

AD7574—SPECIFICATIONS

DC SPECIFICATIONS ($V_{DD} = +5V$, $V_{REF} = -10V$, Unipolar Configuration, $R_{CLK} = 180k\Omega$, $C_{CLK} = 100pF$, unless otherwise noted)

Parameter	Limits		Units	Conditions/Comments
	T _A = +25°C	T _{min} , T _{max} ¹		
ACCURACY				
Resolution	8	8	Bits	Relative Accuracy and Differential Nonlinearity are measured dynamically using the external clock circuit of Figure 7b. Clock frequency is 500kHz (conversion time 15μs).
Relative Accuracy Error				
J, A, S Versions	±3/4	±3/4	LSB max	
K, B, T Versions	±1/2	±1/2	LSB max	
Differential Nonlinearity				Full Scale Error is measured after calibrating out offset error. See Figure 8a and associated calibration procedure for offset. Max Full Scale change from +25°C to T _{min} or T _{max} is ±2LSB.
J, A, S Versions	±7/8	±7/8	LSB max	
K, B, T Versions	±3/4	±3/4	LSB max	
Full Scale Error (Gain Error)				
J, A, S Versions	±5	±6.5	LSB max	Maximum Offset change from +25°C to T _{min} or T _{max} is ±20mV.
K, B, T Versions	±3	±4.5	LSB max	
Offset Error ²				
J, A, S Versions	±60	±80	mV max	
K, B, T Versions	±30	±50	mV max	
Mismatch Between B _{OFS} (Pin 3) and A _{IN} (Pin 4) Resistances ³	±1.5	±1.5	% max	
ANALOG INPUTS				
Input Resistance				±5% for specified transfer accuracy. Degraded transfer accuracy.
At V _{REF} (Pin 2)	5/10/15	5/10/15	kΩ min/typ/max	
At B _{OFS} (Pin 3)	10/20/30	10/20/30	kΩ min/typ/max	
At A _{IN} (Pin 4)	10/20/30	10/20/30	kΩ min/typ/max	
V _{REF} (for Specified Performance)	-10	-10	V	
V _{REF} Range ⁴	-5 to -15	-5 to -15	V	
Nominal Analog Input Range				
Unipolar Mode	0 to + V _{REF}		V	
Bipolar Mode	- V _{REF} to + V _{REF}		V	
LOGIC INPUTS				
RD (Pin 15), CS (Pin 16)				V _{IN} = 0V, V _{DD}
V _{INH} Logic HIGH Input Voltage	+3.0	+3.0	V min	
V _{INL} Logic LOW input Voltage	+0.8	+0.8	V max	
I _{IN} Input Current	1	10	μA max	
C _{IN} Input Capacitance ⁵	5	5	pF max	
CLK (Pin 17)				During Conversion: V _{IN(CLK)} ≥ V _{INH(CLK)} During Conversion V _{IN(CLK)} ≤ V _{INL(CLK)} (see circuit of Figure 7b if external clock operation is required).
V _{INH} Logic HIGH Input Voltage	+3.0	+3.0	V min	
V _{INL} Logic LOW Input Voltage	+0.4	+0.4	V max	
I _{INH} Logic HIGH Input Current	+2	+2	mA max	
I _{INL} Logic LOW Input Current	1	10	μA max	
LOGIC OUTPUTS				
BUSY (Pin 14), DB ₇ to DB ₀ (Pins 6–13)				I _{SOURCE} = 40μA I _{SINK} = 1.6mA V _{OUT} = 0V or V _{DD}
V _{OH} Output HIGH Voltage	+4.0	+4.0	V min	
V _{OL} Output LOW Voltage	+0.4	+0.8	V max	
I _{LKG} DB ₇ to DB ₀ Floating Stage Leakage	1	10	μA max	
Floating State Output Capacitance (DB ₇ to DB ₀) ⁵	7	7	pF max	
Output Code	Unipolar Binary, Offset Binary			See Figures 8a, 9a, 10a, and 8b, 9b, 10b.
POWER REQUIREMENTS				
V _{DD}	+5	+5	V	±5% for specified performance. A _{IN} = 0V, ADC in RESET condition. Conversion complete, prior to RESET.
I _{DD} (STANDBY)	5	5	mA max	
I _{REF}	V _{REF} divided by 5kΩ		max	

