

# Low cost 8-bit monolithic D-A converter

**ZN429E-8  
ZN429J-8  
ZN429D**

## FEATURES

- ZN429E-8 and ZN429D (SO-14)  
Commercial temperature range 0 to 70°C
- ZN429J-8  
Military temperature range -55 to +125°C
- Linearity error  $\pm \frac{1}{2}$  LSB
- Single +5V supply
- Low power consumption : 25mW typ.
- Settling time : 1 $\mu$ s typ.
- TTL and 5V CMOS compatible
- Designed for low-cost applications

## DESCRIPTION

The ZN429 is a monolithic 8-bit D-A converter, containing an R-2R ladder network of diffused resistors with precision bipolar switches.

The recent introduction of the miniature SO-14 package allows a combination of reduced size and surface mountability which enables smaller and simpler P.C.B.'s. to be constructed.

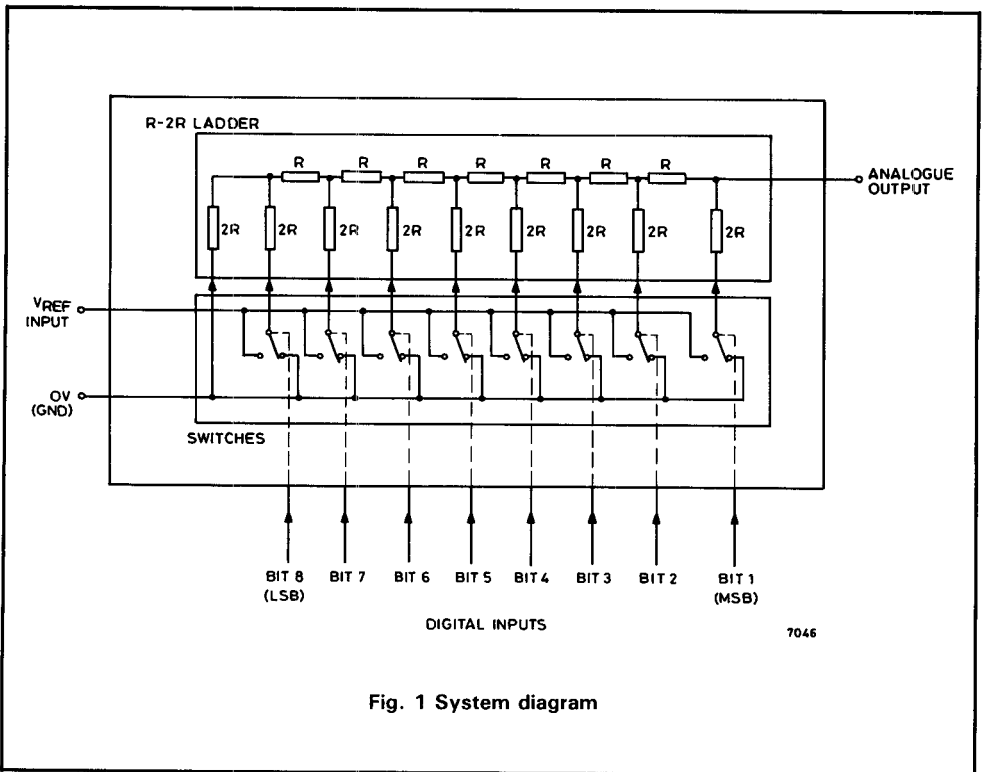


Fig. 1 System diagram

# ZN429E-8 ZN429J-8 ZN429D

## INTRODUCTION

The ZN429 is an 8-bit D-A converter. It contains an advanced design of R-2R ladder network and an array of precision bipolar switches on a single monolithic chip.

The special design of ladder network results in

full 8-bit accuracy using normal diffused resistors.

The converter is of the voltage switching type and uses an R-2R resistor ladder network as shown in Fig. 2.

