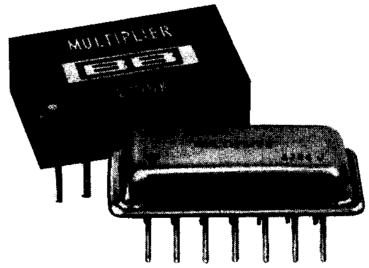
BURR-BROWN®



4204
4206

ANALOG MULTIPLIER-DIVIDER

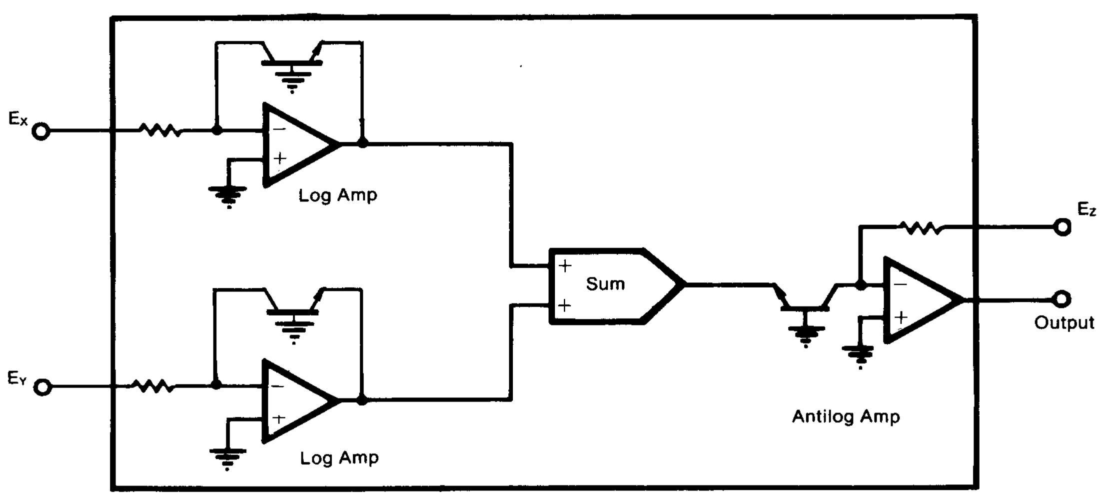
FEATURES

- **HIGH TOTAL ACCURACY**
  0.25% and 0.5% max, no external trims
  0.1% and 0.2% typ. with external trims
- **LOW TEMPERATURE DRIFT**
  100ppm/°C
- **SMALL PACKAGE**
  Dual-in-line metal or plastic
- **LOW COST**

DESCRIPTION

The 4204 and 4206 are four-quadrant analog multipliers offering high accuracy, low noise, and moderate bandwidth at low cost. They use the log/antilog technique and are internally laser-trimmed. Multiply mode accuracies of 0.25% and 0.5% max are guaranteed with no external components. By following the external trim procedure described in the Multiplication section, accuracies can be improved to 0.1% and 0.2% (typical). Accuracy specifications are verified at Burr-Brown by an automatic tester which scans the X-Y plane. Maximum error at any point in the plane is required to be less than the specified values.

The 4204 and 4206 also perform the divide function in two quadrants and the square root function in one quadrant with no external components required. Detailed instructions for these operations are given on the last page.



International Airport Industrial Park - P.O. Box 11400 - Tucson, Arizona 85734 - Tel. (602) 746-1111 - Twx: 910-952-1111 - Cable: BBRCORP - Telex: 66-6491

SPECIFICATIONS

ELECTRICAL

Typical performance at +25°C with rated power supplies unless otherwise noted. Percent specifications refer to percent of full scale (10V).

