16-Bit 250-kSPS Sampling CMOS ANALOG-TO-DIGITAL CONVERTER

Check for Samples: ADS8515

FEATURES

- **Standard ±10-V Input Range**
- **90-dB Min SNR with 20-kHz Input**
- **±2.0 LSB Max INL**
- **±1 LSB Max DNL, 16 Bits, No Missing Code**
- **5-V Analog Supply, Flexible I/O Supply Voltage at 1.65 V to 5.25 V**
- **Pin-Compatible with ADS7805/10 (Low Speed), and 12-Bit ADS7804/8504**
- **Uses Internal or External Reference**
- **Full Parallel Data Output**
- **100-mW Typ Power Dissipation at 250 kSPS**
- **28-Pin SSOP Package**

APPLICATIONS

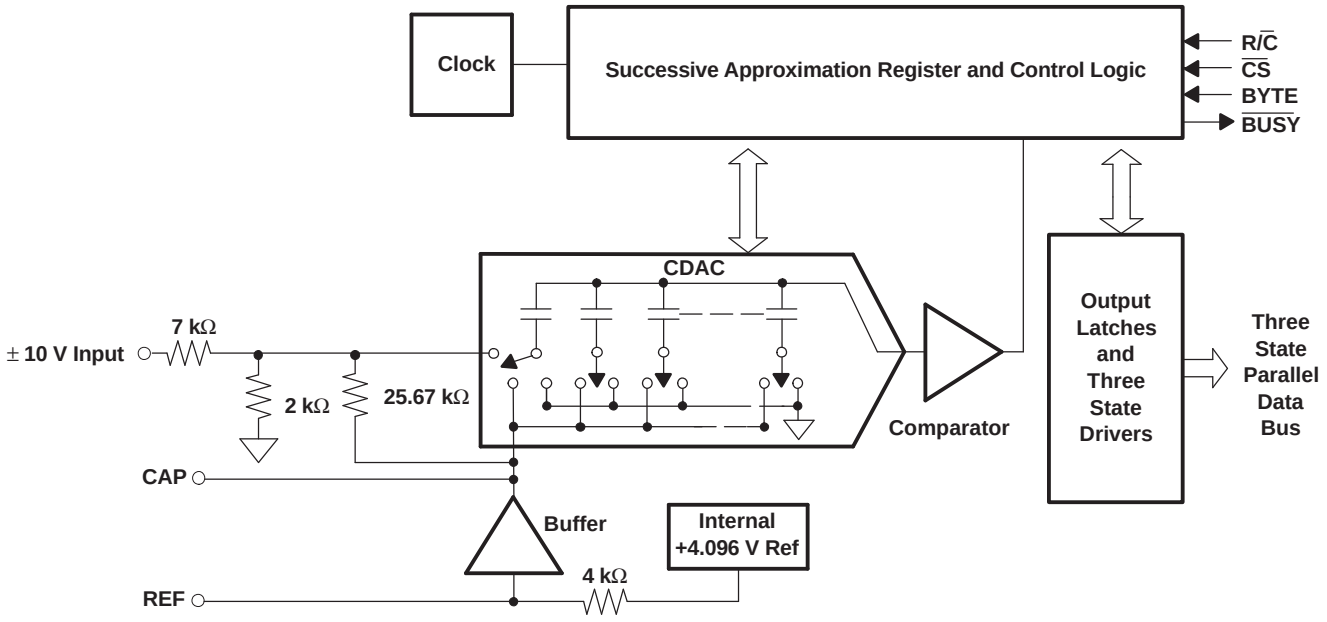
- **Industrial Process Control**
- **Data Acquisition Systems**
- **Digital Signal Processing**
- **Medical Equipment**
- **Instrumentation**

DESCRIPTION

The ADS8515 is a complete 16-bit sampling analog-to-digital (A/D) converter using state-of-the-art CMOS structures. It contains a complete 16-bit, capacitor-based, SAR A/D converter with sample and hold (S/H), reference, clock, interface for microprocessor use, and 3-state output drivers.

The ADS8515 is specified at a 250-kHz sampling rate over the full temperature range. Precision resistors provide an industry standard ±10-V input range, while the innovative design allows operation from a single +5-V supply, with power dissipation under 100 mW.

The ADS8515 is available in a 28-pin SSOP package and is fully specified for operation over the industrial –40°C to 85°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.

All trademarks are the property of their respective owners.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

Copyright © 2007–2010, Texas Instruments Incorporated

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(1)

PRODUCT	MINIMUM INL (LSB)	NO MISSING CODE	MINIMUM SINAD (dB)	SPECIFIED TEMPERATURE RANGE	PACKAGE-LEAD	PACKAGE DESIGNATOR	ORDERING NUMBER	TRANSPORT MEDIA, QTY
ADS8515IB	±2	16 Bits	89	–40°C to 85°C	SSOP-28	DB	ADS8515IBDB	Tube, 50
							ADS8515IBDBR	Tape and Reel, 2000
ADS8515I	±3	16 Bits	87	–40°C to 85°C	SSOP-28	DB	ADS8515IDB	Tube, 50
							ADS8515IDBR	Tape and Reel, 2000

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the ADS8515 product folder at www.ti.com.

ABSOLUTE MAXIMUM RATINGS(1)(2)

Over operating free-air temperature range (unless otherwise noted)

		ADS8515
Analog inputs	V_{IN}	±25V
	CAP	$+V_{ANA}$ + 0.3 V to AGND2 – 0.3 V
	REF	Indefinite short to AGND2, momentary short to V_{ANA}
Ground voltage differences	DGND, AGND1, AGND2	±0.3 V
	V_{ANA}	6 V
	V_{DIG}	6 V
Digital inputs		–0.3 V to $+V_{DIG}$ + 0.3 V
Maximum junction temperature		165°C
Internal power dissipation		825 mW

(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.
(2) All voltage values are with respect to network ground terminal.

Copyright © 2007–2010, Texas Instruments Incorporated

ELECTRICAL CHARACTERISTICS

At T_A = –40°C to 85°C, f_s = 250 kHz, V_{DIG} = V_{ANA} = 5 V, and using internal reference (unless otherwise noted).

PARAMETER		TEST CONDITIONS	ADS8515I			ADS8515IB			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
	Resolution				16			16	Bits
ANALOG INPUT									
	Voltage range			±10			±10		V
	Impedance			8.885			8.885		kΩ
	Capacitance			75			75		pF
THROUGHPUT SPEED									
	Conversion cycle time	Acquire and convert			4			4	µs
	Throughput rate		250			250			kHz
DC ACCURACY									
INL	Integral linearity error		–3		3	–2		2	LSB(1)
DNL	Differential linearity error		–1		2	–1		1	LSB(1)
	No missing codes		16			16			Bits
	Transition noise(2)			0.67			0.67		LSB
	Full-scale error(3) (4)	Int. Ref.	–0.5		0.5	–0.25		0.25	%FSR
	Full-scale error drift	Int. Ref.		±7			±7		ppm/°C
	Full-scale error(3) (4)	Ext. 4.096-V Ref.	–0.25		0.25	–0.1		0.1	%FSR
	Full-scale error drift	Ext. 4.096-V Ref.		±2			±2		ppm/°C
	Bipolar zero error(3)		–4		4	–2		2	mV
	Bipolar zero error drift			±2			±2		ppm/°C
	Power supply sensitivity (V_{DIG} = V_{ANA} = V_D)	+4.75 V < V_D < +5.25 V	–8		8	–8		8	LSB
AC ACCURACY									
SFDR	Spurious-free dynamic range	f_I = 20 kHz	95	102		97	102		dB(5)
THD	Total harmonic distortion	f_I = 20 kHz		–100	–94		–100	–96	dB
SINAD	Signal-to-(noise+distortion)	f_I = 20 kHz	87	91		89	91		dB
		–60-dB Input		30			32		dB
SNR	Signal-to-noise ratio	f_I = 20 kHz	88	92		90	92		dB
	Full-power bandwidth(6)			500			500		kHz
SAMPLING DYNAMICS									
	Aperture delay			5			5		ns
	Transient response	FS Step			2			2	µs
	Overvoltage recovery(7)			150			150		ns
REFERENCE									
	Internal reference voltage		4.076	4.096	4.116	4.076	4.096	4.116	V
	Internal reference source current (must use external buffer)			1			1		µA
	Internal reference drift			8			8		ppm/°C
	External reference voltage range for specified linearity		3.9	4.096	4.2	3.9	4.096	4.2	V
	External reference current drain	Ext. 4.096-V Ref.			100			100	µA
DIGITAL INPUTS									
	Logic levels								
V_{IL}	Low-level input voltage	V_{DIG} = 1.65 V – 5.25 V	–0.3		0.8	–0.3		0.35*V_{DIG}	V
V_{IH}	High-level input voltage	V_{DIG} = 1.65 V – 5.25 V	0.65*V_{DIG}		V_{DIG}+0.3 V	0.65*V_{DIG}		V_{DIG}+0.3 V	V
I_{IL}	Low-level input current	V_{IL} = 0 V			±10			±10	µA
I_{IH}	High-level input current	V_{IH} = 5 V			±10			±10	µA
DIGITAL OUTPUTS									

