

FEATURES

- 35 MSPS Encode Rate
- 16 pF Input Capacitance
- 550 mW Power Dissipation
- Industry-Standard Pinouts
- MIL-STD-883 Compliant Versions Available

APPLICATIONS

- Professional Video Systems
- Special Effects Generators
- Electro-Optics
- Digital Radio
- Electronic Warfare (ECM, ECCM, ESM)

GENERAL DESCRIPTION

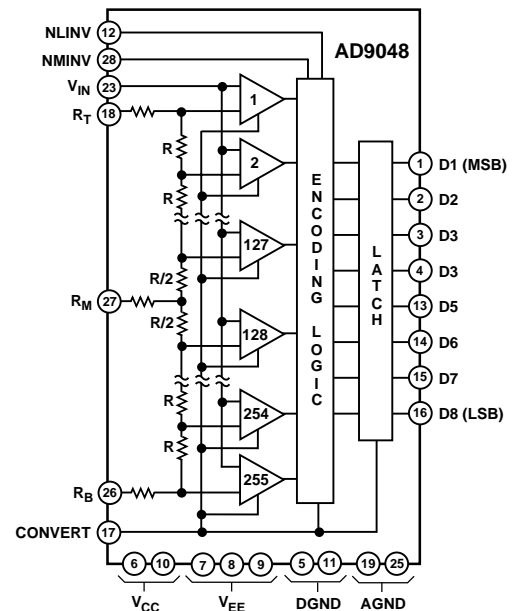
The AD9048 is an 8-bit, 35 MSPS flash converter, made on a high speed bipolar process, which is an alternate source for the TDC1048 unit, offers enhancements over its predecessor. Lower power dissipation makes the AD9048 attractive for a variety of system designs.

Because of its wide bandwidth, it is an ideal choice for real-time conversion of video signals. Input bandwidth is flat with no missing codes.

Clocked latching comparators, encoding logic and output buffer registers operating at minimum rates of 35 MSPS preclude a need for a sample-and-hold (S/H) or track-and-hold (T/H) in most system designs using the AD9048. All digital control inputs and outputs are TTL compatible.

Devices operating over two ambient temperature ranges and with two grades of linearity are available. Linearities of either 0.5 LSB or 0.75 LSB can be ordered for a commercial range of 0°C to +70°C or extended case temperatures of -55°C to +125°C.

FUNCTIONAL BLOCK DIAGRAM



Commercial versions are packaged in 28-lead DIPs; extended temperature versions are available in ceramic DIP and ceramic LCC packages. Both commercial units and MIL-STD-883 units are standard products.

The AD9048 A/D converter is available in versions compliant with MIL-STD-883. Refer to the Analog Devices *Military Products Databook* or current AD9048/883B data sheet for detailed specifications.

REV. C

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AD9048—SPECIFICATIONS (typical with nominal supplies unless otherwise noted)

ABSOLUTE MAXIMUM RATINGS¹

| | |
|--|-------------------------------------|
| V _{CC} to DGND | −0.5 V dc to +7.0 V dc |
| AGND to DGND | −0.5 V dc to +0.5 V dc |
| V _{EE} to AGND | +0.5 V dc to −7.0 V dc |
| V _{IN} , V _{RT} or V _{RB} to AGND | +0.5 V to V _{EE} |
| V _{RT} to V _{RB} | −2.2 V dc to +2.2 V dc |
| CONV, NMINV or NLINV to DGND | −0.5 V dc to +5.5 V dc |
| Applied Output Voltage to DGND | −0.5 V dc to +5.5 V dc ² |
| Applied Output Current, Externally Forced | −1.0 mA to +6.0 mA ^{3,4} |

| | |
|---|----------------------|
| Output Short-Circuit Duration | 1.0 sec ⁵ |
| Operating Temperature Range (Ambient) | |
| AD9048JJ/KJ/JQ/KQ | 0°C to +70°C |
| AD9048SE/SQ/TE/TQ | −55°C to +125°C |
| Maximum Junction Temperature (Plastic) | +150°C ⁶ |
| Maximum Junction Temperature (Hermetic) | +175°C ⁶ |
| Lead Temperature (Soldering, 10 sec) | +300°C |
| Storage Temperature Range | −65°C to +150°C |

