5Vp-p at 10kHz	68	71		70	72		dB
Spurious-Free Dynamic Range	V_{IN} = 2.5Vp-p at 10kHz	72	78		76	80		dB
Channel-to-Channel Isolation	V_{IN} = 2.5Vp-p at 50kHz		100			*		dB
REFERENCE INPUT								
Range		0.1		$+V_{CC}$	*		*	V
Resistance	DCLK Static		5			*		GΩ
Input Current			13	40		*	*	µA
	f_{SAMPLE} = 12.5kHz		2.5			*		µA
	DCLK Static		0.001	3		*	*	µA
DIGITAL INPUT/OUTPUT								
Logic Family			CMOS			*		
Logic Levels								
V_{IH}	$\lvert I_{IH} \rvert \leq +5\mu A$	$+V_{CC}$ • 0.7		5.5	*		*	V
V_{IL}	$\lvert I_{IL} \rvert \leq +5\mu A$	–0.3		+0.8	*		*	V
V_{OH}	I_{OH} = –250µA	$+V_{CC}$ • 0.8			*			V
V_{OL}	I_{OL} = 250µA			0.4			*	V
Data Format			Straight Binary			*		
POWER SUPPLY REQUIREMENTS								
$+V_{CC}$	Specified Performance	2.7		3.6	*		*	V
Quiescent Current			280	650		*	*	µA
	f_{SAMPLE} = 12.5kHz		220			*		µA
	Power-Down Mode[3], $\overline{CS}$ = $+V_{CC}$			3			*	µA
Power Dissipation				1.8			*	mW
TEMPERATURE RANGE								
Specified Performance		–40		+85	*		*	°C

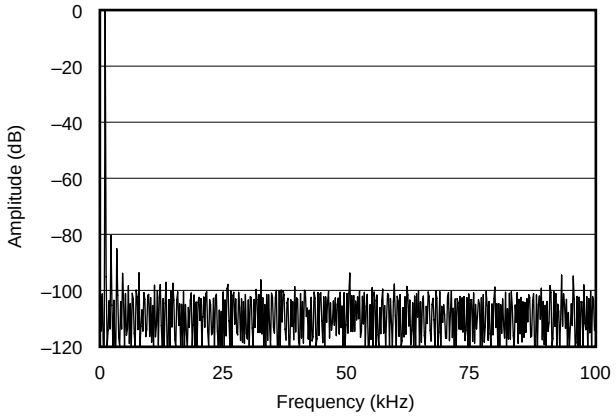
* Same specifications as ADS7841E, P.

NOTE: (1) LSB means Least Significant Bit. With V_{REF} equal to +2.5V, one LSB is 610mV. (2) First five harmonics of the test frequency. (3) Auto power-down mode (PD1 = PD0 = 0) active or $\overline{SHDN}$ = GND.

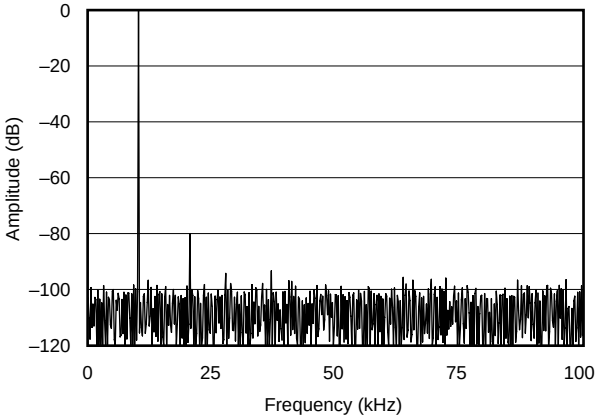
TYPICAL CHARACTERISTICS: +5V

At T_A = +25°C, $+V_{CC}$ = +5V, V_{REF} = +5V, f_{SAMPLE} = 200kHz, and f_{CLK} = 16 • f_{SAMPLE} = 3.2MHz, unless otherwise noted.

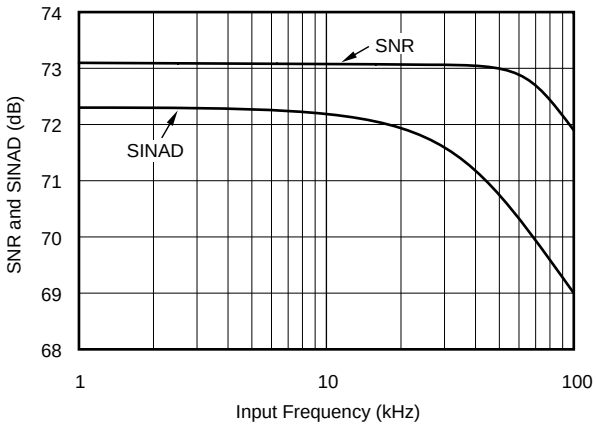
FREQUENCY SPECTRUM
(4096 Point FFT; f_{IN} = 1,123Hz, –0.2dB)



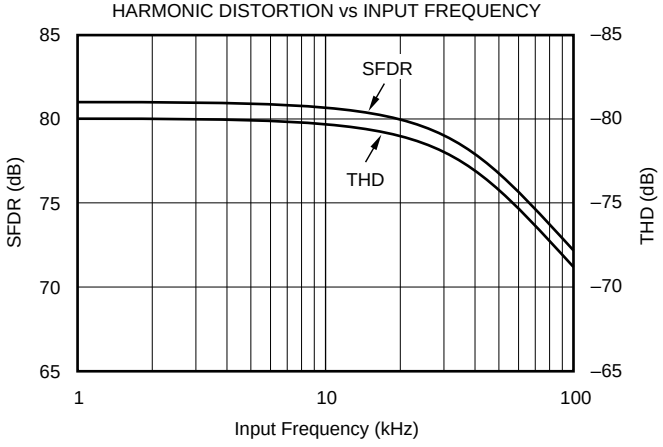
FREQUENCY SPECTRUM
(4096 Point FFT; f_{IN} = 10.3kHz, –0.2dB)



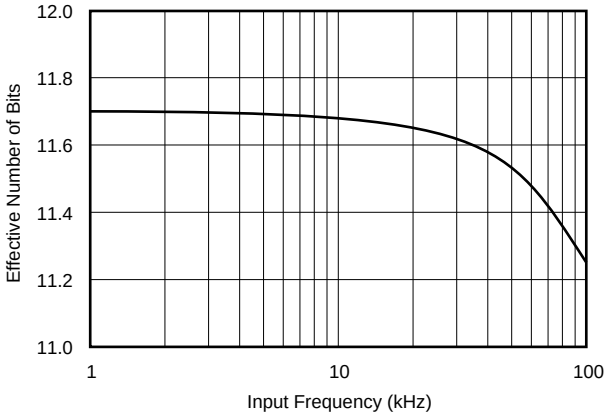
SIGNAL-TO-NOISE RATIO AND SIGNAL-TO-
(NOISE+DISTORTION) vs INPUT FREQUENCY



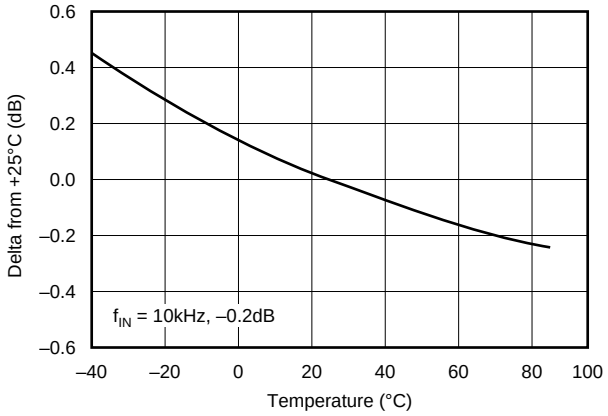
SPURIOUS-FREE DYNAMIC RANGE AND TOTAL
HARMONIC DISTORTION vs INPUT FREQUENCY



EFFECTIVE NUMBER OF BITS
vs INPUT FREQUENCY



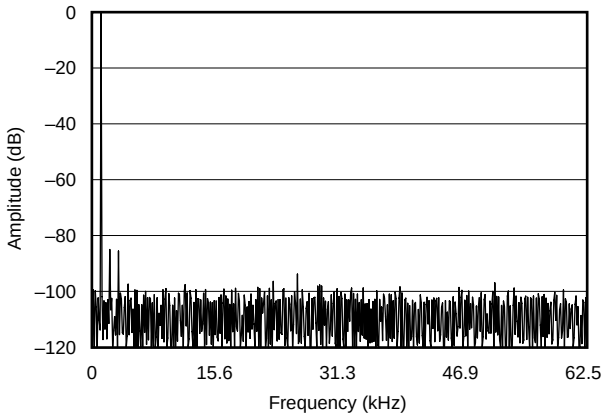
CHANGE IN SIGNAL-TO-(NOISE+DISTORTION)
vs TEMPERATURE



