



## 10-Bit, 20MHz Sampling ANALOG-TO-DIGITAL CONVERTER

### FEATURES

- NO MISSING CODES
- INTERNAL REFERENCE
- LOW DIFFERENTIAL LINEARITY ERROR:  
0.2LSB
- LOW POWER: 195mW
- HIGH SNR: 60dB
- WIDEBAND TRACK/HOLD: 65MHz

### APPLICATIONS

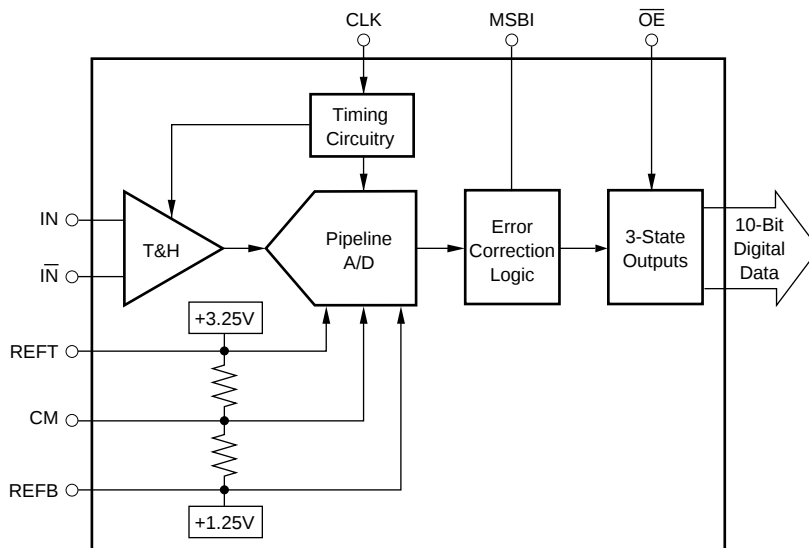
- SET-TOP BOXES
- CABLE MODEMS
- VIDEO DIGITIZING
- CCD IMAGING
  - Camcorders
  - Copiers
  - Scanners
  - Security Cameras
- IF AND BASEBAND DIGITIZATION

### DESCRIPTION

The ADS820 is a low-power, monolithic 10-bit, 20MHz Analog-to-Digital (A/D) converter utilizing a small geometry CMOS process. This complete converter includes a 10-bit quantizer with internal track-and-hold, reference, and a power down feature. It operates from a single +5V power supply and can be configured to accept either differential or single-ended input signals.

The ADS820 employs digital error correction to provide excellent Nyquist differential linearity performance for demanding imaging applications. Its low distortion, high SNR, and high oversampling capability give it the extra margin needed for telecommunications and video applications.

This high performance converter is specified for AC and DC-performance at a 20MHz sampling rate. The ADS820 is available in an SO-28 package.



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.

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## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

|                                                |                                 |
|------------------------------------------------|---------------------------------|
| +V <sub>S</sub> .....                          | +6V                             |
| Analog Input .....                             | 0V to (+V <sub>S</sub> + 300mV) |
| Logic Input .....                              | 0V to (+V <sub>S</sub> + 300mV) |
| Case Temperature .....                         | +100°C                          |
| Junction Temperature .....                     | +150°C                          |
| Storage Temperature .....                      | +125°C                          |
| External Top Reference Voltage (REFT) .....    | +3.4V Max                       |
| External Bottom Reference Voltage (REFB) ..... | +1.1V Min                       |

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability.



## 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<sup>(1)</sup>

| PRODUCT | PACKAGE-LEAD | PACKAGE DESIGNATOR | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER       | TRANSPORT MEDIA, QUANTITY        |
|---------|--------------|--------------------|-----------------------------|-----------------|-----------------------|----------------------------------|
| ADS820  | SO-8         | DW                 | −40°C to +85°C              | ADS820U         | ADS820U<br>ADS820U/1K | Rails, 28<br>Tape and Reel, 1000 |

NOTE: (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at [www.ti.com](http://www.ti.com).

## ELECTRICAL CHARACTERISTICS

At T<sub>A</sub> = +25°C, V<sub>S</sub> = +5V, Sampling Rate = 20MHz, with a 50% duty cycle clock having a 2ns rise/fall time, unless otherwise noted.

| PARAMETER                              | CONDITIONS                   | TEMP  | ADS820U |                         |       | UNITS         |
|----------------------------------------|------------------------------|-------|---------|-------------------------|-------|---------------|
|                                        |                              |       | MIN     | TYP                     | MAX   |               |
| Resolution                             |                              |       |         | 10                      |       | Bits          |
| Specified Temperature Range            | T <sub>AMBIENT</sub>         |       | −40     |                         | +85   | °C            |
| <b>ANALOG INPUT</b>                    |                              |       |         |                         |       |               |
| Differential Full-Scale Input Range    |                              |       | +1.25   |                         | +3.25 | V             |
| Common-Mode Voltage                    |                              |       |         | 2.25                    |       | V             |
| Analog Input Bandwidth (−3dB)          |                              |       |         |                         |       |               |
| Small Signal                           | −20dBFS <sup>(1)</sup> Input | +25°C |         | 400                     |       | MHz           |
| Full Power                             | 0dB Input                    | +25°C |         | 65                      |       | MHz           |
| Input Impedance                        |                              |       |         | 1.25    4               |       | MΩ    pF      |
| <b>DIGITAL INPUT</b>                   |                              |       |         |                         |       |               |
| Logic Family                           |                              |       |         | TTL/HCT Compatible CMOS |       |               |
| Convert Command                        | Start Conversion             |       |         | Falling Edge            |       |               |
| <b>ACCURACY<sup>(2)</sup></b>          |                              |       |         |                         |       |               |
| Gain Error                             | f <sub>S</sub> = 2.5MHz      | +25°C |         | ±0.6                    | ±1.5  | %             |
|                                        |                              | Full  |         | ±1.0                    | ±2.5  | %             |
| Gain Tempco                            |                              |       |         | ±85                     |       | ppm/°C        |
| Power-Supply Rejection of Gain         | Δ +V <sub>S</sub> = ±5%      | +25°C |         | 0.01                    | 0.1   | %FSR/%        |
| Input Offset Error                     |                              | Full  |         | ±2.1                    | ±3.0  | %             |
| Power-Supply Rejection of Offset       | Δ +V <sub>S</sub> = ±5%      | +25°C |         | 0.02                    | 0.1   | %FSR/%        |
| <b>CONVERSION CHARACTERISTICS</b>      |                              |       |         |                         |       |               |
| Sample Rate                            |                              |       | 10k     |                         | 20M   | Sample/s      |
| Data Latency                           |                              |       |         | 6.5                     |       | Convert Cycle |
| <b>DYNAMIC CHARACTERISTICS</b>         |                              |       |         |                         |       |               |
| Differential Linearity Error           |                              |       |         |                         |       |               |
| f = 500kHz                             |                              | +25°C |         | ±0.15                   | ±1.0  | LSB           |
|                                        |                              | Full  |         | ±0.15                   | ±1.0  | LSB           |
| f = 10MHz                              |                              | +25°C |         | ±0.2                    | ±1.0  | LSB           |
|                                        |                              | Full  |         | ±0.2                    | ±1.0  | LSB           |
| No Missing Codes                       |                              | Full  |         | Tested                  |       |               |
| Integral Linearity Error at f = 500kHz |                              | Full  |         | ±0.5                    | ±2.0  | LSB           |
| Spurious-Free Dynamic Range (SFDR)     |                              |       |         |                         |       |               |
| f = 500kHz (−1dBFS input)              |                              | +25°C | 67      | 77                      |       | dBFS          |
|                                        |                              | Full  | 64      | 74                      |       | dBFS          |
| f = 10MHz (−1dBFS input)               |                              | +25°C | 59      | 63                      |       | dBFS          |
|                                        |                              | Full  | 57      | 62                      |       | dBFS          |

NOTE: (1) dBFS refers to dB below Full Scale. (2) Percentage accuracies are referred to the internal A/D Converter Full-Scale Range of 4Vp-p. (3) IMD is referred to the larger of the two input signals. If referred to the peak envelope signal (≈ 0dB), the intermodulation products will be 7dB lower. (4) Based on (SINAD − 1.76)/6.02. (5) No “rollover” of bits.

