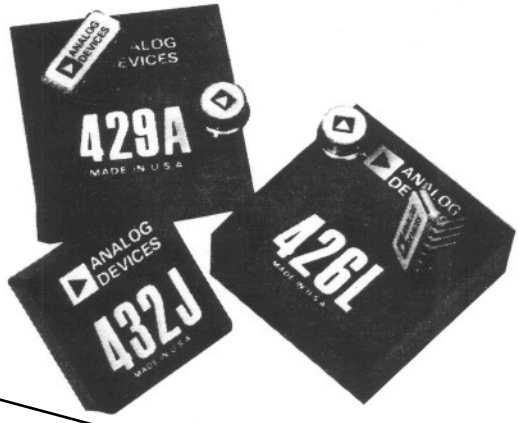
MULTIPLIERS/DIVIDERS
427, 424, 425, 426, 432, 428, 429, 422, AD530, AD531



OBSOLETE

MULTIPLIER CLASSIFICATION AND PRODUCT DESCRIPTION

To assist in selecting the best multiplier for the application, we have classified products according to the technique used to develop the multiply function which essentially determines the capabilities of the device. Analog Devices has focused on the pulse-width/height technique and the variable transconductance technique to develop the multiply/divide function. These two approaches are considered complementary and were selected because of their inherent ability to provide a good balance between performance and cost.

PULSE-WIDTH-HEIGHT MODULATION PRECISION MULTIPLIERS (PWH)

The pulse-width-height modulation technique is capable of producing multipliers of the highest precision. Typical specifications include accuracies from 0.1% to 0.25%, offset drifts to 100μV/°C, output noise of 50μV rms and bandwidths to 100kHz. Multipliers in this group should be used for wide temperature range applications, for analog computing elements, for dividers because of their inherently good drift, noise and low non-linearities, and, in general, for exacting multiplier/divider applications where wide dynamic signal swings are anticipated. Products in this group include models 427. 424, and 425.

MODEL 427 (HIGH ACCURACY): Based on the highly successful Model 424, the 427K is internally trimmed to specified accuracy and requires no external adjustments for multiplication. It uses pulse-width modulation to obtain accuracies to 0.2% (FS), offset drifts as low as 200μV/°C, and nonlinearity of 0.04% maximum, for both inputs. All semiconductors used in this design are hermetically sealed.

Unlike most high accuracy multipliers embodying the modulation principle, 427's high carrier frequency allows a bandwidth rating of 100kHz for -3dB response with no carrier ripple on output. Depending on how it is connected, the 427 can be used for multiplying, dividing, squaring, or square rooting.

The true capability of a multiplier can be best demonstrated when the unit is used in the divide mode, particularly with small denominators. Because the 427 features excellent small signal linearity, the errors are very much smaller than one would predict using 10/x for divider error.

MODEL 424 (HIGH ACCURACY): The model 424 J/K is an untrimmed multiply-only module with performance comparable to that of model 427. In every respect, except for the divide and external trim features, the 424 will perform the 427 task at lower component cost and should be considered for laboratory and industrial applications where external trimming may be conveniently performed to achieve the highest possible accuracies. When externally trimmed, model 424 will perform with 0.2% (424J) and 0.1% (424K) accuracies with bandwidths to 100kHz (−3dB). It may be used to perform division when operated with an external op amp.

MODEL 425: Customers may purchase the model 424 mounted on a PC card which contains all necessary adjustment potentiometers to trim the multiplier to its rated accuracies. Designated model 425J (with 424J) and 425K (with 424K), these models are factory trimmed and offered at a nominal cost above that of 424 alone.

VARIABLE TRANSCONDUCTANCE TYPES

The popular variable transconductance technique complements the PWH approach and should be considered whenever wider bandwidths, to 10MHz, are required along with lower costs and good overall performance. Both discrete and monolithic devices are available using this design approach. Multiplier specifications include accuracies from 0.5% to 2%, bandwidths from 300kHz to 10MHz and drifts from 200μV/°C to 2mV/°C. Each model is capable of 4-quadrant multiplication, or 2-quadrant division. Because the transconductance technique can be optimized in different ways to yield highly specialized performance, models may be classified as: general purpose (models 426, 432, 530 and 531; high performance (model 428); and wide bandwidth (models 429 and 422).