ELECTRICAL CHARACTERISTICS (V_{CC} = +5.0 V; V_{EE} = −5.2 V; Differential Reference Voltage = 2.0 V, unless otherwise noted)

| Parameter (Conditions) | Temp | Test Level | AD9048JJ/JQ | | | AD9048KJ/KQ | | | AD9048SE/SQ | | | AD9048TE/TQ | | | Units |
|---|-------|------------|-------------|-----|-----|-------------|-----|-----|-------------|-----|-----|-------------|-----|-----|-------|
| | | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| RESOLUTION | | | 8 | | | 8 | | | 8 | | | 8 | | | Bits |
| DC ACCURACY | | | | | | | | | | | | | | | |
| Differential Nonlinearity | +25°C | I | 0.4 0.75 | | | 0.3 0.5 | | | 0.4 0.75 | | | 0.3 0.5 | | | LSB |
| | Full | VI | 1.0 | | | 0.75 | | | 1.0 | | | 0.75 | | | LSB |
| Integral Nonlinearity | +25°C | I | 0.6 0.75 | | | 0.4 0.5 | | | 0.6 0.75 | | | 0.4 0.5 | | | LSB |
| | Full | VI | 1.0 | | | 0.75 | | | 1.0 | | | 0.75 | | | LSB |
| No Missing Codes | Full | VI | GUARANTEED | | | GUARANTEED | | | GUARANTEED | | | GUARANTEED | | | |
| INITIAL OFFSET ERROR | | | | | | | | | | | | | | | |
| Top of Reference Ladder | +25°C | I | 5 12 | | | 5 12 | | | 5 12 | | | 5 12 | | | mV |
| | Full | VI | 12 | | | 12 | | | 12 | | | 12 | | | mV |
| Bottom of Reference Ladder | +25°C | I | 4 8 | | | 4 8 | | | 4 8 | | | 4 8 | | | mV |
| | Full | VI | 8 | | | 8 | | | 8 | | | 8 | | | mV |
| Offset Drift Coefficient | Full | V | 20 | | | 20 | | | 20 | | | 20 | | | μV/°C |
| ANALOG INPUT | | | | | | | | | | | | | | | |
| Input Voltage Range | Full | V | −2.1; +0.1 | | | −2.1; +0.1 | | | −2.1; +0.1 | | | −2.1; +0.1 | | | V |
| Input Bias Current ⁷ | +25°C | I | 36 60 | | | 36 60 | | | 36 60 | | | 36 60 | | | μA |
| | Full | VI | 100 | | | 100 | | | 100 | | | 100 | | | μA |
| Input Resistance | +25°C | I | 200 300 | | | 200 300 | | | 200 300 | | | 200 300 | | | kΩ |
| | Full | VI | 40 | | | 40 | | | 40 | | | 40 | | | kΩ |
| Input Capacitance | +25°C | IV | 16 20 | | | 16 20 | | | 16 20 | | | 16 20 | | | pF |
| Full Power Bandwidth ⁸ | +25°C | IV | 10 15 | | | 10 15 | | | 10 15 | | | 10 15 | | | MHz |
| REFERENCE INPUT | | | | | | | | | | | | | | | |
| Positive Reference Voltage ⁹ | Full | V | 0.0 | | | 0.0 | | | 0.0 | | | 0.0 | | | V |
| Negative Reference Voltage ⁹ | Full | V | −2.0 | | | −2.0 | | | −2.0 | | | −2.0 | | | V |
| Differential Reference Voltage | Full | V | 2.0 | | | 2.0 | | | 2.0 | | | 2.0 | | | V |
| Reference Ladder Resistance | Full | VI | 30 60 125 | | | 30 60 125 | | | 30 60 125 | | | 30 60 125 | | | Ω |
| Ladder Temperature Coefficient | Full | V | 0.22 | | | 0.22 | | | 0.22 | | | 0.22 | | | Ω/°C |
| Reference Ladder Current | Full | VI | 23 40 | | | 23 40 | | | 23 40 | | | 23 40 | | | mA |
| Reference Input Bandwidth | +25°C | V | 10 | | | 10 | | | 10 | | | 10 | | | MHz |
| DYNAMIC PERFORMANCE ¹⁰ | | | | | | | | | | | | | | | |
| Conversion Rate | +25°C | I | 35 38 | | | 35 38 | | | 35 38 | | | 35 38 | | | MHz |
| Aperture Delay | +25°C | IV | 2.4 5 | | | 2.4 5 | | | 2.4 5 | | | 2.4 5 | | | ns |
| Aperture Uncertainty (Jitter) | +25°C | IV | 25 50 | | | 25 50 | | | 25 50 | | | 25 50 | | | ps |
| Output Delay (t _{PD}) | +25°C | I | 13 15 | | | 9 15 | | | 9 15 | | | 9 15 | | | ns |
| Output Hold Time (t _{OH}) ¹¹ | +25°C | I | 5 8 | | | 5 8 | | | 5 8 | | | 5 8 | | | ns |
| Transient Response ¹² | +25°C | IV | 6 20 | | | 6 20 | | | 6 20 | | | 6 20 | | | ns |
| Overshoot Recovery Time ¹³ | +25°C | V | 8 | | | 8 | | | 8 | | | 8 | | | ns |
| Rise Time | +25°C | I | 9 | | | 9 | | | 9 | | | 9 | | | ns |
| Fall Time | +25°C | I | 14 | | | 14 | | | 14 | | | 14 | | | ns |
| Output Time Skew ¹⁴ | +25°C | I | 4.5 7 | | | 4.5 7 | | | 4.5 7 | | | 4.5 7 | | | ns |
| NMINV and NLINV INPUTS | | | | | | | | | | | | | | | |
| +0.4 V Input Current | Full | VI | 200 | | | 200 | | | 200 | | | 200 | | | μA |
| +2.4 V Input Current | Full | VI | 150 | | | 150 | | | 150 | | | 150 | | | μA |
| +5.5 V Input Current | Full | VI | 150 | | | 150 | | | 150 | | | 150 | | | μA |
| CONVERT INPUT | | | | | | | | | | | | | | | |
| Logic “1” Voltage | Full | VI | 2.0 | | | 2.0 | | | 2.0 | | | 2.0 | | | V |
| Logic “0” Voltage | Full | VI | 0.8 | | | 0.8 | | | 0.8 | | | 0.8 | | | V |
| Logic “1” Current | Full | VI | 150 | | | 150 | | | 150 | | | 150 | | | μA |
| Logic “0” Current | Full | VI | 500 | | | 500 | | | 500 | | | 500 | | | μA |
| Input Capacitance | +25°C | IV | 4 6 | | | 4 6 | | | 4 6 | | | 4 6 | | | pF |
| Convert Pulsewidth (LOW) | +25°C | I | 18 | | | 18 | | | 18 | | | 18 | | | ns |
| Convert Pulsewidth (HIGH) | +25°C | I | 10 | | | 10 | | | 10 | | | 10 | | | ns |