# ELECTRICAL CHARACTERISTICS (Cont.)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = +5\text{V}$ , Sampling Rate = 20MHz, with a 50% duty cycle clock having a 2ns rise/fall time, unless otherwise noted.

| PARAMETER                                | CONDITIONS                      | TEMP  | ADS820U, E              |      |         | UNITS   |
|------------------------------------------|---------------------------------|-------|-------------------------|------|---------|---------|
|                                          |                                 |       | MIN                     | TYP  | MAX     |         |
| Signal-to-Noise Ratio (SNR)              |                                 | +25°C | 58                      | 60.5 |         | dB      |
| f = 500kHz (–1dBFS input)                |                                 | Full  | 56                      | 60   |         | dB      |
| f = 10MHz (–1dBFS input)                 |                                 | +25°C | 58                      | 60   |         | dB      |
|                                          |                                 | Full  | 56                      | 60   |         | dB      |
| Signal-to-(Noise + Distortion) (SINAD)   |                                 | +25°C | 58                      | 60.5 |         | dB      |
| f = 500kHz (–1dBFS input)                |                                 | Full  | 55                      | 60   |         | dB      |
| f = 10MHz (–1dBFS input)                 |                                 | +25°C | 56                      | 58   |         | dB      |
|                                          |                                 | Full  | 54                      | 57   |         | dB      |
| Differential Gain Error                  | NTSC or PAL                     | +25°C |                         | 0.5  |         | %       |
| Differential Phase Error                 | NTSC or PAL                     | +25°C |                         | 0.1  |         | degrees |
| Effective Bits <sup>(4)</sup>            | $f_{IN} = 3.58\text{MHz}$       |       |                         | 9.5  |         | Bits    |
| Aperture Delay Time                      |                                 | +25°C |                         | 2    |         | ns      |
| Aperture Jitter                          |                                 | +25°C |                         | 7    |         | ps rms  |
| Overvoltage Recovery Time <sup>(5)</sup> | 1.5x Full-Scale Input           | +25°C |                         | 2    |         | ns      |
| <b>OUTPUTS</b>                           |                                 |       |                         |      |         |         |
| Logic Family                             | Logic Selectable                |       | TTL/HCT Compatible CMOS |      |         |         |
| Logic Coding                             | Logic LOW, $C_L = 15\text{pF}$  | Full  | 0                       |      | 0.4     | V       |
| Logic Levels                             | Logic HIGH, $C_L = 15\text{pF}$ | Full  | 2.5                     |      | + $V_S$ | V       |
| 3-State Enable Time                      |                                 |       |                         | 20   | 40      | ns      |
| 3-State Disable Time                     |                                 | Full  |                         | 2    | 10      | ns      |
| <b>POWER-SUPPLY REQUIREMENTS</b>         |                                 |       |                         |      |         |         |
| Supply Voltage: + $V_S$                  | Operating                       | Full  | +4.75                   | +5   | +5.25   | V       |
| Supply Current: + $I_S$                  | Operating                       | +25°C |                         | 39   | 47      | mA      |
|                                          | Operating                       | Full  |                         | 40   | 55      | mA      |
| Power Consumption                        | Operating                       | +25°C |                         | 195  | 235     | mW      |
|                                          | Operating                       | Full  |                         | 200  | 275     | mW      |
| Thermal Resistance, $\theta_{JA}$        |                                 |       |                         | 75   |         | °C/W    |
| SO-28                                    |                                 |       |                         |      |         |         |

NOTE: (1) dBFS refers to dB below Full Scale. (2) Percentage accuracies are referred to the internal A/D Converter Full-Scale Range of 4Vp-p. (3) IMD is referred to the larger of the two input signals. If referred to the peak envelope signal ( $\approx 0\text{dB}$ ), the intermodulation products will be 7dB lower. (4) Based on  $(\text{SINAD} - 1.76)/6.02$ . (5) No "rollover" of bits.

**SO**

| Pin | Signal          |
|-----|-----------------|
| 1   | GND             |
| 2   | Bit 1 (MSB)     |
| 3   | Bit 2           |
| 4   | Bit 3           |
| 5   | Bit 4           |
| 6   | Bit 5           |
| 7   | Bit 6           |
| 8   | Bit 7           |
| 9   | Bit 8           |
| 10  | Bit 9           |
| 11  | Bit 10 (LSB)    |
| 12  | DNC             |
| 13  | DNC             |
| 14  | GND             |
| 15  | +V <sub>S</sub> |
| 16  | CLK             |
| 17  | +V <sub>S</sub> |
| 18  | $\overline{OE}$ |
| 19  | MSBI            |
| 20  | +V <sub>S</sub> |
| 21  | REFB            |
| 22  | CM              |
| 23  | REFT            |
| 24  | +V <sub>S</sub> |
| 25  | GND             |
| 26  | IN              |
| 27  | $\overline{IN}$ |
| 28  | GND             |

DNC: Do Not Connect

| PIN | DESIGNATOR             | DESCRIPTION                                                                                                                                 |
|-----|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | GND                    | Ground                                                                                                                                      |
| 2   | B1                     | Bit 1, Most Significant Bit (MSB)                                                                                                           |
| 3   | B2                     | Bit 2                                                                                                                                       |
| 4   | B3                     | Bit 3                                                                                                                                       |
| 5   | B4                     | Bit 4                                                                                                                                       |
| 6   | B5                     | Bit 5                                                                                                                                       |
| 7   | B6                     | Bit 6                                                                                                                                       |
| 8   | B7                     | Bit 7                                                                                                                                       |
| 9   | B8                     | Bit 8                                                                                                                                       |
| 10  | B9                     | Bit 9                                                                                                                                       |
| 11  | B10                    | Bit 10, Least Significant Bit (LSB)                                                                                                         |
| 12  | DNC                    | Do not connect.                                                                                                                             |
| 13  | DNC                    | Do not connect.                                                                                                                             |
| 14  | GND                    | Ground                                                                                                                                      |
| 15  | +V <sub>S</sub>        | +5V Power Supply                                                                                                                            |
| 16  | CLK                    | Convert Clock Input, 50% Duty Cycle                                                                                                         |
| 17  | +V <sub>S</sub>        | +5V Power Supply                                                                                                                            |
| 18  | $\overline{\text{OE}}$ | HIGH: High Impedance State. LOW or Floating: Normal Operation. Internal pull-down resistor.                                                 |
| 19  | MSBI                   | Most Significant Bit Inversion, HIGH: MSB inverted for complementary output. LOW or Floating: Straight output. Internal pull-down resistor. |
| 20  | +V <sub>S</sub>        | +5V Power Supply                                                                                                                            |
| 21  | REFB                   | Bottom Reference Bypass. For external bypassing of internal +1.25V reference.                                                               |
| 22  | CM                     | Common-Mode Voltage. It is derived by (REFT + REFB)/2.                                                                                      |
| 23  | REFT                   | Top Reference Bypass. For external bypassing of internal +3.25V reference.                                                                  |
| 24  | +V <sub>S</sub>        | +5V Power Supply                                                                                                                            |
| 25  | GND                    | Ground                                                                                                                                      |
| 26  | IN                     | Input                                                                                                                                       |
| 27  | $\overline{\text{IN}}$ | Complementary Input                                                                                                                         |
| 28  | GND                    | Ground                                                                                                                                      |

Timing diagram for the AD7705 showing the relationship between the Convert Clock, Internal Track-and-Hold, and Output Data signals.

The diagram illustrates the sequence of operations: tracking, holding, and data conversion. Key parameters labeled include  $t_{CONV}$  (Convert Clock Period),  $t_L$  (Clock Pulse LOW),  $t_H$  (Clock Pulse HIGH),  $t_D$  (Aperture Delay),  $t_1$  (Data Hold Time), and  $t_2$  (New Data Delay Time).

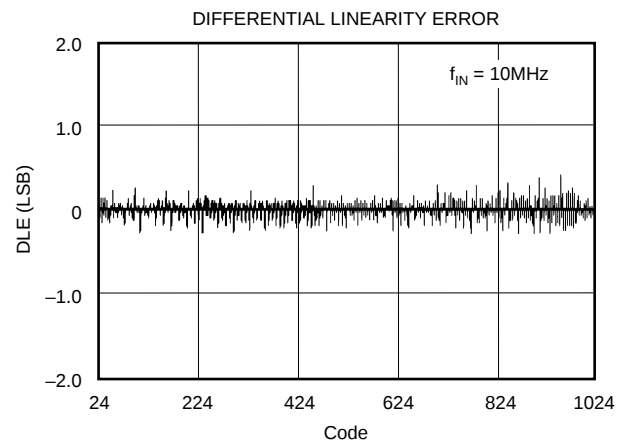
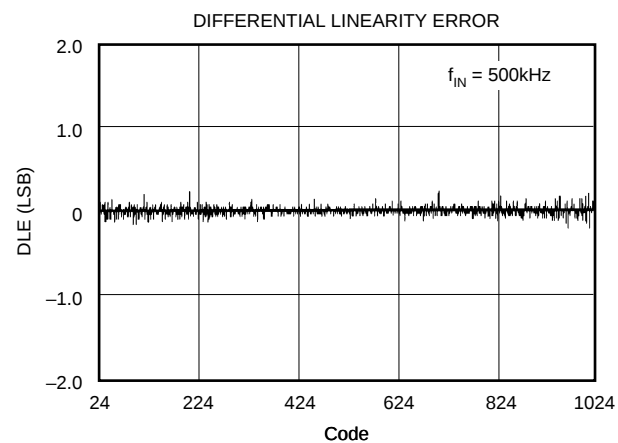
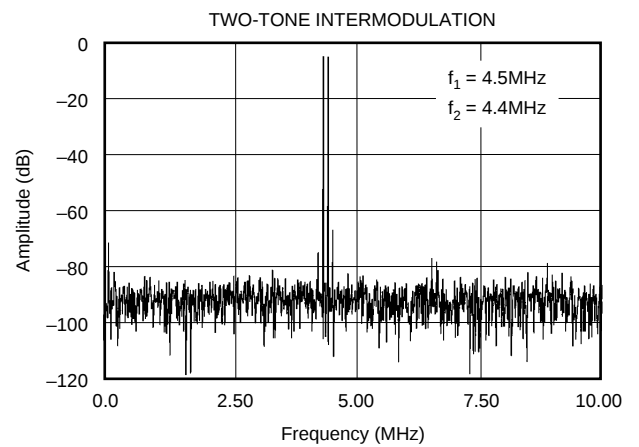
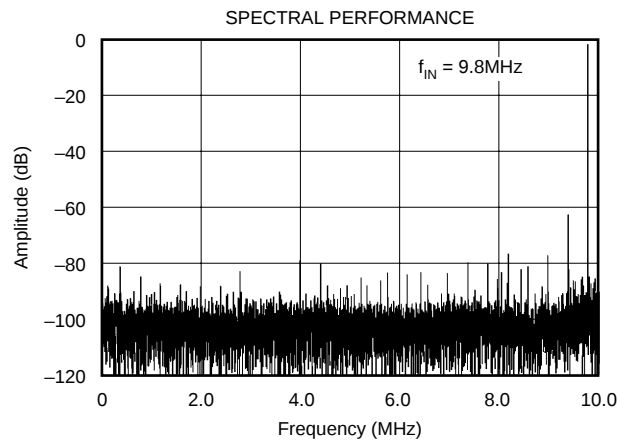
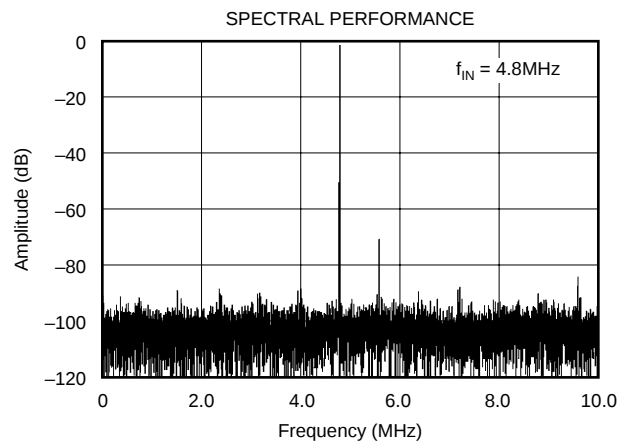
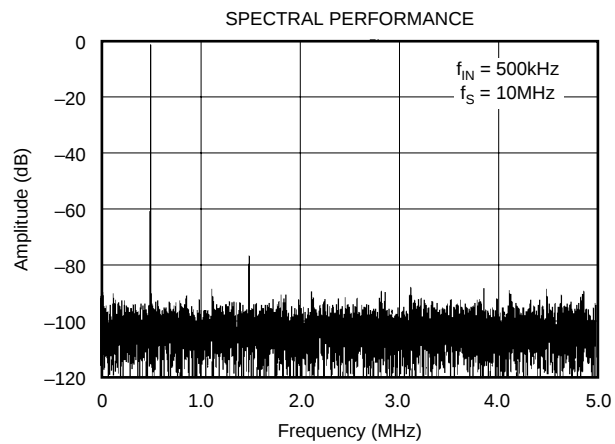
The output data is shown as a sequence of values from  $N-8$  to  $N$ , with "Data Invalid" periods indicated by hatched boxes. A note specifies that the "§" symbol indicates waveform stretching at slower sample rates.