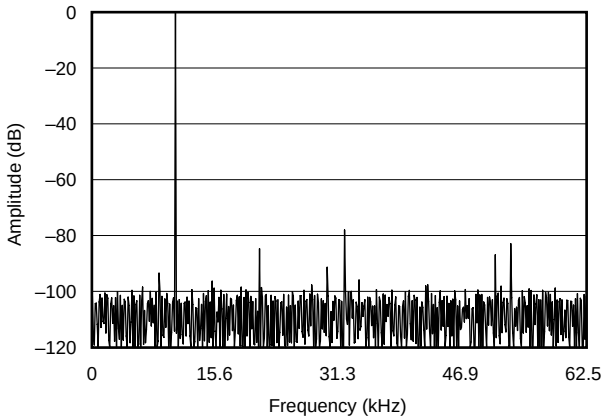
TYPICAL CHARACTERISTICS: +2.7V

At T_A = +25°C, $+V_{CC}$ = +2.7V, V_{REF} = +2.5V, f_{SAMPLE} = 125kHz, and f_{CLK} = 16 • f_{SAMPLE} = 2MHz, unless otherwise noted.

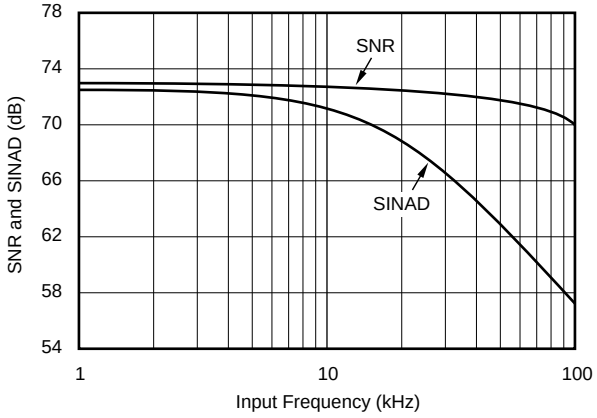
FREQUENCY SPECTRUM
(4096 Point FFT; f_{IN} = 1,129Hz, –0.2dB)



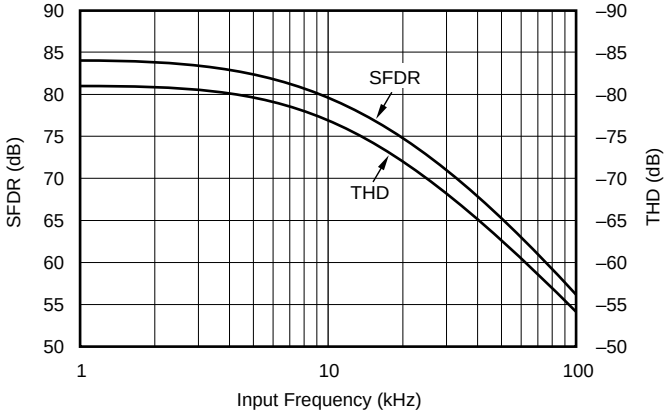
FREQUENCY SPECTRUM
(4096 Point FFT; f_{IN} = 10.6kHz, –0.2dB)



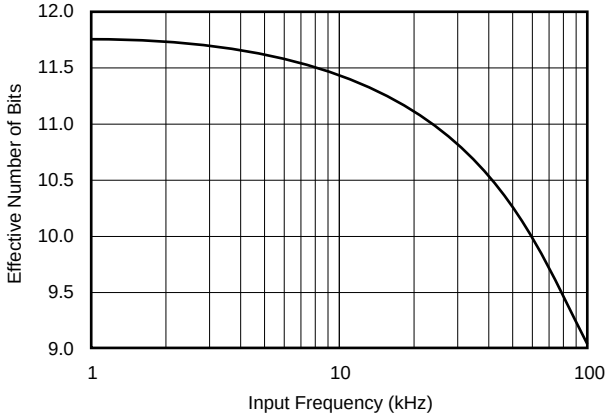
SIGNAL-TO-NOISE RATIO AND SIGNAL-TO-(NOISE+DISTORTION) vs INPUT FREQUENCY



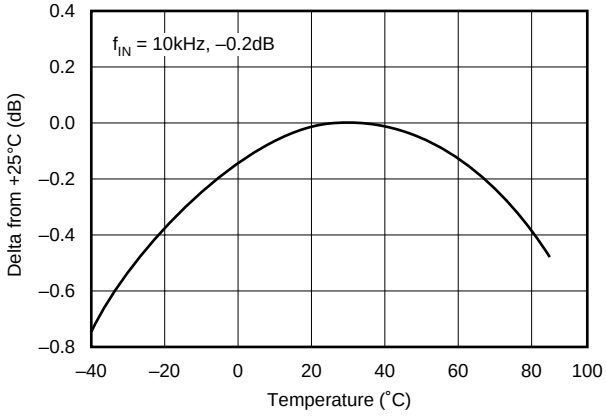
SPURIOUS-FREE DYNAMIC RANGE AND TOTAL HARMONIC DISTORTION vs INPUT FREQUENCY



EFFECTIVE NUMBER OF BITS vs INPUT FREQUENCY



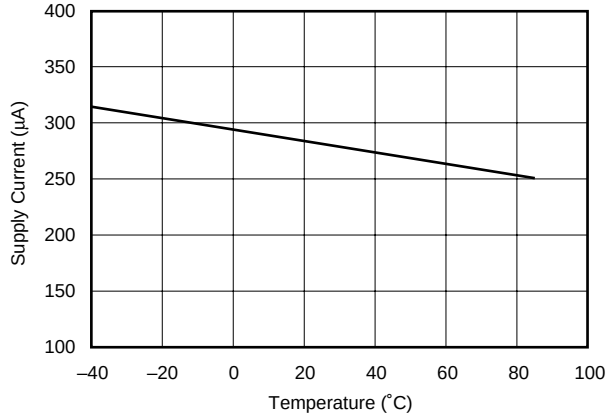
CHANGE IN SIGNAL-TO-(NOISE+DISTORTION) vs TEMPERATURE



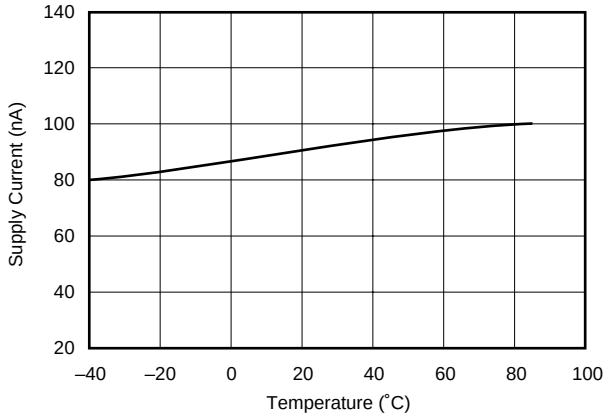
TYPICAL CHARACTERISTICS: +2.7V (Cont.)

At T_A = +25°C, $+V_{CC}$ = +2.7V, V_{REF} = +2.5V, f_{SAMPLE} = 125kHz, and f_{CLK} = 16 • f_{SAMPLE} = 2MHz, unless otherwise noted.