MODEL	4204J, 4206J	4204K, 4206K	4204S
OUTPUT FUNCTION	$E_X E_Y / 10$	*	*
TOTAL ERROR (Multiply Mode)(1)			
Internal trim, max(2)	0.5% max	0.25% max	*
External trim, typ	0.2%	0.1%	0.1%
vs Temperature	0.01%/°C	*	0.02%/°C max
vs Supply	0.02%/%	*	*
INDIVIDUAL ERRORS (Multiply Mode)			
Output Offset X = Y = 0	15mV	5mV	5mV
Scale Factor Error	0.2%	0.1%	0.1%
Nonlinearity:			
X = 20V, p-p, Y = −10VDC	0.005%	*	*
Y = 20V, p-p, X = −10VDC	0.005%	*	*
X = 20V, p-p, Y = +10VDC	0.05%	*	*
X = 20V, p-p, X = +10VDC	0.05%		*
Feedthrough at 50Hz:			
X = 20V, p-p, Y = 0	10mV, p-p		5mV, p-p
Y = 20V, p-p, X = 0	10mV, p-p		5mV, p-p
AC PERFORMANCE			
Slew Rate	1V/μs	*	*
−3dB Small Signal Bandwidth	250kHz	*	*
1% Amplitude Error	33kHz	*	*
1% Vector Error (0.57° phase shift)	2.5kHz	*	*
Full Power Response	20kHz	*	*
OUTPUT NOISE X = Y = 0.0V			
DC to 10kHz	300μV, rms	*	*
INPUT CHARACTERISTICS			
Input Voltage:			
Maximum for Rated Specifications X, Y, Z	±10V	*	*
Maximum Safe Level X, Y, Z	±Supply	*	*
Input Impedance X/Y/Z	25kΩ/25kΩ/100kΩ	*	*
OUTPUT CHARACTERISTICS			
Rated Output: Voltage, min	±10V	*	*
Current, min	±5mA	*	*
Output Impedance	1Ω	*	*
POWER SUPPLY REQUIREMENTS			
Rated Supply	±15VDC	*	*
Operating Range	±14 to ±16V	*	*
Quiescent Current	+15mA, −8.5mA	*	*
TEMPERATURE RANGE, 4206			
Specification	0°C to +70°C	*	
Operating	−25°C to +85°C	*	
Storage	−55°C to +125°C	*	
TEMPERATURE RANGE, 4204			
Specification	−25°C to +85°C	*	−55°C to +125°C
Operating	−55°C to +125°C	*	*
Storage	−65°C to +125°C	*	*

*Same as for 4206J.

NOTES: (1) Total error is a tested maximum and does not represent a sum of the maximum individual errors as the maximum individual errors do not occur at the same X, Y operating point. (2) With output loading of 10kΩ or less.

PIN CONNECTIONS 4204

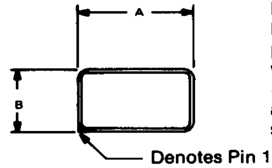
1 E_Z
2 Output
3 $-V_S$
4 Feedthrough Adjust
5 Make No Connection
6 Make No Connection
7 E_X
8 Internal Reference
9 Make No Connection
10 Ground
11 Feedthrough Adjust
12 Offset Adjust
13 E_Y
14 $+V_S$

PIN CONNECTIONS 4206

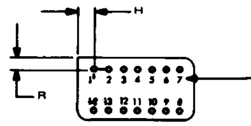
1 E_Z
2 Output
3 $-V_S$
4 Feedthrough Adjust
5 Make No Connection
6 Make No Connection
7 E_X
8 Internal Reference
9 Make No Connection
10 Ground
11 Feedthrough Adjust
12 Offset Adjust
13 E_Y
14 $+V_S$

MECHANICAL

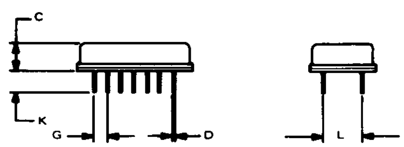
4204



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

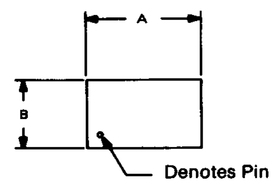


Pin numbers shown for reference only. Numbers are not marked on package.

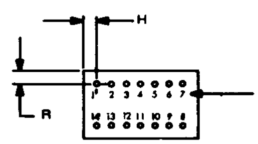


DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.860	.880	21.84	22.35
B	.490	.510	12.45	12.95
C	.170	.250	4.32	6.35
D	.016	.021	0.41	0.53
G	.100 BASIC		2.54 BASIC	
H	.115	.155	2.92	3.94
K	.150	.300	3.81	7.62
L	.300 BASIC		7.62 BASIC	
R	.080	.120	2.03	3.05

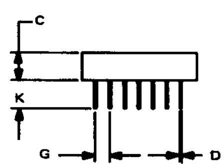
4206



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

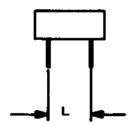


Pin numbers shown for reference only. Numbers are not marked on package.