NOTES

¹Temperature ranges as follows: J, K, Versions, $0^\circ C$ to $+70^\circ C$; A, B, Versions, $-25^\circ C$ to $+85^\circ C$; S, T Versions; $-55^\circ C$ to $+125^\circ C$.

²Typical offset temperature coefficient is $\pm 150\mu V/^\circ C$.

³ R_{BOS}/R_{AIN} mismatch causes transfer function rotation about positive Full Scale. The effect is an offset and a gain term when using the circuit of Figure 9a.

⁴Typical value, not guaranteed or subject to test.

⁵Guaranteed but not tested.

Specifications subject to change without notice.

CAUTION

ESD (electrostatic discharge) sensitive device. The digital control inputs are Zener protected; however, permanent damage may occur on unconnected devices subject to high energy electrostatic fields. Unused devices must be stored in conductive foam or shunts. The protective foam should be discharged to the destination socket before devices are removed.



AC SPECIFICATIONS ($V_{DD} = +5V$, $C_{CLK} = 100pF$, $R_{CLK} = 180k\Omega$ unless otherwise noted)

Symbol	Specification	Limit at $T_A = +25^{\circ}C$	Limit at $T_A = T_{min}$	Limit at $T_A = T_{max}$	Conditions	
STATIC RAM INTERFACE MODE (See Figure 1 and Table I)						
t_{CS}	$\overline{CS}$ Pulse Width Requirement	100ns min	150ns min	150ns min	$\overline{BUSY}$ Load = 20pF $\overline{BUSY}$ Load = 100pF	
t_{WSCS}	$\overline{RD}$ to $\overline{CS}$ Setup Time	0 min	0 min	0 min		
t_{CBPD}	$\overline{CS}$ to $\overline{BUSY}$ Propagation Delay	90ns typ	70ns typ	150ns typ		
		120ns max	120ns max	180ns max		
		120ns type	100ns typ	180ns typ		
		150ns max	150ns max	200ns max	$\overline{DB_0}-\overline{DB_7}$ Load = 100pF $\overline{DB_0}-\overline{DB_7}$ Load = 100pF	
t_{BSR}	$\overline{BUSY}$ to $\overline{RD}$ Setup Time	0 min	0 min	0 min		
t_{BSCS}	$\overline{BUSY}$ to $\overline{CS}$ Setup Time	0 min	0 min	0 min		
t_{RAD}	Data Access Time	120ns typ	100ns typ	180ns typ		
		150ns max	150ns max	220ns max		
		240ns typ	220ns typ	300ns typ	$\overline{DB_0}-\overline{DB_7}$ Load = 100pF	
		300ns max	300ns max	400ns max		
t_{RHD}	Data Hold Time	80ns typ	40ns typ	120ns typ		
		50ns min	30ns min	80ns min		
		120ns max	80ns max	180ns max		
t_{RHCS}	$\overline{CS}$ to $\overline{RD}$ Hold Time	250ns max	200 ns max	500ns max	$f_{CLK} = 500kHz$ Circuit of Figure 7b	
t_{RESET}	Reset Time Requirement	3 μs min	3 μs min	3 μs min		
$t_{CONVERT}$	Conversion Time Using Internal Clock Oscillator	See Typical Data of Figure 7a				
$t_{CONVERT}$	Conversion Time Using External Clock	15 μs	15 μs	15 μs		
ROM INTERFACE MODE (See Figure 2 and Table II)						
t_{RAD}	Data Access Time	Same as RAM Mode			$\overline{BUSY}$ Load = 20 pF	
t_{RHD}	Data Hold Time	Same as RAM Mode				
t_{WBPD}	$\overline{RD}$ HIGH to $\overline{BUSY}$ Propagation Delay	400ns typ	350ns typ	1 μs typ		
		1.5 μs	1.0 μs	2.0 μs		
t_{BSR}	$\overline{BUSY}$ to $\overline{RD}$ LOW Setup Time	$\overline{RD}$ can go LOW prior to $\overline{BUSY} = HIGH$, but must not return HIGH until = $\overline{BUSY} HIGH$. See Table II.				
$t_{CONVERT}$	Conversion Time Using Internal Clock Oscillator	See Typical data of Figure 7a. Add 2 μs to data shown in Figure 7a for ROM Mode				
SLOW – MEMORY INTERFACE MODE (See Figure 3 and Table III)						
t_{CBPD}	$\overline{CS}$ to $\overline{BUSY}$ Propagation Delay	Same as RAM Mode				
t_{RESET}	Reset Time Requirement	Same as RAM Mode				
t_{RAD}	Data Access Time	Same as RAM Mode				
t_{RHD}	Data Hold Time	Same as RAM Mode				
$t_{CONVERT}$	Conversion Time	Same as RAM Mode				

