## FEATURES

- 14-bit resolution
- 12.8 MHz minimum sampling rate
- No missing codes over full military temperature range
- Ideal for both time and frequency-domain applications
- Excellent THD (-81dB) and SNR (78dB)
- Edge-triggered
- Small, 32-pin, ceramic DDIP or SMT
- Low-power, 2 Watts
- Low cost


## GENERAL DESCRIPTION

The low-cost ADS-949 is a 14 -bit, 12.8 MHz sampling $\mathrm{A} / \mathrm{D}$ converter. This device accurately samples full-scale input signals up to Nyquist frequencies with no missing codes. Excellent differential nonlinearity error (DNL), signal-to-noise ratio (SNR), and total harmonic distortion (THD) make the ADS-949 the ideal choice for both time-domain (CCD/FPA imaging, scanners, process control) and frequency-domain (radar, telecommunications, spectrum analysis) applications.
The functionally complete ADS-949 contains a fast-settling sample/hold amplifier, a subranging A/D converter, an internal reference, timing/control logic, and error-correction circuitry. Digital input and output levels are TTL. The ADS-949 only requires the rising edge of a start convert pulse to operate.
Requiring only $+15 \mathrm{~V},+5 \mathrm{~V}$ and -5 V supplies, the ADS-949 typically dissipates just 2 Watts. The device is offered with a Bipolar input range of $\pm 2.5 \mathrm{~V}$ and Unipolar range of 0 to 5 volts. Models are available for use in either commercial ( 0 to $+70^{\circ} \mathrm{C}$ ) or military ( -55 to $+125^{\circ} \mathrm{C}$ ) operating temperature ranges.


## INPUT/OUTPUT CONNECTIONS

| PIN | FUNCTION | PIN | FUNCTION |
| :---: | :--- | :---: | :--- |
| 1 | VIN A | 32 | RANGE |
| 2 | VIN B | 31 | GAIN ADJUST |
| 3 | $-5 V$ | 30 | +5V ANALOG |
| 4 | OFFSET ADJ. | 29 | ANALOG GND |
| 5 | RANGE REF. | 28 | +15V |
| 6 | $2.5 V$ REF. | 27 | +5V DIGITAL |
| 7 | START CONVERT | 26 | DIGITAL GND |
| 8 | EOC | 25 | OVERFLOW |
| 9 | ENABLE | 24 | MSB |
| 10 | BIT 14 (LSB) | 23 | BIT 1 (MSB) |
| 11 | BIT 13 | 22 | BIT 2 |
| 12 | BIT 12 | 21 | BIT 3 |
| 13 | BIT 11 | 20 | BIT 4 |
| 14 | BIT 10 | 19 | BIT 5 |
| 15 | BIT 9 | 18 | BIT 6 |
| 16 | BIT 8 | 17 | BIT 7 |

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


Figure 1. ADS-949 Functional Block Diagram

## ABSOLUTE MAXIMUM RATINGS

| PARAMETERS | LIMITS | UNITS |
| :--- | :---: | :---: |
| +5V Supply (Pins 27, 30) | 0 to +6 | Volts |
| +15V Supply (Pin 28) | 0 to +16 | Volts |
| -5V Supply (Pin 3) | 0 to -5.5 V | Volts |
| Digital Input (Pin 7) | -0.3 to + VDD +0.3 | Volts |
| Analog Input (Pins 1, 2) | $\pm 5$ | Volts |
| Lead Temperature (10 seconds) | +300 | ${ }^{\circ} \mathrm{C}$ |

PHYSICAL/ENVIRONMENTAL

| PARAMETERS | MIN. | TYP. | MAX. | UNITS |
| :---: | :---: | :---: | :---: | :---: |
| Operating Temp. Range, Case <br> ADS-949MC, GC <br> ADS-949MM, GM, <br> Thermal Impedance <br> 日jc <br> $\theta с$ <br> Storage Temperature Range |  |  |  |  |
|  | 0 | - | +70 | ${ }^{\circ} \mathrm{C}$ |
|  | -55 | - | +125 | ${ }^{\circ} \mathrm{C}$ |
|  |  |  |  |  |
|  | - | 6 | - | ${ }^{\circ} \mathrm{C} /$ Watt |
|  | - | 23 | - | ${ }^{\circ} \mathrm{C} /$ Watt |
|  | -65 | - | +150 | ${ }^{\circ} \mathrm{C}$ |
| Package Type Weight | 32-pin, metal-sealed, ceramic DDIP or SMT |  |  |  |