| Parameter (Conditions) | Temp | Test Level | AD9048JJ/JQ | | | AD9048KJ/KQ | | | AD9048SE/SQ | | | AD9048TE/TQ | | | Units |
|---|-------|------------|-------------|------|-----|-------------|------|-----|-------------|------|-----|-------------|------|-----|--------|
| | | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| AC LINEARITY | | | | | | | | | | | | | | | |
| In-Band Harmonics | | | | | | | | | | | | | | | |
| dc to 2.438 MHz ¹⁵ | +25°C | I | 47 | 50 | | 49 | 55 | | 47 | 50 | | 49 | 55 | | dBc |
| dc to 9.35 MHz ¹⁶ | +25°C | V | | 48 | | | 48 | | | 48 | | | 48 | | dBc |
| Signal-to-Noise Ratio (SNR) ¹⁵ | | | | | | | | | | | | | | | |
| 1.248 MHz Input Frequency ¹⁷ | +25°C | I | 43.5 | 44 | | 45 | 46 | | 43.5 | 44 | | 45 | 46 | | dB |
| 2.438 MHz Input Frequency ¹⁷ | +25°C | I | 43 | 44 | | 44 | 46 | | 43 | 44 | | 44 | 46 | | dB |
| 1.248 MHz Input Frequency ¹⁸ | +25°C | I | 52.5 | 53 | | 54 | 55 | | 52.5 | 53 | | 54 | 55 | | dB |
| 2.438 MHz Input Frequency ¹⁸ | +25°C | I | 52 | 53 | | 53 | 55 | | 52 | 53 | | 53 | 55 | | dB |
| Signal-to-Noise Ratio (SNR) ¹⁶ | | | | | | | | | | | | | | | |
| 1.248 MHz Input Frequency ¹⁷ | +25°C | I | 43.5 | 44 | | 45 | 46 | | 43.5 | 44 | | 45 | 46 | | dB |
| 9.35 MHz Input Frequency ¹⁷ | +25°C | V | | 40.5 | | | 40.5 | | | 40.5 | | | 40.5 | | dB |
| Noise Power Ratio (NPR) ¹⁹ | +25°C | IV | 36.5 | 39 | | 36.5 | 39 | | 36.5 | 39 | | 36.5 | 39 | | dB |
| Differential Phase ²⁰ | +25°C | IV | | | 1 | | | 1 | | | 1 | | | 1 | Degree |
| Differential Gain ²⁰ | +25°C | IV | | | 2 | | | 2 | | | 2 | | | 2 | % |
| DIGITAL OUTPUTS | | | | | | | | | | | | | | | |
| Logic "1" Voltage | Full | VI | 2.4 | | | 2.4 | | | 2.4 | | | 2.4 | | | V |
| Logic "0" Voltage | Full | VI | | 0.5 | | | 0.5 | | | 0.5 | | | 0.5 | | V |
| Short Circuit Current ⁵ | Full | VI | | 30 | | | 30 | | | 30 | | | 30 | | mA |
| POWER SUPPLY | | | | | | | | | | | | | | | |
| Positive Supply Current | +25°C | I | | 34 | 56 | | 34 | 56 | | 34 | 56 | | 34 | 56 | mA |
| | Full | VI | | | 58 | | | 58 | | | 58 | | | 58 | mA |
| Negative Supply Current | +25°C | I | | 90 | 110 | | 90 | 110 | | 90 | 110 | | 90 | 110 | mA |
| | Full | VI | | | 120 | | | 120 | | | 120 | | | 120 | mA |
| Nominal Power Dissipation | +25°C | V | | 550 | | | 550 | | | 550 | | | 550 | | mW |
| Reference Ladder Dissipation | +25°C | V | | 45 | | | 45 | | | 45 | | | 45 | | mW |