(1) LSB means least significant bit. For the 16-bit, ±10-V input ADS8515, one LSB is 305 µV.
(2) Typical rms noise at worst case transitions and temperatures.
(3) As measured with fixed resistors shown in Figure 22. Adjustable to zero with external potentiometer.
(4) Full-scale error is the worst case of –full-scale or +full-scale deviation from ideal first and last code transitions, divided by the transition voltage (not divided by the full-scale range) and includes the effect of offset error.
(5) All specifications in dB are referred to a full-scale ±10-V input.
(6) Full-power bandwidth is defined as the full-scale input frequency at which signal-to-(noise + distortion) degrades to 60 dB, or 10 bits of accuracy.
(7) Recovers to specified performance after 2 x FS input overvoltage.

Copyright © 2007–2010, Texas Instruments Incorporated

ELECTRICAL CHARACTERISTICS (continued)

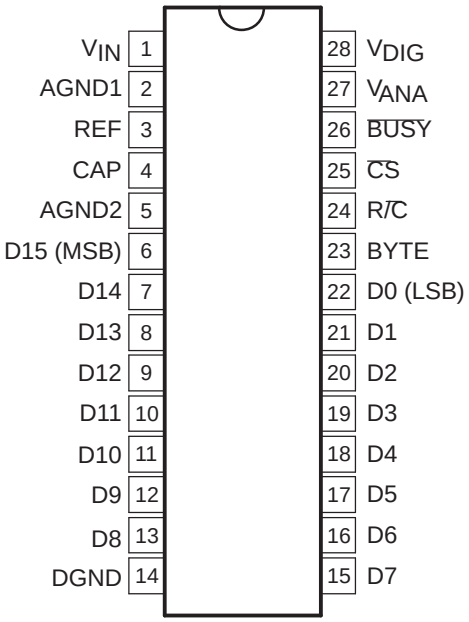
At T_A = –40°C to 85°C, f_S = 250 kHz, V_{DIG} = V_{ANA} = 5 V, and using internal reference (unless otherwise noted).

PARAMETER		TEST CONDITIONS	ADS8515I			ADS8515IB			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
	Data format (parallel 16 bits)								
	Data coding (binary twos complement)								
V_{OL}	Low-level output voltage	I_{SINK} = 1.6 mA			0.4			0.4	V
V_{OH}	High-level output voltage	I_{SOURCE} = 500 µA	0.8×V_{DIG}			0.8×V_{DIG}			V
	Leakage current	Hi-Z state, V_{OUT} = 0 V to V_{DIG}			±5			±5	µA
	Output capacitance	Hi-Z state			15			15	pF
DIGITAL TIMING									
	Bus access timing				83			83	ns
	Bus relinquish timing				83			83	ns
POWER SUPPLIES									
V_{DIG}	Digital input voltage	Must be ≤ V_{ANA}	1.65		5.25	1.65		5.25	V
V_{ANA}	Analog input voltage		4.75	5	5.25	4.75	5	5.25	V
I_{DIG}	Digital input current			0.1	1		0.1	1	mA
I_{ANA}	Analog input current			20	25		20	25	mA
	Power dissipation	f_S = 250 kHz		100	125		100	125	mW
TEMPERATURE RANGE									
	Specified performance		–40		+85	–40		+85	°C
	Derated performance(8)		–55		+125	–55		+125	°C
	Storage		–65		+150	–65		+150	°C
THERMAL RESISTANCE (Θ_{JA})									
	SSOP			67			67		°C/W

(8) The internal reference may not be started correctly beyond the industrial temperature range (–40°C to +85°C); therefore, use of an external reference is recommended.

PIN CONFIGURATION

DB PACKAGE
SSOP-28
(TOP VIEW)



Copyright © 2007–2010, Texas Instruments Incorporated

PIN DESCRIPTIONS

PIN		DIGITAL I/O	DESCRIPTION
NAME	NO.		
AGND1	2		Analog ground. Used internally as ground reference point.
AGND2	5		Analog ground.
$\overline{BUSY}$	26	O	At the start of a conversion, $\overline{BUSY}$ goes low and stays low until the conversion is completed and the digital outputs have been updated.
BYTE	23	I	Selects 8 most significant bits (low) or 8 least significant bits (high).
CAP	4		Reference buffer capacitor. 2.2-μF tantalum capacitor to ground.
$\overline{CS}$	25	I	Internally ORed with R/$\overline{C}$. If R/$\overline{C}$ low, a falling edge on $\overline{CS}$ initiates a new conversion.
DGND	14		Digital ground.
D15 (MSB)	6	O	Data bit 15. Most significant bit (MSB) of conversion results. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D14	7	O	Data bit 14. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D13	8	O	Data bit 13. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D12	9	O	Data bit 12. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D11	10	O	Data bit 11. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D10	11	O	Data bit 10. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D9	12	O	Data bit 9. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D8	13	O	Data bit 8. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D7	15	O	Data bit 7. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D6	16	O	Data bit 6. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D5	17	O	Data bit 5. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D4	18	O	Data bit 4. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D3	19	O	Data bit 3. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D2	20	O	Data bit 2. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D1	21	O	Data bit 1. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
D0 (LSB)	22	O	Data bit 0. Least significant bit (LSB) of conversion results. Hi-Z state when $\overline{CS}$ is high, or when R/$\overline{C}$ is low.
R/$\overline{C}$	24	I	With $\overline{CS}$ low and $\overline{BUSY}$ high, a falling edge on R/$\overline{C}$ initiates a new conversion. With $\overline{CS}$ low, a rising edge on R/$\overline{C}$ enables the parallel output.
REF	3		Reference input/output. 2.2-μF tantalum capacitor to ground.
V_{ANA}	27		Analog supply input. Nominally +5 V. Decouple to ground with 0.1-μF ceramic and 10-μF tantalum capacitors.
V_{DIG}	28		Digital supply input. Can be connected directly to pin 27.
V_{IN}	1		Analog input. See Figure 24.

Copyright © 2007–2010, Texas Instruments Incorporated

TYPICAL CHARACTERISTICS

TOTAL HARMONIC DISTORTION vs INPUT FREQUENCY

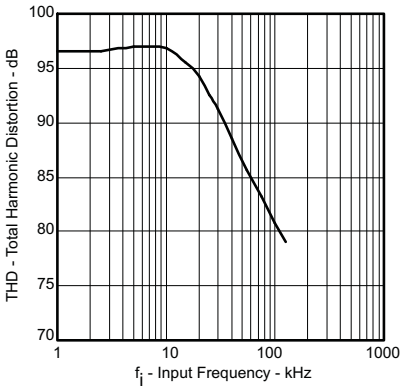


Figure 1.

SIGNAL-TO-NOISE RATIO vs INPUT FREQUENCY

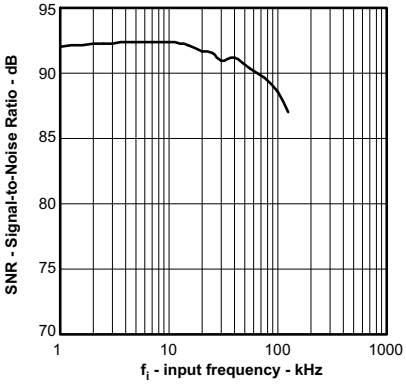


Figure 2.

SIGNAL-TO-NOISE AND DISTORTION vs INPUT FREQUENCY

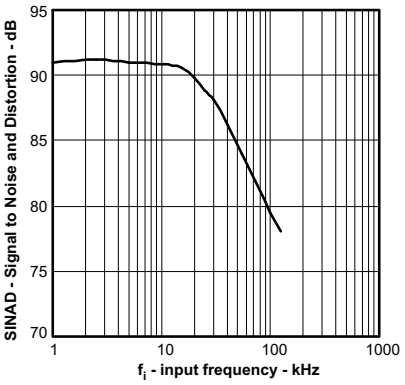


Figure 3.