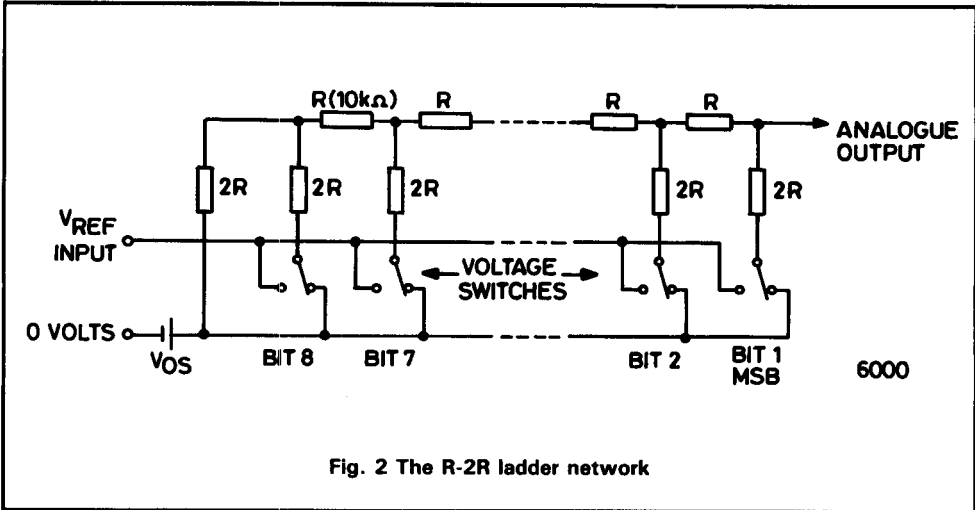


Fig. 2 The R-2R ladder network

Each 2R element is connected either to 0V or  $V_{REF}$  by transistor switches specially designed for low offset voltage (typically 1mV).

Binary weighted voltages are produced at the output of the R-2R ladder, the value depending on the digital number applied to the bit inputs.

An external fixed or varying reference is required

which should have a slope resistance less than  $2\Omega$ .

Suggested external reference sources are the ZN404 or one of the ZN458 range. Each ZN404 is capable of supplying up to five ZN429 circuits and this is increased to ten for the ZN458 range.

## ORDERING INFORMATION

Device type	Operating temperature	Package
ZN429E-8	0 to +70°C	Plastic D.I.L.
ZN429J-8	-55 to +125°C	Ceramic D.I.L.
ZN429D	0 to +70°C	Plastic SO-14

## ABSOLUTE MAXIMUM RATINGS

Supply voltage, $V_{CC}$	+7V
Max. voltage, logic and $V_{REF}$ inputs	+5.5V
Storage temperature range	-55 to +125°C

# ZN429E-8 ZN429J-8 ZN429D

**ELECTRICAL CHARACTERISTICS** (at  $T_{amb} = 25^{\circ}\text{C}$  and  $V_{CC} = +5\text{V}$  unless otherwise specified).

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
<b>Converter</b>						
Resolution		8	–	–	Bits	
Accuracy		8	–	–	Bits	
Non-linearity		–	–	$\pm 0.5$	LSB	Note 1
Differential non-linearity		–	$\pm 0.5$	–	LSB	Note 2
Settling time to 0.5LSB		–	1.0	–	$\mu\text{s}$	1 LSB step
Settling time to 0.5LSB		–	2.0	–	$\mu\text{s}$	All bits ON to OFF or OFF to ON
Offset voltage ZN429J-8 ZN429E-8, ZN429D	$V_{OS}$	–	5.0 3.0	8.0 5.0	mV mV	All bits OFF note 1
$V_{OS}$ temperature co-efficient		–	5	–	$\mu\text{V}/^{\circ}\text{C}$	
Full-scale output		2.545	2.550	2.555	V	All bits ON Ext. $V_{REF} = 2.56\text{V}$
Full-scale temperature coefficient		–	3	–	ppm/ $^{\circ}\text{C}$	Ext. $V_{REF} = 2.560\text{V}$
Non-linearity temp. co-efficient		–	7.5	–	ppm/ $^{\circ}\text{C}$	Relative to F.S.R.
Analogue output resistance	$R_O$	–	10	–	k $\Omega$	
External reference voltage		0	–	3.0	V	
Supply voltage	$V_{CC}$	4.5	–	5.5	V	
Supply current	$I_S$	–	5	9	mA	
High level input voltage	$V_{IH}$	2.0	–	–	V	
Low level input voltage	$V_{IL}$	–	–	0.7	V	
High level input current	$I_{IH}$	–	–	10 100	$\mu\text{A}$ $\mu\text{A}$	$V_{CC} = \text{max}, V_I = 2.4\text{V}$ $V_{CC} = \text{max}, V_I = 5.5\text{V}$
Low level input current	$I_{IL}$	–	–	–0.18	mA	$V_{CC} = \text{max}, V_I = 0.3\text{V}$

