

**FEATURES**

- 18-bit resolution
- 1MHz minimum sampling rate
- No missing codes over extended temperature range
- Very low power, 1.45 Watts
- Small, 32-pin, side-brazed, ceramic TDIP
- Edge-triggered
- Excellent performance
- Ideal for both time and frequency-domain applications
- Low cost



**GENERAL DESCRIPTION**

The ADS-951 is an 18-bit, 1MHz sampling A/D converter. This device accurately samples full-scale input signals up to Nyquist frequencies with no missing codes. This feature, combined with excellent signal-to-noise ratio (SNR) and total harmonic distortion (THD), makes the ADS-951 the ideal choice for both time-domain (medical imaging, scanners, process control) and frequency-domain (radar, telecommunications, spectrum analysis) applications.

Packaged in a 32-pin, side-brazed, metal-sealed, ceramic TDIP, the functionally complete ADS-951 contains a fast-settling sample-hold amplifier, a subranging (two-pass) A/D converter, an internal reference, timing/control logic, and error-correction circuitry. Digital input and output levels are TTL, and the ADS-951 only requires the rising edge of the start convert pulse to operate.

Requiring  $\pm 15V$  and  $\pm 5V$  supplies, the ADS-951 typically dissipates 1.45 Watts. The device is offered with a bipolar ( $\pm 5V$ ) analog input range. Models are available for use in either commercial (0 to  $+70^{\circ}C$ ) or extended ( $-40$  to  $+110^{\circ}C$ )

**INPUT/OUTPUT CONNECTIONS**

| PIN | FUNCTION           | PIN | FUNCTION     |
|-----|--------------------|-----|--------------|
| 1   | BIT 2              | 32  | BIT 3        |
| 2   | BIT 1 (MSB)        | 31  | BIT 4        |
| 3   | ANALOG GROUND      | 30  | BIT 5        |
| 4   | ANALOG INPUT       | 29  | BIT 6        |
| 5   | +5V REFERENCE OUT  | 28  | BIT 7        |
| 6   | GAIN ADJUST        | 27  | BIT 8        |
| 7   | COMPENSATION       | 26  | BIT 9        |
| 8   | -15V SUPPLY        | 25  | BIT 10       |
| 9   | +15V SUPPLY        | 24  | BIT 11       |
| 10  | +5V ANALOG SUPPLY  | 23  | BIT 12       |
| 11  | -5V ANALOG SUPPLY  | 22  | BIT 13       |
| 12  | ANALOG GROUND      | 21  | BIT 14       |
| 13  | DIGITAL GROUND     | 20  | BIT 15       |
| 14  | +5V DIGITAL SUPPLY | 19  | BIT 16       |
| 15  | $\overline{EOC}$   | 18  | BIT 17       |
| 16  | START CONVERT      | 17  | BIT 18 (LSB) |

operating temperature ranges. A proprietary, auto-calibrating, error-correcting circuit enables the device to achieve specified performance over the full military temperature range.