NOTES

¹Maximum ratings are limiting values to be applied individually, and beyond which the serviceability of the device may be impaired. Functional operation under any of these conditions is not necessarily implied. Exposure to absolute maximum rating conditions for extended periods of time may affect device reliability.

²Applied voltage must be current-limited to specified range.

³Forcing voltage must be limited to specified range.

⁴Current is specified as negative when flowing into the device.

⁵Output High; one pin to ground; one second duration.

⁶Typical thermal impedances (no air flow) are as follows:

Ceramic DIP: $\theta_{JA} = 49^{\circ}\text{C}/\text{W}$; $\theta_{JC} = 15^{\circ}\text{C}/\text{W}$ LCC: $\theta_{JA} = 69^{\circ}\text{C}/\text{W}$; $\theta_{JC} = 21^{\circ}\text{C}/\text{W}$

JLCC: $\theta_{JA} = 59^{\circ}\text{C}/\text{W}$; $\theta_{JC} = 19^{\circ}\text{C}/\text{W}$

To calculate junction temperature (T_J), use power dissipation (PD) and thermal impedance: $T_J = \text{PD} (\theta_{JA}) + T_{\text{AMBIENT}} = \text{PD} (\theta_{JC}) + T_{\text{CASE}}$.

⁷Measured with $V_{\text{IN}} = 0$ V and CONVERT low (sampling mode).

⁸Determined by beat frequency testing for no missing codes.

⁹ $V_{\text{RT}} \geq V_{\text{RB}}$ under all circumstances.

¹⁰Outputs terminated with 40 pF and eight 10 Ω pull-up resistors.

¹¹Interval from 50% point of leading edge CONVERT pulse to change in output data.

¹²For full-scale step input, 8-bit accuracy attained in specified time.

¹³Recovers to 8-bit accuracy in specified time after -3 V input overvoltage.

¹⁴Output time skew includes high-to-low and low-to-high transitions as well as bit-to-bit time skew differences.

¹⁵Measured at 20 MHz encode rate with analog input 1 dB below full scale.

