

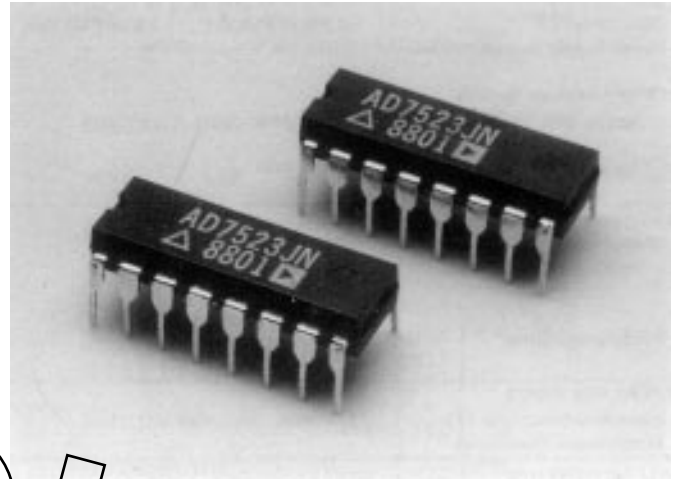
AD7523

## FEATURES

Low Cost  
Fast Settling: 100ns  
Low Power Dissipation  
Low Feedthrough: 1/2LSB @ 200kHz  
Full Four-Quadrant Multiplying

## APPLICATIONS

Battery Operated Equipment  
Low Power, Ratiometric A/D Converters  
Digitally Controlled Gain Circuits  
Digitally Controlled Attenuators  
CRT Character Generation  
Low Noise Audio Gain Control

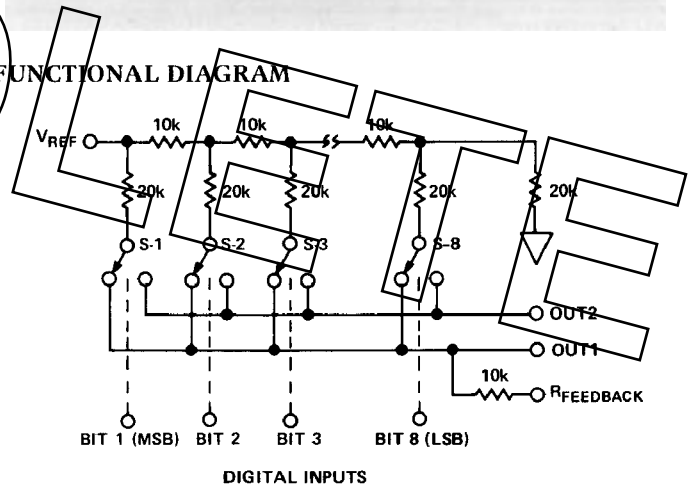


## GENERAL DESCRIPTION

The AD7523 is a low cost, monolithic multiplying digital-to-analog converter packaged in a 16-pin DIP. The device uses an advanced monolithic, thin-film-on-CMOS technology to provide 8-bit resolution with accuracy to 10-bits and very low power dissipation.

The AD7523's excellent multiplying characteristics and low cost allow it to be used in a wide ranging field of applications such as: low noise audio gain control, CRT character generation, motor speed control, digitally controlled attenuators, etc.

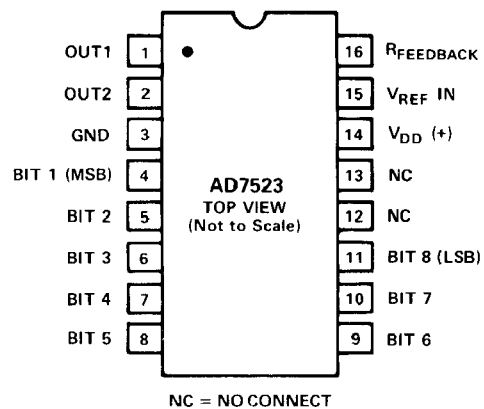
## FUNCTIONAL DIAGRAM



## ORDERING INFORMATION

Model	Linearity	Package	Operating Temperature Range
AD7523JN	$\pm 1/2$ LSB	16 pin Plastic	0 to +70°C
AD7523KN	$\pm 1/4$ LSB		
AD7523LN	$\pm 1/8$ LSB		

## PIN CONFIGURATION



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# SPECIFICATIONS (V<sub>DD</sub> = +15V, V<sub>REF</sub> = +10V unless otherwise noted)