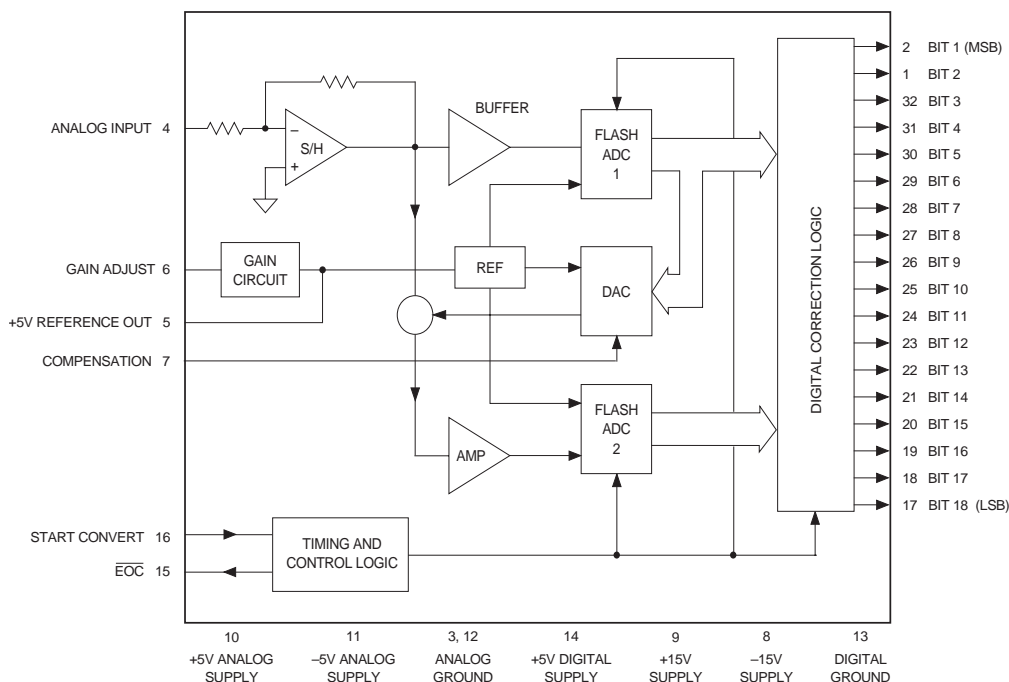


Figure 1. ADS-951 Functional Block Diagram

**ABSOLUTE MAXIMUM RATINGS**

| PARAMETERS                    | LIMITS           | UNITS |
|-------------------------------|------------------|-------|
| +15V Supply (Pin 9)           | 0 to +16         | Volts |
| -15V Supply (Pin 8)           | 0 to -16         | Volts |
| +5V Supply (Pins 10, 14)      | 0 to +6          | Volts |
| -5V Supply (Pin 11)           | 0 to -6          | Volts |
| Digital Input (Pin 16)        | -0.3 to +VDD+0.3 | Volts |
| Analog Input (Pin 4)          | ±15              | Volts |
| Lead Temperature (10 seconds) | +300             | °C    |

**PHYSICAL/ENVIRONMENTAL**

| PARAMETERS                  | MIN.  | TYP. | MAX. | UNITS   |
|-----------------------------|---|------|------|---------|
| Operating Temp. Range, Case | 0   | —    | +70  | °C      |
|                             | -40   | —    | +110 | °C      |
| Thermal Impedance           | —   | 5    | —    | °C/Watt |
|                             | —   | 22   | —    | °C/Watt |
| Storage Temperature Range   | -65   | —    | +150 | °C      |
| Package Type                | 32-pin, side-brazed, metal-sealed, ceramic TDIP |      |      |         |
| Weight                      | 0.46 ounces (13 grams)                          |      |      |         |

**FUNCTIONAL SPECIFICATIONS**

(TA = +25°C, ±VCC = ±15V, ±VDD = ±5V, 1MHz sampling rate, and a minimum 1 minute warmup ① unless otherwise specified.)