SPURIOUS FREE DYNAMIC RANGE vs INPUT FREQUENCY

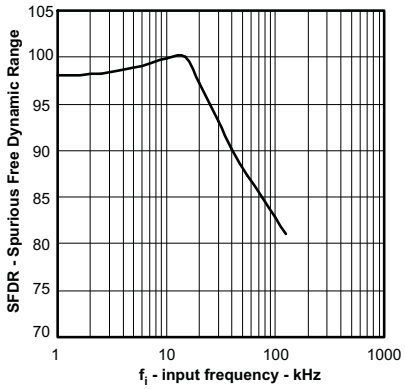


Figure 4.

SIGNAL-TO-NOISE RATIO vs FREE-AIR TEMPERATURE

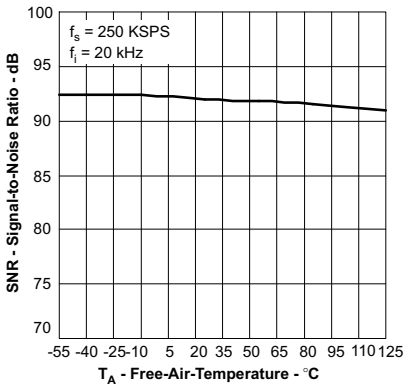


Figure 5.

SIGNAL-TO-NOISE AND DISTORTION vs FREE-AIR TEMPERATURE

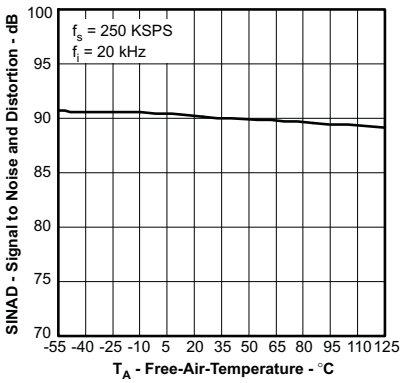


Figure 6.

SPURIOUS FREE DYNAMIC RANGE vs FREE-AIR TEMPERATURE

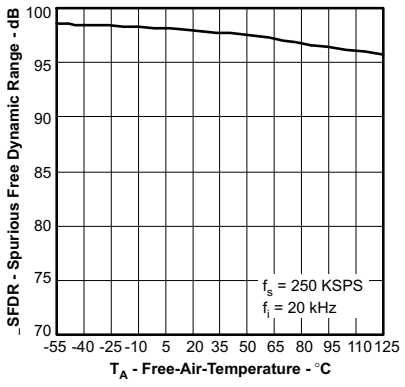


Figure 7.

TOTAL HARMONIC DISTORTION vs FREE-AIR TEMPERATURE

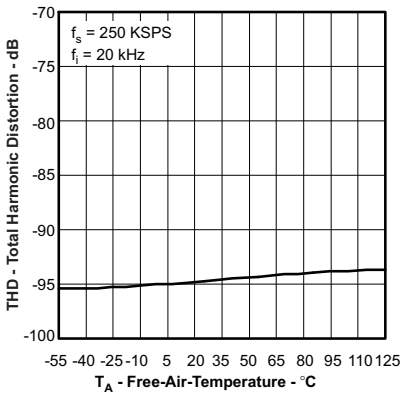


Figure 8.

INTERNAL REFERENCE VOLTAGE vs FREE-AIR TEMPERATURE

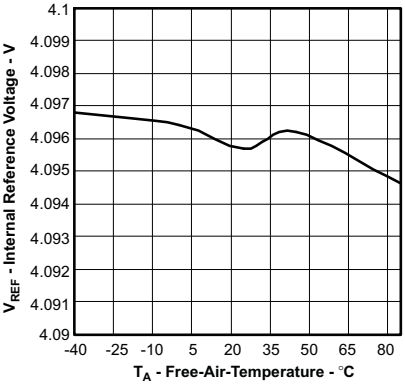


Figure 9.

Copyright © 2007–2010, Texas Instruments Incorporated

TYPICAL CHARACTERISTICS (continued)

BIPOLAR ZERO ERROR vs FREE-AIR TEMPERATURE

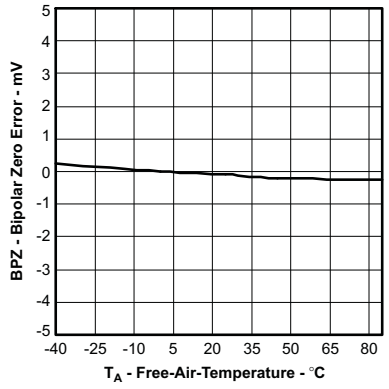


Figure 10.

NEGATIVE FULL-SCALE ERROR vs FREE-AIR TEMPERATURE

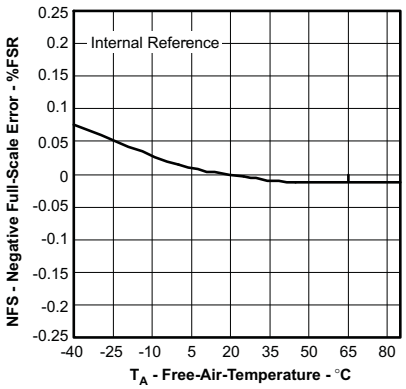


Figure 11.

NEGATIVE FULL-SCALE ERROR vs FREE-AIR TEMPERATURE

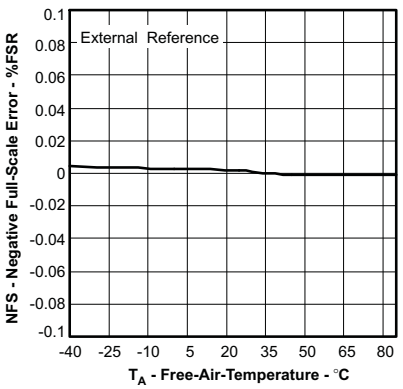


Figure 12.

POSITIVE FULL-SCALE ERROR vs FREE-AIR TEMPERATURE

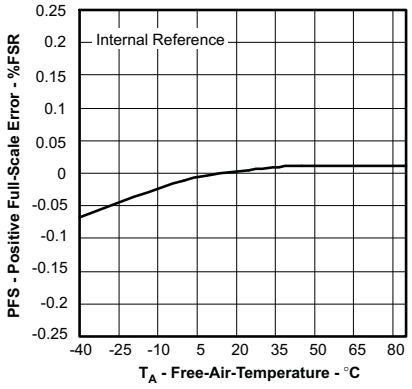


Figure 13.

POSITIVE FULL-SCALE ERROR vs FREE-AIR TEMPERATURE

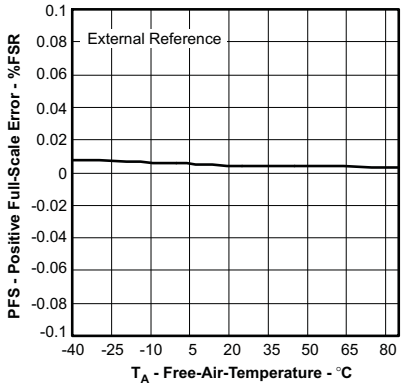


Figure 14.

SUPPLY CURRENT vs FREE-AIR TEMPERATURE

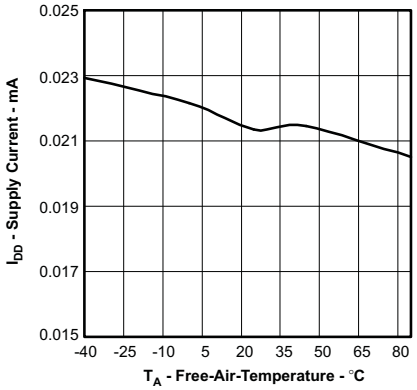


Figure 15.

HISTOGRAM

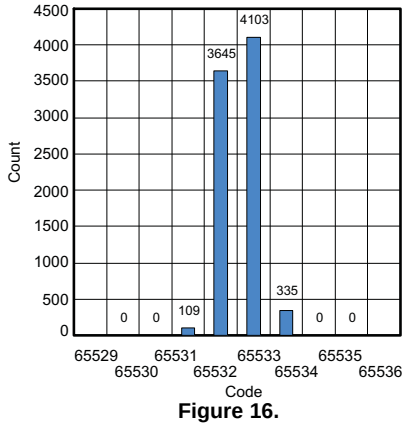


Figure 16.