ABSOLUTE MAXIMUM RATINGS*

V_{DD} to A_{GND}	0V, +7.0V
V_{DD} to D_{GND}	0V, +7.0V
A_{GND} to D_{GND}	-0.3V, V_{DD}
Digital Input Voltage to D_{GND} (Pins 15 and 16)	-0.3V, +15.0V
Digital Output Voltage to D_{GND} (Pins 6-14)	-0.3V, V_{DD}
CLK Input Voltage (Pin 17) to D_{GND}	-0.3V, V_{DD}
V_{REF} (Pin 2)	$\pm 20V$
V_{BOFS} (Pin 3)	$\pm 20V$
V_{AIN} (Pin 4)	$\pm 20V$
Operating Temperature Range	
Commercial (J, K Versions)	0°C to +70°C

*Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation at or above this specification is not implied. Exposure to above maximum rating conditions for extended periods may affect device reliability.

TERMINOLOGY

RESOLUTION: Resolution is a measure of the *nominal* analog change required for a 1-bit change in the A/D converter's digital output. While normally expressed in a number of bits, the analog resolution of an n-bit unipolar A/D converter is $(2^{-n}) V_{REF}$. Thus, the AD7574, an 8-bit A/D converter, can resolve analog voltages as small as $(1/256) (V_{REF})$ when operated in a unipolar mode. When operated in a bipolar mode, the resolution is $(1/128) (V_{REF})$. Resolution does not imply accuracy. Usable resolution is limited by the differential nonlinearity of the A/D converter.

RELATIVE ACCURACY: Relative accuracy is the deviation of the ADC's actual code transition points from a straight line

Industrial (A, B Versions)	-25°C to +85°C
Extended (S, T Versions)	-55°C to +150°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (soldering, 10 secs)	+300°C
Power Dissipation (Package)	
Plastic (Suffix N)	
to +70°C	670mW
Derate above +70°C by	8.3mW/°C
Cerdip (Suffix Q)	
to +75°C	450mW
Derate above +75°C by	6mW/°C

drawn between the devices' measured zero and measured full scale transition points. Relative accuracy, therefore, is a measure of code *position*.

DIFFERENTIAL NONLINEARITY: Differential nonlinearity in an ADC is a measure of the size of an analog voltage range associated with any digital output code. As such, differential nonlinearity specifies code width (usable resolution). An ADC with a specified differential nonlinearity of $\pm n$ bits will exhibit codes ranging in width from 1LSB - n LSB to 1LSB + n LSB. A specified differential nonlinearity of less than $\pm 1LSB$ guarantees no-missing-codes operation.