| ANALOG INPUT  | +25°C |      |       | 0 to +70°C |       |       | -40 to +110°C |       |       | UNITS  |
|---|-------|------|-------|------------|-------|-------|---------------|-------|-------|--------|
|   | MIN.  | TYP. | MAX.  | MIN.       | TYP.  | MAX.  | MIN.          | TYP.  | MAX.  |        |
| Input Voltage Range ②   | —     | ±5   | —     | —          | ±5    | —     | —             | ±5    | —     | Volts  |
| Input Resistance  | —     | 500  | —     | —          | 500   | —     | —             | 500   | —     | Ω      |
| Input Capacitance   | —     | 7    | 15    | —          | 7     | 15    | —             | 7     | 15    | pF     |
| <b>DIGITAL INPUT</b>  |       |      |       |            |       |       |               |       |       |        |
| Logic Levels  |       |      |       |            |       |       |               |       |       |        |
| Logic "1"   | +2.0  | —    | —     | +2.0       | —     | —     | +2.0          | —     | —     | Volts  |
| Logic "0"   | —     | —    | +0.8  | —          | —     | +0.8  | —             | —     | +0.8  | Volts  |
| Logic Loading "1"   | —     | —    | +20   | —          | —     | +20   | —             | —     | +20   | μA     |
| Logic Loading "0"   | —     | —    | -20   | —          | —     | -20   | —             | —     | -20   | μA     |
| Start Convert Positive Pulse Width ③  | 20    | 500  | —     | 20         | 500   | —     | 20            | 500   | —     | ns     |
| <b>STATIC PERFORMANCE</b>   |       |      |       |            |       |       |               |       |       |        |
| Resolution  | —     | 18   | —     | —          | 18    | —     | —             | 18    | —     | Bits   |
| Integral Nonlinearity (fin = 10kHz)   | —     | ±10  | —     | —          | ±10   | —     | —             | ±15   | —     | LSB    |
| Differential Nonlinearity (fin = 10kHz)   | -0.95 | ±0.5 | +1    | -0.95      | ±0.5  | +1    | -0.95         | ±0.50 | +1.25 | LSB    |
| Full Scale Absolute Accuracy  | —     | ±0.1 | ±0.25 | —          | ±0.25 | ±0.4  | —             | ±0.4  | ±0.8  | %FSR   |
| Bipolar Zero Error (Tech Note 2)  | —     | ±0.1 | ±0.15 | —          | ±0.15 | ±0.25 | —             | ±0.25 | ±0.5  | %FSR   |
| Bipolar Offset Error (Tech Note 2)  | —     | ±0.1 | ±0.2  | —          | ±0.2  | ±0.3  | —             | ±0.3  | ±0.6  | %FSR   |
| Gain Error (Tech Note 2)  | —     | ±0.1 | ±0.25 | —          | ±0.25 | ±0.4  | —             | ±0.4  | ±0.9  | %      |
| No Missing Codes (fin = 10kHz)  | 18    | —    | —     | 18         | —     | —     | 18            | —     | —     | Bits   |
| <b>DYNAMIC PERFORMANCE (500kHz Sampling Rate)</b>                                     |       |      |       |            |       |       |               |       |       |        |
| Peak Harmonics (-0.5dB)<br>dc to 100kHz   | —     | -87  | -80   | —          | -87   | -80   | —             | -82   | —     | dB     |
| Total Harmonic Distortion (-0.5dB)<br>dc to 100kHz                                    | —     | -85  | -80   | —          | -85   | -80   | —             | -81   | —     | dB     |
| Signal-to-Noise Ratio<br>(w/o distortion, -0.5dB)<br>dc to 100kHz                     | 91    | 93   | —     | 91         | 93    | —     | —             | 92    | —     | dB     |
| Signal-to-Noise Ratio ④<br>(& distortion, -0.5dB)<br>dc to 100kHz                     | 76    | 84   | —     | 76         | 84    | —     | —             | 80    | —     | dB     |
| DC Noise  | —     | 76   | —     | —          | 76    | —     | —             | 76    | —     | μVrms  |
| Two-Tone Intermodulation<br>Distortion (fin = 100kHz,<br>240kHz, fs = 500kHz, -0.5dB) | —     | -85  | —     | —          | -85   | —     | —             | -81   | —     | dB     |
| Input Bandwidth (-3dB)  |       |      |       |            |       |       |               |       |       |        |
| Small Signal (-20dB input)  | —     | TBD  | —     | —          | TBD   | —     | —             | TBD   | —     | MHz    |
| Large Signal (-0.5dB input)   | —     | TBD  | —     | —          | TBD   | —     | —             | TBD   | —     | MHz    |
| Feedthrough Rejection (fin = 500kHz)  | —     | 84   | —     | —          | 84    | —     | —             | 84    | —     | dB     |
| Slew Rate   | —     | TBD  | —     | —          | TBD   | —     | —             | TBD   | —     | V/μs   |
| Aperture Delay Time   | —     | +20  | —     | —          | +20   | —     | —             | +20   | —     | ns     |
| Aperture Uncertainty  | —     | 5    | —     | —          | 5     | —     | —             | 5     | —     | ps rms |
| S/H Acquisition Time<br>(to ±0.003%FSR, 10V step)                                     | —     | 260  | —     | —          | 260   | —     | —             | 260   | —     | ns     |
| Overvoltage Recovery Time ⑤   | —     | 500  | —     | —          | 500   | —     | —             | 500   | —     | ns     |
| A/D Conversion Rate   | 1     | —    | —     | 1          | —     | —     | 1             | —     | —     | MHz    |