| SYMBOL     | DESCRIPTION                           | MIN | TYP | MAX  | UNITS |
|------------|---------------------------------------|-----|-----|------|-------|
| $t_{CONV}$ | Convert Clock Period                  | 50  |     | 100  | ns    |
| $t_L$      | Clock Pulse LOW                       | 24  | 25  |      | ns    |
| $t_H$      | Clock Pulse HIGH                      | 24  | 25  |      | ns    |
| $t_D$      | Aperture Delay                        |     | 2   |      | ns    |
| $t_1$      | Data Hold Time, $C_L = 0pF$           | 3.9 |     |      | ns    |
| $t_2$      | New Data Delay Time, $C_L = 15pF$ max |     |     | 12.5 | ns    |

NOTE: (1) "§" indicates the portion of the waveform that will stretch out at slower sample rates.

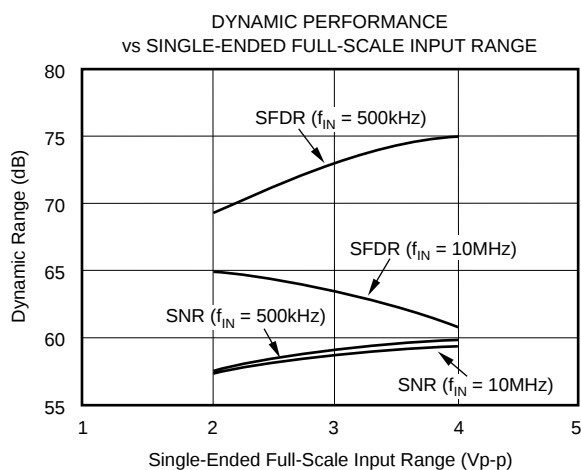
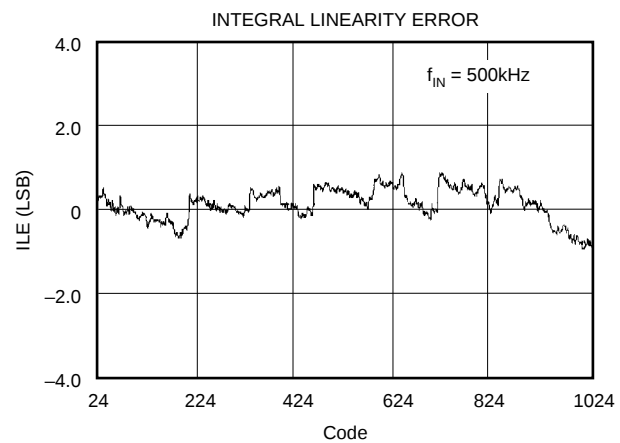
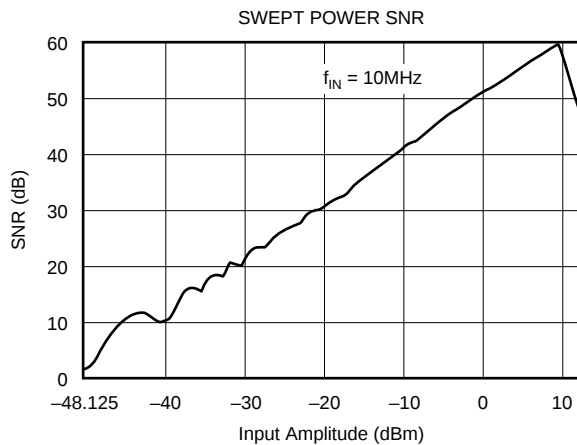
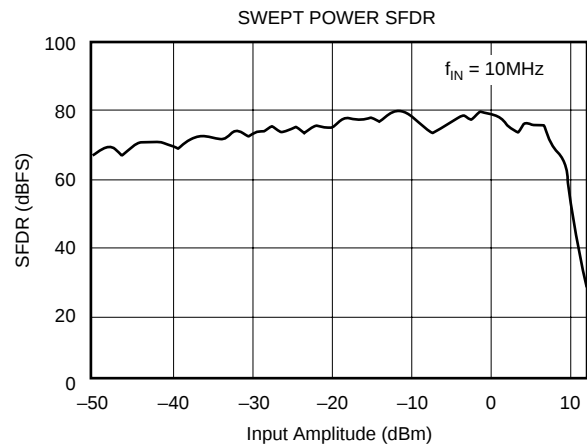
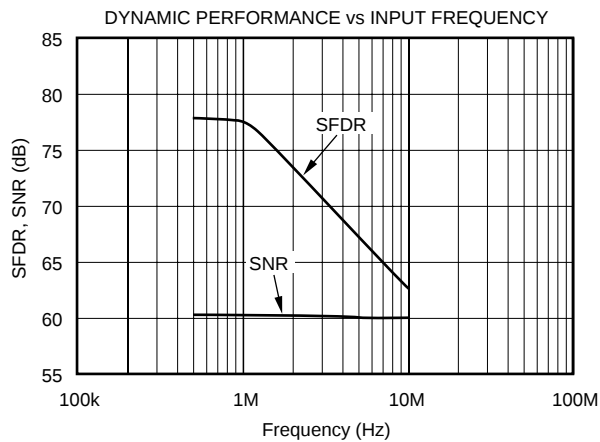
# TYPICAL CHARACTERISTICS

At  $T_A = +25^\circ\text{C}$ ,  $V_S = +5\text{V}$ , Sampling Rate = 20MHz, with a 50% duty cycle clock having a 2ns rise/fall time, unless otherwise noted.

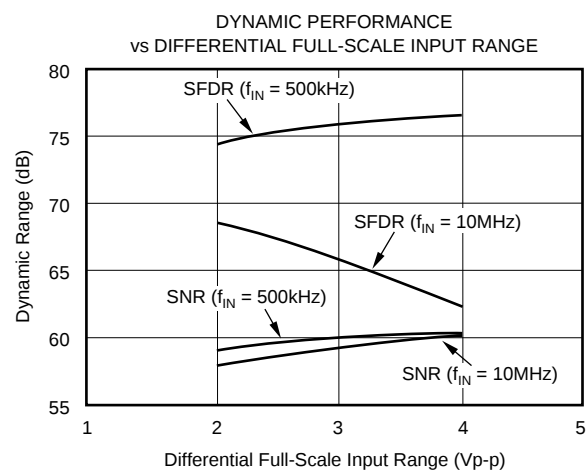


# TYPICAL CHARACTERISTICS (Cont.)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = +5\text{V}$ , Sampling Rate = 20MHz, with a 50% duty cycle clock having a 2ns rise/fall time, unless otherwise noted.