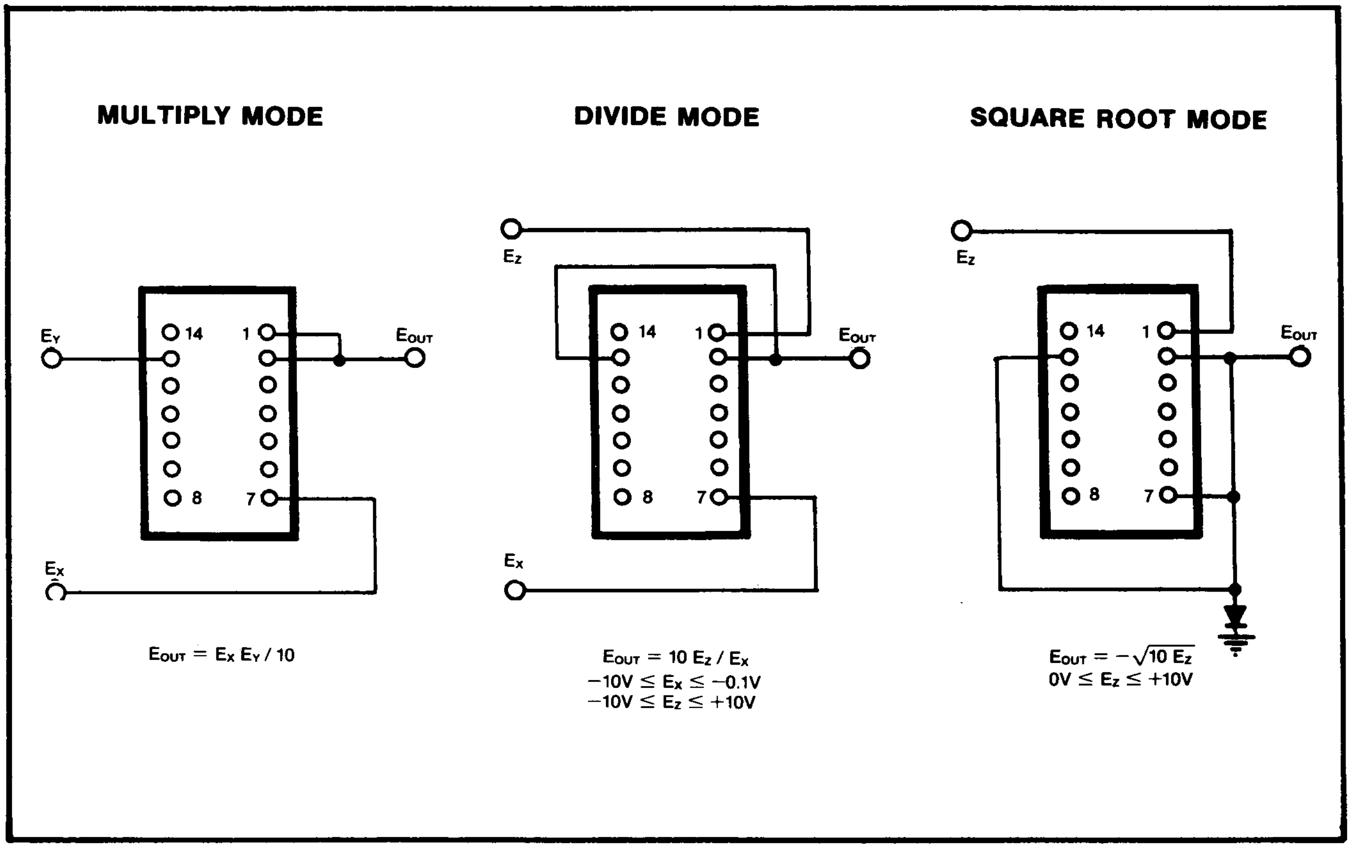
PIN SPACING: 2.5mm (0.1")
ROW SPACING: 7.6mm (0.300")
WEIGHT: 3.4 grams (0.12 oz.)
CONNECTOR: 14-pin DIP 0145MC

Pin material and plating composition conform to Method 208 (solderability) of MIL-STD-202.