| ANALOG OUTPUT   | +25°C                       |       |       | 0 to +70°C |  |       | -40 to +110°C |       |       | UNITS   |
|---|-----------------------------|-------|-------|------------|--|-------|---------------|-------|-------|---------|
|   | MIN.                        | TYP.  | MAX.  | MIN.       | TYP.   | MAX.  | MIN.          | TYP.  | MAX.  |         |
| <b>Internal Reference</b>   |                             |       |       |            |  |       |               |       |       |         |
| Voltage   | +4.95                       | +5.0  | +5.05 | +4.95      | +5.0   | +5.05 | +4.95         | +5.0  | +5.05 | Volts   |
| Drift   | —                           | ±30   | —     | —          | ±30  | —     | —             | ±30   | —     | ppm/°C  |
| <b>External Current</b>   | —                           | 1     | —     | —          | 1  | —     | —             | 1     | —     | mA      |
| <b>DIGITAL OUTPUTS</b>  |                             |       |       |            |  |       |               |       |       |         |
| <b>Logic Levels</b>   |                             |       |       |            |  |       |               |       |       |         |
| Logic "1"   | +2.4                        | —     | —     | +2.4       | —  | —     | +2.4          | —     | —     | Volts   |
| Logic "0"   | —                           | —     | +0.4  | —          | —  | +0.4  | —             | —     | +0.4  | Volts   |
| Logic Loading "1"   | —                           | —     | -4    | —          | —  | -4    | —             | —     | -4    | mA      |
| Logic Loading "0"   | —                           | —     | +4    | —          | —  | +4    | —             | —     | +4    | mA      |
| <b>Output Coding</b>  | Complementary Offset Binary |       |       |            |  |       |               |       |       |         |
| <b>POWER REQUIREMENTS</b>   |                             |       |       |            |  |       |               |       |       |         |
| <b>Power Supply Ranges</b>  |                             |       |       |            |  |       |               |       |       |         |
| +15V Supply   | +14.5                       | +15.0 | +15.5 | +14.5      | +15.0  | +15.5 | +14.5         | +15.0 | +15.5 | Volts   |
| -15V Supply   | -14.5                       | -15.0 | -15.5 | -14.5      | -15.0  | -15.5 | -14.5         | -15.0 | -15.5 | Volts   |
| +5V Supply  | +4.75                       | +5.0  | +5.25 | +4.75      | +5.0   | +5.25 | +4.75         | +5.0  | +5.25 | Volts   |
| -5V Supply  | -4.75                       | -5.0  | -5.25 | -4.75      | -5.0   | -5.25 | -4.75         | -5.0  | -5.25 | Volts   |
| <b>Power Supply Currents</b>  |                             |       |       |            |  |       |               |       |       |         |
| +15V Supply   | —                           | +29   | —     | —          | +29  | —     | —             | +29   | —     | mA      |
| -15V Supply   | —                           | -15   | —     | —          | -15  | —     | —             | -15   | —     | mA      |
| +5V Supply  | —                           | +104  | —     | —          | +104   | —     | —             | +104  | —     | mA      |
| -5V Supply  | —                           | -54   | —     | —          | -54  | —     | —             | -54   | —     | mA      |
| <b>Power Dissipation</b>  | —                           | 1.45  | 1.65  | —          | 1.45   | 1.65  | —             | 1.45  | 1.65  | Watts   |
| <b>Power Supply Rejection</b>   | —                           | —     | ±0.05 | —          | —  | ±0.05 | —             | —     | ±0.05 | %FSR/%V |
| <b>Footnotes:</b>   |                             |       |       |            |  |       |               |       |       |         |
| ① All power supplies must be on before applying a start convert pulse. All supplies and the clock (START CONVERT) must be present during warmup periods. The device must be continuously converting during this time.   |                             |       |       |            | ④ Effective bits is equal to:<br>$\frac{(\text{SNR} + \text{Distortion}) - 1.76 + \left[ 20 \log \frac{\text{Full Scale Amplitude}}{\text{Actual Input Amplitude}} \right]}{6.02}$ |       |               |       |       |         |
| ② Contact DATEL for other input voltage ranges.   |                             |       |       |            | ⑤ This is the time required before the A/D output data is valid once the analog input is back within the specified range.  |       |               |       |       |         |
| ③ A 1MHz clock with a 500nsec positive pulse width (50% duty cycle) is used for all production testing. Any duty cycle may be used as long as a minimum positive pulse width of 20nsec is maintained. For applications requiring lower sampling rates, clock frequencies lower than 1MHz may be used. |                             |       |       |            |  |       |               |       |       |         |