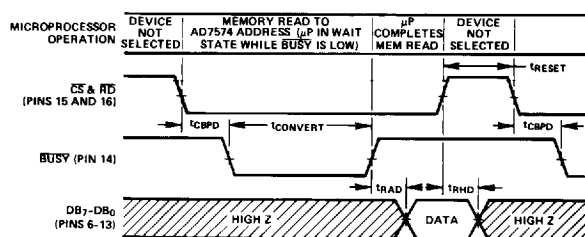


Figure 3. Slow Memory Mode Timing Diagram
($\overline{CS}$ and $\overline{RD}$ Tied Together)

Table III. Truth Table, Slow Memory Mode

AD7574 INPUTS	AD7574 OUTPUTS		AD7574 OPERATION
	$\overline{CS}$ & $\overline{RD}$	BUSY	
H	H	H	NOT SELECTED
L	H	H	START CONVERSION
L	L	L	CONVERSION IN PROGRESS, μP IN WAIT STATE
L	L	H	CONVERSION COMPLETE, μP READS DATA
L	H	H	CONVERTER RESET AND DESELECTED
H	H	H	NOT SELECTED

GENERAL CIRCUIT INFORMATION

BASIC CIRCUIT DESCRIPTION

The AD7574 uses the successive approximations technique to provide an 8-bit parallel digital output. The control logic was designed to provide easy interface to most microprocessors. Most applications require only passive clock components (R & C), a -10V reference, and +5V power.

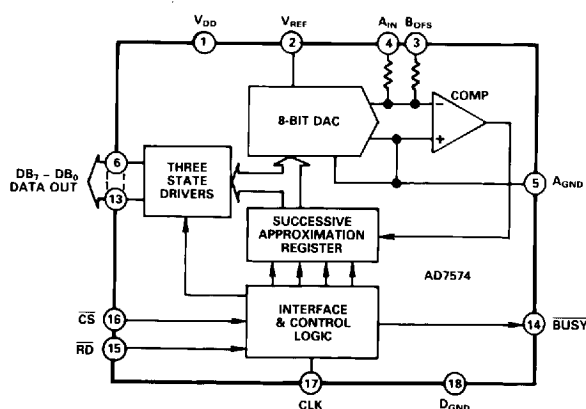


Figure 4. AD7574 Functional Diagram

Figure 4 shows the AD7574 functional diagram. Upon receipt of a start command either via the $\overline{CS}$ or $\overline{RD}$ pins, BUSY goes low indicating conversion is in progress. Successive bits, starting with the most significant bit (MSB) are applied to the input of a DAC. The comparator determines whether the addition of each successive bit causes the DAC output to be greater than or less than the analog input, A_{IN} . If the sum of the DAC bits is less than A_{IN} , the trial bit is left ON, and the next smaller bit is tried. If the sum is greater than A_{IN} , the trial bit is turned OFF and the next smaller bit is tried.

Each successively smaller bit is tried and compared to A_{IN} in this manner until the least significant bit (LSB) decision has been made. At this time BUSY goes HIGH (conversion is complete) indicating the successive approximation register contains a valid representation of the analog input. The $\overline{RD}$ control (see the previous page for details) can then be exercised to activate the three-state buffers, placing data on the $DB_0 - DB_7$ data output pins. $\overline{RD}$ returning HIGH causes the clock oscillator to run for 1 cycle, providing an internal ADC reset (i.e. the SAR is loaded with code 10000000).

DAC CIRCUIT DETAILS

The current weighting D/A converter is a precision multiplying DAC. Figure 5 shows the functional diagram of the DAC as used in the AD7574. It consists of a precision Silicon Chromium thin film R/2R ladder network and 8 N-channel MOS-FET switches operated in single-pole-double-throw.

The currents in each 2R shunt arm are binarily weighted, i.e. the current in the MSB arm is V_{REF} divided by 2R, in the second arm is V_{REF} divided by 4R, etc. Depending on the DAC logic input (A/D output) from the successive approximation register, the current in the individual shunt arms is steered either to A_{GND} or to the comparator summing point.