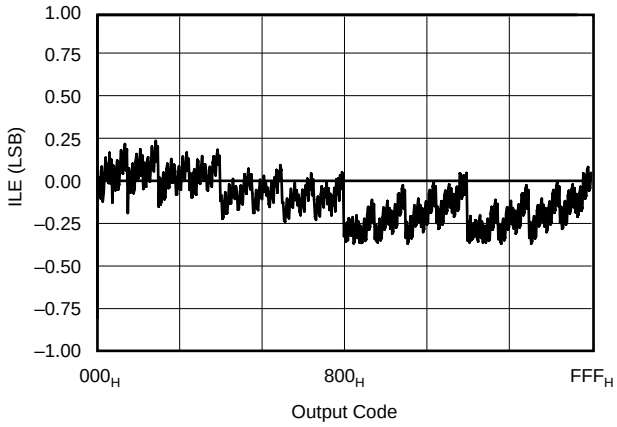
SUPPLY CURRENT vs TEMPERATURE



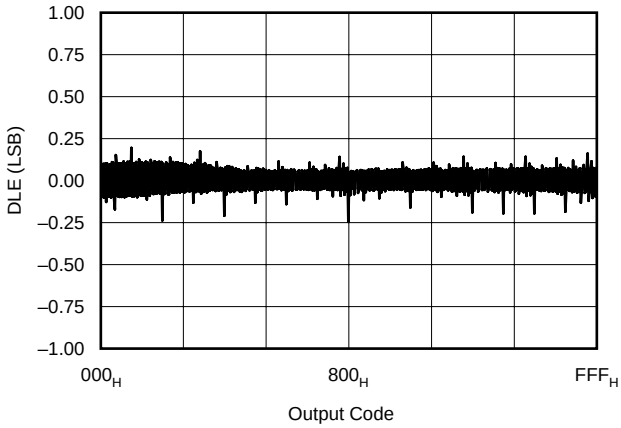
POWER DOWN SUPPLY CURRENT vs TEMPERATURE



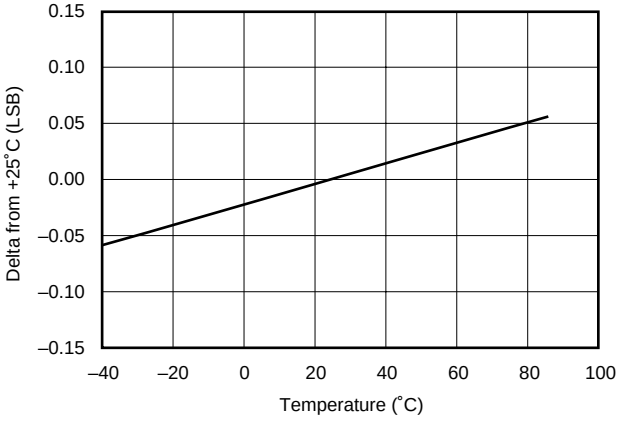
INTEGRAL LINEARITY ERROR vs CODE



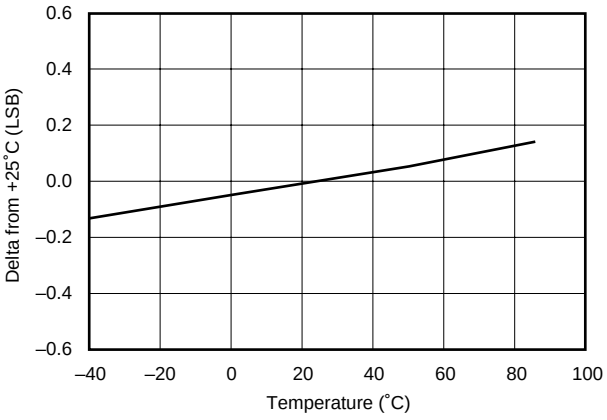
DIFFERENTIAL LINEARITY ERROR vs CODE



CHANGE IN GAIN vs TEMPERATURE



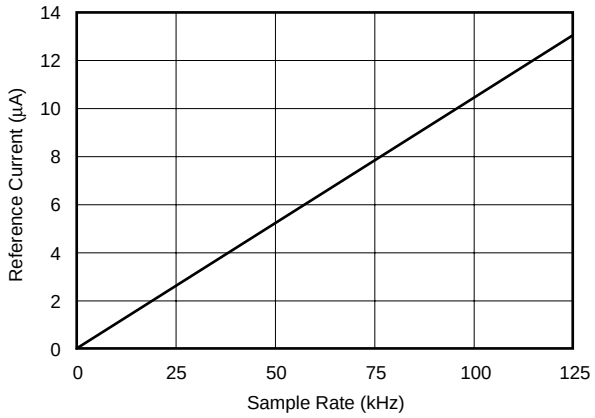
CHANGE IN OFFSET vs TEMPERATURE



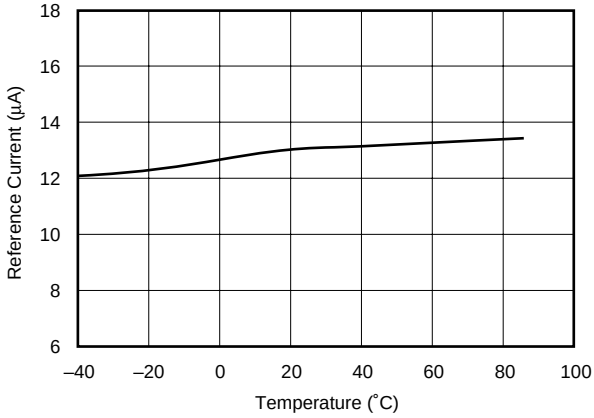
TYPICAL CHARACTERISTICS: +2.7V (Cont.)

At T_A = +25°C, $+V_{CC}$ = +2.7V, V_{REF} = +2.5V, f_{SAMPLE} = 125kHz, and f_{CLK} = 16 • f_{SAMPLE} = 2MHz, unless otherwise noted.

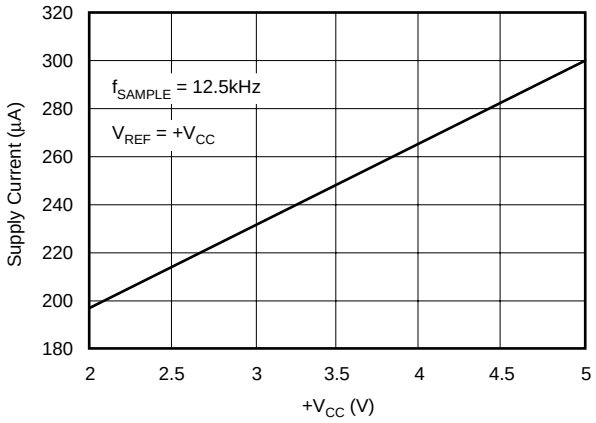
REFERENCE CURRENT vs SAMPLE RATE



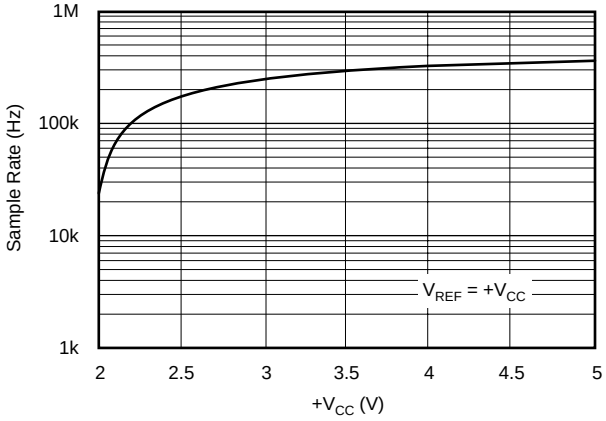
REFERENCE CURRENT vs TEMPERATURE



SUPPLY CURRENT vs $+V_{CC}$



MAXIMUM SAMPLE RATE vs $+V_{CC}$



THEORY OF OPERATION

The ADS7841 is a classic Successive Approximation Register (SAR) ADC. The architecture is based on capacitive redistribution that inherently includes a sample-and-hold function. The converter is fabricated on a 0.6µs CMOS process.