## TECHNICAL NOTES

- Obtaining fully specified performance from the ADS-951 requires careful attention to pc-card layout and power supply decoupling. The device's analog and digital ground systems are not connected to each other internally. For optimal performance, tie all ground pins (3, 12 and 13) directly to a large **analog** ground plane beneath the package.

Bypass all power supplies and the +5V REFERENCE OUTPUT (pin 5) to ground with 10µF tantalum capacitors in parallel with 0.1µF ceramic capacitors. Locate the bypass capacitors as close to the unit as possible. Tie a 47µF capacitor between COMPENSATION (pin 7) and ground.

- The ADS-951 achieves its specified accuracies without the need for external calibration. If required, the device's small initial errors can be reduced to zero using the adjustment circuitry shown in Figure 2. When using this circuitry, or any similar offset and gain calibration hardware, make adjustments following warmup. To avoid interaction, always adjust offset before gain. Float pin 6 if not using gain adjust circuits.

- Applying a start convert pulse while a conversion is in progress ( $\overline{\text{EOC}}$  = logic "1") will initiate a new and probably inaccurate conversion cycle. Data for the interrupted and subsequent conversions will be invalid.

## THERMAL REQUIREMENTS

All DATEL sampling A/D converters are fully characterized and specified over operating temperature (case) ranges of 0 to +70°C and -40 to +110°C. All room-temperature ( $T_A = +25^\circ\text{C}$ ) production testing is performed without the use of heat sinks or forced-air cooling. Thermal impedance figures for each device are listed in their respective specification tables.

These devices do not normally require heat sinks, however, standard precautionary design and layout procedures should be used to ensure devices do not overheat. The ground and power planes beneath the package, as well as all pcb signal runs to and from the device, should be as heavy as possible to help conduct heat away from the package. Electrically-insulating, thermally-conductive "pads" may be installed underneath the package. Devices should be soldered to boards rather than "socketed", and of course, minimal air flow over the surface can greatly help reduce the package temperature.

**CALIBRATION PROCEDURE**

Connect the converter per Table 1 for the appropriate input voltage range. Any offset/gain calibration procedures should not be implemented until the device is fully warmed up. To avoid interaction, adjust offset before gain. The ranges of adjustment for the circuits in Figure 2 are guaranteed to compensate for the ADS-951's initial accuracy errors and may not be able to compensate for additional system errors.

A/D converters are calibrated by positioning their digital outputs exactly on the transition point between two adjacent digital output codes. This is accomplished by connecting LED's to the digital outputs and performing adjustments until certain LED's "flicker" equally between on and off. Other approaches employ digital comparators or microcontrollers to detect when the outputs change from one code to the next.