TYPICAL CHARACTERISTICS (continued)

INL

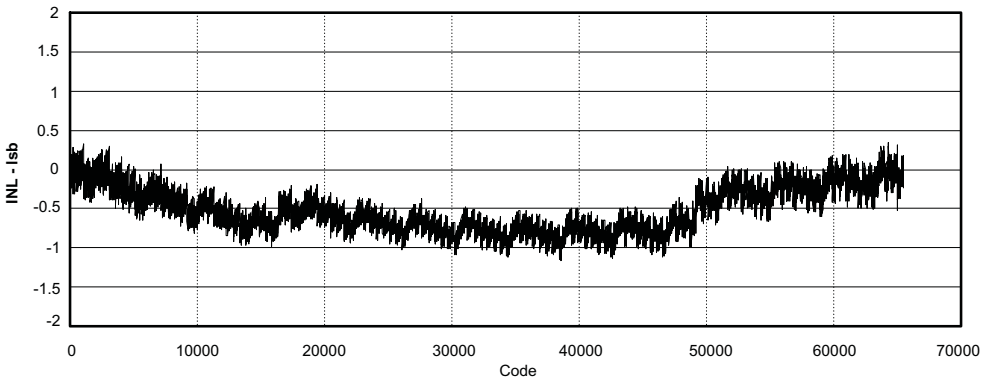


Figure 17.

DNL

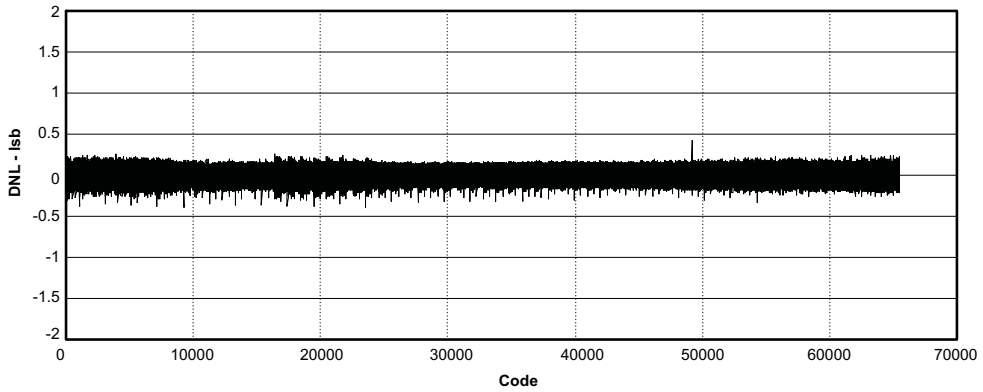


Figure 18.

Copyright © 2007–2010, Texas Instruments Incorporated

BASIC OPERATION

Figure 19 shows a basic circuit to operate the ADS8515 with a full parallel data output. Taking R/$\overline{C}$ (pin 24) low for a minimum of 40 ns initiates a conversion. $\overline{BUSY}$ (pin 26) goes low and stays low until the conversion is completed and the output registers are updated. Data are output in binary twos complement with the MSB on pin 6. $\overline{BUSY}$ going high can be used to latch the data.

The ADS8515 begins tracking the input signal at the end of the conversion. Allowing 4 μs between convert commands assures accurate acquisition of a new signal.

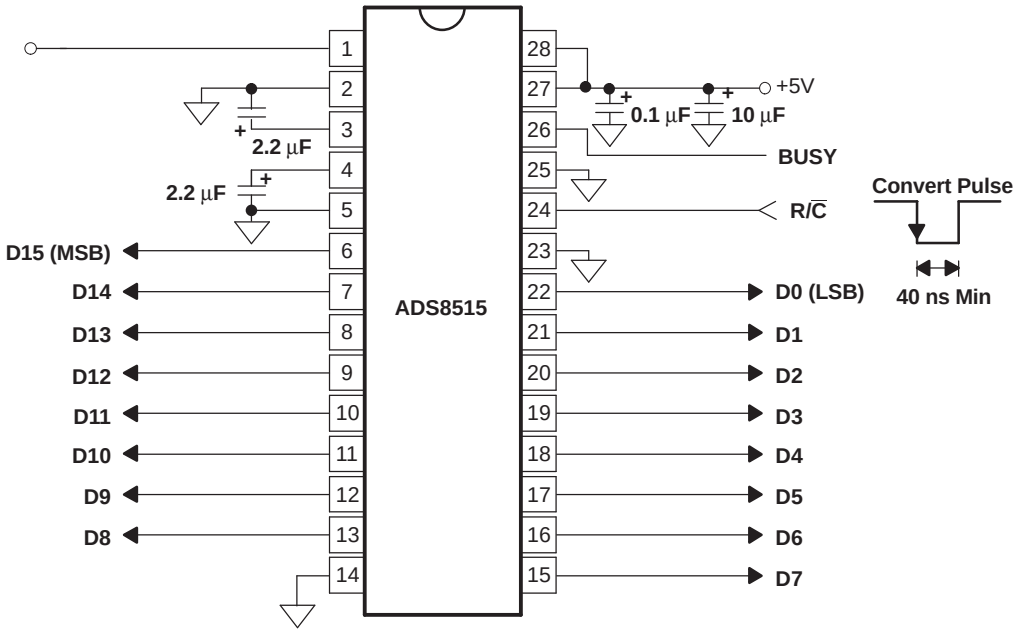


Figure 19. Basic Operation

STARTING A CONVERSION

The combination of $\overline{CS}$ (pin 25) and R/$\overline{C}$ (pin 24) held low for a minimum of 40 ns immediately puts the sample/hold of the ADS8515 in the hold state and starts conversion *n*. $\overline{BUSY}$ (pin 26) goes low and stays low until conversion *n* is completed and the internal output register has been updated.

The ADS8515 begins tracking the input signal at the end of the conversion. Allowing 4 μs between convert commands assures accurate acquisition of a new signal. Refer to Table 1 for a summary of $\overline{CS}$, R/$\overline{C}$, and $\overline{BUSY}$ states and Figure 21, Figure 22, and Figure 23 for the timing diagrams.

$\overline{CS}$ and R/$\overline{C}$ are internally ORed and level triggered. There is no requirement regarding which input goes low first when initiating a conversion. If, however, it is critical that $\overline{CS}$ or R/$\overline{C}$ initiates conversion *n*, be sure the less critical input is low at least 10 ns prior to the initiating input.

To reduce the number of control pins, $\overline{CS}$ can be tied low using R/$\overline{C}$ to control the read and convert modes. The parallel output becomes active whenever R/$\overline{C}$ goes high. Refer to the Reading Data section.

Table 1. Control Line Functions for Read and Convert

$\overline{CS}$	R/$\overline{C}$	$\overline{BUSY}$	OPERATION
1	X	X	None. Databus is in Hi-Z state.
↓	0	1	Initiates conversion *n*. Databus remains in Hi-Z state.
0	↓	1	Initiates conversion *n*. Databus enters Hi-Z state.
0	1	↑	Conversion *n* completed. Valid data from conversion *n* on the databus.
↓	1	1	Enables databus with valid data from conversion *n*.
↓	1	0	Enables databus with valid data from conversion *–1* (1). Conversion *n* in progress.
0	↑	0	Enables databus with valid data from conversion *–1* (1). Conversion *n* in progress.
0	0	↑	New conversion initiated without acquisition of a new signal. Data is invalid. $\overline{CS}$ and/or R/$\overline{C}$ must be high when $\overline{BUSY}$ goes high.
X	X	0	Conversion *n* in progress.

(1) See Figure 21 and Figure 22 for constraints on data valid from conversion *n – 1*.

READING DATA

The ADS8515 outputs full or byte-reading parallel data in binary twos complement data output format. The parallel output is active when R/$\overline{C}$ (pin 24) is high and $\overline{CS}$ (pin 25) is low. Any other combination of $\overline{CS}$ and R/$\overline{C}$ 3-states the parallel output. Valid conversion data can be read in a full parallel, 16-bit word or two 8-bit bytes on pins 6 to 13 and pins 15 to 22. BYTE (pin 23) can be toggled to read both bytes within one conversion cycle. Refer to Table 2 for ideal output codes and Figure 20 for bit locations relative to the state of BYTE.

Table 2. Ideal Input Voltages and Output Codes

DESCRIPTION	ANALOG INPUT	DIGITAL OUTPUT BINARY TWOS COMPLEMENT	
		BINARY CODE	HEX CODE
Full-scale range	±10 V		
Least significant bit (LSB)	305 μV		
Full scale (10 V – 1 LSB)	9.999695 V	0111 1111 1111 1111	7FFF
Midscale	0 V	0000 0000 0000 0000	0000
One LSB below midscale	–305 μV	1111 1111 1111 1111	FFFF
–Full scale	–10 V	1000 0000 0000 0000	8000

Copyright © 2007–2010, Texas Instruments Incorporated

PARALLEL OUTPUT (After a Conversion)

After conversion *n* is completed and the output registers have been updated, $\overline{BUSY}$ (pin 26) goes high. Valid data from conversion *n* are available on D15 to D0 (pins 6 to 13 and 15 to 22). $\overline{BUSY}$ going high can be used to latch the data. Refer to Table 3 and Figure 21, Figure 22, and Figure 23 for timing specifications.

