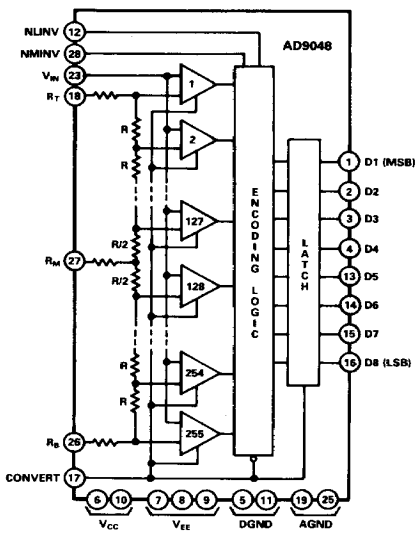
Monolithic 8-Bit Video A/D Converter

AD9048

FEATURES
35MSPS Encode Rate
16pF Input Capacitance
550mW 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)

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The AD9048 is an 8-bit, 35MSPS flash converter, made on a high speed bipolar process, which is an alternate source for the TDC1048 unit but 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 35MSPS 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 0.5LSB or 0.75LSB can be ordered for a commercial range of 0 to +70°C, or extended case temperatures of −55°C to +125°C. Commercial versions are packaged in 28-pin 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.

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

ABSOLUTE MAXIMUM RATINGS[1]

V_{CC} to DGND . . . . . −0.5V dc to +7.0V dc
AGND to DGND . . . . . −0.5V dc to +0.5V dc
V_{EE} to AGND . . . . . +0.5V dc to −7.0V dc
V_{IN}, V_{RT} or V_{RB} to AGND . . . . . +0.5V to V_{EE}
V_{RT} to V_{RB} . . . . . −2.2V dc to +2.2V dc
CONV, NMINV or NLINV to DGND . −0.5V dc to +5.5V dc
Applied Output Voltage to DGND . −0.5V dc to +5.5V dc[2]
Applied Output Current, Externally Forced
. . . . . −1.0mA to +6.0mA[3, 4]
Output Short-Circuit Duration . . . . . 1.0sec[5]
Operating Temperature Range (Ambient)
AD9048JN/KN/JJ/KJ/JQ/KQ . . . . . 0 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, 10sec) . . . . . +300°C
Storage Temperature Range . . . . . −65°C to +150°C

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

Parameter (Conditions)	Temp	Test Level	AD9048JN/JJ/JQ Min	AD9048JN/JJ/JQ Typ	AD9048JN/JJ/JQ Max	AD9048KN/KJ/KQ Min	AD9048KN/KJ/KQ Typ	AD9048KN/KJ/KQ Max	AD9048SE/SQ Min	AD9048SE/SQ Typ	AD9048SE/SQ Max	AD9048TE/TQ Min	AD9048TE/TQ Typ	AD9048TE/TQ Max	Units
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, 8, 9]	+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	III		16	20		16	20		16	20		16	20	pF
Full Power Bandwidth[10]	+25°C	III	10	15		10	15		10	15		10	15		MHz
REFERENCE INPUT															
Positive Reference Voltage[11]	Full	V		0.0			0.0			0.0			0.0		V
Negative Reference Voltage[11]	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	50	90	125	50	90	125	50	90	125	50	90	125	Ω
Ladder Temperature Coefficient	Full	V		0.22			0.22			0.22			0.22		Ω/°C
Reference Ladder Current[12]	Full	VI		23	40		23	40		23	40		23	40	mA
Reference Input Bandwidth	+25°C	V		10			10			10			10		MHz
DYNAMIC PERFORMANCE[13]															
Conversion Rate[12, 14]	+25°C	I	35	38		35	38		35	38		35	38		MHz
Aperture Delay	+25°C	III		2.4	5		2.4	5		2.4	5		2.4	5	ns
Aperture Uncertainty (Jitter)	+25°C	III		25	50		25	50		25	50		25	50	ps
Output Delay (t_{PD})[8, 12]	+25°C	I		13	15		9	15		9	15		9	15	ns
Output Hold Time (t_{OH})[15]	+25°C	I	5	8		5	8		5	8		5	8		ns
Transient Response[16]	+25°C	I		6	20		6	20		6	20		6	20	ns
Overvoltage Recovery Time[17]	+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[18]	+25°C	I		4.5	7		4.5	7		4.5	7		4.5	7	ns
NMINV and NLINV INPUTS[8, 12]															
+0.4V Input Current	Full	VI			200			200			200			200	μA
+2.4V Input Current	Full	VI			10			10			10			10	μA
+5.5V Input Current	Full	VI			10			10			10			10	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 (V_I = +2.4V)[8, 12]	Full	VI			15			15			15			15	μA
Logic "1" Current (V_I = +5.5V)[8, 12]	Full	VI			15			15			15			15	μA
Logic "0" Current[8, 12]	Full	VI			500			500			500			500	μA
Input Capacitance	+25°C	III		4	6		4	6		4	6		4	6	pF
Convert Pulse Width (LOW)	+25°C	I	18			18			18			18			ns
Convert Pulse Width (HIGH)	+25°C	I	10			10			10			10			ns