The basic operation of the ADS7841 is shown in Figure 1. The device requires an external reference and an external clock. It operates from a single supply of 2.7V to 5.25V. The external reference can be any voltage between 100mV and $+V_{CC}$. The value of the reference voltage directly sets the input range of the converter. The average reference input current depends on the conversion rate of the ADS7841.

The analog input to the converter is differential and is provided via a four-channel multiplexer. The input can be provided in reference to a voltage on the COM pin (which is generally ground) or differentially by using two of the four input channels (CH0 - CH3). The particular configuration is selectable via the digital interface.

ANALOG INPUT

Figure 2 shows a block diagram of the input multiplexer on the ADS7841. The differential input of the converter is derived from one of the four inputs in reference to the COM pin or two of the four inputs. Table I and Table II show the relationship between the A2, A1, A0, and SGL/$\overline{\text{DIF}}$ control bits and the configuration of the analog multiplexer. The control bits are provided serially via the DIN pin, see the Digital Interface section of this data sheet for more details.

When the converter enters the hold mode, the voltage difference between the +IN and –IN inputs (as shown in Figure 2) is captured on the internal capacitor array. The voltage on the –IN input is limited between –0.2V and 1.25V, allowing the input to reject small signals that are common to both the +IN and –IN input. The +IN input has a range of –0.2V to $+V_{CC}$ + 0.2V.

The input current on the analog inputs depends on the conversion rate of the device. During the sample period, the source must charge the internal sampling capacitor (typically 25pF). After the capacitor has been fully charged, there is no further input current. The rate of charge transfer from the analog source to the converter is a function of conversion rate.

A2	A1	A0	CH0	CH1	CH2	CH3	COM
0	0	1	+IN				–IN
1	0	1		+IN			–IN
0	1	0			+IN		–IN
1	1	0				+IN	–IN

TABLE I. Single-Ended Channel Selection (SGL/$\overline{\text{DIF}}$ HIGH).

A2	A1	A0	CH0	CH1	CH2	CH3	COM
0	0	1	+IN	–IN			
1	0	1	–IN	+IN			
0	1	0			+IN	–IN	
1	1	0			–IN	+IN	

TABLE II. Differential Channel Control (SGL/$\overline{\text{DIF}}$ LOW).

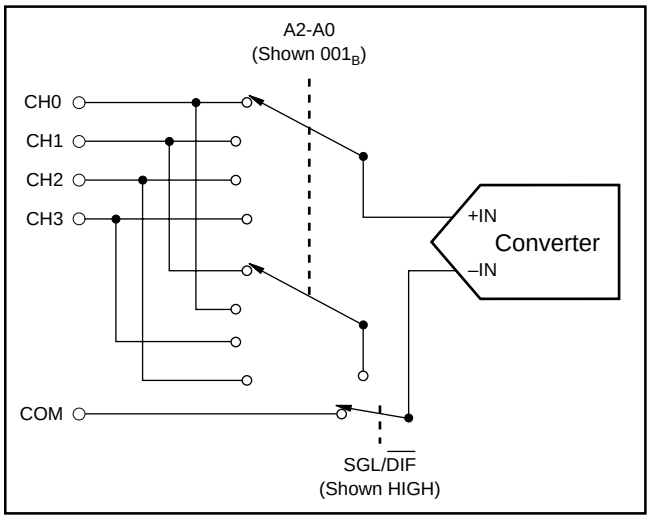


FIGURE 2. Simplified Diagram of the Analog Input.

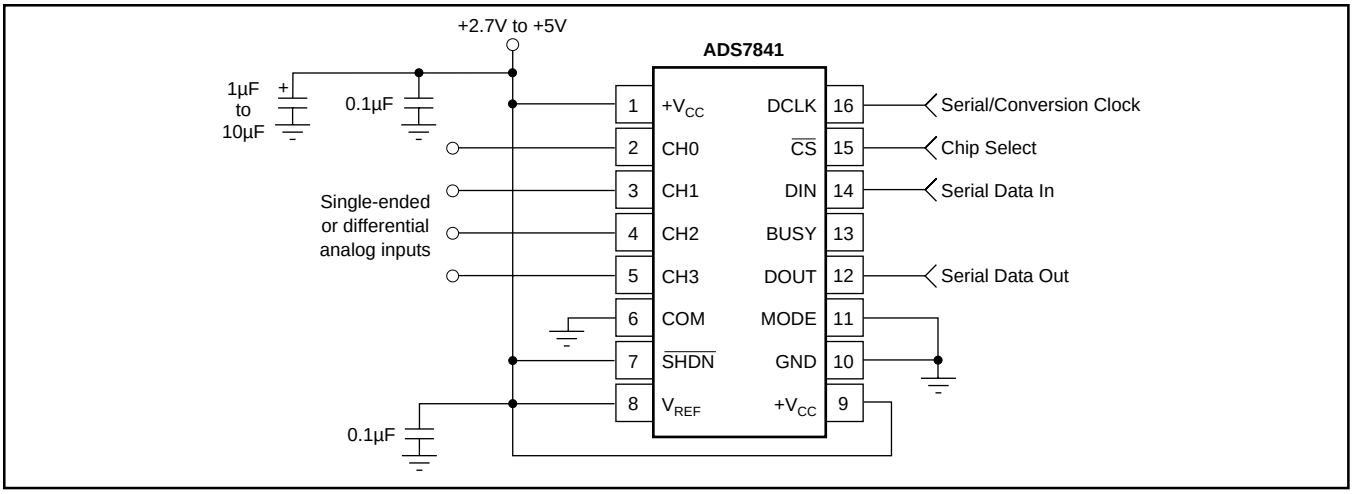


FIGURE 1. Basic Operation of the ADS7841.

REFERENCE INPUT

The external reference sets the analog input range. The ADS7841 will operate with a reference in the range of 100mV to $+V_{CC}$. Keep in mind that the analog input is the difference between the +IN input and the –IN input, see Figure 2. For example, in the single-ended mode, a 1.25V reference, and with the COM pin grounded, the selected input channel (CH0 - CH3) will properly digitize a signal in the range of 0V to 1.25V. If the COM pin is connected to 0.5V, the input range on the selected channel is 0.5V to 1.75V.

There are several critical items concerning the reference input and its wide voltage range. As the reference voltage is reduced, the analog voltage weight of each digital output code is also reduced. This is often referred to as the LSB (least significant bit) size and is equal to the reference voltage divided by 4096. Any offset or gain error inherent in the ADC will appear to increase, in terms of LSB size, as the reference voltage is reduced. For example, if the offset of a given converter is 2LSBs with a 2.5V reference, then it will typically be 10LSBs with a 0.5V reference. In each case, the actual offset of the device is the same, 1.22mV.

Likewise, the noise or uncertainty of the digitized output will increase with lower LSB size. With a reference voltage of 100mV, the LSB size is 24μV. This level is below the internal noise of the device. As a result, the digital output code will not be stable and vary around a mean value by a number of LSBs. The distribution of output codes will be gaussian and the noise can be reduced by simply averaging consecutive conversion results or applying a digital filter.

With a lower reference voltage, care should be taken to provide a clean layout including adequate bypassing, a clean (low-noise, low-ripple) power supply, a low-noise reference, and a low-noise input signal. Because the LSB size is lower, the converter will also be more sensitive to nearby digital signals and electromagnetic interference.

The voltage into the V_{REF} input is not buffered and directly drives the Capacitor Digital-to-Analog Converter (CDAC) portion of the ADS7841. Typically, the input current is 13μA with a 2.5V reference. This value will vary by microamps depending on the result of the conversion. The reference current diminishes directly with both conversion rate and reference voltage. As the current from the reference is drawn on each bit decision, clocking the converter more quickly during a given conversion period will not reduce overall current drain from the reference.