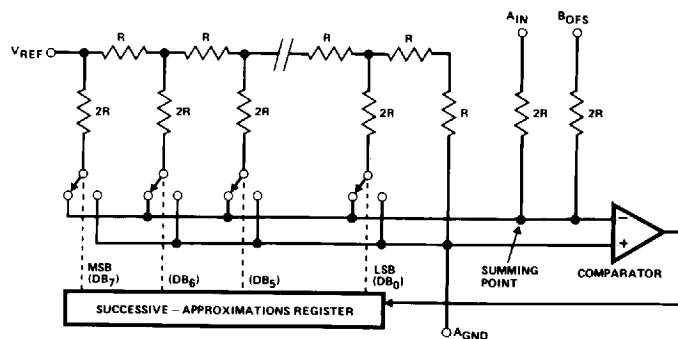


Figure 5. D/A Converter As Used In AD7574

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APPLICATION HINTS

1. TIMING & CONTROL

In the AD7574 when a conversion is finished the fresh data must be read before a new conversion can be started.

Failure to observe the timing restrictions of Figures 1, 2 or 3 may cause the AD7574 to change interface modes. For example, in the RAM mode, holding $\overline{CS}$ LOW too long after $\overline{RD}$ goes HIGH will cause a new convert start (i.e. the converter moved into the ROM mode).

2. LOGIC DEGLITCHING IN μP APPLICATIONS

Unspecified states on the address bus (due to different rise and fall times on the address bus) can cause glitches at the AD7574 $\overline{CS}$ or $\overline{RD}$ terminals. These glitches can cause unwanted convert starts, reads, or resets. The best way to avoid glitches is to gate the address decoding logic with $\overline{RD}$ or $\overline{WR}$ (8080) or $\overline{VMA}$ (6800) when in the ROM or RAM mode. When in the slow-memory mode, the $\overline{ALE}$ (8085) or $\overline{SYNC}$ (8080) signal should be used to latch the address.

3. INPUT LOADING AT V_{REF} , A_{IN} AND $BOFS$

To prevent loading errors due to the finite input resistance at the V_{REF} , A_{IN} or $BOFS$ pins, low impedance driving sources must be used (i.e. op amp buffers or low output-Z reference).

4. RATIOMETRIC OPERATION

Ratiometric performance is inherent to A/D converters such as the AD7574 which use a multiplying DAC weighting network. However,

the user should recognize that comparator limitations such as offset voltage, input noise and gain will cause degradation of the transfer characteristics when operating with reference voltages less than -10V in magnitude.

5. OFFSET CORRECTION

Offset error in the transfer characteristic can be trimmed by offsetting the buffer amplifier which drives the AD7574 A_{IN} pin (pin 4). This can be done either by summing a cancellation current into the amplifier's summing junction, or by tapping a voltage divider which sits between V_{DD} and V_{REF} and applying the tap voltage to the amplifier's positive input (an example of a resistive tap offset adjust is shown in Figure 10a where R_8 , R_9 and R_{10} can be used to offset the ADC).

6. ANALOG AND DIGITAL GROUND

It is recommended that $AGND$ and $DGND$ be connected locally to prevent the possibility of injecting noise into the AD7574. In systems where the $AGND$ - $DGND$ intertie is not local, connect back-to-back diodes (IN914 or equivalent) between the AD7574 $AGND$ and $DGND$ pins.

7. INITIALIZATION AFTER POWER-UP

Execute a memory READ to the AD7574 address location, and subsequently ignore the data. The AD7574 is internally reset when reading out data, i.e. the data readout is destructive.

CLOCK OSCILLATOR

The AD7574 has an internal asynchronous clock oscillator which starts upon receipt of a convert start command, and ceases oscillating when conversion is complete.

The clock oscillator requires an external R and C as shown in Figure 6. Nominal conversion times versus R_{CLK} and C_{CLK} is shown in Figure 7a. The curves shown in Figure 7a are applicable when operating in the RAM or slow-memory interface modes. When operating in the ROM interface mode, add $2\mu s$ to the typical conversion time values shown.