PARAMETER	T <sub>A</sub> = +25°C	T <sub>A</sub> = T <sub>min</sub> to T <sub>max</sub>	TEST CONDITION
<b>STATIC ACCURACY</b>			
Resolution	8 Bits min	8 Bits min	
Nonlinearity <sup>1</sup>			V <sub>OUT1</sub> = V <sub>OUT2</sub> = 0V
AD7523JN	±1/2LSB max (±0.2% FSR max)	±1/2LSB max (±0.2% FSR max)	
AD7523KN	±1/4LSB max (±0.1% FSR max)	±1/4LSB max (±0.1% FSR max)	
AD7523LN	±1/8LSB max (±0.05% FSR max)	±1/8LSB max (±0.05% FSR max)	
Monotonicity	Guaranteed over T <sub>min</sub> to T <sub>max</sub>		V <sub>OUT1</sub> = V <sub>OUT2</sub> = 0V
Gain Error <sup>1,2,3</sup>	-1.5% of FSR min, +1.5% of FSR max	-1.8% of FSR min, +1.8% of FSR max	Digital Inputs = V <sub>INH</sub> V <sub>DD</sub> = +14V to +15V
Power Supply Rejection (Gain) <sup>1,2</sup>	0.02% per % max	0.03% per % max	Digital Inputs = V <sub>INH</sub>
Output Leakage Current			V <sub>OUT1</sub> = V <sub>OUT2</sub> = 0V, V <sub>REF</sub> = ±10V
I <sub>OUT1</sub> (pin 1)	±50nA max	±200nA max	Digital Inputs = V <sub>INL</sub>
I <sub>OUT2</sub> (pin 2)	±50nA max	±200nA max	V <sub>OUT1</sub> = V <sub>OUT2</sub> = 0V, V <sub>REF</sub> = ±10V Digital Inputs = V <sub>INH</sub>
<b>DYNAMIC PERFORMANCE</b>			
Output Current			To 0.2% FSR, Load = 100Ω
Settling Time <sup>4</sup>	150ns max	200ns max	Digital Inputs = V <sub>INH</sub> to V <sub>INL</sub> or V <sub>INL</sub> to V <sub>INH</sub>
Feedthrough Error <sup>4</sup>	±1/2LSB max	±1LSB max	Digital Inputs = V <sub>INL</sub> V <sub>REF</sub> = 20V p-p, 200kHz sinewave
<b>REFERENCE INPUT</b>			
Input Resistance (pin 15)	5kΩ min, 20kΩ max		V <sub>OUT1</sub> = V <sub>OUT2</sub> = 0V
Temperature Coefficient		-500ppm/°C max	
<b>ANALOG OUTPUTS<sup>4</sup></b>			
Output Capacitance			Digital Inputs = V <sub>INH</sub>
C <sub>OUT1</sub> (pin 1)	100pF max	100pF max	
C <sub>OUT2</sub> (pin 2)	30pF max	30pF max	Digital Inputs = V <sub>INL</sub>
C <sub>OUT1</sub> (pin 1)	30pF max	30pF max	
C <sub>OUT2</sub> (pin 2)	100pF max	100pF max	
<b>DIGITAL INPUTS</b>			
Logic Thresholds			
V <sub>INH</sub>	+14.5V min	+14.5V min	
V <sub>INL</sub>	+0.5V max	+0.5V max	
Input Leakage Current			V <sub>IN</sub> = 0V or +15V
I <sub>IN</sub> (per input)	±1μA max	±1μA max	
Input Capacitance			
C <sub>IN</sub> <sup>4</sup>	4pF max	4pF max	
Input Coding	Unipolar Binary of Offset Binary (see next page)		
<b>POWER REQUIREMENTS</b>			
V <sub>DD</sub> Range	+5V min, +16V max	+5V min, +16V max	Device Functionality. Accuracy is tested and guaranteed only at V <sub>DD</sub> = +15V
I <sub>DD</sub>	100μA max	100μA max	Digital Inputs = V <sub>INH</sub> or V <sub>INL</sub>

**NOTES:**

<sup>1</sup> FSR is Full Scale Range.

<sup>2</sup> Using internal feedback resistor, Full Scale Range (FSR) is equal to (V<sub>REF</sub> - 1LSB) in the unipolar circuit on the next page.