Parameter (Conditions)	Temp	Test Level	AD9048JN/JJ/JQ Min	AD9048JN/JJ/JQ Typ	AD9048JN/JJ/JQ Max	AD9048KN/KJ/KQ Min	AD9048KN/KJ/KQ Typ	AD9048KN/KJ/KQ Max	AD9048SE/SQ Min	AD9048SE/SQ Typ	AD9048SE/SQ Max	AD9048TE/TQ Min	AD9048TE/TQ Typ	AD9048TE/TQ Max	Units
AC LINEARITY															
In-Band Harmonics															
dc to 2.438MHz[19]	+25°C	I	47	50		49	55		47	50		49	55		dBc
dc to 9.35MHz[20]	+25°C	V		48			48			48			48		dBc
Signal-to-Noise Ratio (SNR)[19]															
1.248MHz Input Frequency[21]	+25°C	I	43.5	44		45	46		43.5	44		45	46		dB
2.438MHz Input Frequency[21]	+25°C	I	43	44		44	46		43	44		44	46		dB
1.248MHz Input Frequency[22]	+25°C	I	52.5	53		54	55		52.5	53		54	55		dB
2.438MHz Input Frequency[22]	+25°C	I	52	53		53	55		52	53		53	55		dB
Signal-to-Noise Ratio (SNR)[20]															
1.248MHz Input Frequency[21]	+25°C	I	43.5	44		45	46		43.5	44		45	46		dB
9.35MHz Input Frequency[21]	+25°C	V		40.5			40.5			40.5			40.5		dB
Noise Power Ratio (NPR)[23]	+25°C	III	36.5	39		36.5	39		36.5	39		36.5	39		dB
Differential Phase[24]	+25°C	III			1			1			1			1	Degree
Differential Gain[24]	+25°C	III			2			2			2			2	%
DIGITAL OUTPUTS															
Logic "1" Voltage[14]	Full	VI	2.4			2.4			2.4			2.4			V
Logic "0" Voltage[9, 14]	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 (+5.5V)	+25°C	I		34	46		34	46		34	46		34	46	mA
(V_{EE} = −5.5V)	Full	VI			48			48			48			48	mA
Negative Supply Current (−5.5V)	+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:
[1]Maximum 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.
[2]Applied voltage must be current-limited to specified range.
[3]Forcing voltage must be limited to specified range.
[4]Current is specified as negative when flowing into the device.
[5]Output High; one pin to ground; one second duration.
[6]Typical thermal impedances (no air flow) are as follows:
Ceramic DIP: θ_{JA} = 49°C/W; θ_{JC} = 15°C/W LCC: θ_{JA} = 69°C/W; θ_{JC} = 21°C/W
Plastic DIP: θ_{JA} = 58°C/W; θ_{JC} = 16°C/W PLCC: θ_{JA} = 59; θ_{JC} = 19
To calculate junction temperature (T_J), use power dissipation (PD) and thermal impedance:
$T_J = PD(\theta_{JA}) + T_{AMBIENT} = PD(\theta_{JC}) = + T_{CASE}$
[7]Measured with V_{IN} = 0V and CONVERT low (sampling mode).
[8]V_{CC} = +5.5V
[9]V_{EE} = −5.5V
[10]Determined by beat frequency testing for no missing codes.
[11]$V_{RT} \geq V_{RB}$ under all circumstances.
[12]V_{EE} = −4.9V
[13]Outputs terminated with 40pF and 810Ω pull-up resistors.
[14]V_{CC} = +4.5V
[15]Interval from 50% point of leading edge CONVERT pulse to change in output data.
[16]For full scale step input, 8-bit accuracy attained in specified time.
[17]Recovers to 8-bit accuracy in specified time after −3V input overvoltage.
[18]Output time skew includes high-to-low and low-to-high transitions as well as bit-to-bit time skew differences.
[19]Measured at 20MHz encode rate with analog input 1dB below full scale.
[20]Measured at 35MHz encode rate with analog input 1dB below full scale.
[21]RMS signal to rms noise.
[22]Peak signal to rms noise.
[23]DC to 8MHz noise bandwidth with 1.248MHz slot; four sigma loading; 20MHz encode.
[24]Clock frequency = 4 × NTSC = 14.32MHz. Measured with 40-IRE modulated ramp.
Specifications subject to change without notice.