DIGITAL INTERFACE

Figure 3 shows the typical operation of the ADS7841's digital interface. This diagram assumes that the source of the digital signals is a microcontroller or digital signal processor with a basic serial interface (note that the digital inputs are over-voltage tolerant up to 5.5V, regardless of $+V_{CC}$). Each communication between the processor and the converter consists of eight clock cycles. One complete conversion can be accomplished with three serial communications, for a total of 24 clock cycles on the DCLK input.

The first eight clock cycles are used to provide the control byte via the DIN pin. When the converter has enough information about the following conversion to set the input multiplexer appropriately, it enters the acquisition (sample) mode. After three more clock cycles, the control byte is complete and the converter enters the conversion mode. At this point, the input sample-and-hold goes into the hold mode. The next twelve clock cycles accomplish the actual Analog-to-Digital conversion. A thirteenth clock cycle is needed for the last bit of the conversion result. Three more clock cycles are needed to complete the last byte (DOUT will be LOW). These will be ignored by the converter.

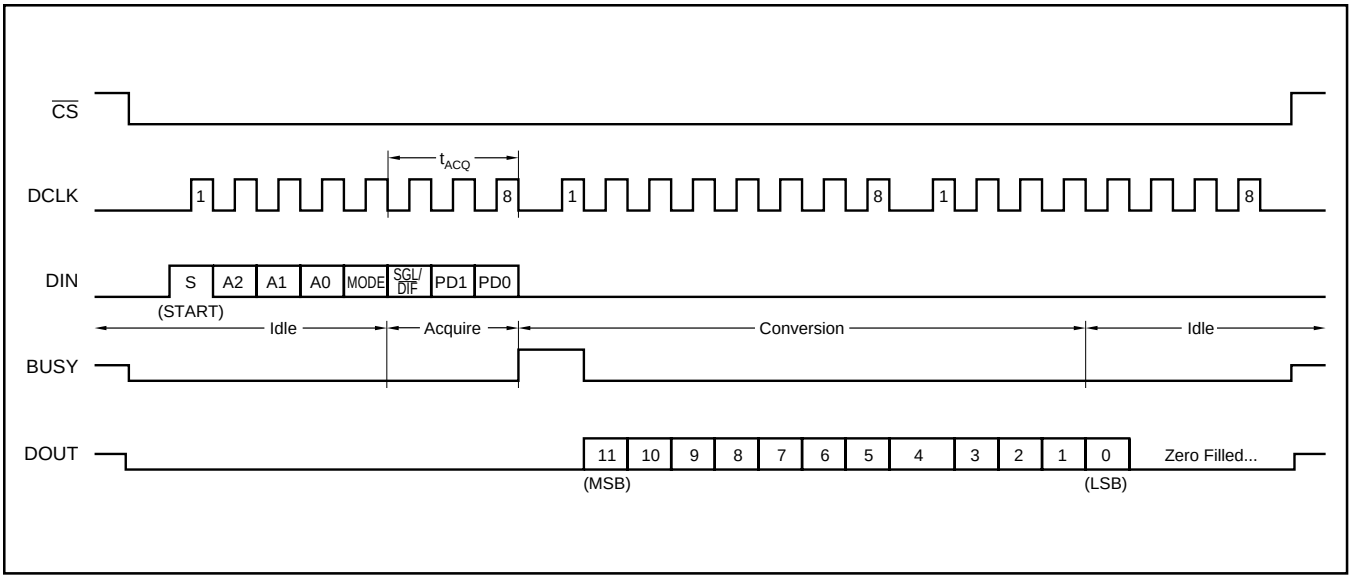


FIGURE 3. Conversion Timing, 24-Clocks per Conversion, 8-Bit Bus Interface. No DCLK delay required with dedicated serial port.

Control Byte

Also shown in Figure 3 is the placement and order of the control bits within the control byte. Tables III and IV give detailed information about these bits. The first bit, the 'S' bit, must always be HIGH and indicates the start of the control byte. The ADS7841 will ignore inputs on the DIN pin until the start bit is detected. The next three bits (A2 - A0) select the active input channel or channels of the input multiplexer (see Tables I and II and Figure 2).

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
S	A2	A1	A0	MODE	SGL/$\overline{\text{DIF}}$	PD1	PD0

TABLE III. Order of the Control Bits in the Control Byte.

BIT	NAME	DESCRIPTION
7	S	Start Bit. Control byte starts with first HIGH bit on DIN. A new control byte can start every 15th clock cycle in 12-bit conversion mode or every 11th clock cycle in 8-bit conversion mode.
6 - 4	A2 - A0	Channel Select Bits. Along with the SGL/$\overline{\text{DIF}}$ bit, these bits control the setting of the multiplexer input, see Tables I and II.
3	MODE	12-Bit/8-Bit Conversion Select Bit. If the MODE pin is HIGH, this bit controls the number of bits for the next conversion: 12-bits (LOW) or 8-bits (HIGH). If the MODE pin is LOW, this bit has no function and the conversion is always 12 bits.
2	SGL/$\overline{\text{DIF}}$	Single-Ended/Differential Select Bit. Along with bits A2 - A0, this bit controls the setting of the multiplexer input, see Tables I and II.
1 - 0	PD1 - PD0	Power-Down Mode Select Bits. See Table V for details.

TABLE IV. Descriptions of the Control Bits within the Control Byte.

The MODE bit and the MODE pin work together to determine the number of bits for a given conversion. If the MODE pin is LOW, the converter always performs a 12-bit conversion regardless of the state of the MODE bit. If the MODE pin is HIGH, then the MODE bit determines the number of bits for each conversion, either 12 bits (LOW) or 8 bits (HIGH).

The SGL/$\overline{\text{DIF}}$ bit controls the multiplexer input mode: either single-ended (HIGH) or differential (LOW). In single-ended mode, the selected input channel is referenced to the COM pin. In differential mode, the two selected inputs provide a differential input. See Tables I and II and Figure 2 for more information. The last two bits (PD1 - PD0) select the power-down mode, as shown in Table V. If both inputs are HIGH, the device is always powered up. If both inputs are LOW, the device enters a power-down mode between conversions. When a new conversion is initiated, the device will resume normal operation instantly—no delay is needed to allow the device to power up and the very first conversion will be valid.

16-Clocks per Conversion

The control bits for conversion n+1 can be overlapped with conversion 'n' to allow for a conversion every 16 clock cycles, as shown in Figure 4. This figure also shows possible serial communication occurring with other serial peripherals between each byte transfer between the processor and the converter. This is possible provided that each conversion completes within 1.6ms of starting. Otherwise, the signal that has been captured on the input sample-and-hold may droop enough to affect the conversion result. In addition, the ADS7841 is fully powered while other serial communications are taking place.

PD1	PD0	Description
0	0	Power-down between conversions. When each conversion is finished, the converter enters a low power mode. At the start of the next conversion, the device instantly powers up to full power. There is no need for additional delays to assure full operation and the very first conversion is valid.
0	1	Reserved for Future Use
1	0	Reserved for Future Use
1	1	No power-down between conversions, device always powered.

TABLE V. Power-Down Selection.