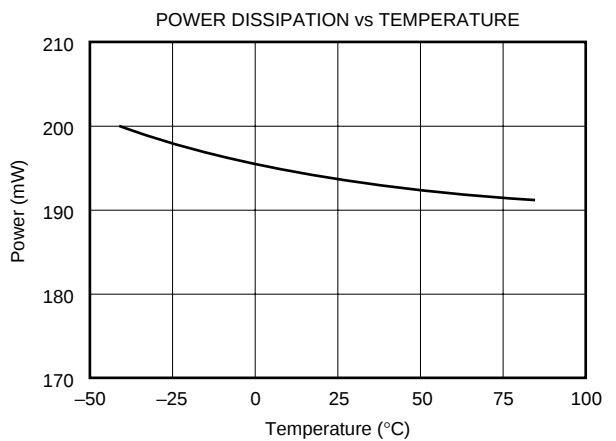
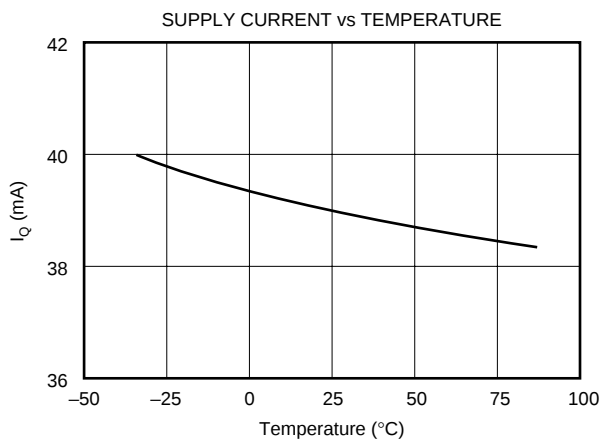
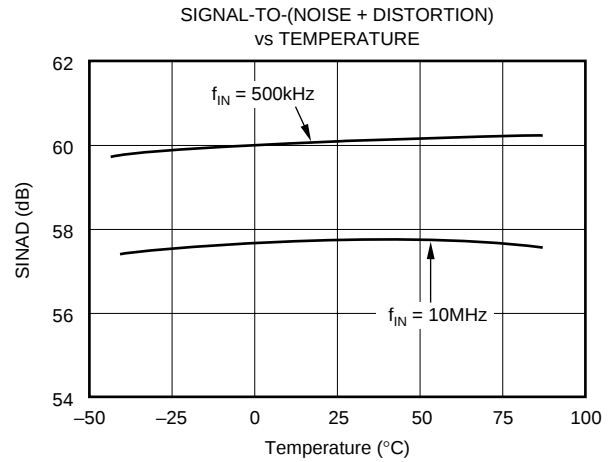
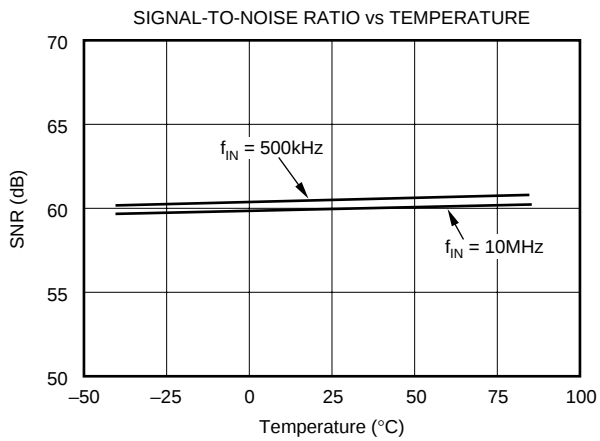
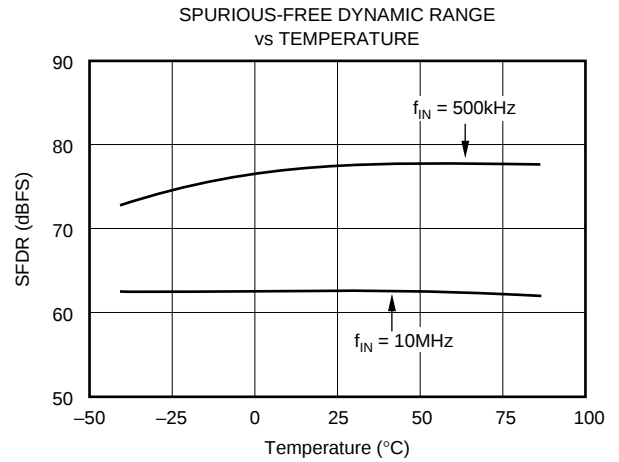
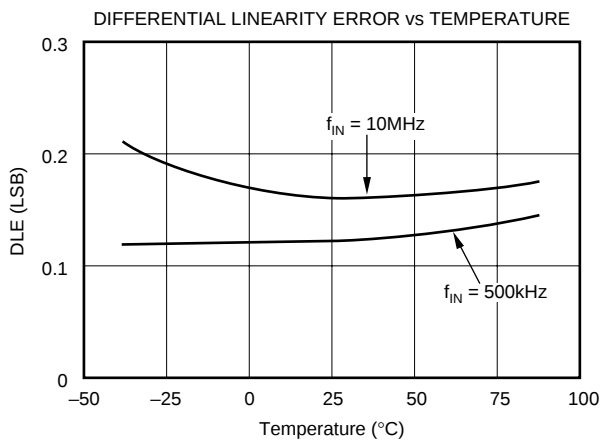
NOTE:  $\text{REF}_{\text{EXT}}$  varied,  $\text{REFB}$  is fixed at the internal value of +1.25V.



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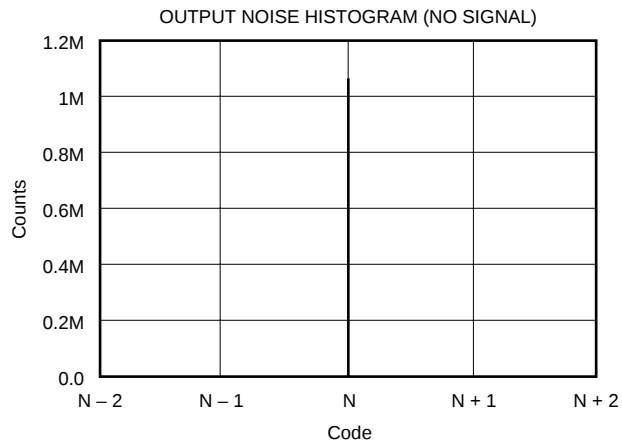
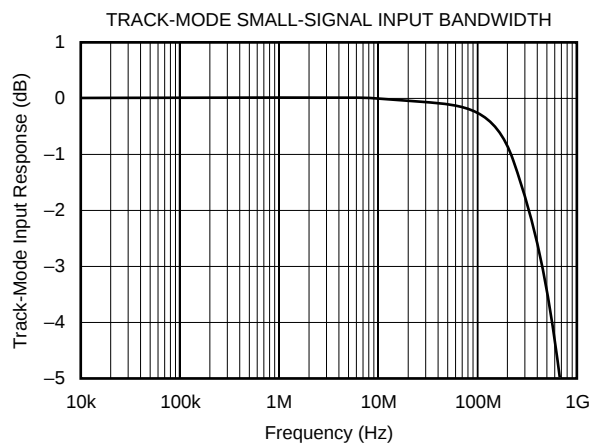
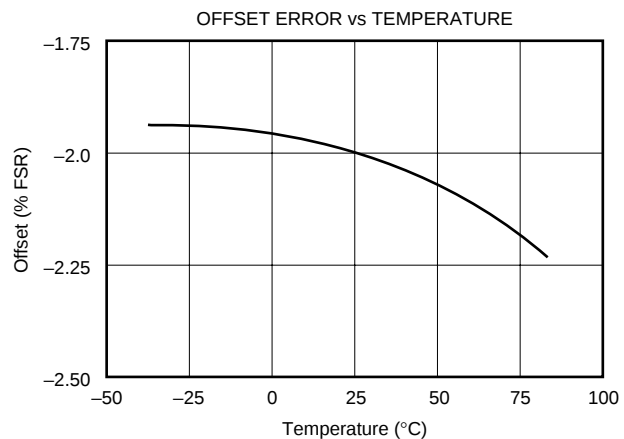
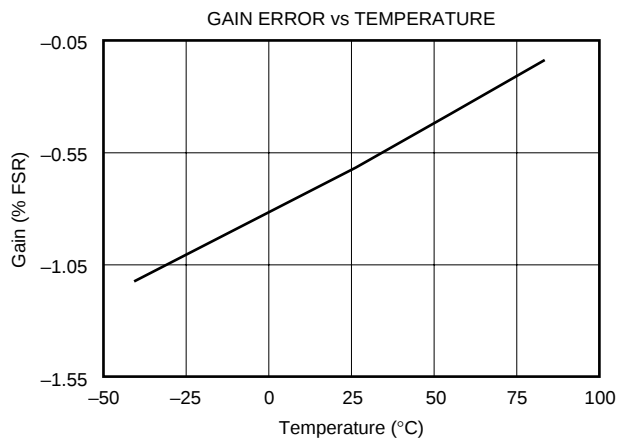
# TYPICAL CHARACTERISTICS (Cont.)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = +5\text{V}$ , Sampling Rate = 20MHz, with a 50% duty cycle clock having a 2ns rise/fall time, unless otherwise noted.



# TYPICAL CHARACTERISTICS (Cont.)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = +5\text{V}$ , Sampling Rate = 20MHz, with a 50% duty cycle clock having a 2ns rise/fall time, unless otherwise noted.



# THEORY OF OPERATION

The ADS820 is a high-speed, sampling A/D converter with pipelining. It uses a fully differential architecture and digital error correction to ensure 10-bit resolution. The differential track-and-hold circuit is shown in Figure 1. The switches are controlled by an internal clock that has a non-overlapping, two-phase signal,  $\phi 1$  and  $\phi 2$ . At the sampling time the input signal is sampled on the bottom plates of the input capacitors. In the next clock phase,  $\phi 2$ , the bottom plates of the input capacitors are connected together and the feedback capacitors are switched to the op amp output. At this time, the charge redistributes between  $C_1$  and  $C_H$ , completing one track-and-hold cycle. The differential output is a held DC representation of the analog input at the sample time. The track-and-hold circuit can also convert a single-ended input signal into a fully differential signal for the quantizer.