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.790	.810	20.07	20.57
B	.490	.510	12.45	12.95
C	.190	.210	4.83	5.33
D	.018	.021	0.46	0.53
G	.100 BASIC		2.54 BASIC	
H	.080	.115	2.03	2.92
K	.130	.300	3.30	7.62
L	.300 BASIC		7.62 BASIC	
R	.080	.115	2.03	2.92

OPERATING MODES



ADJUSTMENTS

Although the products will achieve specified performance in the multiply mode with no external trimming, optimized performance can be achieved with external adjustments. The proper connections and the trim procedures are explained below.

The 4204 and 4206 will operate within specification with any combination of input signals. The best performance, however, will be obtained in the second, third, and fourth quadrants. That is, if four quadrant operations are not needed, the performance can be optimized by constraining operation to quadrants 2, 3 and 4 rather than 1.

MULTIPLICATION

Multiplication Trim Procedure (Figure 1)

1) Set $E_X = 0$ and apply a 10Vp-p sine wave (50Hz) to E_Y: Adjust R_1 for minimum output.
2) Set $E_Y = 0$ and apply a 10Vp-p sine wave (50Hz) to E_X: Adjust R_2 for minimum output.
3) Set $E_X = E_Y = 0$: Adjust R_3 for $E_{OUT} = 0.00V$.
4) Set $E_X = E_Y = +10.000V \pm 1mV$: Adjust R_4 for $E_{OUT} = +10.000V \pm 2mV$.

P

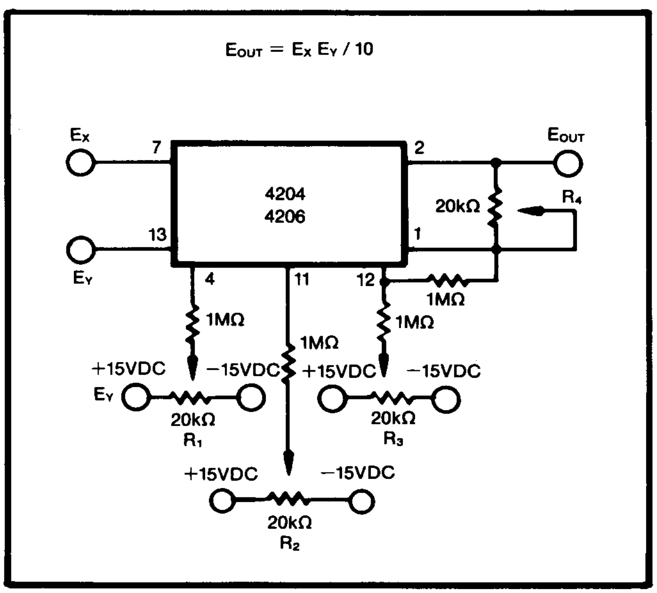


FIGURE 1. Multiplication Trim Procedure.