FUNCTIONAL SPECIFICATIONS
$\left(\mathrm{TA}=+25^{\circ} \mathrm{C},+\mathrm{VDD}=+5 \mathrm{~V},-\mathrm{VDD}=-5 \mathrm{~V},+\mathrm{VcC}=+15 \mathrm{~V}, 12.8 \mathrm{MHz}\right.$ sampling rate, $\pm 2.5 \mathrm{~V}$ input range, and a minimum 3 minute warmup (1) unless otherwise specified.)

| ANALOG INPUT | $+25^{\circ} \mathrm{C}$ |  |  | 0 to $+70^{\circ} \mathrm{C}$ |  |  | -55 to $+125^{\circ} \mathrm{C}$ |  |  | UNITS |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |  |
| Bipolar Input Voltage Range (2) | $\pm 1$ | - | $\pm 2.5$ | $\pm 1$ | - | $\pm 2.5$ | $\pm 1$ | - | $\pm 2.5$ | Volts |
| Unipolar Input Voltage Range (2) | 0 to 2 | - | 0 to 5 | 0 to 2 | - | 0 to 5 | 0 to 2 | - | 0 to 5 | Volts |
| Input Resistance (Vin A) | - | 400 | - | - | 400 | - | - | 400 | - | $\Omega$ |
| Input Capacitance | - | 6 | 15 | - | 6 | 15 | - | 6 | 15 | pF |
| DIGITAL INPUT |  |  |  |  |  |  |  |  |  |  |
| 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 | $\mu \mathrm{A}$ |
| Logic Loading "0" | - | - | -20 | - | - | -20 | - | - | -20 | $\mu \mathrm{A}$ |
| Start Convert Positive Pulse Width (3) | - | 50 | - | - | 50 | - | - | 50 | - | ns |
| STATIC PERFORMANCE |  |  |  |  |  |  |  |  |  |  |
| Resolution | - | 14 | - | - | 14 | - | - | 14 | - | Bits |
| Integral Nonlinearity | - | $\pm 0.75$ | - | - | $\pm 0.75$ | - | - | $\pm 1$ | - | LSB |
| Differential Nonlinearity (fin $=10 \mathrm{kHz}$ ) | -0.95 | $\pm 0.5$ | +1.25 | -0.95 | $\pm 0.5$ | +1.25 | -0.95 | $\pm 0.5$ | +1.5 | LSB |
| Full Scale Absolute Accuracy | - | $\pm 0.15$ | $\pm 0.4$ | - | $\pm 0.15$ | $\pm 0.4$ | - | $\pm 0.4$ | $\pm 0.8$ | \%FSR |
| Bipolar Zero Error (Tech Note 2) | - | $\pm 0.1$ | $\pm 0.3$ | - | $\pm 0.1$ | $\pm 0.3$ | - | $\pm 0.3$ | $\pm 0.6$ | \%FSR |
| Gain Error (Tech Note 2) | - | $\pm 0.2$ | $\pm 0.4$ | - | $\pm 0.2$ | $\pm 0.4$ | - | $\pm 0.4$ | $\pm 1.5$ | \% |
| No Missing Codes (fin = 10kHz) | 14 | - | - | 14 | - | - | 14 | - | - | Bits |
| DYNAMIC PERFORMANCE |  |  |  |  |  |  |  |  |  |  |
| Peak Harmonics (-0.5dB) |  |  |  |  |  |  |  |  |  |  |
| dc to 1 MHz | - | -83 | -76 | - | -83 | -75 | - | -79 | -71 | dB |
| 1 MHz to 2.5 MHz | - | -78 | -72 | - | -78 | -72 | - | -73 | -68 | dB |
| 2.5MHz to 5 MHz | - | -76 | -71 | - | -76 | -71 | - | -71 | -65 | dB |
| Total Harmonic Distortion ( -0.5 dB ) dc to 1 MHz | - | -81 | -74 | - | -81 | -74 | - | -77 | -70 | dB |
| 1 MHz to 2.5 MHz | - | -81 | -74 | - | -81 | -71 | - | -77 | -66 | dB |
| 2.5 MHz to 5 MHz | - | -74 | -69 | - | -74 | -69 | - | -69 | -63 | dB |
| Signal-to-Noise Ratio <br> (w/o distortion, -0.5 dB ) |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 1 MHz to 2.5 MHz | 72 | 77 | - | 72 | 77 | - | 70 | 77 | - | dB |
| 2.5 MHz to 5 MHz | 72 | 76 | - | 72 | 76 | - | 70 | 76 | - | dB |
| Signal-to-Noise Ratio(4) |  |  |  |  |  |  |  |  |  |  |
| dc to 1 MHz | 70 | 77 | - | 70 | 74 | - | 68 | 73 | - | dB |
| 1 MHz to 2.5 MHz | 70 | 74 | - | 70 | 74 | - | 66 | 71 | - | dB |
| 2.5MHz to 5MHz | 69 | 73 | - | 69 | 73 | - | 65 | 70 | - | dB |
| Noise | - | 150 | - | - | 150 | - | - | 150 | - | $\mu \mathrm{Vrms}$ |
| Two-tone Intermodulation |  |  |  |  |  |  |  |  |  |  |
| Distortion (fin $=2.45 \mathrm{MHz}$, |  |  |  |  |  |  |  |  |  |  |
| $\left.1.975 \mathrm{MHz}, \mathrm{fs}^{=} 10 \mathrm{MHz},-0.5 \mathrm{~dB}\right)$ | - | -82 | - | - | -82 | - | - | -82 | - | dB |
| Input Bandwidth ( -3 dB ) |  |  |  |  |  |  |  |  |  |  |
| Small Signal (-20dB input) | - | 30 | - | - | 30 | - | - | 30 | - | MHz |
| Large Signal ( -0.5 dB input) | - | 20 | - | - | 20 | - | - | 20 | - | MHz |
| Feedthrough Rejection ( $\mathrm{fin}=5 \mathrm{MHz}$ ) | - | 85 | - | - | 85 | - | - | 85 | - | dB |
| Slew Rate | - | $\pm 400$ | - | - | $\pm 400$ | - | - | $\pm 400$ | - | V/ $/ \mathrm{s}$ |
| Aperture Delay Time | - | +5 | - | - | +5 | - | - | +5 | - | ns |
| Aperture Uncertainty | - | 2 | - | - | 2 | - | - | 2 | - | ps rms |