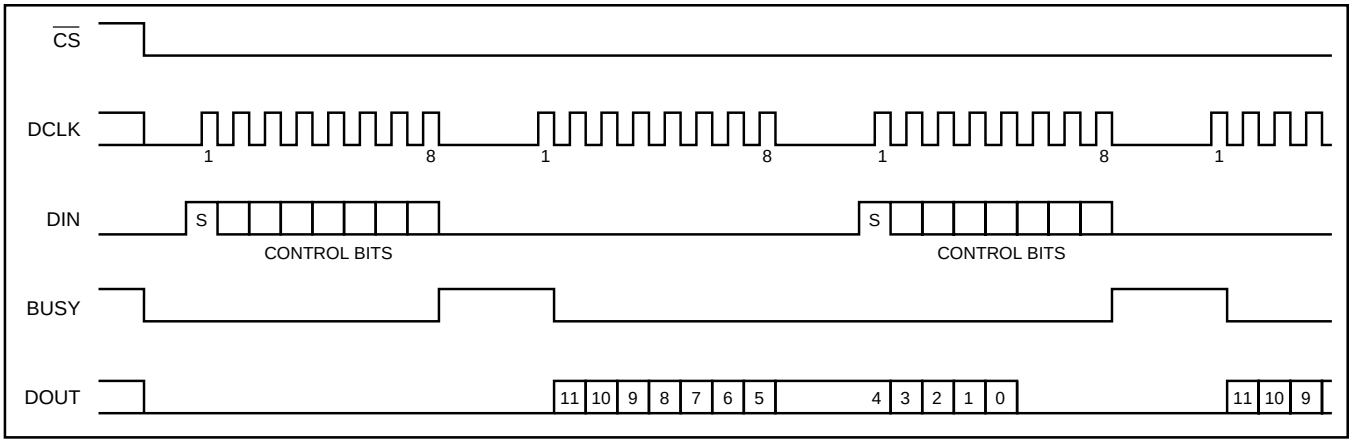


FIGURE 4. Conversion Timing, 16-Clocks per Conversion, 8-bit Bus Interface. No DCLK delay required with dedicated serial port.

Digital Timing

Figure 5 and Tables VI and VII provide detailed timing for the digital interface of the ADS7841.

15-Clocks per Conversion

Figure 6 provides the fastest way to clock the ADS7841. This method will not work with the serial interface of most microcontrollers and digital signal processors as they are generally not capable of providing 15 clock cycles per serial transfer. However, this method could be used with Field Programmable Gate Arrays (FPGAs) or Application Specific Integrated Circuits (ASICs). Note that this effectively increases the maximum conversion rate of the converter beyond the values given in the specification tables, which assume 16 clock cycles per conversion.

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{ACQ}	Acquisition Time	1.5			µs
t_{DS}	DIN Valid Prior to DCLK Rising	100			ns
t_{DH}	DIN Hold After DCLK HIGH	10			ns
t_{DO}	DCLK Falling to DOUT Valid			200	ns
t_{DV}	$\overline{CS}$ Falling to DOUT Enabled			200	ns
t_{TR}	$\overline{CS}$ Rising to DOUT Disabled			200	ns
t_{CSS}	$\overline{CS}$ Falling to First DCLK Rising	100			ns
t_{CSH}	$\overline{CS}$ Rising to DCLK Ignored	0			ns
t_{CH}	DCLK HIGH	200			ns
t_{CL}	DCLK LOW	200			ns
t_{BD}	DCLK Falling to BUSY Rising			200	ns
t_{BDV}	$\overline{CS}$ Falling to BUSY Enabled			200	ns
t_{BTR}	$\overline{CS}$ Rising to BUSY Disabled			200	ns

TABLE VI. Timing Specifications ($+V_{CC}$ = +2.7V to 3.6V, T_A = –40°C to +85°C, C_{LOAD} = 50pF).

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{ACQ}	Acquisition Time	900			ns
t_{DS}	DIN Valid Prior to DCLK Rising	50			ns
t_{DH}	DIN Hold After DCLK HIGH	10			ns
t_{DO}	DCLK Falling to DOUT Valid			100	ns
t_{DV}	$\overline{CS}$ Falling to DOUT Enabled			70	ns
t_{TR}	$\overline{CS}$ Rising to DOUT Disabled			70	ns
t_{CSS}	$\overline{CS}$ Falling to First DCLK Rising	50			ns
t_{CSH}	$\overline{CS}$ Rising to DCLK Ignored	0			ns
t_{CH}	DCLK HIGH	150			ns
t_{CL}	DCLK LOW	150			ns
t_{BD}	DCLK Falling to BUSY Rising			100	ns
t_{BDV}	$\overline{CS}$ Falling to BUSY Enabled			70	ns
t_{BTR}	$\overline{CS}$ Rising to BUSY Disabled			70	ns

TABLE VII. Timing Specifications ($+V_{CC}$ = +4.75V to +5.25V, T_A = –40°C to +85°C, C_{LOAD} = 50pF).

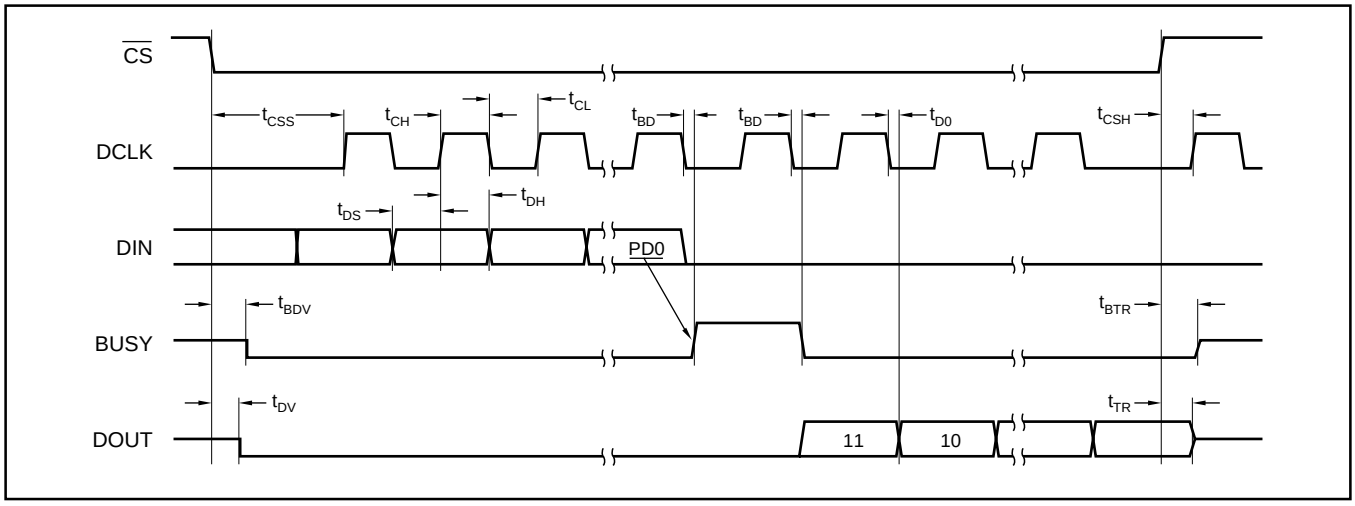


FIGURE 5. Detailed Timing Diagram.

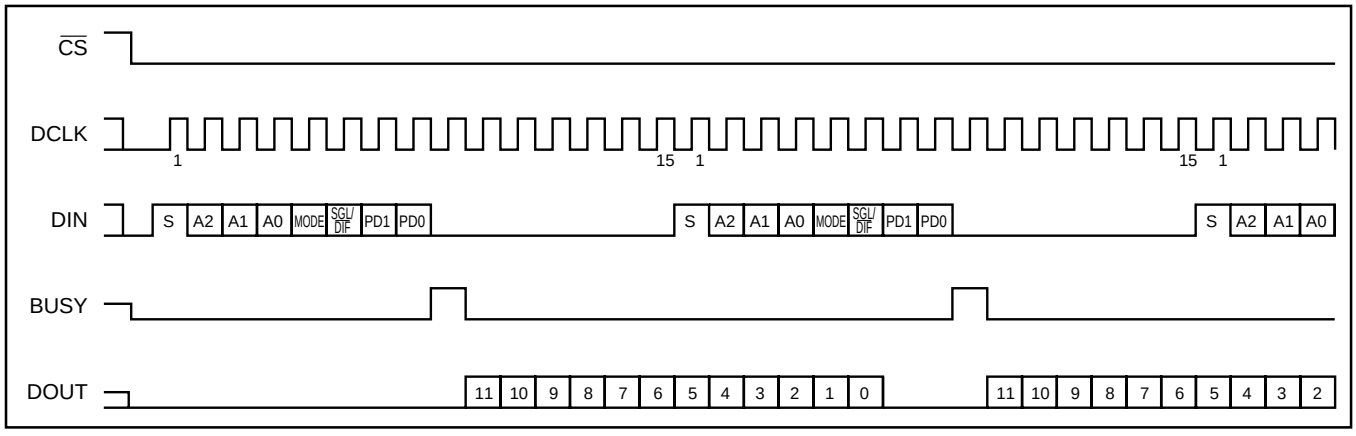


FIGURE 6. Maximum Conversion Rate, 15-Clocks per Conversion.