The pipelined quantizer architecture has nine stages with each stage containing a 2-bit quantizer and a 2-bit Digital-to-Analog Converter (DAC), as shown in Figure 2. Each 2-bit quantizer stage converts on the edge of the sub-clock, which is twice the frequency of the externally applied clock. The output of each quantizer is fed into its own delay line to

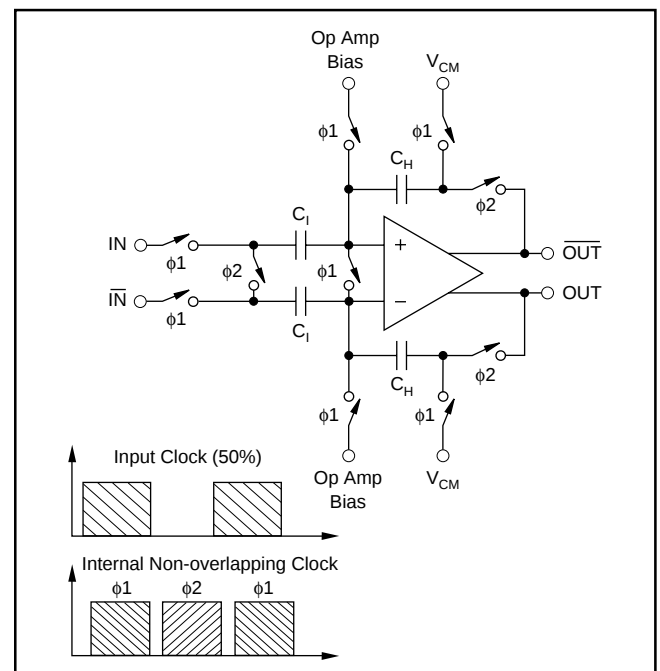


FIGURE 1. Input Track-and-Hold Configuration with Timing Signals.

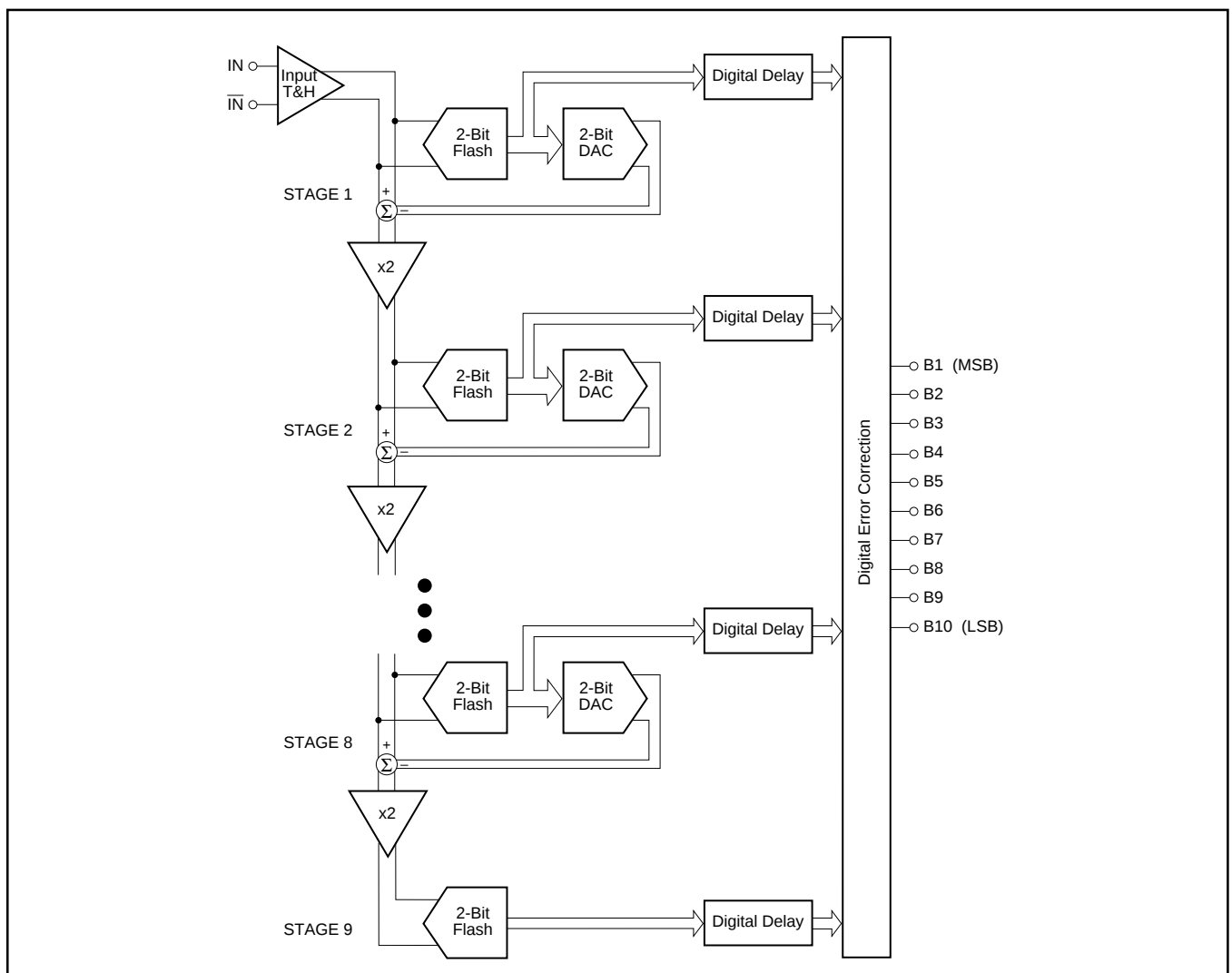


FIGURE 2. Pipeline A/D Converter Architecture.

time-align it with the data created from the following quantizer stages. This aligned data is fed into a digital error correction circuit that can adjust the output data based on the information found on the redundant bits. This technique gives the ADS820 excellent differential linearity and ensures no missing codes at the 10-bit level.

There is a 6.5 clock cycle data latency from the start convert signal to the valid output data. The output data is available in Straight Offset Binary (SOB) or Binary Two's Complement (BTC) format.

## THE ANALOG INPUT AND INTERNAL REFERENCE

The analog input of the ADS820 can be configured in various ways and driven with different circuits, depending on the nature of the signal and the level of performance desired. The ADS820 has an internal reference that sets the full-scale input range of the A/D converter. The differential input range has each input centered around the common-mode of +2.25V, with each of the two inputs having a full-scale range of +1.25V to +3.25V. Since each input is 2Vp-p and 180° out-of-phase with the other, a 4V differential input signal to the quantizer results. The positive full-scale reference (REFT) and the negative full-scale reference (REFB) are brought out for external bypassing, as shown in Figure 3. In addition, the common-mode (CM) voltage may be used as a reference to provide the appropriate offset for the driving circuitry. However, care must be taken not to appreciably load this reference node. For more information regarding external references, single-ended inputs, and ADS820 drive circuits, refer to the applications section.

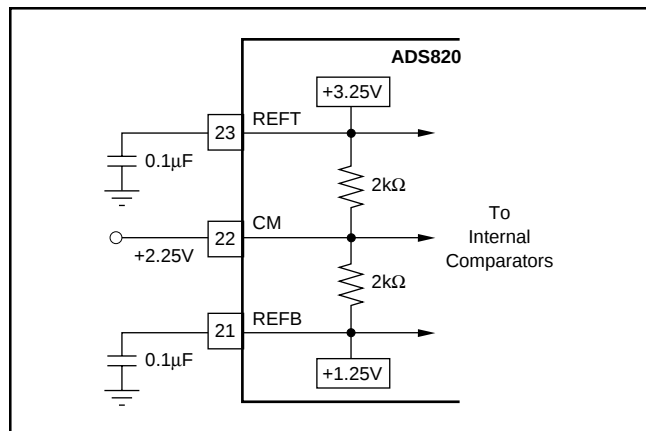


FIGURE 3. Internal Reference Structure.

## CLOCK REQUIREMENTS

The CLK pin accepts a CMOS level clock input. The rising and falling edge of the externally applied convert command clock controls the various interstage conversions in the pipeline. Therefore, the duty cycle of the clock should be held at 50% with low jitter and fast rise and fall times of 2ns or less. This is especially important when digitizing a high-frequency input and operating at the maximum sample rate. Deviation from a 50% duty cycle will effectively shorten some of the interstage settling times, thus degrading the SNR and DNL performance.