**Notes:**

1. The ZN429J-8 differs from the ZN429E-8 and the ZN429D in the following respects:
  - (a) For the ZN429J-8, the maximum linearity error may increase to  $\pm 0.4\%$  FSR i.e.  $\pm 1\text{LSB}$  over the temperature ranges  $-55$  to  $0^{\circ}\text{C}$  and  $+70$  to  $+125^{\circ}\text{C}$ .
  - (b) Offset voltage. The difference is due to package lead resistance. This offset will normally be removed by the setting up procedure, and because the offset temperature coefficient is low, the specified accuracy will be maintained.
2. Monotonic over full temperature range.

# ZN429E-8 ZN429J-8 ZN429D

## APPLICATIONS

### (1) Unipolar D-A converter

The nominal output range of the ZN429 is 0 to  $V_{REF IN}$  through a  $10k\Omega$  resistance. Other output ranges can readily be obtained using an external amplifier.

The resulting full-scale range is given by

$$V_{OUT FS} = \left( 1 + \frac{R1}{R2} \right) V_{REF IN} = G \cdot V_{REF IN}$$

The impedance at the inverting input is  $R1 // R2$

and for low drift with temperature this parallel combination should be equal to the ladder resistance ( $10k\Omega$ ). The required nominal values of  $R1$  and  $R2$  are given by

$$R1 = 10Gk\Omega \text{ and } R2 = 10G/(G-1) k\Omega$$

Using these relationships a table of nominal resistance values for  $R1$  and  $R2$  can be constructed for  $V_{REF IN} = 2.5V$ .

Output range	G	R1	R2
+ 5V	2	20k $\Omega$	20k $\Omega$
+ 10V	4	40k $\Omega$	13.33k $\Omega$

For gain setting  $R1$  is adjusted about its nominal value. Practical circuit realisations (including amplifier stabilising components) for + 5 and

+ 10V output ranges are given in Fig. 4. Settling time for a major transition is  $2.5\mu s$  typical.