The AD7574 is guaranteed to provide transfer accuracy to published specifications for conversion times down to $15\mu s$, as indicated by the unshaded region of Figure 7a. Conversion times faster than $15\mu s$ can cause transfer accuracy degradation.

OPERATION WITH EXTERNAL CLOCK

For applications requiring a conversion time close to or equal to $15\mu s$, an external clock is recommended. Using an external clock precludes the possibility of converting faster than $15\mu s$ (which can cause transfer accuracy degradation) due to temperature drift — as may be the case when using the internal clock oscillator.

Figure 7b shows how the external clock must be connected. The $\overline{BUSY}$ output of the AD7574 is connected to the three-state enable input of a 74125 three-state buffer. R_1 is used as a pullup, and can be between $6k\Omega$ and $100k\Omega$. A 500kHz clock will provide a conversion time of $15\mu s$.

The external clock should be used only in the static-RAM or slow-memory interface mode, and *not* in the ROM mode.

Timing constraints for external clock operation are as follows:

STATIC RAM MODE

1. When initiating a conversion, $\overline{CS}$ should go LOW on a positive clock edge to provide optimum settling time for the MSB.
2. A data READ can be initiated any time after $\overline{BUSY} = 1$.

SLOW-MEMORY MODE

1. When initiating a conversion, $\overline{CS}$ and $\overline{RD}$ should go LOW

on a positive clock edge to provide optimum settling time for the MSB.

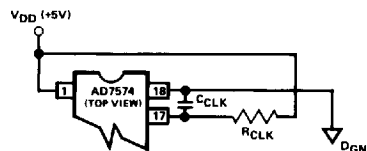


Figure 6. Connecting R_{CLK} and C_{CLK} To CLK Oscillator

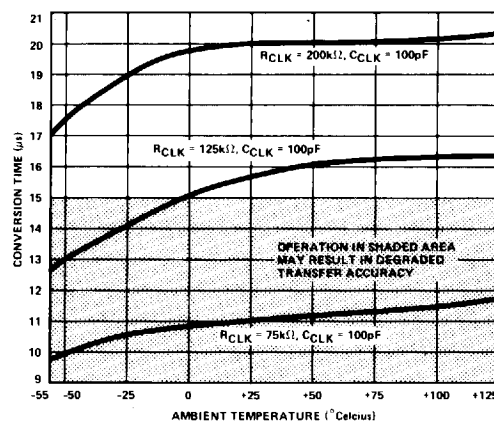


Figure 7a. Typical Conversion Time vs. Temperature For Different R_{CLK} and C_{CLK} (Applicable to RAM and Slow-Memory Modes. For ROM Mode add $2\mu s$ to values shown)

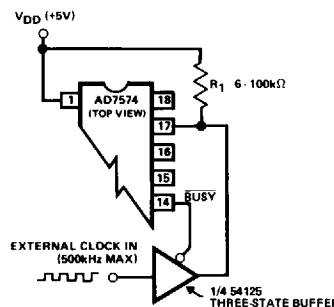


Figure 7b. External Clock Operation (Static RAM and Slow-Memory Mode)

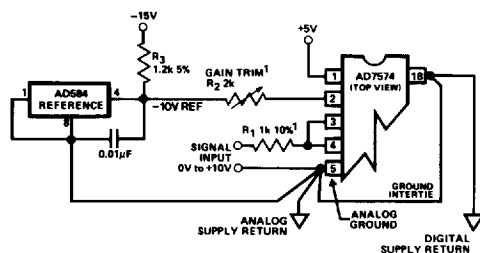
UNIPOLAR BINARY OPERATION

Figures 8a and 8b show the analog circuit connections and typical transfer characteristic for unipolar operation. An AD584 is used as the -10V reference.