PARALLEL OUTPUT (During a Conversion)

After conversion *n* has been initiated, valid data from conversion *–1* can be read and are valid up to t_2 after the start of conversion *n*. Do not attempt to read data from t_2 after the start of conversion *n* until $\overline{BUSY}$ (pin 26) goes high; this may result in reading invalid data. Refer to Table 3 and Figure 21, Figure 22, and Figure 23 for timing specifications.

Note: For the best possible performance, data should not be read during a conversion. The switching noise of the asynchronous data transfer can cause digital feedthrough degrading the converter performance.

The number of control lines can be reduced by tying $\overline{CS}$ low while using the falling edge of R/$\overline{C}$ to initiate conversions and the rising edge of R/$\overline{C}$ to activate the output mode of the converter. See Figure 21.

Table 3. Conversion Timing

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{w1}	Pulse duration, convert	40			ns
t_a	Access time, data valid after R/$\overline{C}$ low		0.8	1.2	µs
t_{pd}	Propagation delay time, $\overline{BUSY}$ from R/$\overline{C}$ low		6	20	ns
t_{w2}	Pulse duration, $\overline{BUSY}$ low			2	µs
t_{d1}	Delay time, $\overline{BUSY}$ after end of conversion		5		ns
t_{d2}	Delay time, aperture		5		ns
t_{conv}	Conversion time			2	µs
t_{acq}	Acquisition time	2			µs
t_{dis}	Disable time, bus	10	15	83	ns
t_{d3}	Delay time, $\overline{BUSY}$ after data valid	35	50		ns
t_v	Valid time, previous data remains valid after R/$\overline{C}$ low	1.5	2		µs
$t_{conv} + t_{acq}$	Throughput time			4	µs
t_{su}	Setup time, R/$\overline{C}$ to $\overline{CS}$	10			ns
t_c	Cycle time between conversions	4			µs
t_{en}	Enable time, bus	10	15	30	ns
t_{d4}	Delay time, BYTE	10	15	30	ns

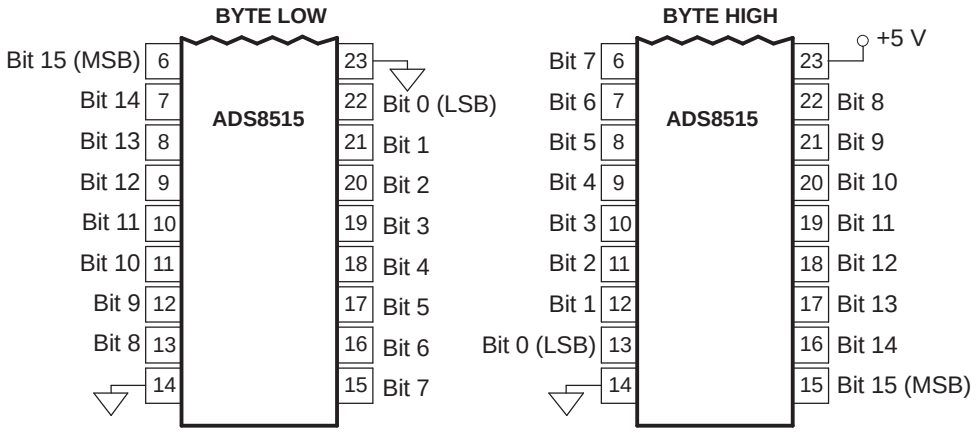


Figure 20. Bit Locations Relative to State of BYTE (Pin 23)

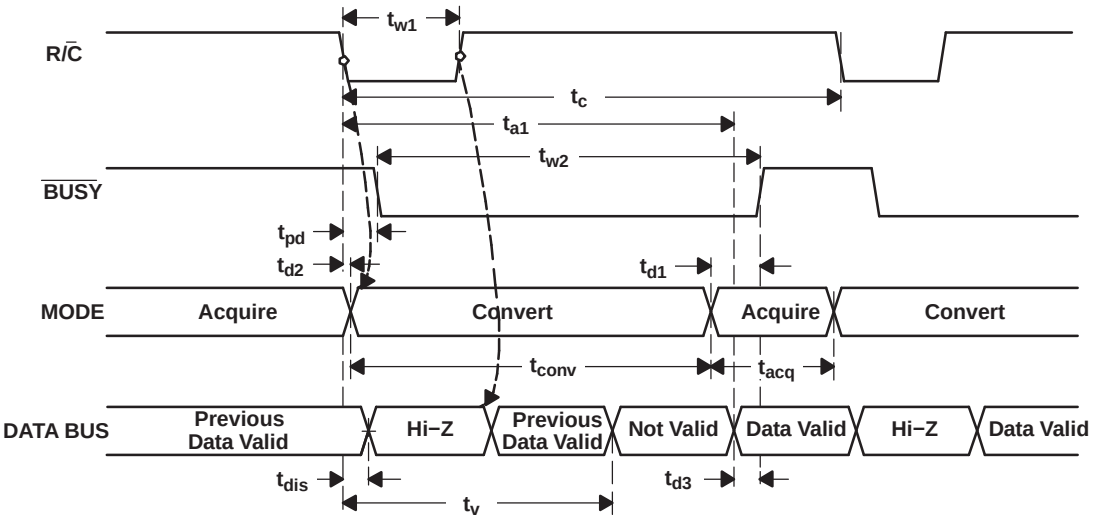


Figure 21. Conversion Timing with Outputs Enabled after Conversion ($\overline{CS}$ Tied Low)

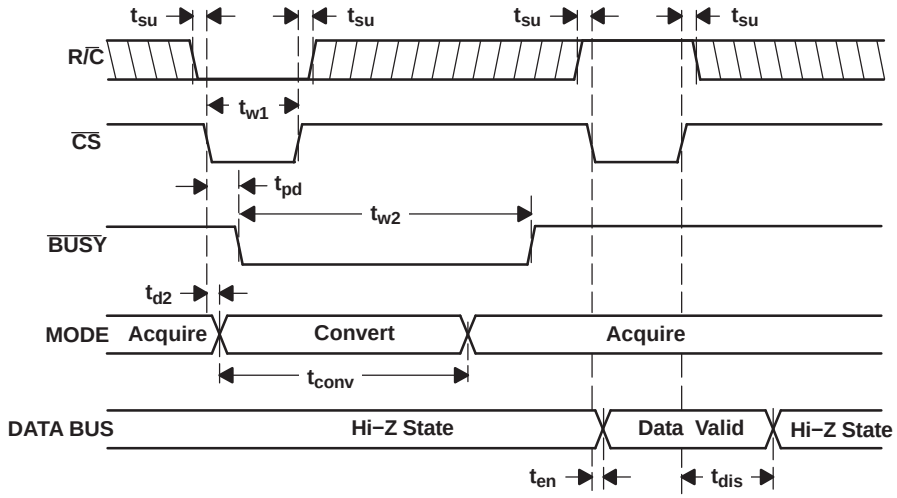


Figure 22. Using $\overline{CS}$ to Control Conversion and Read Timing

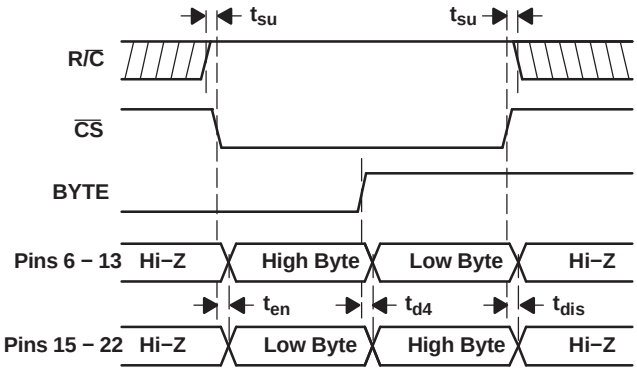


Figure 23. Using $\overline{CS}$ and BYTE to Control Data Bus

Copyright © 2007–2010, Texas Instruments Incorporated

ADC RESET

The ADC reset function of the ADS8515 can be used to terminate the current conversion cycle. Bringing R/$\overline{C}$ low for at least 40 ns while BUSY is low will initiate the ADC reset. To initiate a new conversion, R/$\overline{C}$ must return to the high state and remain high long enough to acquire a new sample (see Table 3, t_c) before going low to initiate the next conversion sequence. In applications that do not monitor the BUSY signal, it is recommended that the ADC reset function be implemented as part of a system initialization sequence.