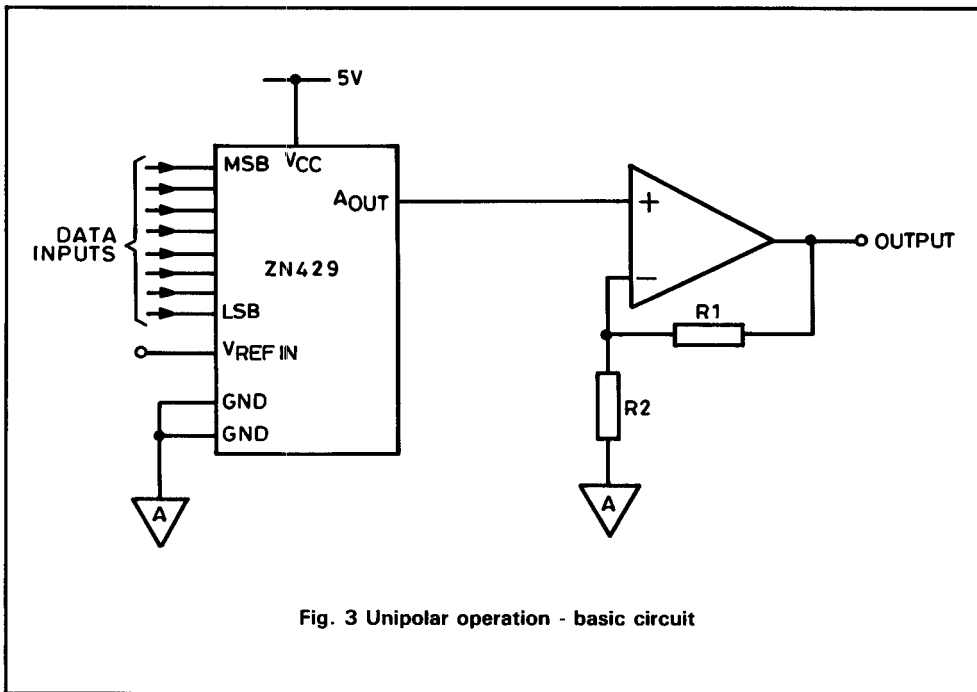
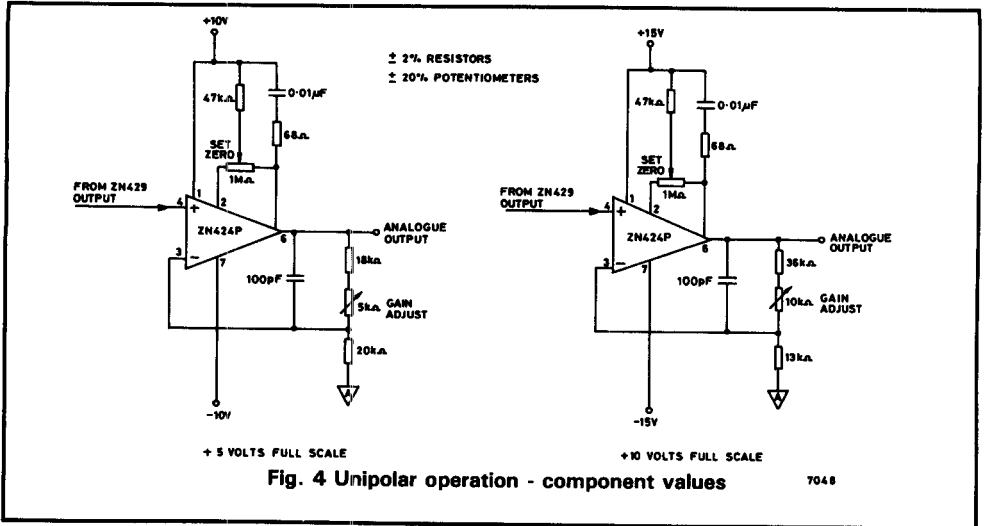


Fig. 3 Unipolar operation - basic circuit

# ZN429E-8 ZN429J-8 ZN429D



### UNIPOLAR ADJUSTMENT PROCEDURE

- (i) Set all bits to OFF (LOW) and adjust zero until  $V_{OUT} = 0.0000V$
- (ii) Set all bits ON (HIGH) and adjust gain until  $V_{OUT} = FS - 1LSB$ .

### UNIPOLAR SETTING UP POINTS

Output range, +FS	LSB	FS - 1LSB
+ 5V	19.5mV	4.9805V
+ 10V	39.1mV	9.9609V

$$1LSB = \frac{FS}{256}$$

### UNIPOLAR LOGIC CODING

Input code (Binary)	Analogue output (Nominal value)
11111111	FS - 1LSB
11111110	FS - 2LSB
11000000	$\frac{3}{4}FS$
10000001	$\frac{1}{2}FS + 1LSB$
10000000	$\frac{1}{2}FS$
01111111	$\frac{1}{2}FS - 1LSB$
01000000	$\frac{1}{4}FS$
00000001	1LSB
00000000	0

# ZN429E-8 ZN429J-8 ZN429D

## (2) Bipolar D-A converter

For bipolar operation the output from the ZN429 is offset by half full-scale by connecting a

resistor R3 between  $V_{REF IN}$  and the inverting input of the buffer amplifier (Fig. 5).