Data Format

The ADS7841 output data is in straight binary format, as shown in Figure 7. This figure shows the ideal output code for the given input voltage and does not include the effects of offset, gain, or noise.

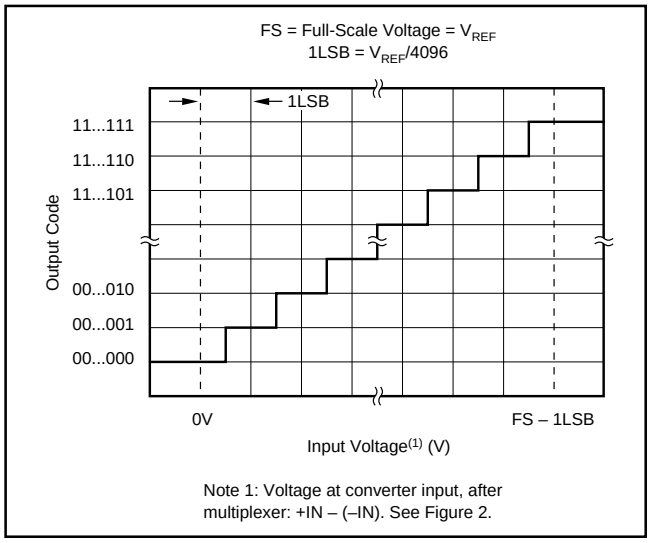


FIGURE 7. Ideal Input Voltages and Output Codes.

8-Bit Conversion

The ADS7841 provides an 8-bit conversion mode that can be used when faster throughput is needed and the digital result is not as critical. By switching to the 8-bit mode, a conversion is complete four clock cycles earlier. This could be used in conjunction with serial interfaces that provide a 12-bit transfer or two conversions could be accomplished with three 8-bit transfers. Not only does this shorten each conversion by four bits (25% faster throughput), but each conversion can actually occur at a faster clock rate. This is because the internal settling time of the ADS7841 is not as critical, settling to better than 8 bits is all that is needed. The clock rate can be as much as 50% faster. The faster clock rate and fewer clock cycles combine to provide a 2x increase in conversion rate.

POWER DISSIPATION

There are three power modes for the ADS7841: full power (PD1 - PD0 = 11B), auto power-down (PD1 - PD0 = 00B), and shutdown ($\overline{SHDN}$ LOW). The affects of these modes varies depending on how the ADS7841 is being operated. For example, at full conversion rate and 16 clocks per conversion, there is very little difference between full power mode and auto power-down. Likewise, if the device has entered auto power-down, a shutdown ($\overline{SHDN}$ LOW) will not lower power dissipation.

When operating at full-speed and 16-clocks per conversion (see Figure 4), the ADS7841 spends most of its time acquiring or converting. There is little time for auto power-down, assuming that this mode is active. Thus, the difference between full power mode and auto power-down is negligible. If the conversion rate is decreased by simply slowing the frequency of the DCLK input, the two modes remain approximately equal. However, if the DCLK frequency is kept at the maximum rate during a conversion, but conversion are simply done less often, then the difference between the two modes is dramatic. Figure 8 shows the difference between reducing the DCLK frequency ("scaling" DCLK to match the conversion rate) or maintaining DCLK at the highest frequency and reducing the number of conversion per second. In the later case, the converter spends an increasing percentage of its time in power-down mode (assuming the auto power-down mode is active).

If DCLK is active and $\overline{CS}$ is LOW while the ADS7841 is in auto power-down mode, the device will continue to dissipate some power in the digital logic. The power can be reduced to a minimum by keeping $\overline{CS}$ HIGH. The differences in supply current for these two cases are shown in Figure 9.

Operating the ADS7841 in auto power-down mode will result in the lowest power dissipation, and there is no conversion time "penalty" on power-up. The very first conversion will be valid. $\overline{SHDN}$ can be used to force an immediate power-down.

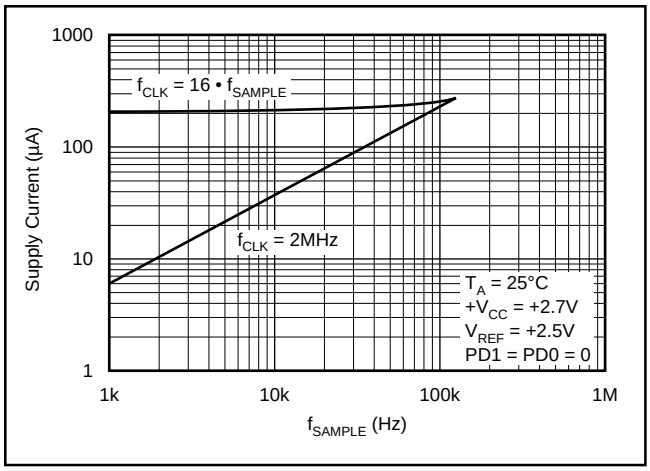


FIGURE 8. Supply Current vs Directly Scaling the Frequency of DCLK with Sample Rate or Keeping DCLK at the Maximum Possible Frequency.

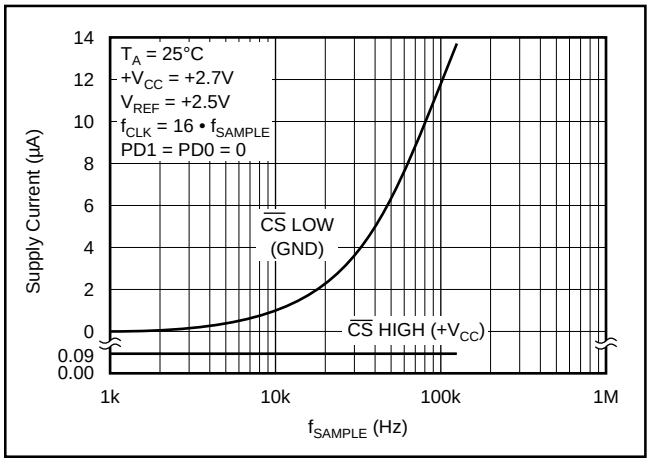


FIGURE 9. Supply Current vs State of $\overline{CS}$.

LAYOUT

For optimum performance, care should be taken with the physical layout of the ADS7841 circuitry. This is particularly true if the reference voltage is low and/or the conversion rate is high.

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, during any single conversion for an n-bit SAR converter, there are n "windows" in which large external transient voltages can easily affect the conversion result. Such glitches might originate from switching power supplies, nearby digital logic, and 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. The error can change if the external event changes in time with respect to the DCLK input.

With this in mind, power to the ADS7841 should be clean and well bypassed. A 0.1µF ceramic bypass capacitor should be placed as close to the device as possible. In addition, a 1µF to 10µF capacitor and a 5Ω or 10Ω series resistor may be used to low-pass filter a noisy supply.

The reference should be similarly bypassed with a 0.1µF capacitor. Again, a series resistor and large capacitor can be used to low-pass filter the reference voltage. If the reference voltage originates from an op amp, make sure that it can drive the bypass capacitor without oscillation (the series resistor can help in this case). The ADS7841 draws very little current from the reference on average, but it does place larger demands on the reference circuitry over short periods of time (on each rising edge of DCLK during a conversion).

The ADS7841 architecture offers no inherent rejection of noise or voltage variation in regards to the reference input. This is of particular concern when the reference input is tied to the power supply. Any noise and ripple from the supply will appear directly in the digital results. While high frequency noise can be filtered out as discussed in the previous paragraph, voltage variation due to line frequency (50Hz or 60Hz) can be difficult to remove.