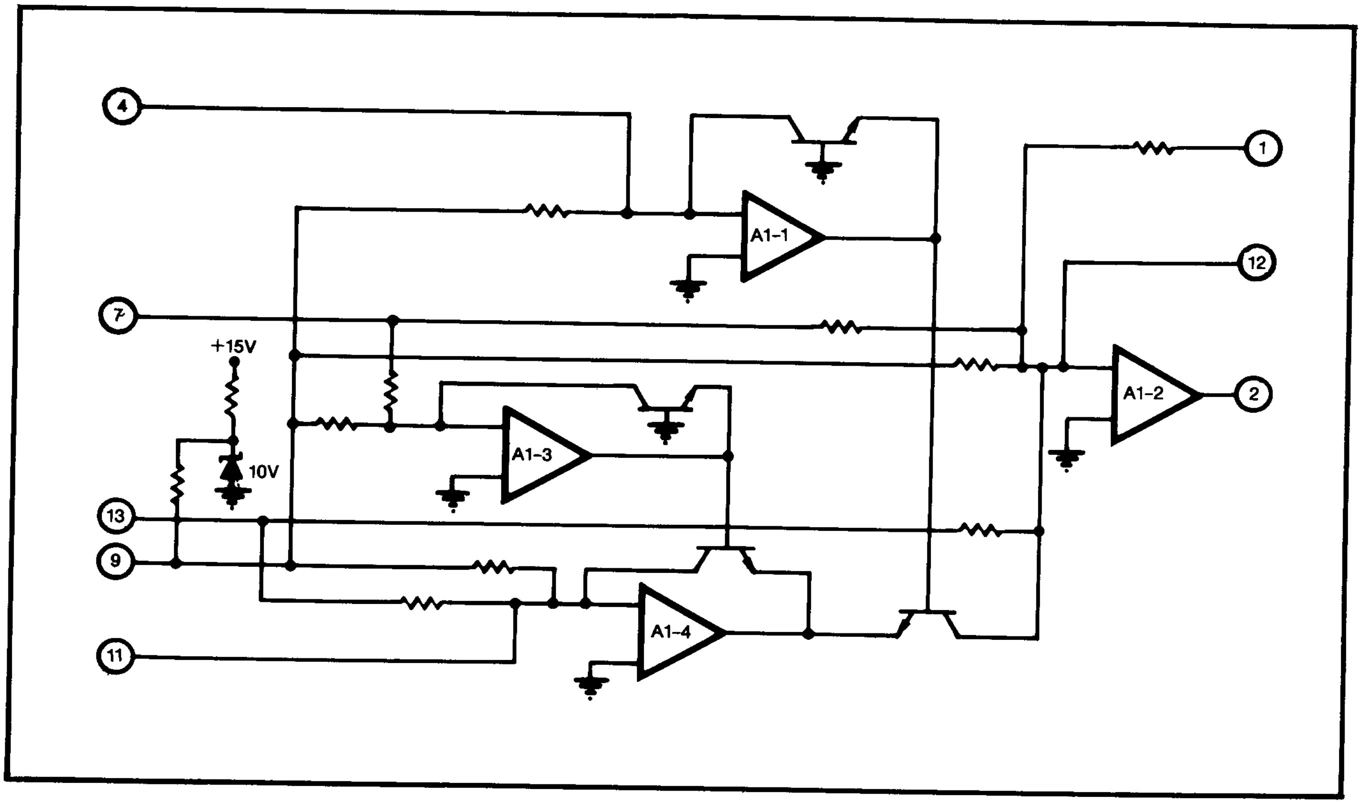
OUTPUT DISTORTION

The output distortion of the 4204 and 4206 is of most interest in modulator applications. The curve for Output Distortion characterizes this distortion with one input held at +10 or −10VDC. A sine wave is applied to the other input. The sine wave amplitude is held constant at 20Vp-p while frequency is varied.

AC FEEDTHROUGH

This variation of feedthrough as a function of frequency is illustrated in the curve above. One of the inputs is a zero while a 20Vp-p sine wave is applied at the other input. The output feedthrough generally has substantial harmonic content and is measured in millivolts, peak-to-peak.