¹⁶Measured at 35 MHz encode rate with analog input 1 dB below full scale.

¹⁷RMS signal to rms noise.

¹⁸Peak signal to rms noise.

¹⁹DC to 8 MHz noise bandwidth with 1.248 MHz slot; four sigma loading; 20 MHz encode.

²⁰Clock frequency = $4 \times \text{NTSC} = 14.32$ MHz. Measured with 40-IRE modulated ramp.

Specifications subject to change without notice.

EXPLANATION OF TEST LEVELS

Test Level I – 100% production tested.

Test Level II – 100% production tested at +25°C and sample tested at specific temperatures.

Test Level III – Sample tested only.

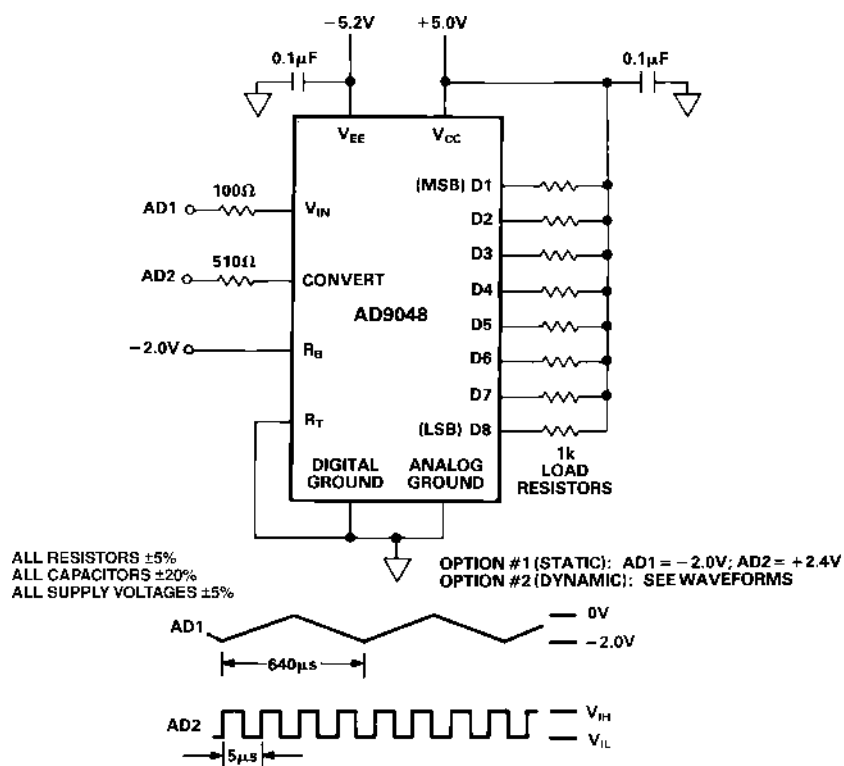
Test Level IV – Parameter is guaranteed by design and characterization testing.

Test Level V – Parameter is a typical value only.

Test Level VI – All devices are 100% production tested at +25°C. 100% production tested at temperature extremes for military temperature devices; sample tested at temperature extremes for commercial/industrial devices.

PIN FUNCTION DESCRIPTIONS

| Pin | Description | Pin | Description |
|-----------------|---|-----------------|--|
| D1–D8 | Eight digital outputs. D1 (MSB) is the most significant bit of the digital output word; D8 (LSB) is the least significant bit. | R _B | Most negative reference voltage for internal reference ladder. |
| AGND | One of two analog ground returns. Both grounds should be connected together and to low impedance ground plane near the AD9048. | R _M | Midpoint tap on internal reference ladder. |
| DGND | One of two digital ground returns. Both grounds should be connected together and to low impedance ground plane near the AD9048. | R _T | Most positive reference voltage for internal reference ladder. |
| V _{CC} | Positive supply terminals; nominally +5.0 V. | V _{IN} | Analog input signal pin. |
| V _{EE} | Negative supply terminals; nominally –5.2 V. | NMINV | “Not Most Significant Bit Invert.” In normal operation, this pin floats high; logic LOW at NMINV inverts most significant bit of digital output word [D1 (MSB)]. |
| CONVERT | Input for conversion signal; sample of analog input signal taken on rising edge of this pulse. | NLINV | “Not Least Significant Bit Invert.” In normal operation, this pin floats high; logic LOW at NLINV inverts the seven least significant bits of the digital output word. |



Burn-In Diagram

AD9048

THEORY OF OPERATION

Refer to the Functional Block Diagram of the AD9048. The AD9048 comprises three functional sections: a comparator array, encoding logic and output latches.