EXPLANATION OF TEST LEVELS

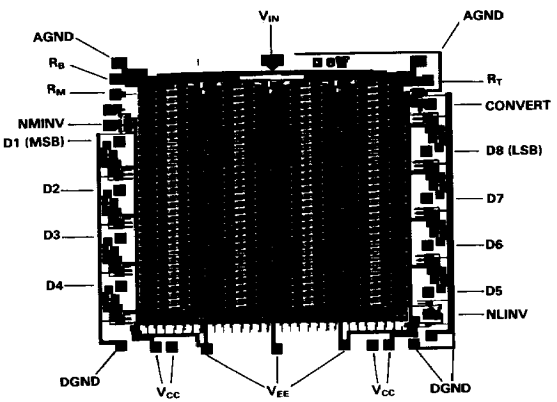
Test Level I – 100% production tested.
Test Level II – 100% production tested at +25°C and sample tested at specified temperatures.
Test Level III – Sample tested only.
Test Level IV – Parameter is guaranteed by design and characterization testing.
Test Level V – Parameter is a typical value only.
Test 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.

ORDERING GUIDE

Model	Linearity	Temperature	Package Option[1]
AD9048JN	0.75LSB	0 to +70°C	N-28
AD9048KN	0.5LSB	0 to +70°C	N-28
AD9048JJ	0.75LSB	0 to +70°C	J-28
AD9048KJ	0.5LSB	0 to +70°C	J-28
AD9048JQ	0.75LSB	0 to +70°C	Q-28
AD9048KQ	0.5LSB	0 to +70°C	Q-28
AD9048SE[2]	0.75LSB	−55°C to +125°C	E-28A
AD9048TE[2]	0.5LSB	−55°C to +125°C	E-28A
AD9048SQ[2]	0.75LSB	−55°C to +125°C	Q-28
AD9048TQ[2]	0.5LSB	−55°C to +125°C	Q-28

NOTES
[1]E = Leadless Ceramic Chip Carrier; J = J-Leaded Ceramic; N = Plastic DIP; Q = Cerdip.
For outline information see Package Information section.
[2]For specifications, refer to Analog Devices *Military Products Databook*.