General Purpose

MODEL 426 (GENERAL PURPOSE 1%, 0.5%): Available as an internally trimmed 1% (J, K) or 0.5% (L) accurate multiplier/divider, Model 426 should be considered as a first choice for most general purpose designs and OEM applications. External trimming further improves performance to 0.6% (J, K) and 0.35% (L). Nonlinearities are held to a low 0.6% (X) and 0.3% (Y) for models 426 (J & K), allowing the user to assign that input signal with the widest dynamic range to the 0.3% (Y) input terminal for better accuracy. For even better performance, model 426 L should be selected for lowest drift and good linearity and feedthrough characteristics.

MODEL 432 (ECONOMY): Using hermetically sealed components, the models 432 J(K), 2%(1%) multiplier/dividers, are internally trimmed and are available in a compact package for low cost OEM applications requiring field interchangeable modules with no additional trimming. External trimming will improve accuracy from 2%(1%) to 1%(0.6%). Performance, reliability and bandwidth are comparable to model 530. OEM discounts are available.

MODEL AD530 (MONOLITHIC): With the transfer function XY/10, the AD530 is the first IC multiplier/divider to include the transconductance multiplying element, the built-in reference and the output op amp all on the same chip. Available in both industrial (AD530 J, K or L) and military grades (AD530S), its compact package and good performance make it an ideal choice for high reliability assignments. The AD530 needs only four trim pots to achieve accuracies to ±0.5% of full scale. Bandwidth is 1MHz and slew rate 45V/μsec. The AD530 is available in both the TO-100 metal can and TO-116 ceramic dual-in-line packages.

MODEL AD531 (MONOLITHIC): TRANSFER FUNCTION $(X_1 - X_2)Y/Z$. Not just a multiplier, the AD531 is truly a computation circuit that is ideally suited to such applications as AGC, True rms-to-DC conversion, ratio determination, absolute value and vector computation. Like the AD530, the AD531 combines the transconductance element, a precision stable reference and the output op amp on a single monolithic structure. Flexibility of operation is achieved by virtue of the programmable scale factor capability and the differential input feature. In addition to verification of accuracy at +25°C, the AD531L and AD531S are further tested for maximum error limits of ±1.5% and ±3.0%, respectively, at their extreme operating temperature limits. The AD531 is available in the TO-116 ceramic dual-in-line package.

MODEL AD532 (MONOLITHIC-INTERNALLY TRIMMED): TRANSFER FUNCTION $(X_1 - X_2)(Y_1 - Y_2)/10$. The AD532J, AD532K and AD532S are the industry's first internally-trimmed monolithic multiplier/dividers. They guarantee maximum multiplying errors of ±2.0%, ±1.0% and ±1.0% of full scale (10V) at +25°C, respectively, without the need for any external trim networks or output op amp. In addition, the differential X and Y inputs provide significant operating flexibility for both algebraic computation and transducer instrumentation applications. Further, the AD532 can be used as a direct replacement for some popular IC multipliers that require external trimming, such as the AD530. The AD532J and AD532K are rated for operation from 0 to +70°C. The AD532S will operate from -55°C to +125°C with a maximum multiplying error of ±4.0% of full scale. All designs are available in both the TO-100 metal can and the TO-116 ceramic dual-in-line packages.

High Performance

MODEL 428: (LOW DRIFT): This device meets high performance requirements for many applications where component price and accuracy are key factors. As a trans-conductance multiplier, it approaches the performance of more expensive multipliers, using modulation techniques, but at lower costs. Factory trimmed to 0.5% with offset drift of 200μV/°C, enables model 428K to operate over a 50°C temperature range with less than 1% error increase.

Both 428J and 428K may be externally trimmed for an improved accuracy of 0.25% and operated as dividers and square root circuits. The nonlinearity component of error is particularly low in this unit, resulting in excellent performance as a divider. For example: 50mV maximum error for a 10:1 dynamic range of denominator.

In addition to its excellent DC performance, it has 300kHz small signal bandwidth (−3dB) and full power output to beyond 70kHz, considerably exceeding the audio range.

Wideband

MODEL 429 (HIGH ACCURACY): This unit should be considered for all new multiplier/divider designs requiring the best possible speed, drift and accuracy performance. The model 429 factory trimmed, is available as a 429A (1%, 2mV/°C) and 429B (0.5%, 1 mV/°C) both with 10MHz response. Capable of multiplying or dividing, models 429 A/B may be easily converted to the divide mode with external pin interconnections. Accuracies may be improved upon for models 429A (from 1% to 0.7%) and 429B (from 0.5% to 0.3%) with external trimming. Note, that although model 429 is an improvement over model 422, these devices are not pin compatible.