Within the array, the analog input signal to be digitized is compared with 255 reference voltages. The outputs of all comparators whose references are below the input signal level will be high; outputs whose references are above that level will be low.

The n-of-255 code that results from this comparison is applied to the encoding logic where it is converted into binary coding. When it is inverted with dc signals applied to the NLINV and/or NMINV pins, it becomes twos complement.

After encoding, the signal is applied to the output latch circuits where it is held constant between updates controlled by the application of CONVERT pulses.

The AD9048 uses strobed latching comparators in which comparator outputs are either high or low, as dictated by the analog input level. Data appearing at the output pins have a pipeline delay of one encode cycle.

Input signal levels between the references applied to R_T (Pin 18) and R_B (Pin 26) will appear at the output as binary numbers between 0 and 255, inclusive. Signals outside that range will show up as either full-scale positive or full-scale negative outputs. No damage will occur to the AD9048 as long as the input is within the voltage range of V_{EE} to +0.5 V.

The significantly reduced input capacitance of the AD9048 lowers the drive requirements of the input buffer/amplifier and also induces much smaller phase shift in the analog input signal.

Applications that depend on controlled phase shift at the converter input can benefit from using the AD9048 because of its inherently lower phase shift.

The CONVERT, analog input and digital output circuits are shown in Figure 1.

System timing, which provides details on delays through the AD9048 as well as the relationships of various timing events, is shown in Figure 2.

Dynamic performance of the AD9048, i.e., typical signal-to-noise ratio, is illustrated in Figures 3 and 4.