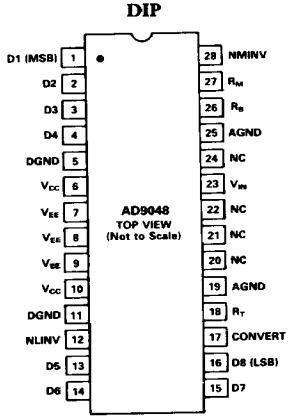
MECHANICAL INFORMATION



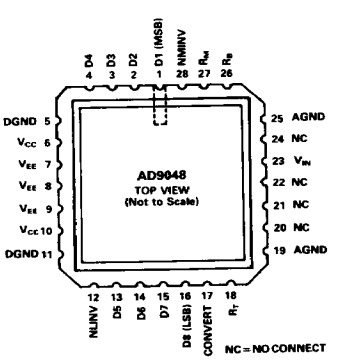
Die Dimensions	127 × 140 × 4 (±2) mils
Pad Dimensions	4 × 4 mils
Metalization	Gold
Backing	None
Substrate Potential	V_{EE}
Passivation	Nitride
Die Attach	Gold Eutectic
Bond Wire	1 mil Gold; Gold Ball Bonding

PIN CONFIGURATIONS

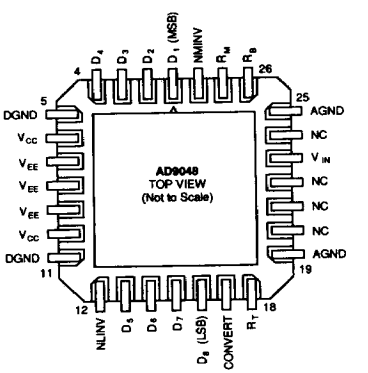
DIP



LCC

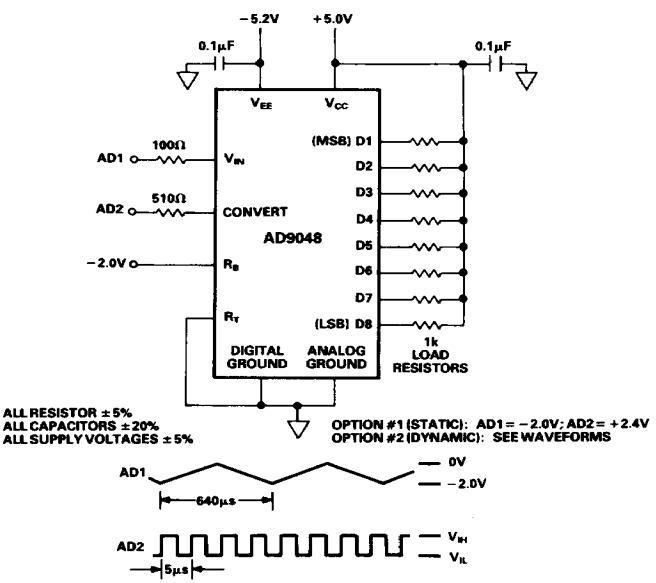


J-Leaded Ceramic



FUNCTIONAL DESCRIPTION

Pin Name	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.
AGND	One of two analog ground returns. Both grounds should be connected together and to low impedance ground plane near the AD9048.
DGND	One of two digital ground returns. Both grounds should be connected together and to low impedance ground plane near the AD9048.
V_{CC}	Positive supply terminals; nominally +5.0V.
V_{EE}	Negative supply terminals; nominally −5.2V.
CONVERT	Input for conversion signal; sample of analog input signal taken on rising edge of this pulse.
R_B	Most negative reference voltage for internal reference ladder.
R_M	Midpoint tap on internal reference ladder.
R_T	Most positive reference voltage for internal reference ladder.
V_{IN}	Analog input signal pin.
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)].
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.



AD9048 Burn-In Diagram

THEORY OF OPERATION

Refer to the 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; and outputs whose references are above that level will be low.

The n-of-255 code which 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 +0.5V.

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 which 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, AD9048 Input/Output Circuits.