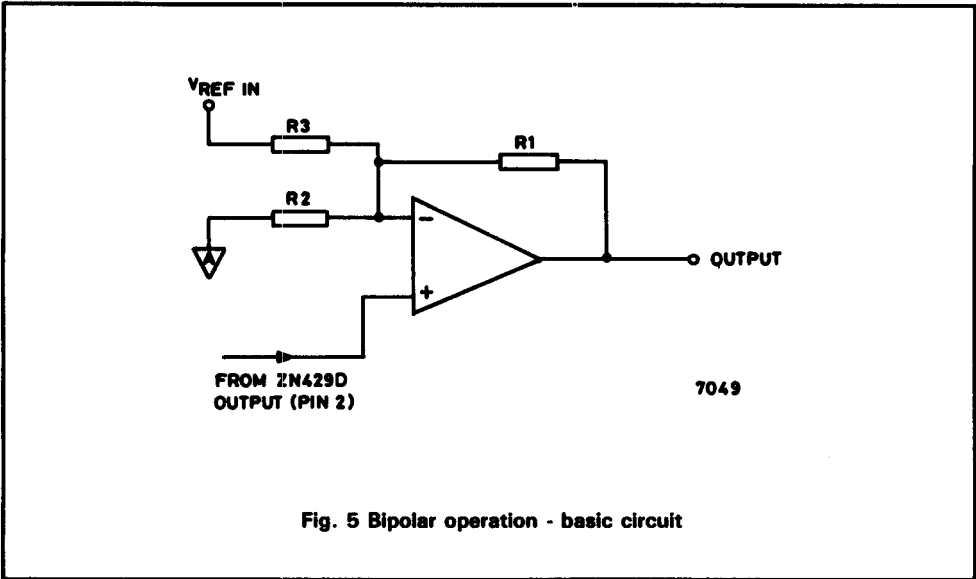


Fig. 5 Bipolar operation - basic circuit

When the digital input of the ZN429 is zero the analogue output is zero and the amplifier output should be  $-$  full-scale. An input of all ones to the D-A will give a ZN429 output of  $\approx V_{REF IN}$  and the amplifier output required is  $+$  full-scale. Also, to match the ladder resistance, the parallel combination of R1, R2 and R3 should be  $10k\Omega$ .

The nominal values of R1, R2 and R3 which meet these conditions are given by

$R1 = 20Gk\Omega$ ,  $R2 = 20G/(G-1)k\Omega$  and  $R3 = 20k\Omega$  where the resultant output range is  $\pm G.V_{REF IN}$ .

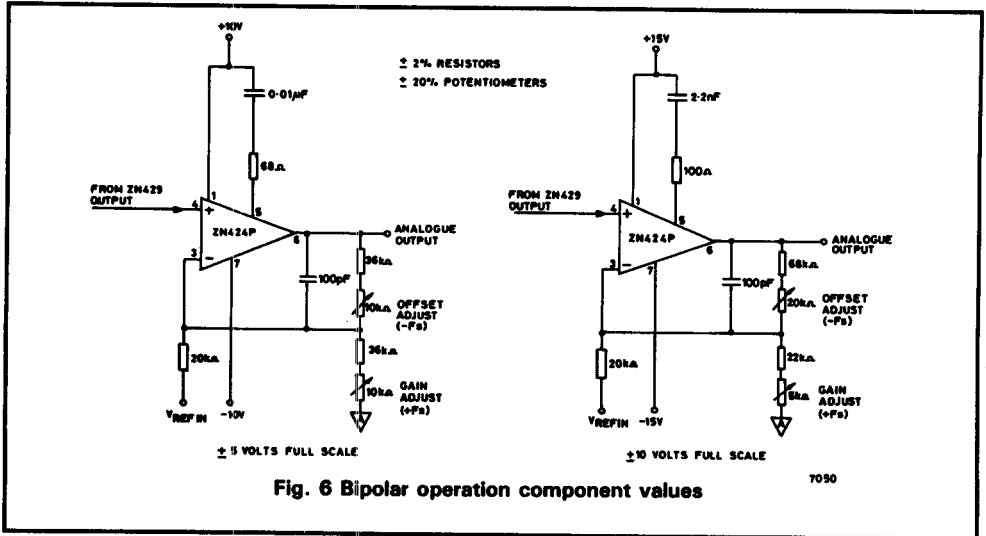
Assuming that  $V_{REF IN} = 2.5V$  the nominal values of resistors for  $\pm 5$  and  $\pm 10V$  output ranges are given in the following table.