Calibration is as follows:

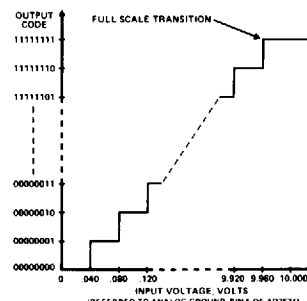
OFFSET

Offset must be trimmed out in the signal conditioning circuitry used to drive the signal input terminals shown in Figure 8a. An example of an offset trim is shown in Figure 10a, where R_8 , R_9 and R_{10} comprise a simple voltage tap which is applied to the amplifier's positive input.



Note 1: R_1 and R_2 can be omitted if gain trim is not required

Figure 8a. AD7574 Unipolar (0V to +10V) Operation (Output Code is Straight Binary)



Note: Approximate bit weights are shown for illustration. Nominal bit weight for a -10V reference is $\approx 39.1\text{mV}$

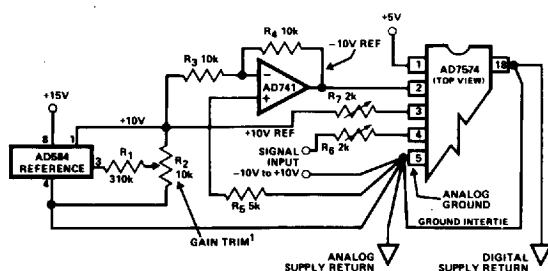
Figure 8b. Nominal Transfer Characteristic For Unipolar Circuit of Figure 8a

BIPOLAR (OFFSET BINARY) OPERATION

Figures 9a and 9b illustrate the analog circuitry and transfer characteristic for bipolar operation. Output coding is offset binary. As in unipolar operation, offset correction can be performed at the buffer amplifier used to drive the signal input terminals of Figure 9a (Resistors R_8 , R_9 and R_{10} in Figure 10a show how offset trim can be done at the buffer amplifier).

Calibration is as follows:

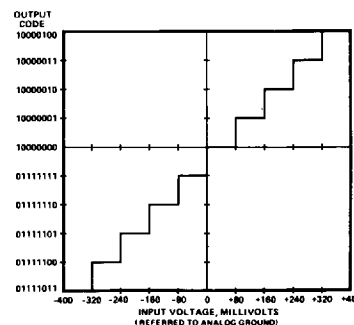
1. Adjust R_6 and R_7 for minimum resistance across the potentiometers.
2. Apply +10.000V to the buffer amplifier used to drive the signal input (i.e. -10.000V at R_6).
3. While performing continuous conversions, trim R_6 or R_7 (whichever required) until DB_7 - DB_1 are LOW and the LSB (DB_0) flickers.



Note 1: R_1 and R_2 can be omitted if gain trim is not required

Figure 9a. AD7574 Bipolar (-10V to +10V) Operation (Output Code is Offset Binary)

4. Apply 0V to the buffer amplifier used to drive the signal input terminals.
5. Doing continuous conversions, trim the offset circuit of the buffer amplifier until the ADC output code flickers between 01111111 and 10000000.
6. Apply +10.000V to the input of the buffer amplifier (i.e. -10.000V as applied to R_6).
7. Doing continuous conversions, trim R_2 until DB_7 - DB_1 are LOW and the LSB (DB_0) flickers.
8. Apply -9.922V to the input of the buffer amplifier (i.e. +9.922V at the input side of R_6).
9. If the ADC output code is not 11111110 ± 1 bit, repeat the calibration procedure.



Note: Approximate bit weights are shown for illustration. Nominal bit weight for $\pm 10\text{V}$ full scale is $\approx 78.1\text{mV}$

Figure 9b. Nominal Transfer Characteristic Around Major Carry for Bipolar Circuit of Figure 9a

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BIPOLAR (COMPLEMENTARY OFFSET BINARY) OPERATION

Figure 10a shows the analog connections for complementary offset binary operation. The typical transfer characteristic is shown in Figure 10b. In this bipolar mode, the ADC is fooled into believing it is operated in a unipolar mode - i.e. the +10V to -10V analog input is conditioned into a 0 to +10V signal range. R_2 is the gain adjust, while R_9 is the offset adjust.