## TECHNICAL NOTES

1. Obtaining fully specified performance from the ADS-949 requires careful attention to pc card layout and power supply decoupling. The device's analog and digital ground systems are connected to each other internally. For optimal performance, tie all ground pins (26 and 29) directly to a large analog ground plane beneath the package.
Bypass all power supplies to ground with $4.7 \mu \mathrm{~F}$ tantalum capacitors in parallel with $0.1 \mu \mathrm{~F}$ ceramic capacitors. Locate the bypass capacitors as close to the unit as possible.
2. The ADS-949 achieves its specified accuracies without the need for external calibration. It is recommended that the
+5 VA and +5 VD supplies should be powered up from the same source. If required, the device's small initial offset and gain errors can be reduced to zero using the adjustment circuitry shown in Figure 2,3.
When using this circuitry, or any similar offset and gain calibration hardware, make adjustments following warmup. To avoid interaction, always adjust offset before gain.
3. Applying a start convert pulse while a conversion is in progress $(\overline{\mathrm{EOC}}=\operatorname{logic} 1)$ will initiate a new and inaccurate conversion cycle. Data for the interrupted and subsequent conversions will be invalid.
4. A passive bandpass filter is used at the input of the $A / D$ for all production testing.

## CALIBRATION PROCEDURE

Any offset and/or gain calibration procedures should not be implemented until devices are fully warmed up. To avoid interaction, offset must be adjusted before gain. The ranges of adjustment for the circuits in Figures 2 and 3 are guaranteed to compensate for the ADS-949'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 can be accomplished by connecting LED's to the digital outputs and adjusting 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.

Offset adjusting for the ADS-949 is normally accomplished at the point where the MSB is a 1 and all other output bits are 0's and the LSB just changes from a 0 to a 1 . This digital output transition ideally occurs when the applied analog input is $+1 / 2$ LSB ( $+153 \mu \mathrm{~V}$ ).

Gain adjusting is accomplished when all bits are 1's and the LSB just changes from a 1 to a 0 . This transition ideally occurs when the analog input is at +full scale minus $11 / 2$ LSB's (+2.49954V)

## Zero/Offset Adjust Procedure

1. Apply a train of pulses to the START CONVERT input (pin 7) so the converter is continuously converting.
2. Apply $+153 \mu \mathrm{~V}$ to the ANALOG INPUT (pin 1 )
3. Adjust the offset potentiometer until the output bits are 10000000000000 and the LSB flickers between 0 and 1 .

## Gain Adjust Procedure

1. Apply +2.49954 V to the ANALOG INPUT (pin 1).
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 input signal to obtain the output coding listed in Table 2.