INPUT RANGES

The ADS8515 offers a standard ±10-V input range. Figure 24 shows the necessary circuit connections for the ADS8515 with and without hardware trim. Offset and full-scale error specifications are tested and specified with the fixed resistors shown in Figure 25(b). Full-scale error includes offset and gain errors measured at both +FS and –FS. Adjustments for offset and gain are described in the *Calibration* section of this data sheet.

The offset and gain are adjusted internally to allow external trimming with a single supply. The external resistors compensate for this adjustment and can be left out if the offset and gain are corrected in software (refer to the *Calibration* section).

The nominal input impedance of 6.35 kΩ results from the combination of the internal resistor network shown on the front page of the product data sheet. The input resistor divider network provides inherent overvoltage protection assured to at least ±25 V. The 1% resistors used for the external circuitry do not compromise the accuracy or drift of the converter. They have little influence relative to the internal resistors, and tighter tolerances are not required.

The input signal must be referenced to AGND1. This minimizes the ground loop problem typical to analog designs. The analog signal should be driven by a low impedance source. A typical driving circuit using an OPA627 or OPA132 is shown in Figure 24.

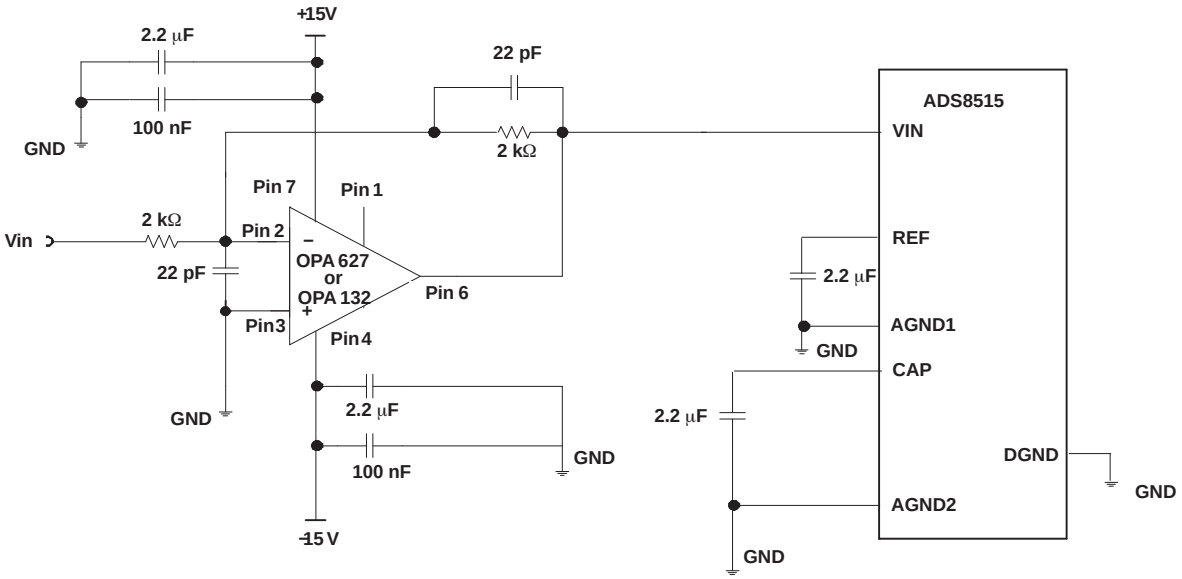


Figure 24. Typical Driving Circuit (±10 V, No Trim)

APPLICATION INFORMATION

CALIBRATION

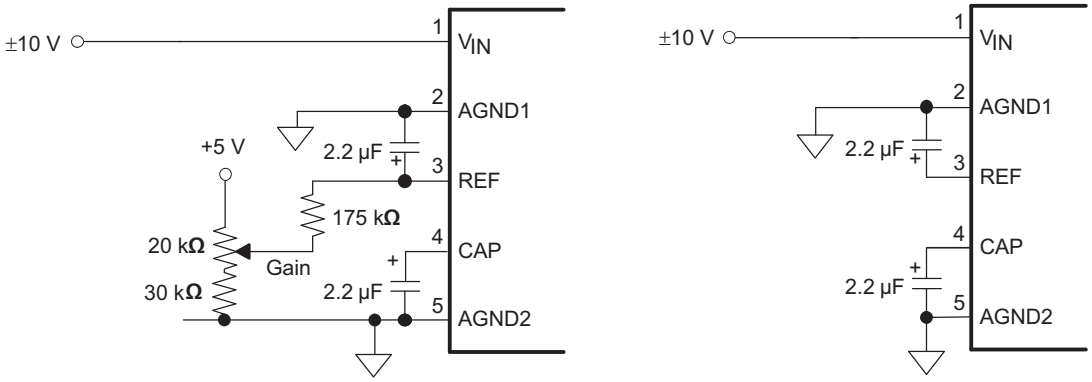
The gain of the ADS8515 can be trimmed in software. To achieve optimum performance, several iterations may be required.

Hardware Calibration

To calibrate the gain of the ADS8515, install the resistors and potentiometer as shown in Figure 25(a). The calibration range is approximately ±100 mV.

Software Calibration

The offset and gain of the ADS8515 is calibrated with software. See Figure 25(b) for the circuit connections.



(a) ±10 V With Hardware Trim

(b) ±10 V Without Hardware Trim

Note: Use 1% metal film resistors.

Figure 25. Circuit Diagram For Software Trim

REFERENCE

The ADS8515 can operate with its internal 4.096-V reference or an external reference. By applying an external reference to pin 5, the internal reference can be bypassed. The reference voltage at REF is buffered internally with the output on CAP (pin 4).

The internal reference has an 8 ppm/°C drift (typical) and accounts for approximately 20% of the full-scale error (FSE = ±0.5% for low grade, ±0.25% for high grade).

REF

REF (pin 3) is an input for an external reference or the output for the internal 4.096-V reference. A 2.2-µF capacitor should be connected as close to the REF pin as possible. The capacitor and the output resistance of REF create a low-pass filter to bandlimit noise on the reference. Using a smaller value capacitor introduces more noise to the reference degrading the SNR and SINAD. The REF pin should not be used to drive external ac or dc loads.

The range for the external reference is 3.9 V to 4.2 V and determines the actual LSB size. Increasing the reference voltage increases the full-scale range and the LSB size of the converter which can improve the SNR.

Copyright © 2007–2010, Texas Instruments Incorporated

CAP

CAP (pin 4) is the output of the internal reference buffer. A 2.2-μF capacitor should be placed as close to the CAP pin as possible to provide optimum switching currents for the CDAC throughout the conversion cycle and compensation for the output of the internal buffer. Using a capacitor any smaller than 1 μF can cause the output buffer to oscillate and may not have sufficient charge for the CDAC. Capacitor values larger than 2.2 μF have little affect on improving performance. The ESR (equivalent series resistance) of these compensation capacitors is also critical. Keep the total ESR under 3 Ω. See the *Typical Characteristics* section for how the worst case INL is affected by ESR.

The output of the buffer is capable of driving up to 2 mA of current to a dc load, but any external load from the CAP pin may degrade the linearity of the ADS8515. Using an external buffer allows the internal reference to be used for larger dc loads and ac loads. Do not attempt to directly drive an ac load with the output voltage on CAP. This causes performance degradation of the converter. The ESR (equivalent series resistance) of these compensation capacitors is also critical. Keep the total ESR under 3 Ω. See the *Typical Characteristics* section concerning how ESR affects performance.

LAYOUT

POWER

The analog power pin (V_{ANA}) and digital power pin (V_{DIG}) can be tied together from the same +5V power supply, or from two different power-supply sources. The ADS8515 uses 90% of its power from the analog circuitry, and therefore should be considered as an analog component. Care must be taken to ensure that both the analog and digital power supplies power on before any voltage is applied to the analog input pin. Failure to do so may create a latch-up condition. There is no power sequencing requirement between V_{ANA} and V_{DIG}.

GROUNDING

Three ground pins are present on the ADS8515. DGND is the digital supply ground. AGND2 is the analog supply ground. AGND1 is the ground which all analog signals internal to the A/D converter are referenced. AGND1 is more susceptible to current induced voltage drops and must have the path of least resistance back to the power supply.