Calibration is as follows (adjust offset before gain):

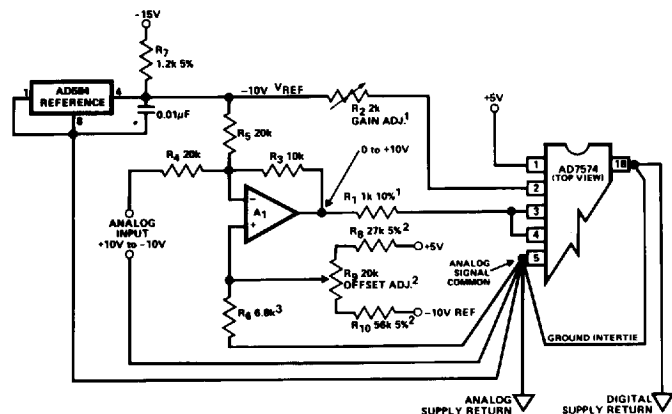
OFFSET

1. Apply 0V to the analog input shown in Figure 10a.

2. While performing continuous conversions, adjust R_9 until the converter output flickers between codes 01111111 and 10000000.

GAIN (FULL SCALE)

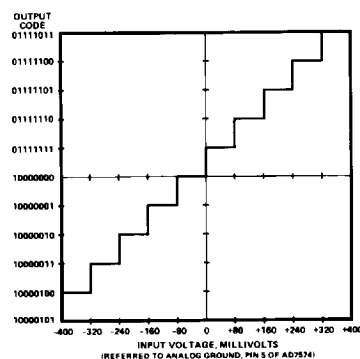
1. Apply -9.922V across the analog input terminals shown in Figure 10a.
2. While performing continuous conversions, adjust R_2 until $DB_7 - DB_1$ are HIGH and the LSB (DB_0) flickers between HIGH and LOW.



Notes:

1. R_1 and R_2 can be omitted if gain trim is not required
2. R_8 , R_9 and R_{10} can be omitted if offset trim is not required
3. $R_6 \parallel R_8 \parallel R_{10} = 5k\Omega$. If R_8 , R_9 and R_{10} not used, make $R_6 = 5k\Omega$

Figure 10a. AD7574 Bipolar Operation (-10V to +10V)
(Output Code is Complementary Offset Binary)



Note: Approximate bit weights are shown for illustration. Nominal bit weight for $\pm 10V$ full scale is $\approx 78.1mV$

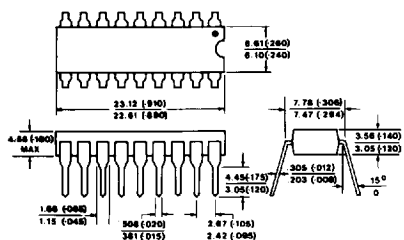
Figure 10b. Nominal Transfer Characteristic Around Major Carry for Bipolar Circuit of Figure 10a

MECHANICAL INFORMATION

OUTLINE DIMENSIONS

Dimensions are shown in inches and (mm).

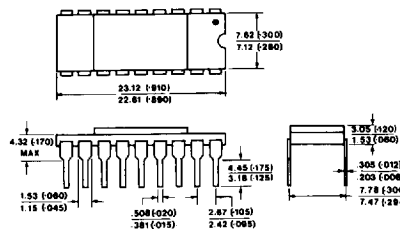
18 PIN PLASTIC DIP



Notes:

1. Lead no. 1 identified by dot or notch.
2. Dimensions in mm (in.).
3. Leads are solder plated KOVAR or ALLOY 42.

18 PIN CERAMIC DIP



Notes:

1. Lead no. 1 identified by dot or notch.
2. Leads will be either gold or tin plated in accordance with MIL-M-38510 requirements.
3. Cavity lid is electrically isolated.