## DIGITAL OUTPUT DATA

The 10-bit output data is provided at CMOS logic levels. The standard output coding is Straight Offset Binary where a full-scale input signal corresponds to all "1's" at the output. This condition is met with pin 19 LOW or Floating due to an internal pull-down resistor. By applying a high voltage to this pin, a BTC output will be provided where the most significant bit is inverted. The digital outputs of the ADS820 can be set to a high impedance state by driving  $\overline{OE}$  (pin 18) with a logic HIGH. Normal operation is achieved with pin 18 LOW or Floating due to internal pull-down resistors. This function is provided for testability purposes and is not meant to drive digital buses directly or be dynamically changed during the conversion process.

| DIFFERENTIAL INPUT <sup>(1)</sup>            | OUTPUT CODE                      |                       |
|----------------------------------------------|----------------------------------|-----------------------|
|                                              | SOB<br>PIN 19<br>FLOATING or LOW | BTC<br>PIN 19<br>HIGH |
| +FS (IN = +3.25V, $\overline{IN}$ = +1.25V)  | 1111111111                       | 0111111111            |
| +FS -1LSB                                    | 1111111111                       | 0111111111            |
| +FS -2LSB                                    | 1111111110                       | 0111111110            |
| +3/4 Full Scale                              | 1110000000                       | 0110000000            |
| +1/2 Full Scale                              | 1100000000                       | 0100000000            |
| +1/4 Full Scale                              | 1010000000                       | 0010000000            |
| +1LSB                                        | 1000000001                       | 0000000001            |
| Bipolar Zero (IN = $\overline{IN}$ = +2.25V) | 1000000000                       | 0000000000            |
| -1LSB                                        | 0111111111                       | 1111111111            |
| -1/4 Full Scale                              | 0110000000                       | 1110000000            |
| -1/2 Full Scale                              | 0100000000                       | 1100000000            |
| -3/4 Full Scale                              | 0010000000                       | 1010000000            |
| -FS +1LSB                                    | 0000000001                       | 1000000001            |
| -FS (IN = +1.25V, $\overline{IN}$ = +3.25V)  | 0000000000                       | 1000000000            |

NOTE: (1) In the single-ended input mode, +FS = +4.25V and -FS = +0.25V.

TABLE I. Coding Table for the ADS820.

## APPLICATIONS

### DRIVING THE ADS820

The ADS820 has a differential input with a common mode of +2.25V. For AC-coupled applications, the simplest way to create this differential input is to drive the primary winding of a transformer with a single-ended input. A differential output is created on the secondary if the center tap is tied to the (CM) voltage of +2.25V, as per Figure 4. This transformer-coupled input arrangement provides good high frequency

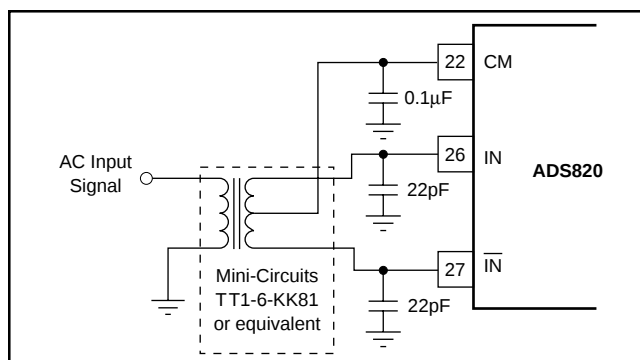


FIGURE 4. AC-Coupled Single-Ended to Differential Drive Circuit Using a Transformer.

AC performance. It is important to select a transformer that gives low distortion and does not exhibit core saturation at full-scale voltage levels. Since the transformer does not appreciably load the ladder, there is no need to buffer the CM output in this instance. In general, it is advisable to keep the current draw from the CM output pin below  $0.5\mu\text{A}$  to avoid nonlinearity in the internal reference ladder. A FET input operational amplifier, such as the OPA130, can provide a buffered reference for driving external circuitry. The analog IN and  $\overline{\text{IN}}$  inputs should be bypassed with 22pF capacitors to minimize track-and-hold glitches and to improve high-input frequency performance.

Figure 5 illustrates another possible low-cost interface circuit that utilizes resistors and capacitors in place of a transformer. Depending on the signal bandwidth, the component values should be carefully selected in order to maintain the performance outlined in the data sheet. The input capacitors,  $C_{\text{IN}}$ , and the input resistors,  $R_{\text{IN}}$ , create a high-pass filter with the lower corner frequency at  $f_c = 1/(2\pi R_{\text{IN}} C_{\text{IN}})$ . The corner frequency can be reduced by either increasing the value of  $R_{\text{IN}}$  or  $C_{\text{IN}}$ . If the circuit operates with a  $50\Omega$  or  $75\Omega$  impedance level, the resistors are fixed and only the value of the capacitor can be increased. Usually AC-coupling capacitors are electrolytic or tantalum capacitors with values of  $1\mu\text{F}$  or higher. It should be noted that these large capacitors become inductive with increased input frequency, which could lead to signal amplitude errors or oscillation. To maintain a low ac-coupling impedance throughout the signal band, a small value (e.g.  $1\mu\text{F}$ ) ceramic capacitor could be added in parallel with the polarized capacitor.

Capacitors  $C_{\text{SH1}}$  and  $C_{\text{SH2}}$  are used to minimize current glitches resulting from the switching in the input track and hold stage and to improve signal-to-noise performance. These capacitors can also be used to establish a low-pass filter and effectively reduce the noise bandwidth. In order to create a real pole, resistors  $R_{\text{SER1}}$  and  $R_{\text{SER2}}$  were added in series with

each input. The cutoff frequency of the filter is determined by  $f_c = 1/(2\pi R_{\text{SER}} \cdot (C_{\text{SH}} + C_{\text{ADC}}))$  where  $R_{\text{SER}}$  is the resistor in series with the input,  $C_{\text{SH}}$  is the external capacitor from the input to ground, and  $C_{\text{ADC}}$  is the internal input capacitance of the A/D converter (typically 4pF).

Resistors  $R_1$  and  $R_2$  are used to derive the necessary common-mode voltage from the buffered top and bottom references. The total load of the resistor string should be selected so that the current does not exceed 1mA. Although the circuit in Figure 5 uses two resistors of equal value so that the common-mode voltage is centered between the top and bottom reference ( $+2.25\text{V}$ ), it is not necessary to do so. In all cases the center point,  $V_{\text{CM}}$ , should be bypassed to ground in order to provide a low-impedance ac ground.

If the signal needs to be DC-coupled to the input of the ADS820, an operational amplifier input circuit is required. In the differential input mode, any single-ended signal must be modified to create a differential signal. This can be accomplished by using two operational amplifiers; one in the noninverting mode for the input and the other amplifier in the inverting mode for the complementary input. The low distortion circuit in Figure 6 will provide the necessary input shifting required for signals centered around ground. It also employs a diode for output level shifting to ensure a low distortion  $+3.25\text{V}$  output swing. Another DC-coupled circuit is shown in Figure 7. Other amplifiers can be used in place of the OPA860s if the lowest distortion is not necessary. If output level shifting circuits are not used, care must be taken to select operational amplifiers that give the necessary performance when swinging to  $+3.25\text{V}$  with a  $\pm 5\text{V}$  supply operational amplifier. The OPA620 and OPA621, or the lower power OPA820 can be used in place of the OPA860s in Figure 6. In that configuration, the OPA820 will typically swing to within 100mV of positive full scale.

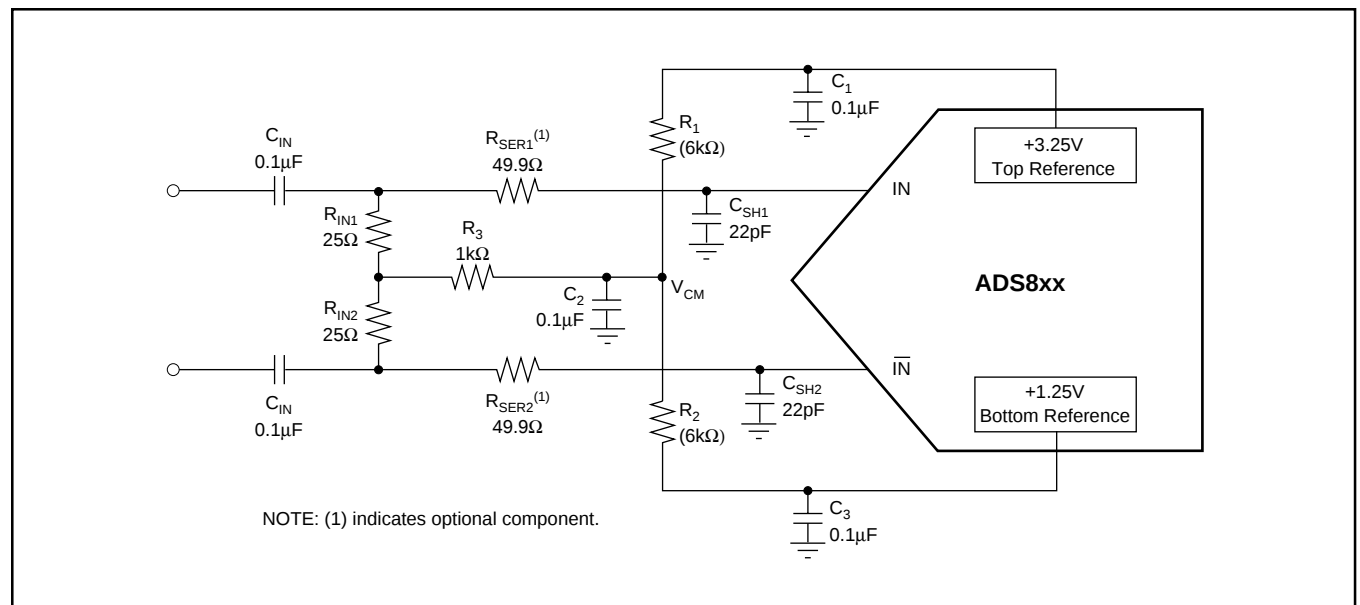


FIGURE 5. AC-Coupled Differential Input Circuit.