<sup>3</sup> Max gain change from +25°C to T<sub>min</sub> or T<sub>max</sub> is ±0.3% FSR.

<sup>4</sup> Guaranteed by design. Not subject to test.

Specifications subject to change without notice.

## ABSOLUTE MAXIMUM RATINGS

(T<sub>A</sub> = +25°C unless otherwise stated)

V <sub>DD</sub> to GND	-0V to +17V
V <sub>REF</sub> to GND	±25V
Digital Input Voltage (V <sub>IN</sub> ) to GND	-0.3V to V <sub>DD</sub> + 0.3V
V <sub>OUT1</sub> , V <sub>OUT2</sub> to GND	-0.3V to V <sub>DD</sub>

## Power Dissipation (Package)

To +70°C	670mW
Derate above +70°C by	8.3mW/°C
Operating Temperature Range	0 to +70°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 10sec)	+300°C

## CAUTION:

ESD (Electro-Static Discharge) sensitive device. The digital control inputs are diode 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.



## BASIC OPERATION

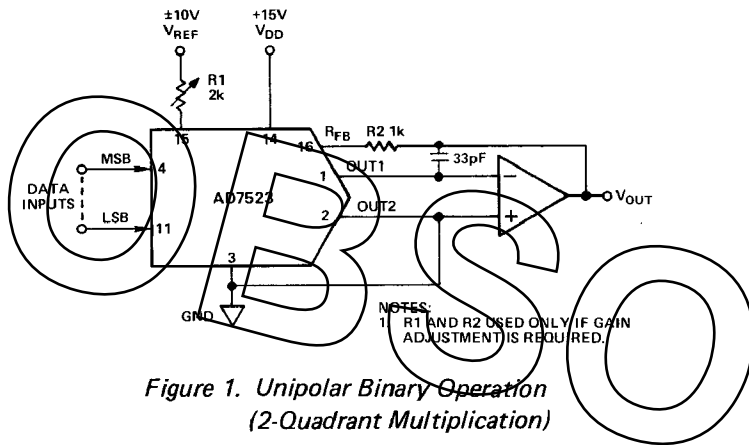


Figure 1. Unipolar Binary Operation (2-Quadrant Multiplication)

### DIGITAL INPUT ANALOG OUTPUT

MSB	LSB	ANALOG OUTPUT
1	1	$-V_{REF} \left( \frac{255}{256} \right)$
1	0	$-V_{REF} \left( \frac{129}{256} \right)$
1	0	$-V_{REF} \left( \frac{128}{256} \right) = -\frac{V_{REF}}{2}$
0	1	$-V_{REF} \left( \frac{127}{256} \right)$
0	0	$-V_{REF} \left( \frac{1}{256} \right)$
0	0	$-V_{REF} \left( \frac{0}{256} \right) = 0$

Note:  $1\text{LSB} = (2^{-8})(V_{REF}) = \left( \frac{1}{256} \right) (V_{REF})$

Table I. Unipolar Binary Code Table

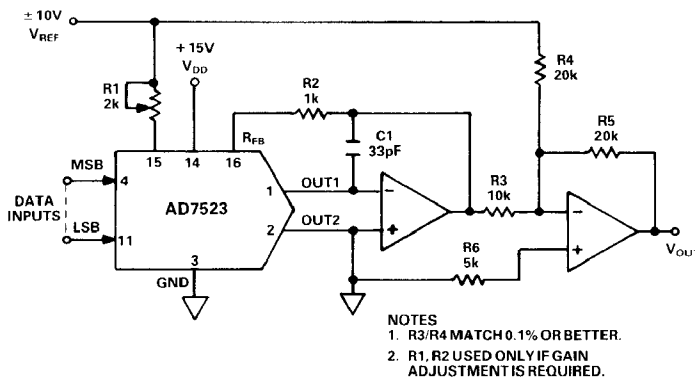


Figure 2. Bipolar (4-Quadrant) Operation

### DIGITAL INPUT ANALOG OUTPUT

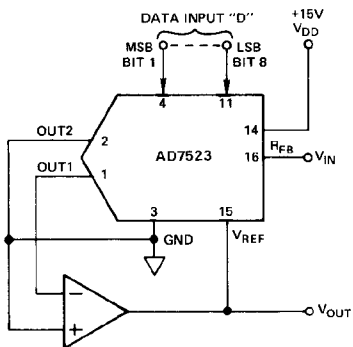
MSB	LSB	ANALOG OUTPUT
1	1	$-V_{REF} \left( \frac{127}{128} \right)$
1	0	$-V_{REF} \left( \frac{1}{128} \right)$
1	0	0
0	1	$+V_{REF} \left( \frac{1}{128} \right)$
0	0	$+V_{REF} \left( \frac{127}{128} \right)$
0	0	$+V_{REF} \left( \frac{128}{128} \right)$