Table 1. Gain and Zero Adjust

| INPUT VOLTAGE <br> RANGE | ZERO ADJUST <br> +1⁄2 $\mathbf{L S B}$ | GAIN ADJUST <br> +FS $\mathbf{- 1} 1 / 2$ LSB |
| :---: | :---: | :---: |
| $\pm 2.5 \mathrm{~V}$ | $+153 \mu \mathrm{~V}$ | +2.49954 V |



Figure 2. Typical ADS-949 Bipolar Connection Diagram

## THERMAL REQUIREMENTS

All DATEL sampling A/D converters are fully characterized and specified over operating temperature (case) ranges of 0 to $+70^{\circ} \mathrm{C}$ and -55 to $+125^{\circ} \mathrm{C}$. All room temperature ( $\mathrm{T}_{\mathrm{A}}=+25^{\circ} \mathrm{C}$ ) 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.

In more severe ambient conditions, the package/junction temperature of a given device can be reduced dramatically (typically $35 \%$ ) by using one of DATEL's HS Series heat sinks. See Ordering Information for the assigned part number. See page 1-183 of the DATEL Data Acquisition Components Catalog for more information on the HS Series. Request DATEL Application Note AN8, "Heat Sinks for DIP Data Converters", or contact DATEL directly, for additional information.

Table 3. Output Coding

| STRAIGHT BIN. |  |  |  | INPUT VOLT. $\pm 2.5 \mathrm{~V}$ | BIPOLAR SCALE |
| :---: | :---: | :---: | :---: | :---: | :---: |
| UNIPOLAR SCALE | $\begin{aligned} & \text { INPUT VOLT. } \\ & 0 \mathrm{TO}+5 \mathrm{~V} \end{aligned}$ | MSB LSB | OUTPUT CODING MSB LSB |  |  |
| +FS - 1 LSB | +4.999695 | 11111111111111 | 01111111111111 | +2.499695 | +FS - 1LSB |
| +7/8 FS | +4.375000 | 11100000000000 | 01100000000000 | +1.875000 | +3/4FS |
| +3/4 FS | +3.75000 | 11000000000000 | 01000000000000 | +1.250000 | +1/2FS |
| +1/2 FS | +2.500000 | 10000000000000 | 00000000000000 | 0.000000 | 0 |
| +1/4 FS | +1.250000 | 01000000000000 | 11000000000000 | -1.250000 | -1/2FS |
| +1/8 FS | +0.625000 | 00100000000000 | 10100000000000 | -1.875000 | -3/4FS |
| +1 LSB | +0.000305 | 00000000000001 | 10000000000001 | -2.499695 | FS+1LSB |
| 0 | 0.000000 | 00000000000000 | 10000000000000 | -2.500000 | -FS |
|  |  | OFF. BINARY | TWO'S COMP. |  |  |


(1) Bypass Pins 5, 6, 32 with a $4.7 \mu \mathrm{~F}$ to Analog Ground.

Note: The Voltage Value at Pin 32 (Range) sets the input voltage range of the ADS-949
eg: If Pin 6 (2.5V Reference Out) is tied to the Range Pin 32 (20k Pot is shorted), then the input range of the ADS-949 becomes 0 to 5 V
If the 20 k Pot is set at midrange then the input range of the ADS-949 becomes 0 to 2.5 V

Figure 3. Typical ADS-949 Unipolar Connection Diagram


Figure 5. FFT Analysis of ADS-949
$(f \mathrm{fs}=12.8 \mathrm{MHz}$, fin $=3.85 \mathrm{MHz}, \operatorname{Vin}=-0.5 \mathrm{~dB}, 16,384$ point FFT $)$


Figure 6. ADS-949 Histogram


Note: 1 . Scale is approximately 10 ns per division. All values are Typical.
Figure 7. ADS-949 Timing Diagram

## MECHANICAL DIMENSIONS

INCHES（mm）


ORDERING INFORMATION

|  | OPERATING | 32－PIN |  |
| :--- | :---: | :---: | :--- |
| MODEL | TEMP．RANGE | PACKAGE | ACCESSORIES |
| ADS－949MC | 0 to $+70^{\circ} \mathrm{C}$ | DDIP | ADS－B949 Evaluation Board（without ADS－949） |
| ADS－949MM | -55 to $+125^{\circ} \mathrm{C}$ | DDIP |  |
| ADS－949／883 | -55 to $+125^{\circ} \mathrm{C}$ | DDIP |  |
| ADS－949GC | 0 to $+70^{\circ} \mathrm{C}$ | SMT |  |
| ADS－949GM | -55 to $+125^{\circ} \mathrm{C}$ | SMT |  |

Receptacles for PC board mounting can be ordered through AMP，Inc．，Part \＃3－331272－8（Component Lead Socket）， 32 required．For MIL－STD－883 product specifcation，contact DATEL．
ISO 9001

REGISTERED DS－0434A

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