THEORY OF OPERATION



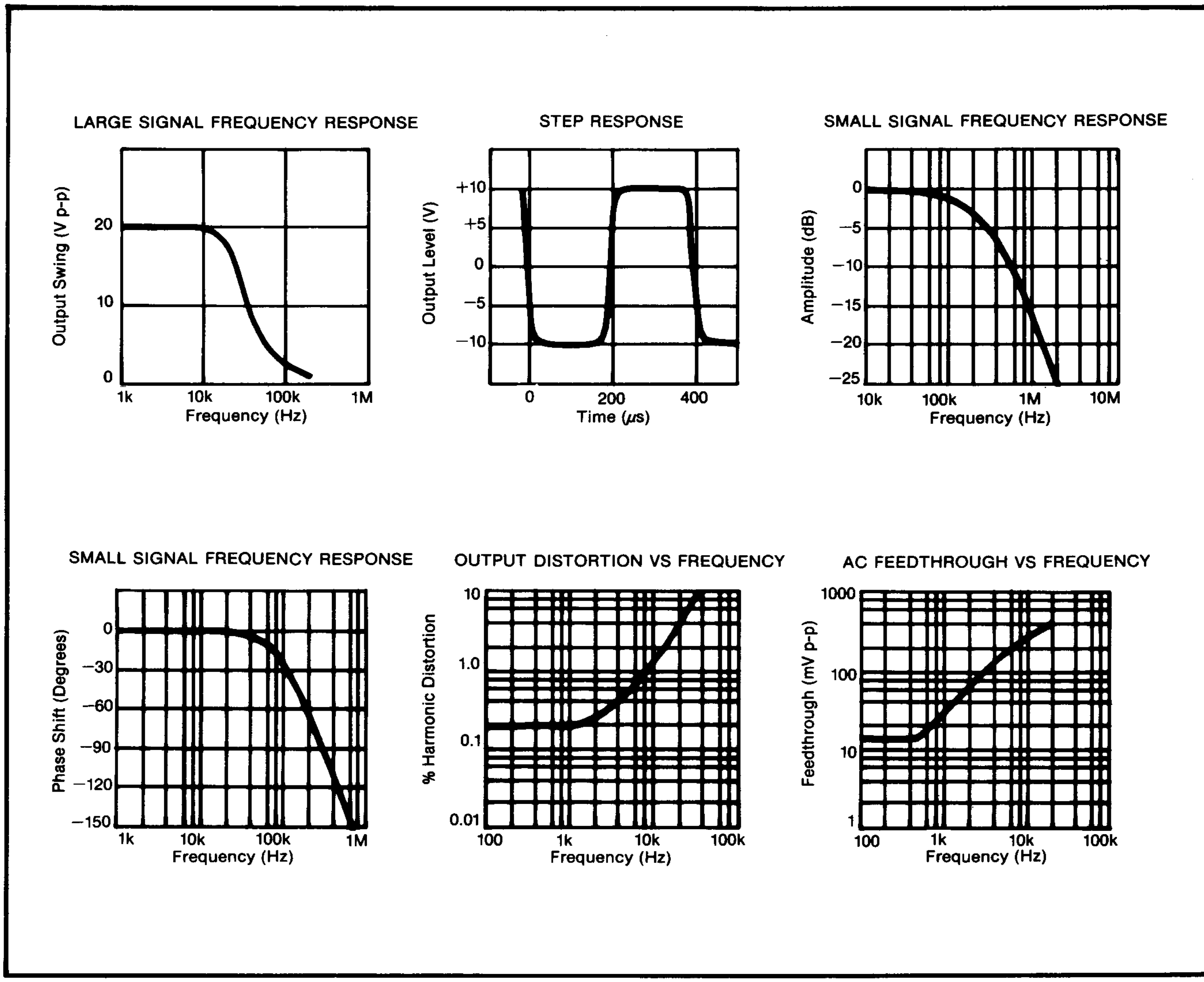
These products' log-antilog multiplication technique is based upon the logarithmic voltage-current relationship in a semiconductor junction. This action is shown by the simplified equation:

$$V_{BE} = (KT/q)(\ln I_C - \ln I_S)$$

where V_{BE} is the transistor's emitter-base voltage, I_C is the transistor collector current, I_S is the collector saturation current, K is Bolzmann's constant, q is the charge of one electron and T is the absolute temperature in degrees Kelvin. As can be seen from the equation, the logarithmic function is extremely temperature sensitive. The 4204 and 4206, however, have excellent temperature characteristics because the log and antilog circuitry have equal and opposite temperature drifts which cancel to a first order approximation. The log and antilog circuits will compensate each other to the extent that the various logging transistors are matched to each other. These transistors are placed adjacently on a monolithic chip to obtain the best possible matching, and so the best possible performance.

TYPICAL PERFORMANCE CURVES

At +25°C and ±15VDC.



DISCUSSION OF PERFORMANCE CURVES

LARGE SIGNAL FREQUENCY RESPONSE

This response curve describes the output voltage capability of the 4204 and 4206 as a function of frequency. The measurement is made with one input at +10 or −10VDC, and with a sine wave applied at the other input. An output distortion of 0.5% is allowed.

STEP RESPONSE

Step response is measured with one input at +10 or −10VDC and with a 20Vp-p square wave applied at the other input.