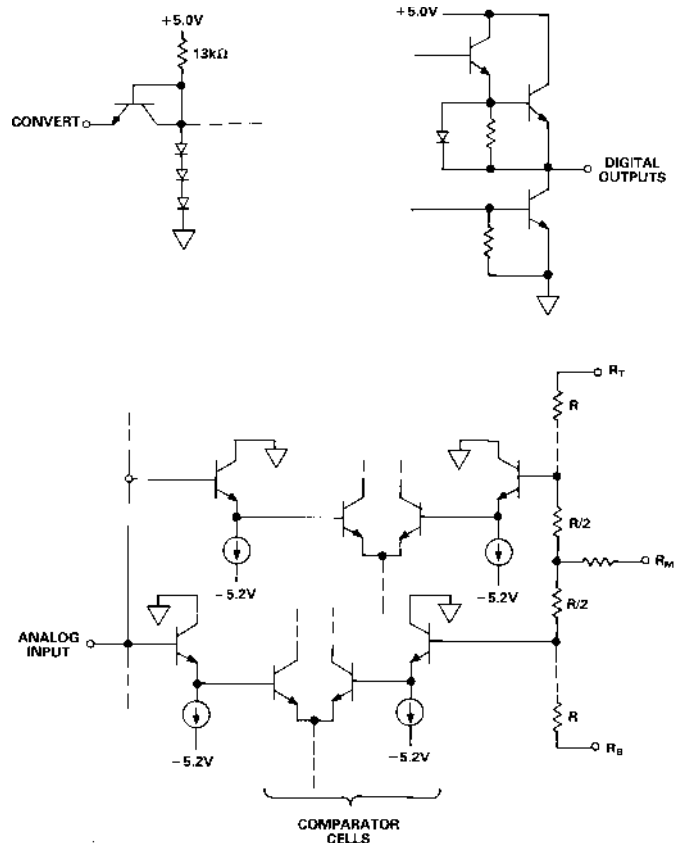


Figure 1. Input/Output Circuits

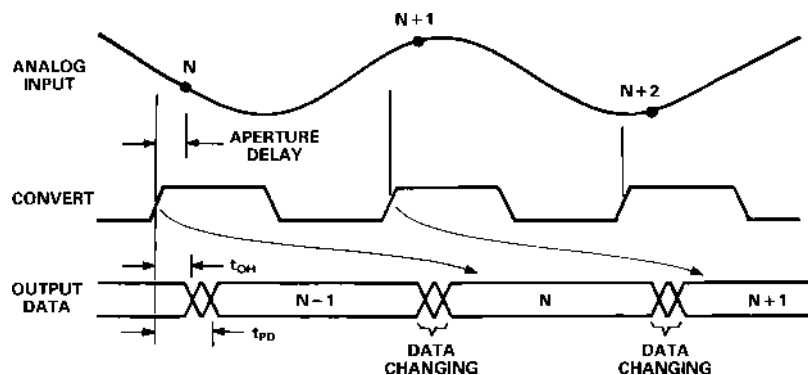


Figure 2. Timing Diagram

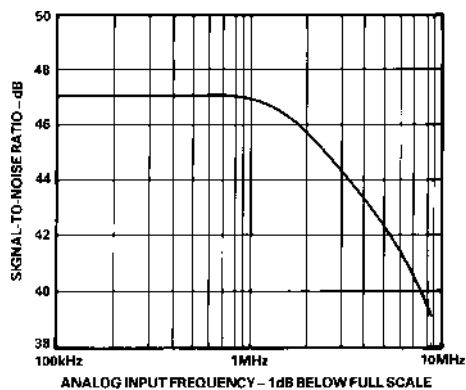


Figure 3. Dynamic Performance (20 MHz Encode Rate)

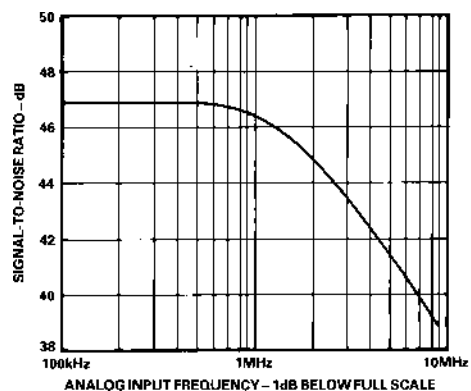


Figure 4. Dynamic Performance (35 MHz Encode Rate)

LAYOUT SUGGESTIONS

Designs that use the AD9048 or any other high speed device must follow some basic layout rules to ensure optimum performance.

The first requirement is to have a large, low impedance ground plane under and around the converter. If the system uses separate analog and digital grounds, both should be solidly connected together, and to the ground plane, as closely to the AD9048 as practical to avoid ground loop currents.

Ceramic 0.1 μF decoupling capacitors should be placed as closely as possible to the supply pins of the AD9048. For decoupling low frequency signals, use 10 μF tantalum capacitors, also connected as closely as practical to voltage supply pins.

Within the AD9048, reference currents may vary because of coupling between the clock and input signals. As a result, it is important that the ends of the reference ladder, R_T (Pin 18) and R_B (Pin 28), be connected to low impedances (as measured from ground).

If the AD9048 is being used in a circuit in which the reference is not varied, a bypass capacitor to ground is strongly recommended. In applications that use varying references, they must be driven from a low impedance source.