For the ADS-951, offset adjusting is normally accomplished when the analog input is 0 minus 1/2LSB (-19µV). See Table 2 for the proper bipolar output coding.

Gain adjusting is accomplished when the analog input is at nominal full scale minus 1 1/2LSB's (-4.999943V).

**Zero/Offset Adjust Procedure**

1. Apply a train of pulses to the START CONVERT input (pin 16) so that the converter is continuously converting.
2. For bipolar zero/offset adjust, apply -19µV to the ANALOG INPUT (pin 4).
3. Adjust the offset potentiometer until the output code flickers equally between 01 1111 1111 1111 1111 and 10 0000 0000 0000 0000.

**Gain Adjust Procedure**

1. Apply -4.999943V to the ANALOG INPUT (pin 4).
2. Adjust the gain potentiometer until all output bits are 1's and the LSB flickers between 1 and 0.
3. To confirm proper operation of the device, vary the applied input voltage to obtain the output coding listed in Table 2.

**Table 1. Input Connections**

| INPUT VOLTAGE RANGE | ZERO ADJUST (-1/2 LSB) | GAIN ADJUST (-FS +1 1/2 LSB) |
|---------------------|------------------------|------------------------------|
| ±5V                 | -19µV                  | -4.999943                    |

**Table 2. Output Coding**

| COMPLEMENTARY OFFSET BINARY |                   |               |                     |
|-----------------------------|-------------------|---------------|---------------------|
| BIPLOAR SCALE               | INPUT VOLTAGE ±5V | OUTPUT CODING |                     |
|                             |                   | MSB           | LSB                 |
| +FS -1 LSB                  | +4.999962         | 00            | 0000 0000 0000 0000 |
| +3/4 FS                     | +3.750000         | 00            | 0111 1111 1111 1111 |
| +1/2 FS                     | +2.500000         | 00            | 1111 1111 1111 1111 |
| 0                           | +0.000000         | 01            | 1111 1111 1111 1111 |
| -1/2 FS                     | -2.500000         | 10            | 1111 1111 1111 1111 |
| -3/4 FS                     | -3.750000         | 11            | 0111 1111 1111 1111 |
| -FS +1 LSB                  | -4.999962         | 11            | 1111 1111 1111 1110 |
| -FS                         | -5.000000         | 11            | 1111 1111 1111 1111 |