SMALL SIGNAL FREQUENCY RESPONSE

These curves are the amplitude and phase response of the 4204 and 4206's transfer function, when one input is held at +10 or −10VDC. A sine wave signal is applied to the other input. Small signal response requires that the amplitude of the input sine wave be adjusted so that the output signal does not reach the slew rate limitation.

DIVISION

The 4204 and 4206 may be used as a two-quadrant divider without the need for an external operational amplifier. It should, however, be noted that the maximum output error is approximately given by

$$\text{divider error} \approx 10\varepsilon_M / E_X$$

where ε_M is the total error specification for the multiply mode. Obviously, divider error becomes excessively large for small values of E_X. A 10:1 denominator range is usually the practical limit. If accurate division is required over a wide dynamic range of denominator voltage, the Burr-Brown Model DIV100 is recommended (0.25% max., over a 40:1 range).

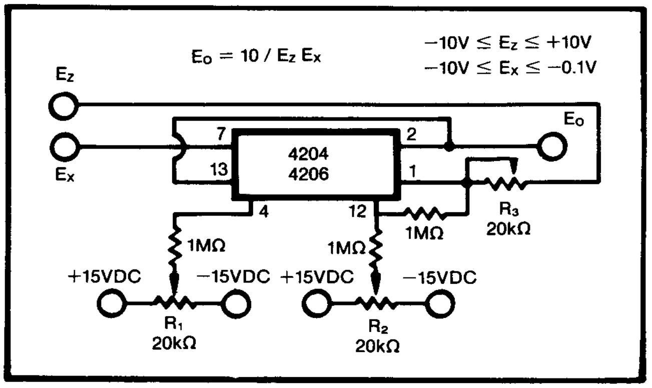


FIGURE 2. Division Trim Procedure.

Division Trim Procedure (Figure 2)

1) Set all potentiometers near mid-scale.
2) Set $E_Z = 0V$, $E_X \approx -10V$, adjust R_2 such that $E_O = 0.000V \pm 2mV$.
3) Set $E_X = E_Z = -10.000VDC \pm 2mV$, adjust R_3 such that $E_O = +10.000VDC \pm 2mV$.
4) Set $E_X = E_Z \approx$ minimum value required by application, adjust R_1 such that $E_O = +10.000VDC \pm 5mV$.
5) Repeat steps 2 through 4 if necessary.

SQUARE ROOT

The pin connections for the Square Root mode of operation are similar to those for division, except that the denominator input is connected to the output node. Errors in the Square root mode of operation become troublesome for small values of E_Z. However, the output error does not increase so rapidly as in the divide mode. The actual output for small values of E_Z is given approximately by

$$E_{OUT} \approx -\sqrt{10\,E_Z + 10\,\varepsilon_M}$$

where ε_M is the total error specifed for Multiply mode. This equation can be used to determine the feasibility of using either of these products as a square rooter for a given application. For operation over a much wider dynamic range, with improved accuracy, the Model 4302 multifunction converter is recommended.

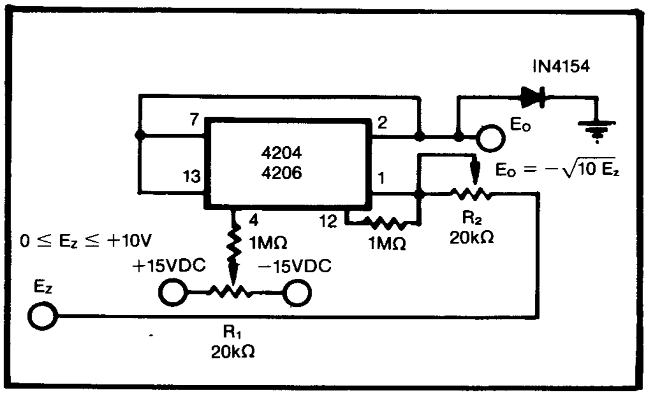


FIGURE 3. Square Root Trim Procedure.

Square Root Trim Procedure (Figure 3)

1) Set $E_Z = +10.000VDC \pm 2mV$, adjust R_2 such that $E_O = +10.000VDC \pm 2mV$.
2) Set $E_Z \approx$ minimum value required by application (E_{ZM}), adjust R_1 such that $E_O = -\sqrt{10\,E_{ZM}} \pm 2mV$.
3) Repeat steps 1 and 2 if necessary.

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