

# MULTIPLIER - DIVIDER

### **FEATURES**

- DIFFERENTIAL INPUTS
- LASER-TRIMMED
- GUARANTEED ACCURACY 0.5% and 1%
- SELF-CONTAINED
   No additional parts required
- LOW NOISE 120Vrms, 10Hz – 10kHz
- DIP PACKAGE

## APPLICATIONS

- MULTIPLICATION
- DIVISION
- SQUARING
- SQUARE ROOTING
- ADAPTIVE CONTROL
- ALGEBRAIC COMPUTATION
- POWER COMPUTATION

# DESCRIPTION

The 4214 family of multipliers are low-cost integrated circuit multiplier/dividers designed for general purpose usage. In addition to four-quadrant multiplication, they also perform division and square rooting of analog signals. They do not require use of additional amplifiers to perfrom these functions. The 4214 is laser-trimmed prior to final packaging and is guaranteed to its rated accuracy with no external components—a distinct advantage from standpoints of cost and reliability.

The 4214 contains its own zener-regulated references and, as a result, is much less sensitive to supply voltage variation than were earlier IC multipliers. The multipliers' output noise is only 120Vrms in a 10Hz to 10kHz bandwidth.

The unit is packaged in a 14-pin ceramic DIP package and available in both -25°C to +85°C and -55°C to +125°C specification temperature ranges.

# **SPECIFICATIONS**

### **ELECTRICAL**

Typical performance at +25°C with rated power supplies unless otherwise noted.

OUTPUT FUNCTION	(X, - X-) (		
	$\frac{(X_1 - X_2)(Y_1 - Y_2)}{10} + Z_2$		
TOTAL ERROR(1)			
Without Trimming Error vs Temperature (-25°C to +85°C), (AP and BP) (-55°C to +125°C), (RM and SM)	1% max 0.5% max 0.008%; "C typ., 0.02%; "C max 0.025%; "C typ., 0.05% "C max		
Error vs Supply	0.05%/%		
INDIVIDUAL ERRORS			
Output Offset	10mV typ	7mV typ	
vs Temperature	50mV max 0.7mV/°C typ 2mV/°C max	25mV max 0.3mV/°C typ 0.7mV/°C max	
vs Supply	0.25m		
Scale Factor Error	0.12%		
vs Temperature	0.008%; °C 0.05%; %		
vs Supply Nonlinearity	0.03	70 70	
$X(X = 20V p-p, Y = \pm 10VDC)$	±0.0	08%	
$Y(Y = 20V p-p, X = \pm 10VDC)$		01%	
Feedthrough at 50 Hz			
X = 20V p-p. Y = 0	30mV p-p		
Y = 20V p-p, X = 0	6mV p-p		
vs Temperature		V p-p:°C	
vs Supply	0.15mV	p-p. %	
AC PERFORMANCE			
Small Signal ±3dB Flatness	610	kHz	
Small Signal ±1% Flatness	90 kHz		
Small Signal ±1% Vector Error (0.57" Phase Shift)	7.5 kHz		
Full Power Bandwidth	330 kHz		
Sirw Rate	23V - µs 1.7µs		
Settling Time to 1% (20V step)	1	γμ3	
OUTPUT NOISE (X = Y = 0)			
10 Hz to 10 kHz		V rms	
10 Hz to 10 MHz	700µ	V rms	
INPUT CHARACTERISTICS			
Input Voltage Range			
Rated Operation, min.		10V	
Absolute max		±V.	
Input Impedance, X, Y, Z'a		Mn	
Input Bias Current, X. Y. Z	ļ.,	4μΛ	
OUTPUT CHARACTERISTICS			
Rated Output		±5mA min	
Output Impedance		1.50	
POWER SUPPLY REQUIREMENTS			
Rated Voltage	1 ±	15V	
Operating Range		to ±20VDC	
Quiescent Current	±5	5.5mA	
	1410	1- AREVO	
TEMPEDATURE DANCE			
TEMPERATURE RANGE		to +85°C	
TEMPERATURE RANGE AP and BP Rated Performance (specification) RM and SM Operation	-55°C	10 +125°C 10 +125°C	

