

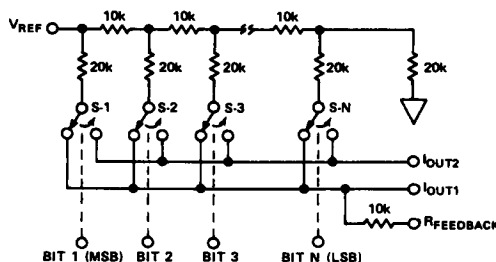
## AD7530, AD7531

### FEATURES

**AD7530: 10-Bit Resolution**  
**AD7531: 12-Bit Resolution**  
**8-, 9- and 10-Bit End Point Linearity**  
**DTL/TTL/CMOS Compatible**  
**Nonlinearity Tempco: 2ppm of FSR/°C**  
**Low Power Dissipation: 20mW**  
**Current Settling Time: 500ns**  
**Feedthrough Error: 10mV p-p @ 50kHz**  
**Low Cost**

**Note: AD7533 is Recommended for New 10-Bit Designs.**  
**AD7541A or AD7545 is Recommended for New 12-Bit Designs.**

### AD7530, AD7531 FUNCTIONAL BLOCK DIAGRAM



DIGITAL INPUTS (DTL/TTL/CMOS COMPATIBLE)

AD7530: N = 10

AD7531: N = 12

(Switches shown in "High" state)

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### GENERAL DESCRIPTION

The AD7530 (AD7531) is a low cost, monolithic 10-bit (12-bit) multiplying digital-to-analog converter packaged in a 16-pin (18-pin) DIP. The device uses advanced CMOS and thin film technologies providing up to 10-bit accuracy with DTL/TTL/CMOS compatibility.

The AD7530 (AD7531) operates from a +5V to +15V supply and dissipates only 20mW, including the ladder network.

Typical applications include: digital/analog multiplication, CRT character generation, programmable power supplies, digitally controlled gain circuits, etc.

### PACKAGE IDENTIFICATION<sup>1</sup>

Suffix D: Ceramic DIP

AD7530: (D16A)

AD7531: (D18A)

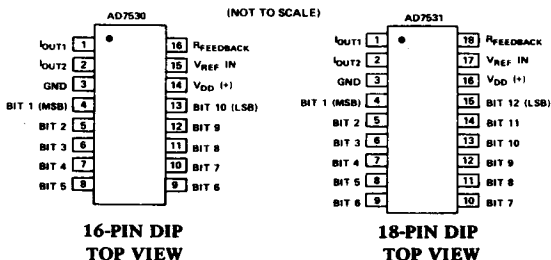
Suffix N: Plastic DIP

AD7530: (N16B)

AD7531: (N18B)

<sup>1</sup> See Section 19 for package outline information.

### PIN CONFIGURATION



### ORDERING INFORMATION

Nonlinearity	Temperature Range	
	0 to +70°C	-25°C to +85°C
0.2% (8-Bit)	AD7530JN	AD7530JD
	AD7531JN	AD7531JD
0.1% (9-Bit)	AD7530KN	AD7530KD
	AD7531KN	AD7531KD
0.05% (10-Bit)	AD7530LN	AD7530LD
	AD7531LN	AD7531LD

# SPECIFICATIONS

( $V_{DD} = +15$ ,  $V_{REF} = +10V$ ,  $T_A = +25^\circ C$  unless otherwise noted)