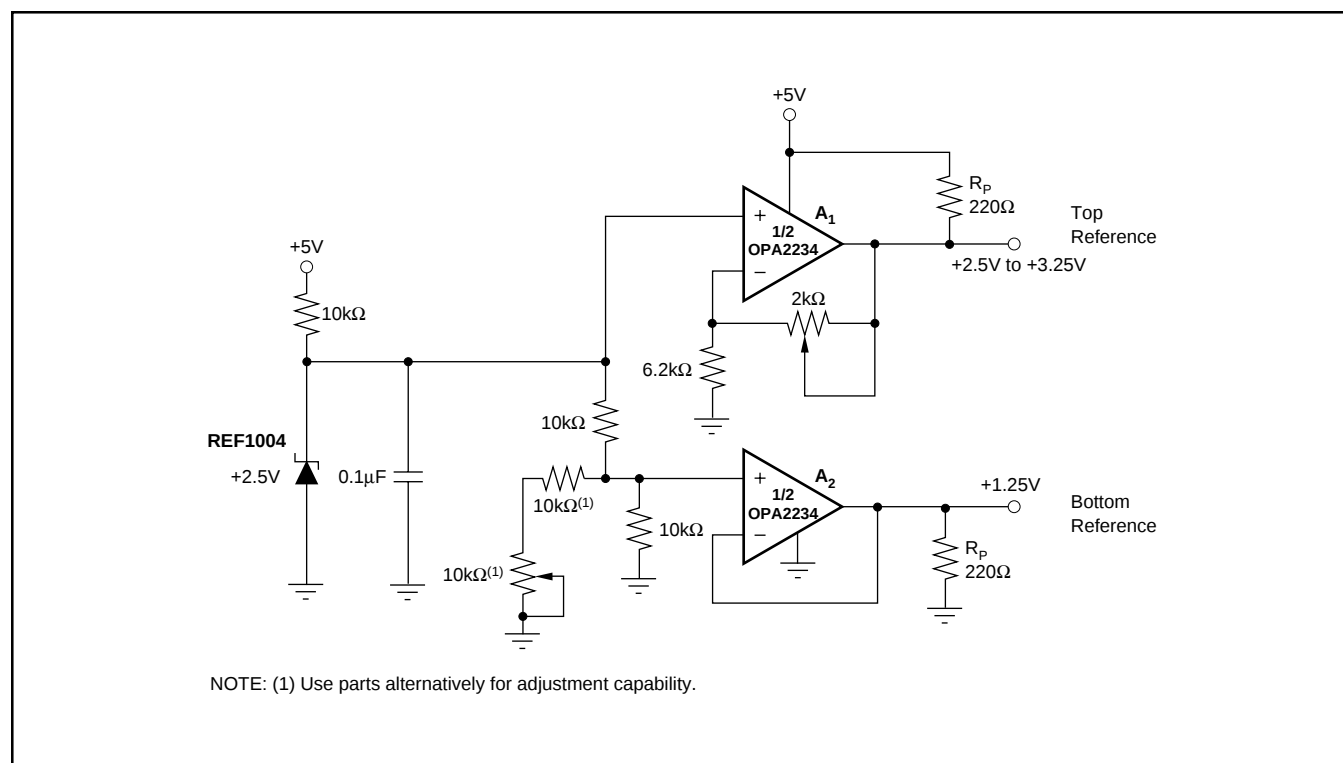
Full Scale = +0.25V to +4.25V with internal references.

## EXTERNAL REFERENCES AND ADJUSTMENT OF FULL-SCALE RANGE

set halfway between the two references. This feature can be used to adjust the gain error, improve gain drift, or to change the full-scale input range of the ADS820. Changing the full-scale range to a lower value has the benefit of easing the swing requirements of external input amplifiers. The external references can vary as long as the value of the external top reference ( $REF_{T\_EXT}$ ) is less than or equal to +3.4V, the value of the external bottom reference ( $REF_{B\_EXT}$ ) is greater than or equal to +1.1V, and the difference between the external references are greater than or equal to 800mV.

The circuit in Figure 9 works completely on a single +5V supply. As a reference element, it uses micro-power reference REF1004-2.5, which is set to a quiescent current of 0.1mA. Amplifier  $A_2$  is configured as a follower to buffer the +1.25V generated from the resistor divider. To provide the necessary current drive, a pull-down resistor,  $R_p$  is added.

Amplifier A<sub>1</sub> is configured as an adjustable gain stage, with a range of approximately 1 to 1.32. The pull-up resistor again relieves the op amp from providing the full current drive. The value of the pull-up and pull-down resistors is not critical and can be varied to optimize power consumption. The need for pull-up/down resistors depends only on the drive capability of the selected drive amplifiers and thus can be omitted.



**ADS820**  
SBAS037B

## PC-BOARD LAYOUT AND BYPASSING

A well-designed, clean PC-board layout will assure proper operation and clean spectral response. Proper grounding and bypassing, short lead lengths, and the use of ground planes are particularly important for high frequency circuits. Multilayer PC boards are recommended for best performance but if carefully designed, a two-sided pc board with large, heavy ground planes can give excellent results. It is recommended that the analog and digital ground pins of the ADS820 be connected directly to the analog ground plane. In our experience, this gives the most consistent results. The A/D converter power-supply commons should be tied together at the analog ground plane. Power supplies should be bypassed with 0.1μF ceramic capacitors as close to the pin as possible.

## DYNAMIC PERFORMANCE TESTING

The ADS820 is a high-performance converter and careful attention to test techniques is necessary to achieve accurate results. Highly accurate phase-locked signal sources allow high-resolution FFT measurements to be made without using data windowing functions. A low jitter signal generator such as the HP8644A for the test signal, phase-locked with a low jitter HP8022A pulse generator for the A/D converter clock,

gives excellent results. Low-pass filtering (or bandpass filtering) of test signals is absolutely necessary to test the low distortion of the ADS820. Using a signal amplitude slightly lower than full scale will allow a small amount of “headroom” so that noise or DC-offset voltage will not overrange the A/D converter and cause clipping on signal peaks.

## DYNAMIC PERFORMANCE DEFINITIONS

1. Signal-to-Noise-and-Distortion Ratio (SINAD):

$$10 \log \frac{\text{Sinewave Signal Power}}{\text{Noise + Harmonic Power (first 15 harmonics)}}$$

2. Signal-to-Noise Ratio (SNR):

$$10 \log \frac{\text{Sinewave Signal Power}}{\text{Noise Power}}$$

3. Intermodulation Distortion (IMD):

$$10 \log \frac{\text{Highest IMD Product Power (to 5th order)}}{\text{Sinewave Signal Power}}$$

IMD is referenced to the larger of the test signals  $f_1$  or  $f_2$ . Five “bins” either side of peak are used for calculation of fundamental and harmonic power. The “0” frequency bin (DC) is not included in these calculations, as it is of little importance in dynamic signal processing applications.



## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish | MSL Peak Temp<br>(3) | Op Temp (°C) | Top-Side Markings<br>(4) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|------------------|----------------------|--------------|--------------------------|-------------------------|
| ADS820E          | OBSOLETE      | SSOP         | DB                 | 28   |                | TBD                        | Call TI          | Call TI              | -40 to 85    |                          |                         |
| ADS820E/1K       | OBSOLETE      | SSOP         | DB                 | 28   |                | TBD                        | Call TI          | Call TI              | -40 to 85    |                          |                         |
| ADS820U          | ACTIVE        | SOIC         | DW                 | 28   | 20             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | ADS820U                  | <a href="#">Samples</a> |
| ADS820UG4        | ACTIVE        | SOIC         | DW                 | 28   | 20             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU        | Level-2-260C-1 YEAR  | -40 to 85    | ADS820U                  | <a href="#">Samples</a> |

(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.

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**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

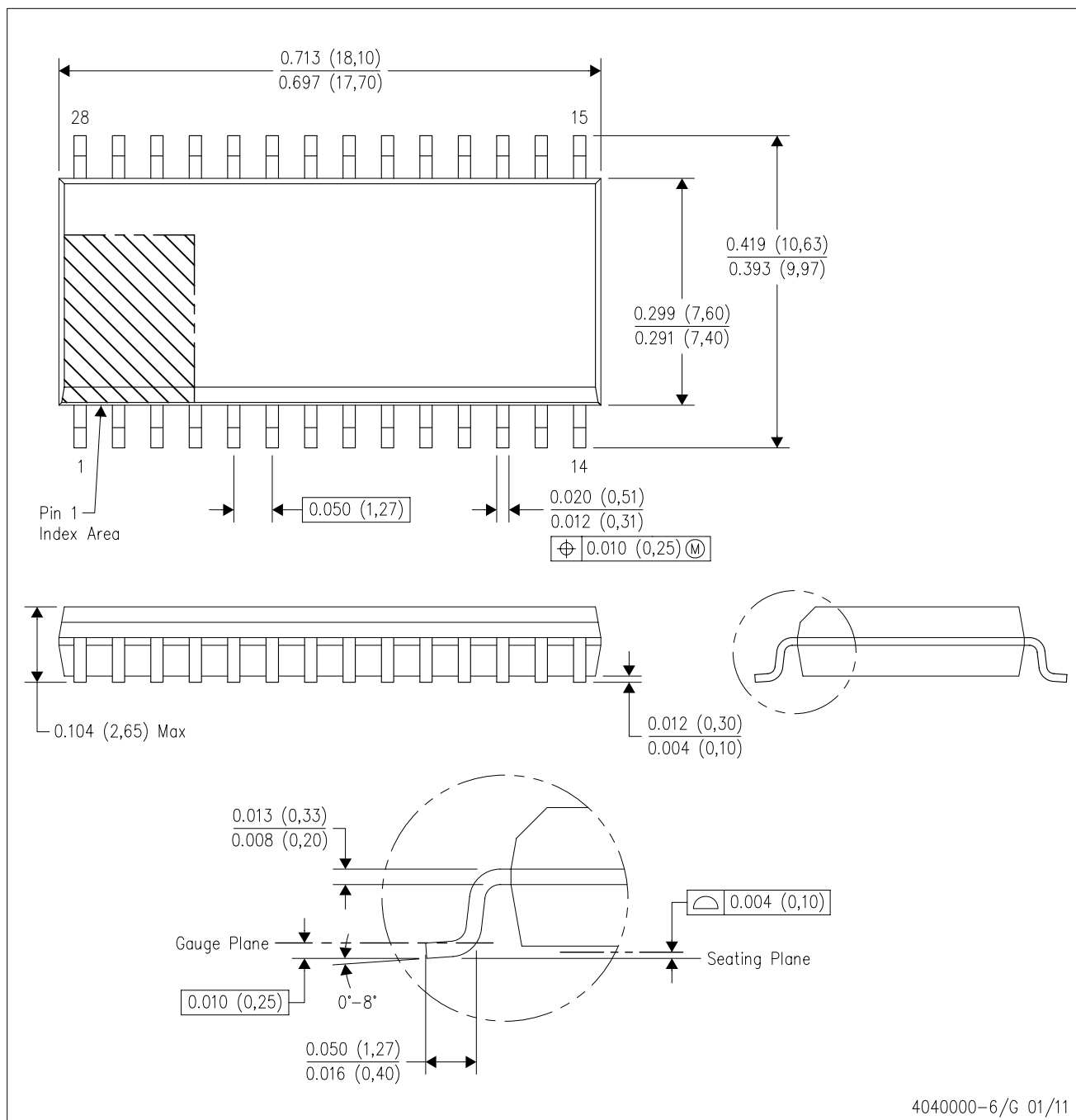
(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "--" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

