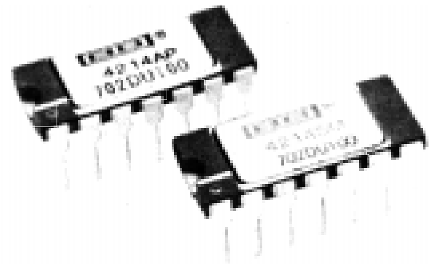
BURR-BROWN®

4214



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.

SBOS176

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SPECIFICATIONS

ELECTRICAL

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

MODEL	4214AP/RM	4214BP/SM
OUTPUT FUNCTION	$\frac{(X_1 - X_2)(Y_1 - Y_2)}{10} + Z_2$	
TOTAL ERROR[1]		
Without Trimming	1% max	0.5% max
Error vs Temperature (-25°C to +85°C), (AP and BP)	0.008%/°C typ., 0.02%/°C max	
(-55°C to +125°C), (RM and SM)	0.025%/°C typ., 0.05%/°C max	
Error vs Supply	0.05%/%	
INDIVIDUAL ERRORS		
Output Offset	10mV typ 50mV max	7mV typ 25mV max
vs Temperature	0.7mV/°C typ 2mV/°C max	0.3mV/°C typ 0.7mV/°C max
vs Supply	0.25mV/%	
Scale Factor Error	0.12%	
vs Temperature	0.008%/°C	
vs Supply	0.05%/%	
Nonlinearity		
X(X = 20V p-p, Y = ±10VDC)	±0.08%	
Y(Y = 20V p-p, X = ±10VDC)	±0.01%	
Feedthrough at 50 Hz		
X = 20V p-p, Y = 0	30mV p-p	
Y = 20V p-p, X = 0	6mV p-p	
vs Temperature	0.1mV 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	
Slew Rate	23V/μs	
Settling Time to 1% (20V step)	1.7μs	
OUTPUT NOISE (X = Y = 0)		
10 Hz to 10 kHz	120μV rms	
10 Hz to 10 MHz	700μV rms	
INPUT CHARACTERISTICS		
Input Voltage Range		
Rated Operation, min.	±10V	
Absolute max	±V_s	
Input Impedance, X, Y, Z[2]	10 MΩ	
Input Bias Current, X, Y, Z	1.4μA	
OUTPUT CHARACTERISTICS		
Rated Output	±10V at ±5mA min	
Output Impedance	1.5Ω	
POWER SUPPLY REQUIREMENTS		
Rated Voltage	±15V	
Operating Range	±8.5VDC to ±20VDC	
Quiescent Current	±5.5mA	
TEMPERATURE RANGE		
Rated Performance (specification) AP and BP	-25°C to +85°C	
Rated Performance (specification) RM and SM	-55°C to +125°C	
Operation	-55°C to +125°C	
Storage	-65°C to +150°C	

1. Total error is the maximum allowed value of the sum of the individual errors.
2. Z_2 input impedance is 10 MΩ 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 25kΩ.

MECHANICAL

Ceramic Dual-In-Line

NOTE: Leads in true position within 0.010" (0.25mm) R at MMC at seating plane.

Pin numbers shown for reference only. Numbers may not be marked on package.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	.670	.710	17.02	18.03
C	.065	.170	1.65	4.32
D	.015	.021	0.38	0.53
F	.045	.060	1.14	1.52
G	.100 BASIC		2.54 BASIC	
H	.025	.070	0.64	1.78
J	.008	.012	0.20	0.30
K	.120	.240	3.05	6.10
L	.300 BASIC		7.62 BASIC	
M	—	10°	—	10°
N	.009	.060	0.23	1.52

CONNECTION DIAGRAM

TYPICAL PERFORMANCE CURVES

CMR(dB)
70
60
50
40
30
20

Output Amplitude (dB)
-10
-15
-20
100k 1M 10M
Frequency (Hz)

FIGURE 3. Small-signal Frequency Response.

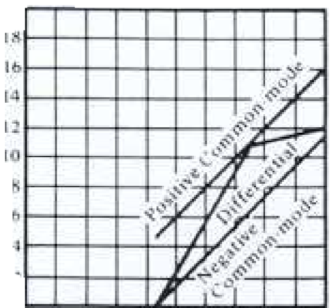

FIGURE 4. Input Range for Linear Response.

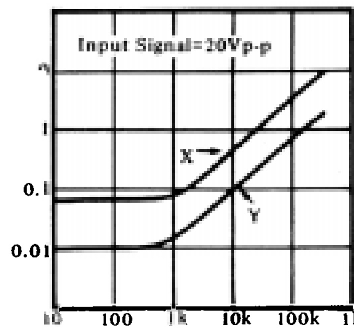

FIGURE 5. Nonlinearity vs. Frequency.

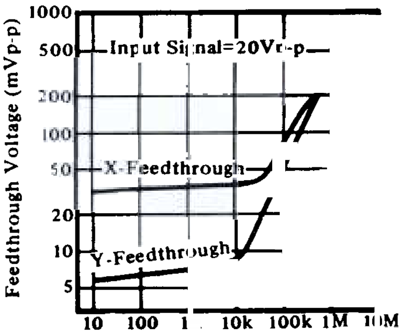

FIGURE 6. Feedthrough vs. Frequency.

Saturated Output Voltage (V)
20
15
10
2 4 6 14
Output Current (mA)

FIGURE 7. Max. Output Voltage vs. Output Current.

Power Supply Current (mA)

FIGURE 10. Simplified Equivalent Circuit.

OPERATING MODES MULTIPLICATION

The 4214 is a general purpose multiplier/divider with three sets of differential inputs viz. X, Y, and Z. Its open-loop transfer function is

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

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_1 the multiplication mode transfer function is obtained and is expressed as

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

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,

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

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 $\frac{3\,\epsilon m}{(X_1 - X_2)}$ for $(X_1 - X_2)$ much less than 10V.

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

$$\text{Square root output } e_o = \sqrt{10\,(Z_1 - Z_2) + 10\,\epsilon m}$$

where ϵm 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.

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

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.

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
4214AP	NRND	CDIP SB	JD	14	27	Green (RoHS & no Sb/Br)	Call TI	N / A for Pkg Type
4214BP	NRND	CDIP SB	JD	14	27	Green (RoHS & no Sb/Br)	Call TI	N / A for Pkg Type

[1] 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.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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