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

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

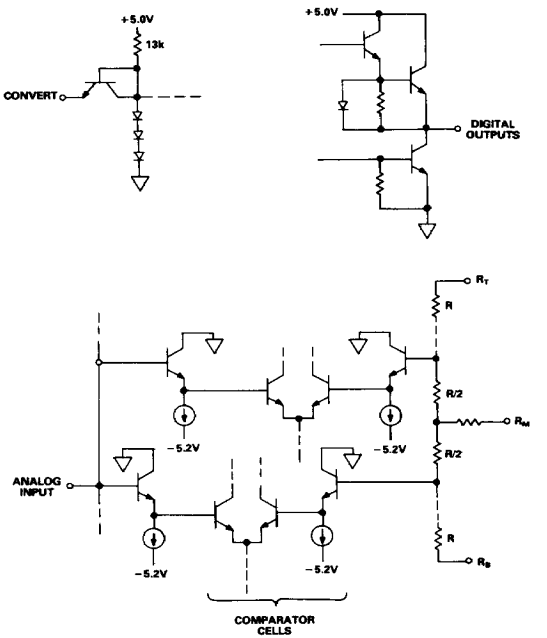


Figure 1. Input/Output Circuits

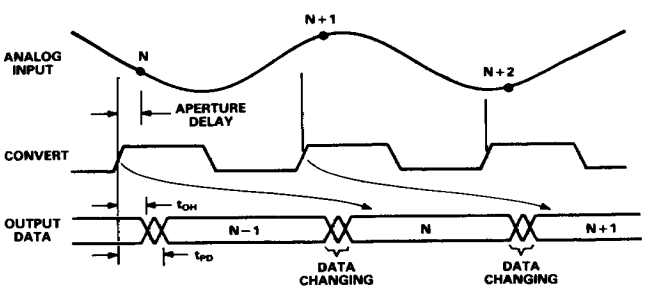


Figure 2. AD9048 Timing Diagram

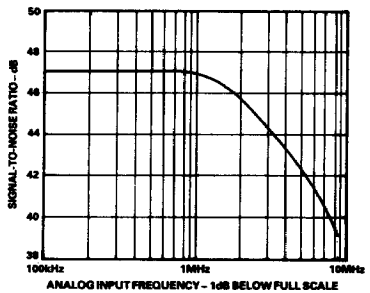


Figure 3. AD9048 Dynamic Performance (20MHz Encode Rate)

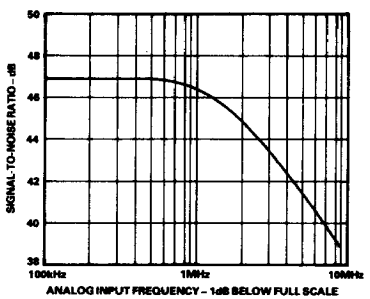


Figure 4. AD9048 Dynamic Performance (35MHz Encode Rate)

LAYOUT SUGGESTIONS

Designs which use the AD9048 or any other high-speed device must follow some basic layout rules to insure 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 connected solidly together and to the ground plane as close to the AD9048 as practical, to avoid ground loop currents.

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

Within the AD9048, reference currents may vary because of coupling between the clock and input signals. Because of this, 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 which use varying references, they must be driven from a low impedance source.

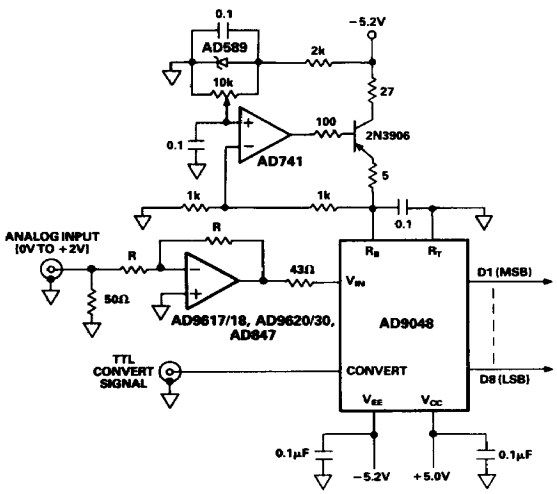


Figure 5. AD9048 Typical Connections

AD9048 Truth Table

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