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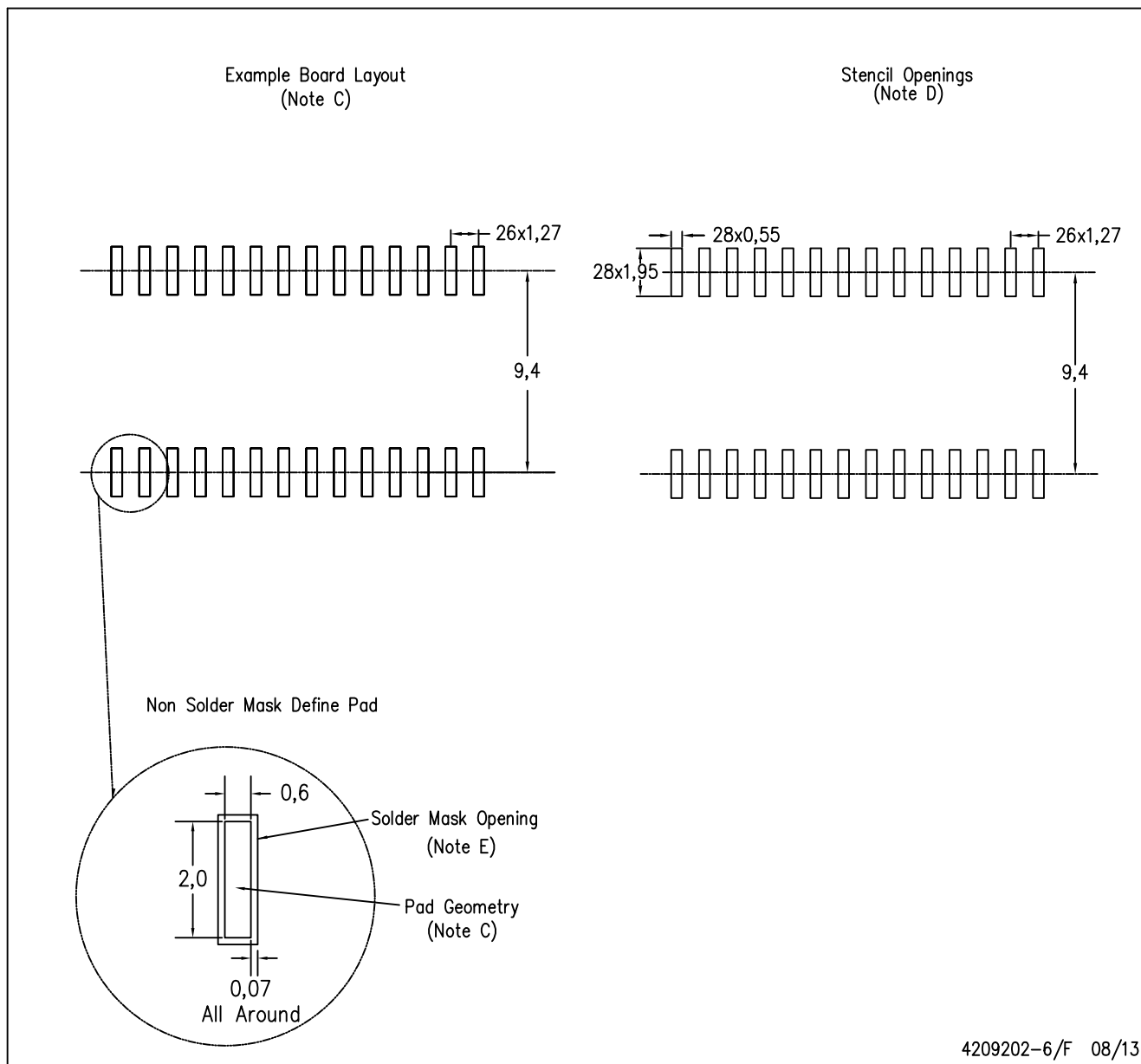
PLASTIC SMALL OUTLINE



- NOTES:
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  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - D. Falls within JEDEC MS-013 variation AE.

DW (R-PDSO-G28)

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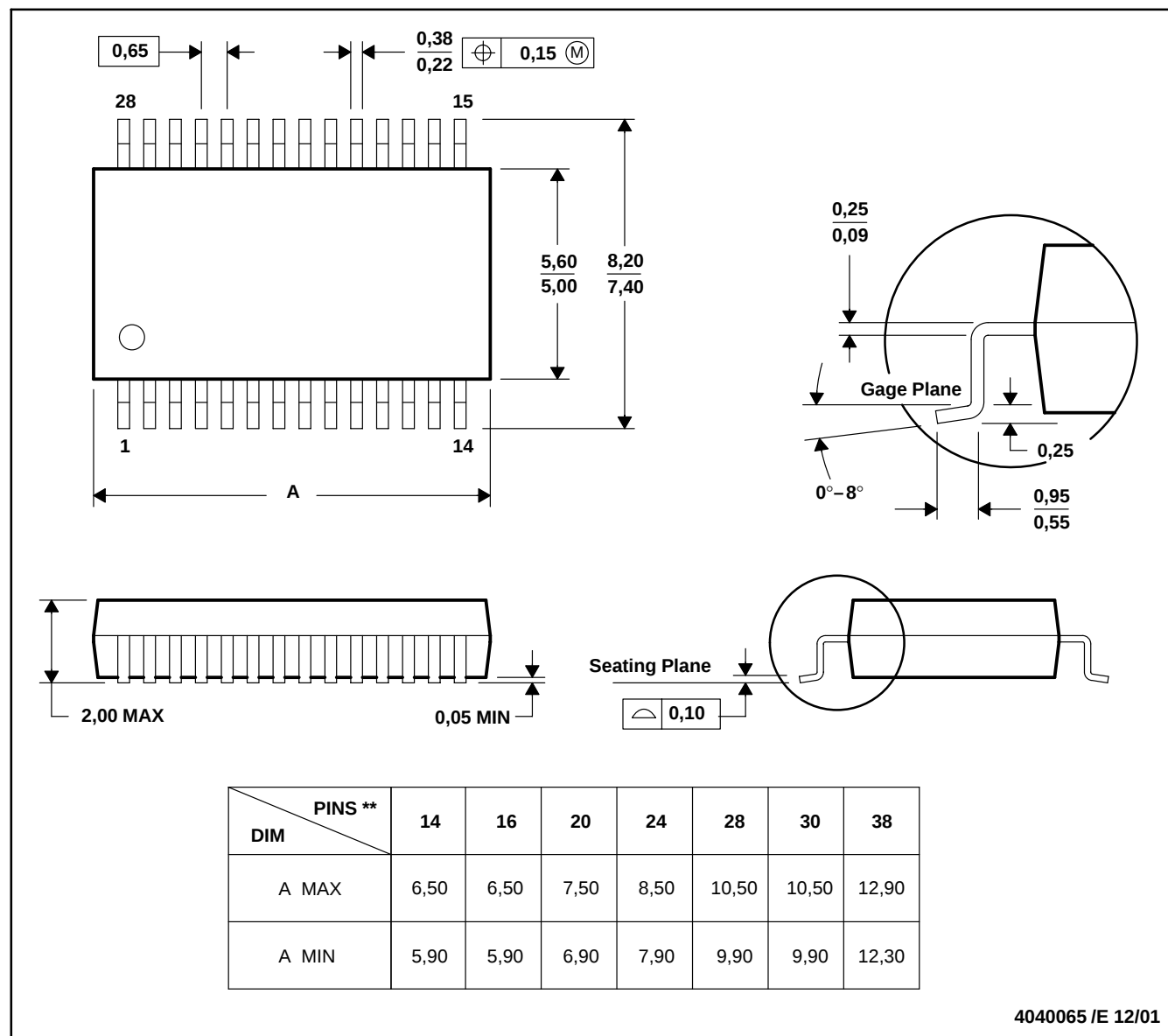


- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Refer to IPC7351 for alternate board design.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

## DB (R-PDSO-G\*\*)

## PLASTIC SMALL-OUTLINE

28 PINS SHOWN



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  - Falls within JEDEC MO-150

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