Note:  $1\text{LSB} = (2^{-7})(V_{REF}) = \left( \frac{1}{128} \right) (V_{REF})$

Table II. Bipolar (Offset Binary) Code Table

# APPLICATIONS

## DIVIDER (DIGITALLY CONTROLLED GAIN)



### EQUATIONS

$$V_{OUT} = -\frac{V_{IN}}{D}$$

$$A_v = \frac{V_{OUT}}{V_{IN}} = -\frac{1}{D} \quad \text{where: } A_v = \text{Voltage Gain}$$

and where:

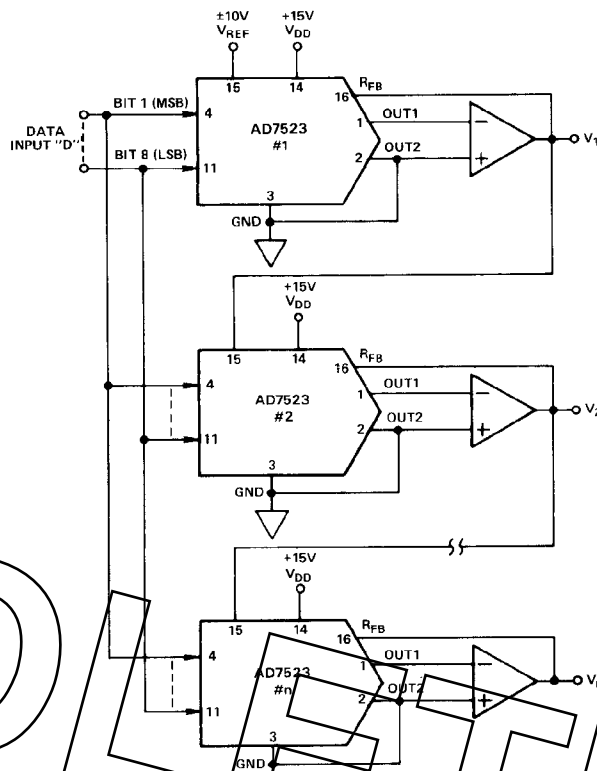
$$D = \frac{\text{BIT 1}}{2^1} + \frac{\text{BIT 2}}{2^2} + \dots + \frac{\text{BIT 8}}{2^8}$$

(BIT N = 1 or 0)

### EXAMPLES

- D = 00000000,  $A_v = -A_{v0}$  (OP AMP)
- D = 00000001,  $A_v = -\frac{1}{256}$
- D = 10000000,  $A_v = -\frac{1}{128} = -2$
- D = 11111111,  $A_v = -\frac{1}{255}$

## POWER GENERATION



### CIRCUIT EQUATIONS

$$V_1 = -(V_{REF})(D^1)$$

$$V_2 = +(V_{REF})(D^2)$$

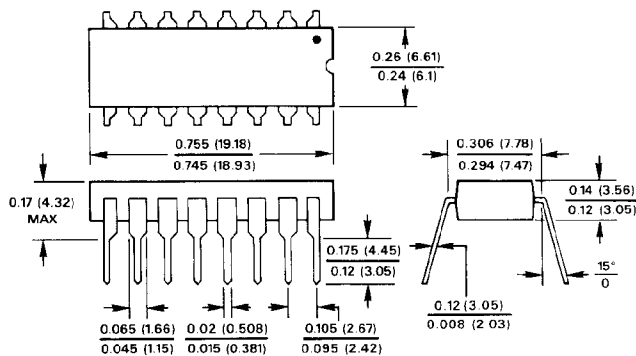
$$V_n = -(V_{REF})(D^n), n \text{ an odd integer}$$

$$V_n = +(V_{REF})(D^n), n \text{ an even integer}$$

## OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

### 16 PIN PLASTIC DIP



1. LEAD NO. 1 IDENTIFIED BY DOT OR NOTCH
2. LEADS ARE SOLDER PLATED KOVAR OR ALLOY 42.