All the ground pins of the A/D converter should be tied to the analog ground plane, separated from the system digital logic ground, to achieve optimum performance. Both analog and digital ground planes should be tied to the *system* ground as near to the power supplies as possible. This helps to prevent dynamic digital ground currents from modulating the analog ground through a common impedance to power ground.

SIGNAL CONDITIONING

The FET switches used for the sample hold on many CMOS A/D converters release a significant amount of charge injection which can cause the driving op amp to oscillate. The FET switch on the ADS8515, compared to the FET switches on other CMOS A/D converters, releases 5% to 10% of the charge. There is also a resistive front end which attenuates any charge which is released. The end result is a minimal requirement for the antialias filter on the front end. Any op amp sufficient for the signal in an application is sufficient to drive the ADS8515.

The resistive front end of the ADS8515 also provides an assured ±25-V overvoltage protection. In most cases, this eliminates the need for external input protection circuitry.

INTERMEDIATE LATCHES

The ADS8515 does have 3-state outputs for the parallel port, but intermediate latches should be used if the bus is to be active during conversions. If the bus is not active during conversion, the 3-state outputs can be used to isolate the A/D converter from other peripherals on the same bus. The 3-state outputs can also be used when the A/D converter is the only peripheral on the data bus.

Intermediate latches are beneficial on any monolithic A/D converter. The ADS8515 has an internal LSB size of 38 μV. Transients from fast switching signals on the parallel port, even when the A/D converter is 3-stated, can be coupled through the substrate to the analog circuitry causing degradation of converter performance.

Copyright © 2007–2010, Texas Instruments Incorporated

REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision C (August 2010) to Revision D **Page**

- Deleted row from *Absolute Maximum Ratings* regarding V_{DIG} to V_{ANA} 2
- Deleted text regarding V_{ANA} from the pin 28 description in the *Pin Description* table 5
- Changed text in first and second sentences of the *Power* section 15

Changes from Revision B (June 2010) to Revision C **Page**

- Updated document format to current standards 1
- Added text to end of *Power* section 15

Copyright © 2007–2010, Texas Instruments Incorporated

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
ADS8515IBDB	ACTIVE	SSOP	DB	28	50	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ADS8515I B	Samples
ADS8515IBDBR	ACTIVE	SSOP	DB	28	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ADS8515I B	Samples
ADS8515IBDBRG4	ACTIVE	SSOP	DB	28	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ADS8515I B	Samples
ADS8515IDB	ACTIVE	SSOP	DB	28	50	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ADS8515I	Samples
ADS8515IDBR	ACTIVE	SSOP	DB	28	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	ADS8515I	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

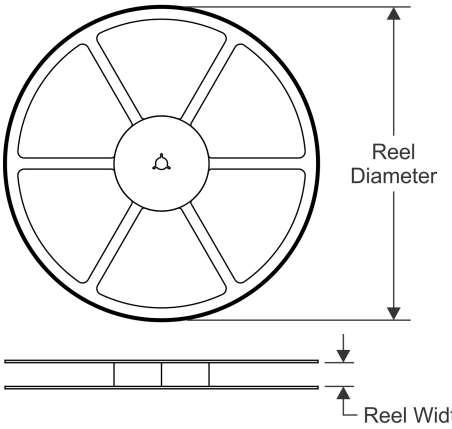
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

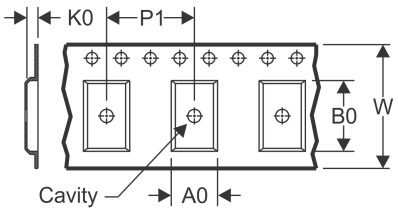
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

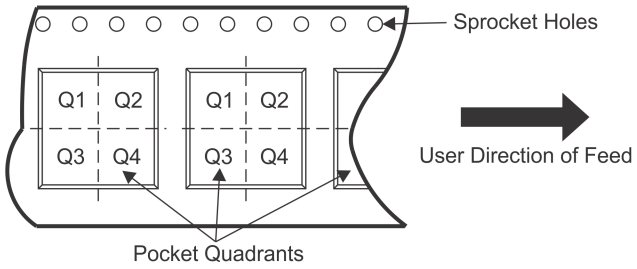


TAPE DIMENSIONS



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

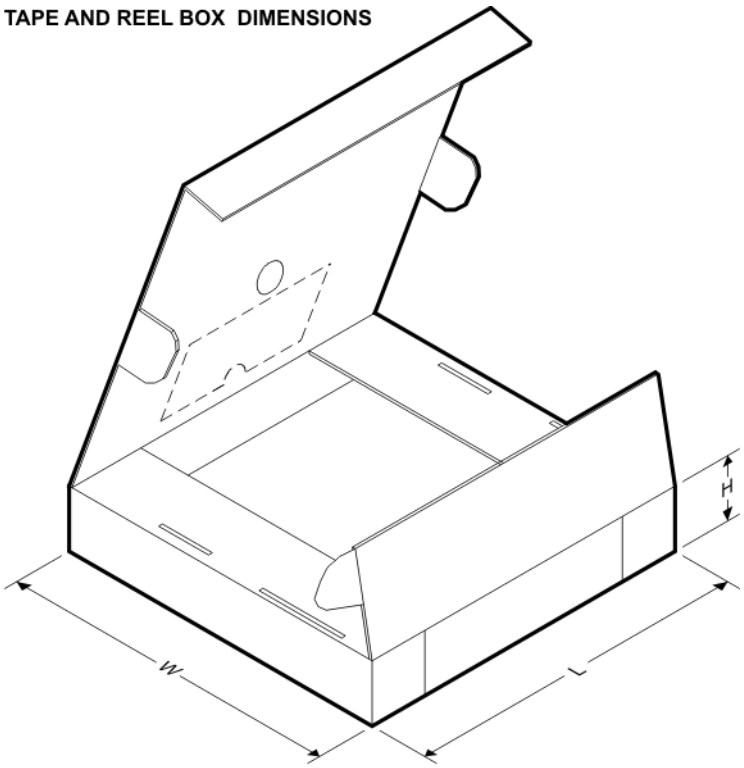
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
ADS8515IBDBR	SSOP	DB	28	2000	330.0	16.4	8.1	10.4	2.5	12.0	16.0	Q1
ADS8515IDBR	SSOP	DB	28	2000	330.0	16.4	8.1	10.4	2.5	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

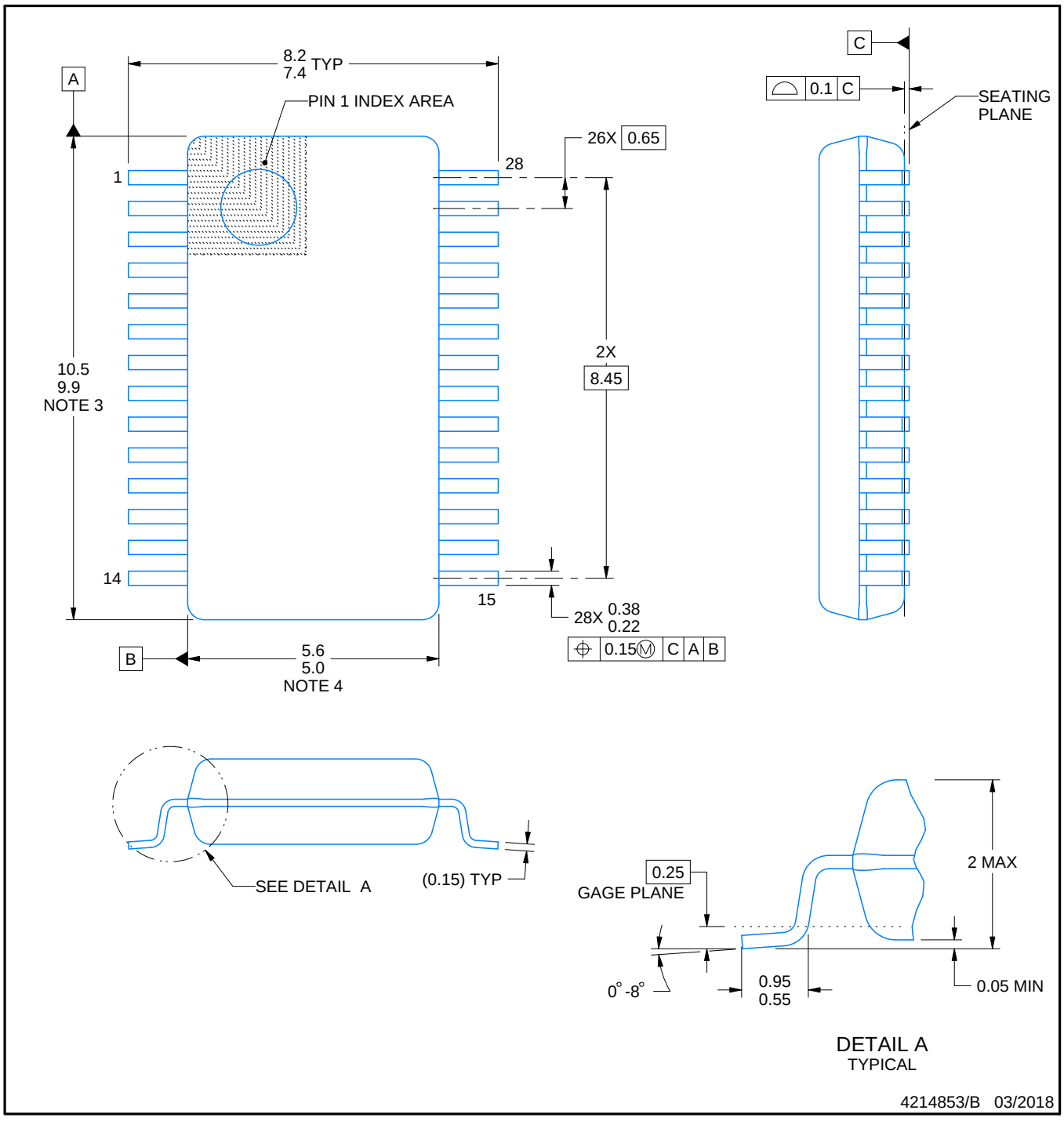
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
ADS8515IBDBR	SSOP	DB	28	2000	350.0	350.0	43.0
ADS8515IDBR	SSOP	DB	28	2000	350.0	350.0	43.0