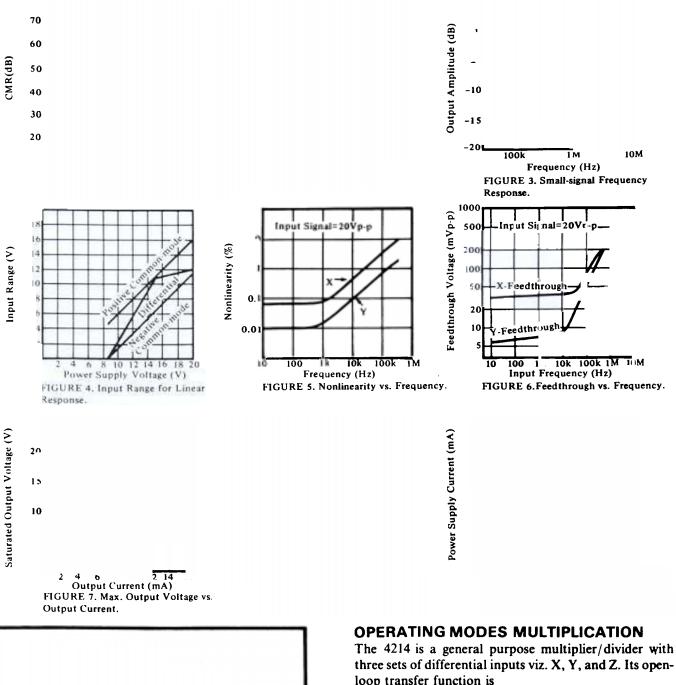
### **MECHANICAL**

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### **CONNECTION DIAGRAM**

- 1. Total error is the maximum allowed value of the sum of the individual errors.
- 2.  $Z_2$  input impedance is 10 M $\Omega$  typ with Pin 11 open circuit. If Pin 11 is grounded or used for optional offset adjustment the  $Z_2$  input impedance may become as low as 25k $\Omega$ .

## TYPICAL PERFORMANCE CURVES



three sets of differential inputs viz. X, Y, and Z. Its openloop transfer function is

$$e_0 = A \left[ \frac{(X_1 - X_2)(Y_1 - Y_2)}{10} - (Z_1 - Z_2) \right]$$

where, A is the open-loop gain of the internal output amplifier (see the simplified equivalent circuit, Figure 10). Due to very high gain  $(A \rightarrow \infty)$  of the output amplifier the feedback from the output to any of the inputs will establish the relationship

$$Z_1 - Z_2 = (X_1 - X_2) (Y_1 - Y_2) / 10$$

Taking output at Z<sub>1</sub> the multiplication mode transfer function is obtained and is expressed as

$$e_0 = \frac{(X_1 - X_2)(Y_1 - Y_2)}{10} + Z_2.$$

This connection of 4214 is shown on page 2.

#### DIVISION

The 4214 may be used as a two quadrant divider, without the need for an external op amp. Note that the maximum output error in the divide mode is given approximately by,

Divider error 
$$\simeq \frac{10 \in m}{X_1 - X_2}$$
, where  $\in m$  is

the total error specified for the multiply mode. The divider error, as shown above, becomes excessively large for small values of  $(X_1 - X_2)$ . A 10:1 denominator range is usually the practical limit. This is true for all such units, where a multiplier is used in voltage feedback mode to generate "divide" function.

If more accurate division is required over wide range of denominator voltages, the Burr-Brown model 4291 is recommended (0.25% max error over 100:1 range).

For optimum performance, the Z offset should be nulled by letting the input be zero and adjusting  $R_1$  for zero output. This offset adjustment will improve the divider error to about  $3 \\in \\mathred{m}$  for  $(X_1 - X_2)$  much less than 10V.  $(X_1 - X_2)$ 

FIGURE 11. Divide Mode Connections—4214.

#### **SQUARE ROOT**

By applying feedback from the output to both the X and Y inputs, the square root function can be obtained. The errors in the square root mode become large for small values of Z input. The actual output is approximately

Square root output  $e_0 = \sqrt{10(Z_1 - Z_2) + 10} \in m$ where  $\in m$  is the total error for the multiply mode.

Burr-Brown's multifunction converter model 4302 is recommended for applications requiring more accuracy over wider dynamic range.

The output offset should be nulled for optimum performance by allowing the input to be its smallest expected value and adjusting  $R_1$  for the proper output voltage.

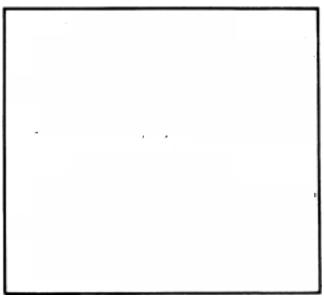


FIGURE 12. Square Root Mode Connections—4214.

### SINE FUNCTION GENERATOR

Two 4214's can be connected with implicit feedback as shown in Figure 13 to implement the following sine function approximation.

$$e_0 = \frac{1.5715 e_i - 0.004317 e_i^3}{1 + 0.001398 e_i^2} = 10 \sin 9 e_i$$

The theory and procedures for developing virtually any function generator or linearization circuit can be found in the new Burr-Brown/McGraw Hill book "FUNCTION CIRCUIT - Design and Applications."

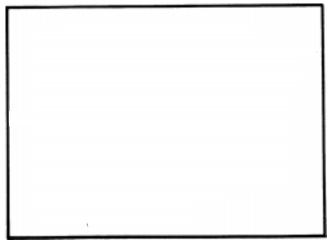


FIGURE 13. Sine Function Connections—4214.

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### PACKAGE OPTION ADDENDUM

www.ti.com 16-Jun-2009

#### PACKAGING INFORMATION

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
4214AP	NRND	CDIP SB	JD	14	TBD	Call TI	Call TI

<sup>(1)</sup> The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

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(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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