MODEL 422 (HIGH FREQUENCY): This unit is available as a 1% multiplier with a 5MHz bandwidth, and may be operated as a divider when connected with an external op amp. Model 422A and 422K, with 2mV/°C and 1mV/°C offset drifts respectively, may be externally trimmed for 0.7% accuracy to improve on the 1% factory trimmed specification.

MULTIPLIERS/DIVIDERS (Discrete)

SPECIFICATION SUMMARY (Typical @ 25°C and ±15VDC unless otherwise specified)

	VARIABLE TRANSCONDUCTANCE TYPES		
Models [1]	**Economy** 432J (432K)	**General Purpose** 426A (426K) (426L)	**Wideband** 422A (422K)
Full Scale Accuracy [2]	2% (1%)	1% (1%) (0.5%)	1%
Divides and Square Roots	YES	YES	Division requires external amp
Multiplication Characteristics			
Output Function	XY/10	XY/10	XY/10
Error, Internal Trim (±)	2% (1%) max	1% (1%) (0.5%) max	1% (1%) max
Error, External Trim (±)	1.0% (0.6%)	0.6% (0.6%) (0.35%)	0.7% (0.7%)
Accuracy vs. Temperature (±)	0.06%/°C (0.04%/°C)	0.05%/°C (0.04%/°Cmax) (0.04%/°Cmax)	0.05%/°C (0.04%/°C max)
Accuracy vs. Supply (±)	0.1%/%	0.03%/%	0.05%/%
Warm up Time to Specifications	1 min	1 sec	1 sec
Output Offset (±)			
Initial	20mV (25mV max)	20mV	25mV
Average vs. Temperature 0°C to +70°C	2mV/°C (1mV/°C)	2mV/°C (1mV/°C max) (1mV/°C max)	2mV/°C (1mV/°C max)
Average vs. Supply	10mV/%	2mV/%	1mV/%
Scale Factor (±)			
Initial Error	1% (0.5%)	0.5% (0.5%) (0.25%)	0.5%
Non Linearity (±)			
X Input (X = 20V p-p, Y = ±10VDC)	0.8% (0.6% max)	0.6% (0.6%) (0.25%) max	0.6% max
Y Input (Y = 20V p-p, X = ±10VDC)	0.4% (0.3% max)	0.3% (0.3%) (0.25%) max	0.3% max
Feedthrough			
X = 0, Y = 20V p-p 50Hz	80mV (50mV) p-p max	60mV (60mV) (40mV) p-p max	50mV p-p max
with external trim	30mV p-p	20mV p-p	8mV p-p
Y = 0, X = 20V p-p 50Hz	120mV (100mV) p-p max	100mV (100mV) (40mV) p-p max	100mV p-p max
with external trim	N/A	60mV (60mV) (20mV) p-p	35 mV p-p
Feedthrough vs. Temperature, each input	1mV p-p/°C	2mV p-p/°C	2mV p-p/°C
Bandwidth			
−3dB Small Signal	1MHz	400kHz	2MHz min
Full Power Response	700kHz	80kHz	2MHz min
Slew Rate	45V/μsec	5V/μsec	120V/μsec min
Small Signal Amplitude Error (±)	1% @ 40kHz	1% at 40kHz	1% at 300kHz min
Small Signal Vector Error (±)	1% @ 10kHz	1% at 10kHz	1% at 50kHz min
Settling Time for ±10V Step	1μsec to 2%	3μsec to 1%	0.4μsec to 1%
Overload Recovery	3μsec	3μsec	0.15μsec
Output Noise			
5Hz to 10kHz	600μV rms	500μV rms	500μV rms
5Hz to 5MHz	3mV rms	2.5mV rms	2.5mV rms
Output Characteristics [4]			
Voltage at Rated Load (min)	±10V	±11V	±11V
Current (min)	±5mA	±11mA	±11mA
Load Capacitance Limit	0.001μF	1μF	0.01μF
Input Resistance			
X/Y/Z Input	10MΩ/10kΩ/36kΩ	25kΩ/25kΩ/200kΩ	10kΩ/11kΩ/N/A
Input Bias Current			
X/Y/Z Input	2μA each	+100nA/+100nA/−50μA	+100nA each
Maximum Input Voltage			
For Rated Accuracy	±10.1V	±10.5V	±10.5V
Safe Level	±Vs	±18V	±16V
Power Supply (V_S)			
Rated Performance	±15V	±14.7 to ±15.3V	±14.7 to ±15.3V
Operating	±12 to ±18V	±11.5 to ±18V	±14 to ±16V
Quiescent Current	±4.5mA	±5mA	±12mA
Temperature Range [5]			
Rated Performance	0°C to +70°C	−25 to +85°C (0 to +70°C) (0 to +70°C)	−25°C to +85°C (0°C to +70°C)
Operating	−25°C to +85°C	−25°C to +85°C	−25°C to +85°C
Storage	−55°C to +125°C	−55°C to +125°C	−55°C to +125°C
Package Outline	QC-2	FA-4	FA-3
Case Dimensions	1.1" x 1.1" x 0.4"	1.5" x 1.5" x 0.6"	1.5" x 1.5" x 0.6"
	$29 ($45)	$45 ($59) ($69)	$109 ($139)
	$27 ($43)	$43 ($57) ($67)	$104 ($129)