The GND pin should be connected to a clean ground point. In many cases, this will be the "analog" ground. Avoid connections which are too near the grounding point of a microcontroller or digital signal processor. If needed, run a ground trace directly from the converter to the power supply entry point. The ideal layout will include an analog ground plane dedicated to the converter and associated analog circuitry.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
ADS7841E	Active	Production	SSOP (DBQ) | 16	75 | TUBE	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	ADS 7841E
ADS7841E.B	Active	Production	SSOP (DBQ) | 16	75 | TUBE	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	ADS 7841E
ADS7841E/2K5	Active	Production	SSOP (DBQ) | 16	2500 | LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-	ADS 7841E
ADS7841E/2K5.B	Active	Production	SSOP (DBQ) | 16	2500 | LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	ADS 7841E
ADS7841EB	Active	Production	SSOP (DBQ) | 16	75 | TUBE	Yes	Call TI	Level-2-260C-1 YEAR	-	ADS 7841E
ADS7841EB.B	Active	Production	SSOP (DBQ) | 16	75 | TUBE	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	ADS 7841E
ADS7841EB/2K5	Active	Production	SSOP (DBQ) | 16	2500 | LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-	ADS 7841E
ADS7841EB/2K5.B	Active	Production	SSOP (DBQ) | 16	2500 | LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	ADS 7841E
ADS7841EG4	Active	Production	SSOP (DBQ) | 16	75 | TUBE	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	ADS 7841E
ADS7841ES	Active	Production	SSOP (DBQ) | 16	75 | TUBE	Yes	Call TI	Level-2-260C-1 YEAR	-	ADS 7841E
ADS7841ES.B	Active	Production	SSOP (DBQ) | 16	75 | TUBE	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	ADS 7841E

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) MSL rating/Peak reflow: The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) Part marking: There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

OTHER QUALIFIED VERSIONS OF ADS7841 :

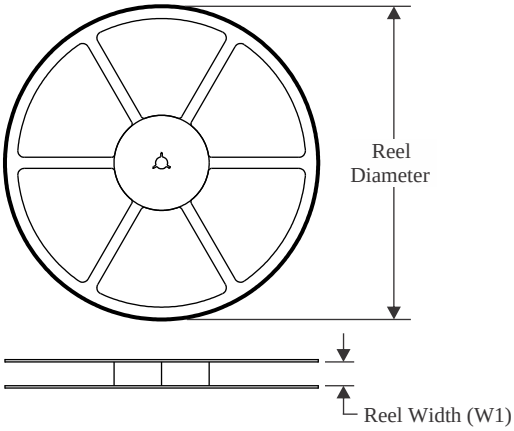
- Automotive : ADS7841-Q1

NOTE: Qualified Version Definitions:

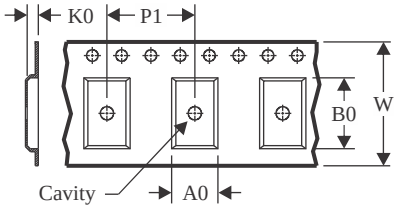
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

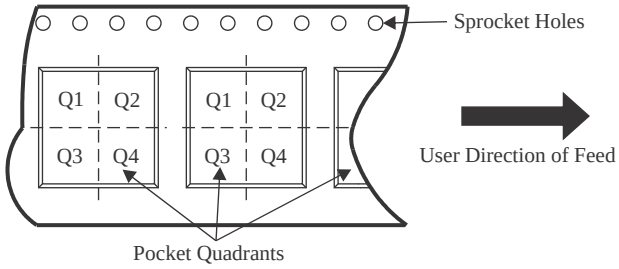


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

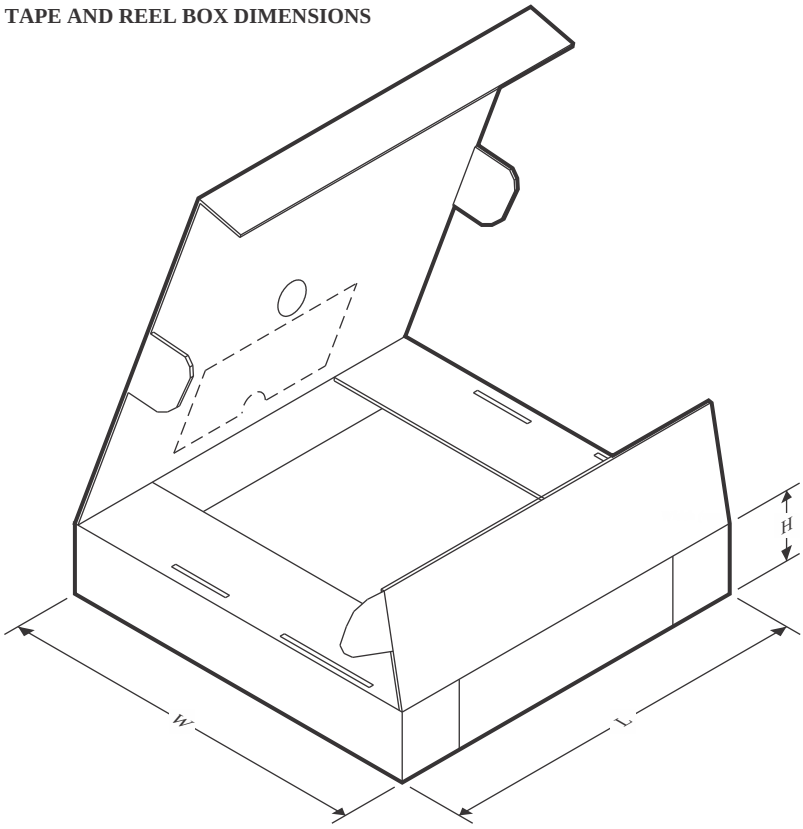
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
ADS7841E/2K5	SSOP	DBQ	16	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
ADS7841EB/2K5	SSOP	DBQ	16	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

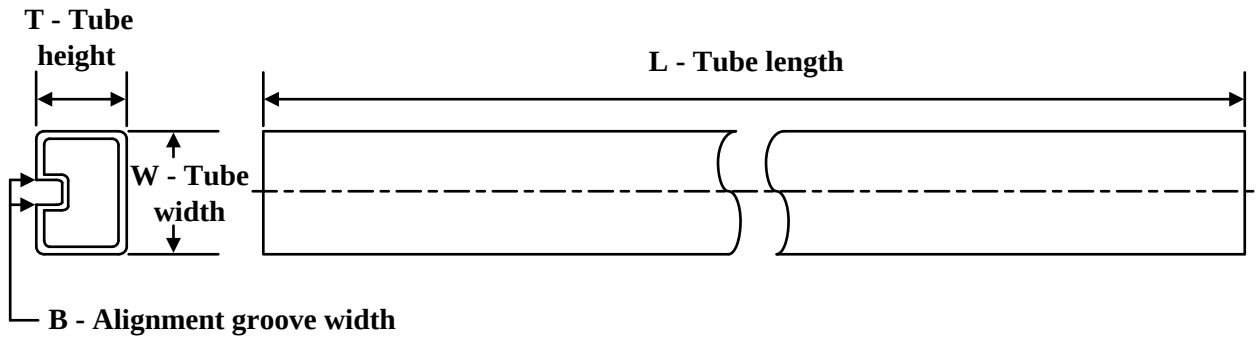
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
ADS7841E/2K5	SSOP	DBQ	16	2500	353.0	353.0	32.0
ADS7841EB/2K5	SSOP	DBQ	16	2500	353.0	353.0	32.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
ADS7841E	DBQ	SSOP	16	75	506.6	8	3940	4.32
ADS7841E.B	DBQ	SSOP	16	75	506.6	8	3940	4.32
ADS7841EB	DBQ	SSOP	16	75	506.6	8	3940	4.32
ADS7841EB.B	DBQ	SSOP	16	75	506.6	8	3940	4.32
ADS7841EG4	DBQ	SSOP	16	75	506.6	8	3940	4.32
ADS7841ES	DBQ	SSOP	16	75	506.6	8	3940	4.32
ADS7841ES.B	DBQ	SSOP	16	75	506.6	8	3940	4.32

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265