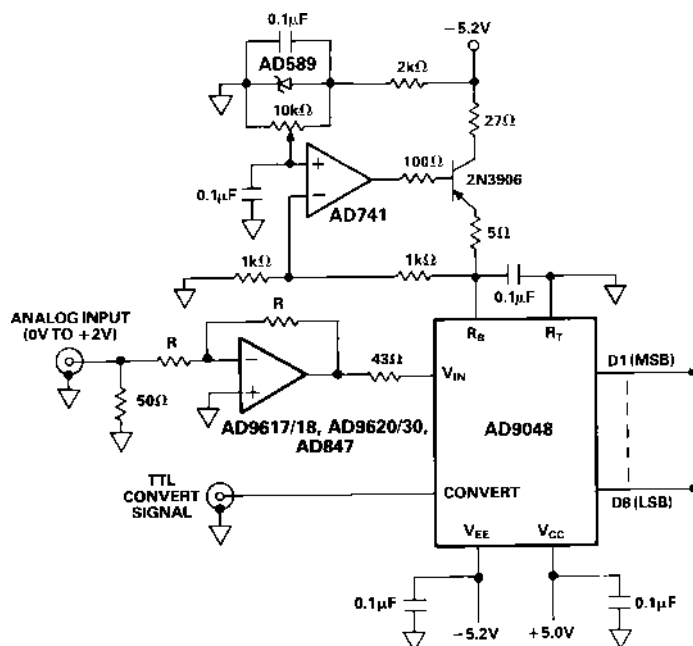


Figure 5. Typical Connections

Table I. Truth Table

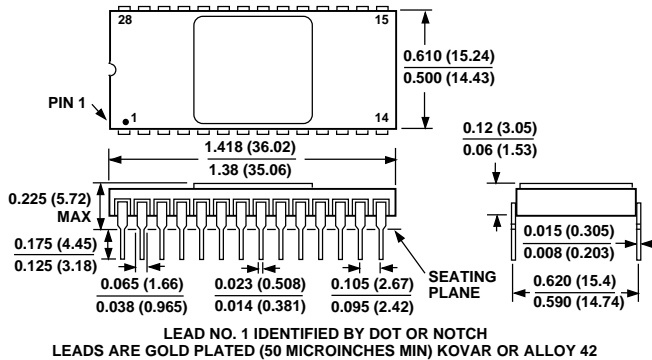
| Step | Range | | Binary | | Offset Twos Complement | |
|------|----------------|---------------|-----------|----------|------------------------|----------|
| | | | True | Inverted | True | Inverted |
| 000 | -2.000 V FS | -2.0480 V FS | NMINV = 1 | 0 | 0 | 1 |
| | 7.8431 mV Step | 8.000 mV Step | NLINV = 1 | 0 | 1 | 0 |
| 001 | 0.0000 V | 0.0000 V | 00000000 | 11111111 | 10000000 | 01111111 |
| 001 | -0.0078 V | -0.0080 V | 00000001 | 11111110 | 10000001 | 01111110 |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| 127 | -0.9961 V | -1.0160 V | 01111111 | 10000000 | 11111111 | 00000000 |
| 128 | -1.0039 V | -1.0240 V | 10000000 | 01111111 | 00000000 | 11111111 |
| 129 | -1.0118 V | -1.0320 V | 10000001 | 01111110 | 00000001 | 11111110 |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| . | . | . | . | . | . | . |
| 254 | -1.9921 V | -2.0320 V | 11111110 | 00000001 | 01111110 | 10000001 |
| 255 | -2.0000 V | -2.0400 V | 11111111 | 00000000 | 01111111 | 10000000 |

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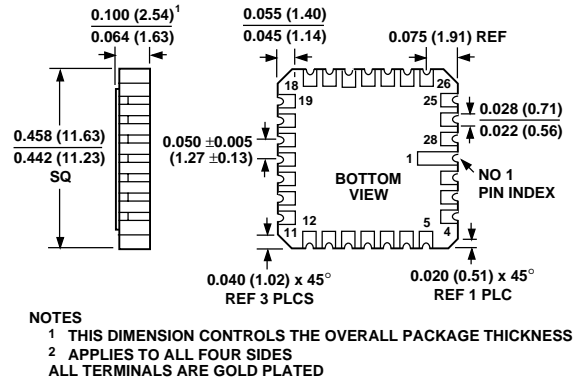
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

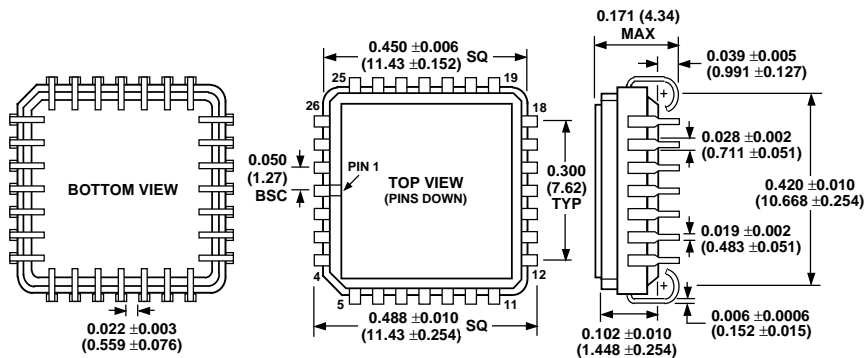
28-Lead Ceramic Side-Brazed DIP



28-Terminal Leadless Chip Carrier



28-Lead J-Lead Package



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