PARAMETER	AD7530	AD7531	TEST CONDITIONS
<b>DC ACCURACY (Note 1)</b>			
Resolution	10 Bits	12 Bits	
Relative Accuracy	AD7530J AD7530K AD7530L	0.2% of FSR max (8 Bit) 0.1% of FSR max (9 Bit) 0.05% of FSR max (10 Bit)	*
Nonlinearity Tempco		2ppm of FSR/ $^\circ C$ max	*
Gain Error		0.3% of FSR typ	*
Gain Error Tempco		10ppm of FSR/ $^\circ C$ max	*
Output Leakage Current (Either Output)		300nA max	*
Power Supply Rejection	50ppm of FSR/% typ	*	-10V < $V_{REF}$ < +10V  Over specified temperature range.
<b>AC ACCURACY</b>			
Output Current Settling Time	500ns typ	*	To 0.05% All digital inputs low to high and high to low
Feedthrough Error (Note 2)	10mV p-p max	*	$V_{REF} = 20V$ p-p, 50kHz. All digital inputs low
<b>REFERENCE INPUT</b>			
Input Range	$\pm 10V$	*	
Input Resistance	$\pm 1mA$	*	
	10k $\Omega$ typ	*	
<b>ANALOG OUTPUT</b>			
Output Current Range (Both Outputs)	$\pm 1mA$	*	
Output Capacitance	$I_{OUT1}$ $I_{OUT2}$	120pF typ 37pF typ	*
	$I_{OUT1}$ $I_{OUT2}$	37pF typ 120pF typ	*
Output Noise (Both Outputs)	Equivalent to 10k $\Omega$ Johnson noise typ	*	All digital inputs high  All digital input low
<b>DIGITAL INPUTS (Note 3)</b>			
Low State Threshold	0.8V max	*	Over specified temperature range
High State Threshold	2.4V min	*	Over specified temperature range
Input Current (low to high state)	1 $\mu A$ typ	*	
Input Coding	Binary	*	See Tables I & II
<b>POWER REQUIREMENTS</b>			
Power Supply Voltage Range	+5V to +15V	*	
$I_{DD}$	5nA typ 2mA max	*	All digital inputs at GND All digital inputs high or low
Total Dissipation	20mW typ	*	

## NOTES

<sup>1</sup> Full scale range (FSR) is 10V for unipolar mode and  $\pm 10V$  for bipolar mode.

<sup>2</sup> To minimize feedthrough with the ceramic package, the user must ground the metal lid. If the lid is not grounded, then the feedthrough is 10mV typical and 30mV maximum.

<sup>3</sup> Digital input levels should not go below ground or exceed the positive supply voltage, otherwise damage may occur.

\*Same specifications as for AD7530.

Specifications subject to change without notice.

### ABSOLUTE MAXIMUM RATINGS

( $T_A = +25^\circ\text{C}$  unless otherwise noted)

$V_{DD}$ (to Gnd)	+17V
$V_{REF}$ (to Gnd)	$\pm 25\text{V}$
Digital Input Voltage Range	$V_{DD}$ to Gnd
Voltage at Pin 1, Pin 2	-100mV to $V_{DD}$
Power Dissipation (package)	
up to $+75^\circ\text{C}$	450mW
Operating Temperature	
JN, KN, LN Versions	0 to $+75^\circ\text{C}$
JD, KD, LD Versions	$-25^\circ\text{C}$ to $+85^\circ\text{C}$
Storage Temperature	$-65^\circ\text{C}$ to $+150^\circ\text{C}$

### CAUTION:

1. Do not apply voltages higher than  $V_{DD}$  or less than GND potential on any terminal except  $V_{REF}$ .
2. The digital control inputs are zener protected; however, permanent damage may occur on unconnected units under high energy electrostatic fields. Keep unused units in conductive foam at all times.

## APPLICATIONS

### UNIPOLAR BINARY OPERATION (2-QUADRANT MULTIPLICATION)

Figure 1 shows the analog circuit connections required for unipolar binary (2-quadrant multiplication) operation. The logic inputs are omitted for clarity. With a dc reference voltage or current (positive or negative polarity) applied at pin 15, the circuit is a unipolar D/A converter. With an ac reference voltage or current the circuit provides 2-quadrant multiplication (digitally controlled attenuation). The input/output relationship is shown in Table I. Protection Schottky shown in Figure 1 is not required when using TRIFET output amplifiers such as the AD542 or AD544.

R1 provides full scale trim capability [i.e.—load the DAC register to 11 1111 1111, adjust R1 for  $V_{OUT} = -V_{REF}$  ( $1 - 2^{-10}$ )]. Alternatively, Full Scale can be adjusted by omitting R1 and R2 and trimming the reference voltage magnitude.

C1 phase compensation (10 to 25pF) may be required for stability when using high speed amplifiers. (C1 is used to cancel the pole formed by the DAC internal feedback resistance and output capacitance at  $I_{OUT1}$ ).

Amplifier A1 should be selected or trimmed to provide  $V_{OS} \leq 10\%$  of the voltage resolution at  $V_{OUT}$ . Additionally, the amplifier should exhibit a bias current which is low over the temperature range of interest (bias current causes output offset at  $V_{OUT}$  equal to  $I_B$  times the DAC feedback resistance, nominally 15k $\Omega$ ).