PACKAGE OUTLINE

DB0028A

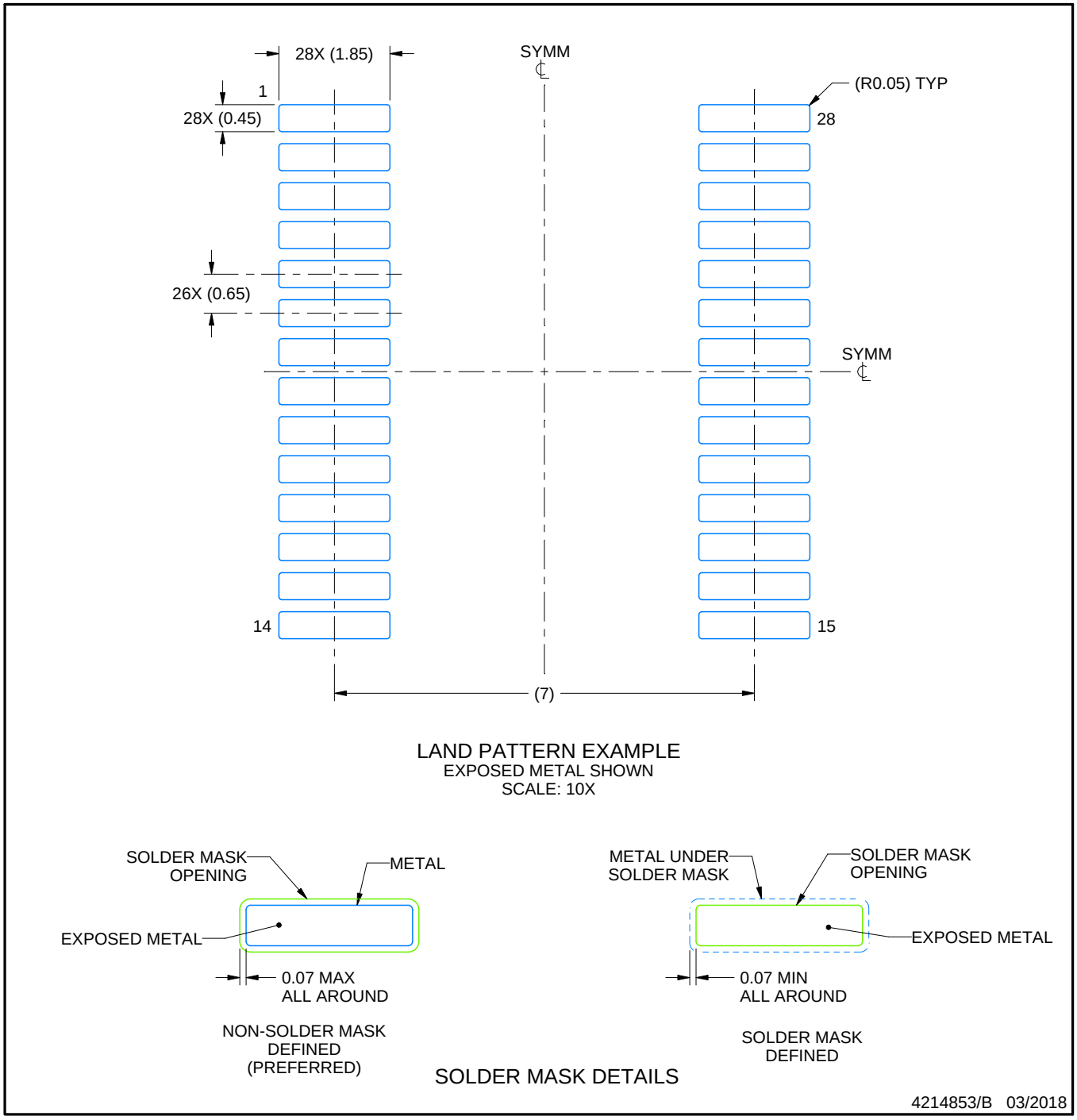
SSOP - 2 mm max height

SMALL OUTLINE PACKAGE



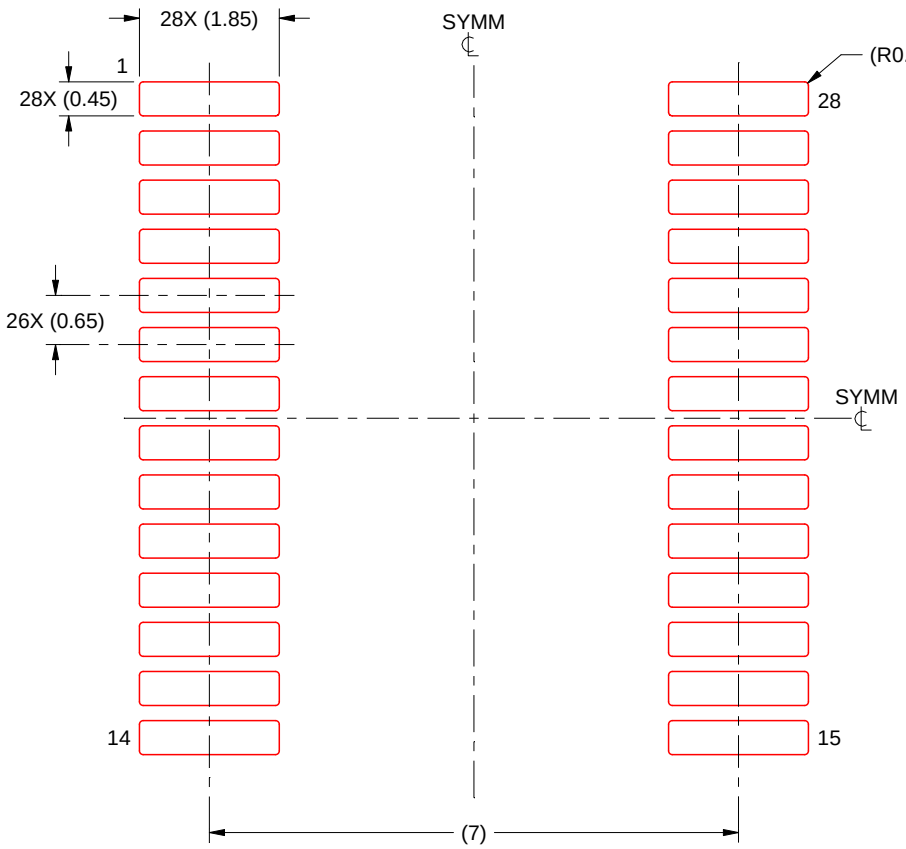
NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-150.



NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4214853/B 03/2018

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), 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, 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 (www.ti.com/legal/termsofsale.html) 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2020, Texas Instruments Incorporated