Output range	G	R1	R2	R3
$\pm 5V$	2	$40k\Omega$	$40k\Omega$	$20k\Omega$
$\pm 10V$	4	$80k\Omega$	$26.67k\Omega$	$20k\Omega$

Minus full-scale (OFFSET) is set by adjusting R1 about its nominal value relative to R3. Plus full-scale (GAIN) is set by adjusting R2 relative to R1

Settling time for a major transition is  $2.5\mu s$  typical.

# ZN429E-8 ZN429J-8 ZN429D



**Fig. 6 Bipolar operation component values**

7030

### BIPOLAR ADJUSTMENT PROCEDURE

- (i) Set all bits to OFF (LOW) and adjust OFFSET until the amplifier output reads - FULL-SCALE.
- (ii) Set all bits ON (HIGH) and adjust gain until the amplifier reads + (FULL-SCALE - 1LSB).

### BIPOLAR SETTING UP POINTS

Input range, $\pm$ FS	LSB	- FS	+ (FS - 1LSB)
$\pm 5V$	39.1mV	- 5.0000V	+ 4.9609V
$\pm 10V$	78.1mV	- 10.0000V	+ 9.9219V

$$1\text{LSB} = \frac{2\text{FS}}{256}$$

### BIPOLAR LOGIC CODING

Input code (Offset binary)	Analogue output (Nominal value)
11111111	+ (FS - 1LSB)
11111110	+ (FS - 2LSB)
11000000	+ $\frac{1}{2}$ FS
10000001	+ 1LSB
10000000	0
01111111	- 1LSB
01000000	- $\frac{1}{2}$ FS
00000001	- (FS - 1LSB)
00000000	- FS

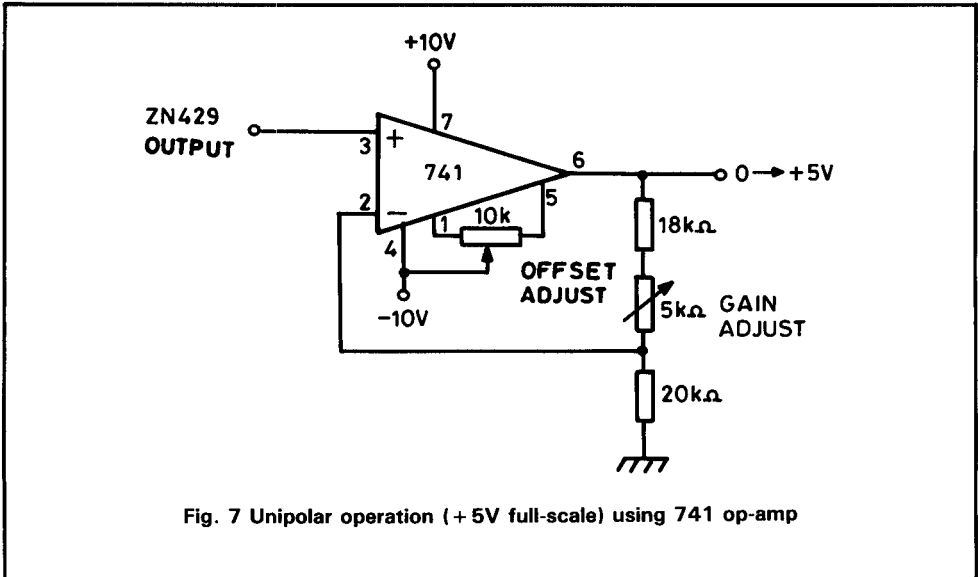
# ZN429E-8 ZN429J-8 ZN429D

For both unipolar and bipolar operation, an alternative output buffer, employing the 741 operational amplifier, or any other suitable op-amp, may be used.

The feedback resistors chosen are as indicated

in the relevant sections.

The following circuit shows the use of the 741 in the unipolar operation mode for a voltage output range of 0→5V with a 2.5V reference.





# ZN429E-8 ZN429J-8 ZN429D

## PIN CONNECTIONS