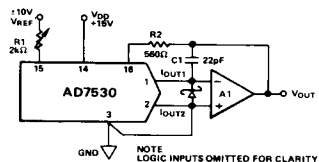


Figure 1. Unipolar Binary Operation  
(2-Quadrant Multiplication)

DIGITAL INPUT	ANALOG OUTPUT
1 1 1 1 1 1 1 1 1 1	$-V_{REF} (1 - 2^{-10})$
1 0 0 0 0 0 0 0 0 1	$-V_{REF} (1/2 + 2^{-10})$
1 0 0 0 0 0 0 0 0 0	$\frac{-V_{REF}}{2}$
0 1 1 1 1 1 1 1 1 1	$-V_{REF} (1/2 - 2^{-10})$
0 0 0 0 0 0 0 0 0 1	$-V_{REF} (2^{-10})$
0 0 0 0 0 0 0 0 0 0	0

NOTE: 1 LSB =  $2^{-10} V_{REF}$

Table I. Code Table — Unipolar Binary Operation

### BIPOLAR OPERATION

#### (4-QUADRANT MULTIPLICATION)

Figure 2 and Table II illustrate the circuitry and code relationship for bipolar operation. With a dc reference (positive or negative polarity) or an ac reference the circuit provides offset binary operation. Protection Schottky shown in Figure 2 is not required when using TRIFET output amplifiers such as the AD542 or AD544.

With the DAC register loaded to 10 0000 0000, adjust R1 for  $V_{OUT} = 0\text{V}$  (alternatively, one can omit R1 and R2 and adjust the ratio of R3 to R4 for  $V_{OUT} = 0\text{V}$ ). Full Scale trimming can be accomplished by adjusting the amplitude of  $V_{REF}$  or by varying the value of R5.

As in unipolar operation, A1 must be chosen for low  $V_{OS}$  and low  $I_B$ . R3, R4 and R5 must be selected for matching and tracking. Mismatch of 2R3 to R4 causes both offset and Full Scale error. Mismatch of R5 to R4 or 2R3 causes Full Scale error. C1 phase compensation (10pF to 25pF) may be required for stability.

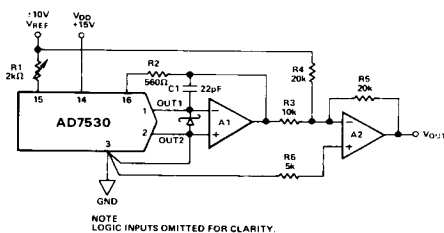


Figure 2. Bipolar Operation (4-Quadrant Multiplication)

DIGITAL INPUT	ANALOG OUTPUT
1 1 1 1 1 1 1 1 1 1	$-V_{REF} (1 - 2^{-9})$
1 0 0 0 0 0 0 0 0 1	$-V_{REF} (2^{-9})$
1 0 0 0 0 0 0 0 0 0	0
0 1 1 1 1 1 1 1 1 1	$V_{REF} (2^{-9})$
0 0 0 0 0 0 0 0 0 1	$V_{REF} (1 - 2^{-9})$
0 0 0 0 0 0 0 0 0 0	$V_{REF}$

NOTE: 1 LSB =  $2^{-9} V_{REF}$

Table II. Code Table — Bipolar (Offset Binary) Operation

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## TERMINOLOGY

**RELATIVE ACCURACY:** Relative accuracy or end-point nonlinearity is a measure of the maximum deviation from a straight line passing through the end-points of the DAC transfer function. It is measured after adjusting for ideal zero and full scale and is expressed in % or ppm of full scale range or (sub) multiples of 1LSB.

**RESOLUTION:** Value of the LSB. For example, a unipolar converter with  $n$  bits has a resolution of  $(2^{-n})(V_{REF})$ . A bipolar converter of  $n$  bits has a resolution of  $[2^{-(n-1)}](V_{REF})$ . Resolution in no way implies linearity.

**SETTLING TIME:** Time required for the output function of the DAC to settle to within 1/2 LSB for a given digital input stimulus, i.e., 0 to Full Scale.

**GAIN:** Ratio of the DAC's operational amplifier output voltage to the input voltage.

**FEEDTHROUGH ERROR:** Error caused by capacitive coupling from  $V_{REF}$  to output with all switches OFF.

**OUTPUT CAPACITANCE:** Capacity from  $I_{OUT1}$  and  $I_{OUT2}$  terminals to ground.

**OUTPUT LEAKAGE CURRENT:** Current which appears on  $I_{OUT1}$  terminal with all digital inputs LOW or on  $I_{OUT2}$  terminal when all inputs are HIGH.