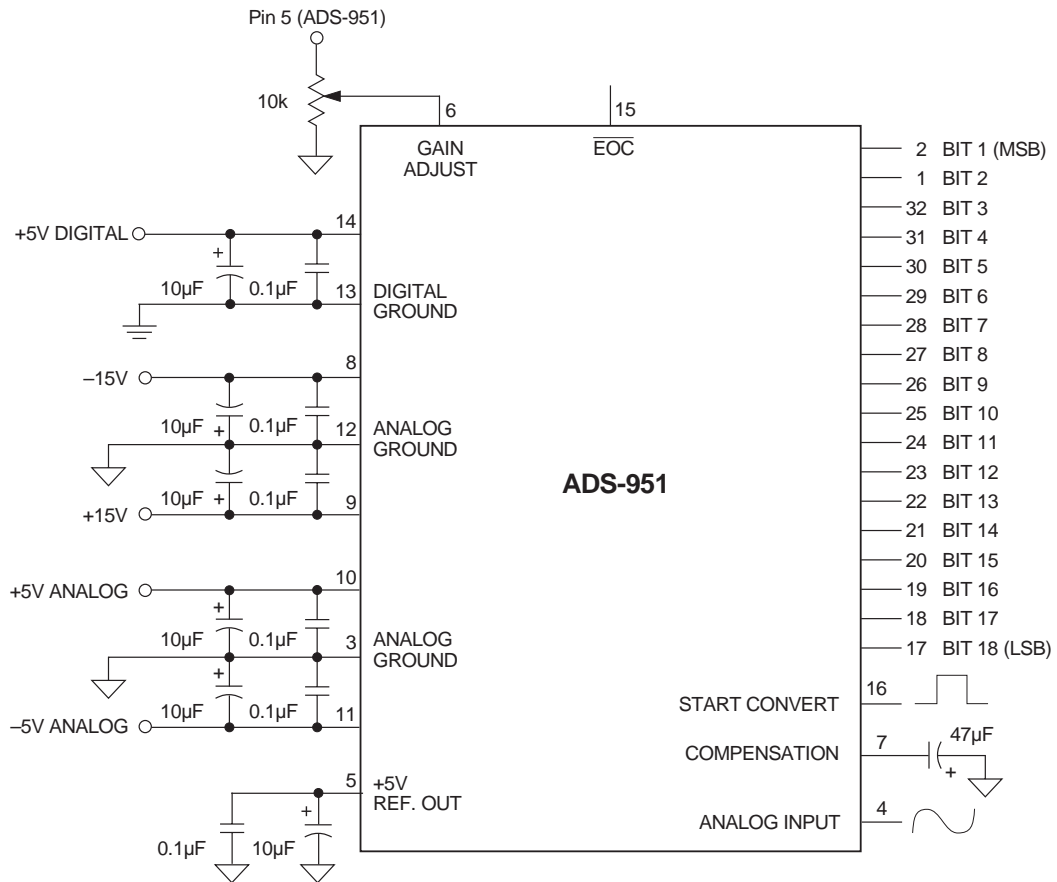


Figure 2. Typical ADS-951 Connection Diagram

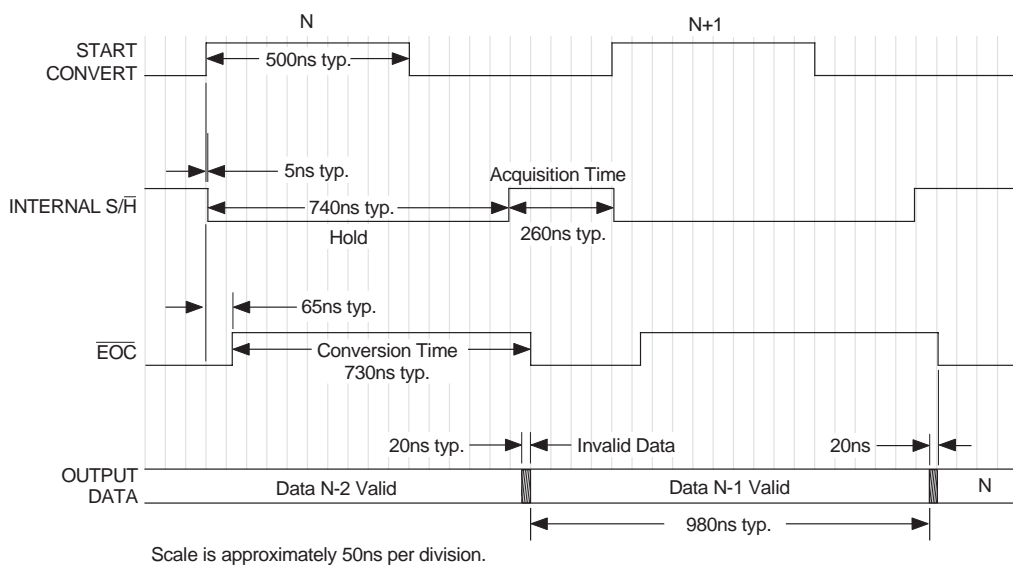
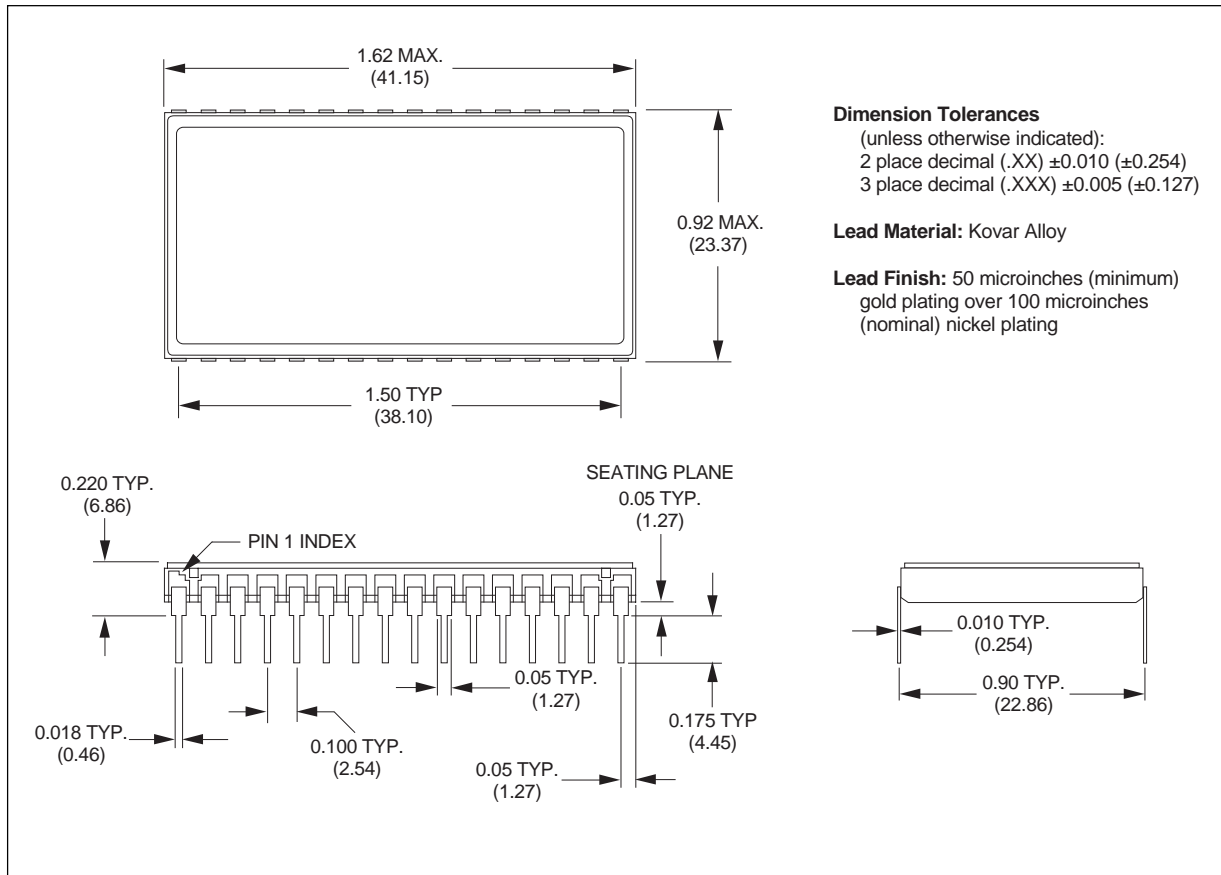


Figure 3. ADS-951 Timing Diagram

**MECHANICAL DIMENSIONS INCHES (mm)**



**ORDERING INFORMATION**

| MODEL NUMBER | OPERATING TEMP. RANGE | 32-PIN PACKAGE | ACCESSORIES                                 |
|--------------|-----------------------|----------------|---|
| ADS-951MC    | 0 to +70°C            | TDIP           | ADS-B951 Evaluation Board (without ADS-951) |
| ADS-951ME    | -40 to +110°C         | TDIP           |   |

Receptacles for PC board mounting can be ordered through AMP, Inc., Part # 3-331272-8 (Component Lead Socket), 32 required. For availability of MIL-STD-883 product, contact DATEL.