NOTES:

[1] Parentheses indicate specification for the high performance (K or L version) model of each multiplier when it differs from the J or A version. For example, order Model 427J for 0.25% accuracy, Model 427K for 0.2% accuracy.

[2] All accuracy and error specifications, when expressed as percentages, refer to % of full scale (10V).

[3] Model 424 available for $20 additional on printed circuit board with preadjusted trim pots. Card socket supplied. Order Model 425J or 425K.

		PRECISION (PWH) TYPES	
Accurate Wideband **429A (429B)**	**Accurate Low Drift** **428J (428K)**	**High Accuracy** **424J (424K) 425**[3]	**High Accuracy** **427J (427K)**
1% (0.5%)	0.5%	0.2% (0.1%)	0.25% (0.2%)
YES	YES	Division requires external amp	YES
XY/10 1% (0.5%) max 0.7% (0.3%) 0.05%/°C (0.04%/°C max) 0.05%/% 1 sec	XY/10 0.5% (0.5%) max 0.25% (0.25%) 0.02%/°C (max) 0.02%/% 1 min	XY/10 Untrimmed 0.2% (0.1%) max 0.02%/°C (max) 0.02%/% 1 min	XY/10 0.25% (0.2%) max 0.15% (0.1% max) 0.02%/°C max 0.02%/% 1 min
20mV (10mV) max 2mV/°C (1mV/°C max) 1mV/%	10mV 0.5mV/°C (0.2mV/°C max) 2mV/%	Adj. to zero 0.2mV/°C (0.2mV/°C max) 2mV/%	5mV 0.2mV/°C (0.2mV/°C max) 1mV/%
0.5% (0.25%)	0.25%	Adj. to 0.1% (0.05%)	0.1% (0.05%)
0.5% (0.2%) max 0.3% (0.2%) max	0.25% max 0.25% max	0.08% (0.04%) max 0.08% (0.04%) max	0.08% (0.04%) max 0.08% (0.04%) max
50mV (20mV) p-p max 10mV (10mV) p-p 100mV (30mV) p-p max 50mV (20mV) p-p 2mV p-p/°C	40mV p-p max 10mV p-p 40mV p-p max 10mV p-p 1mV p-p/°C	N/A 2mV (1mV) p-p N/A 4mV (2mV) p-p 0.2mV p-p/°C	20mV p-p max 4mV p-p 20mV p-p max 5mV p-p 0.2mV p-p/°C
10MHz 2MHz min 120V/µsec min 1% at 300kHz min 1% at 50kHz min 0.5µsec to 1% 0.15µsec	300kHz 70kHz 4V/µsec 1% at 40kHz 1% at 2kHz 5µsec to 0.5% 3µsec	100kHz 40kHz 3V/µsec 0.1% at 4kHz 1% at 700Hz 15µsec to 0.1% 10µsec	100kHz 30kHz 2V/µsec 0.1% at 4kHz 1% at 700Hz 20µsec to 0.1% 10µsec
200µV rms 1.5mV rms	500µV rms 2.5mV rms	50µV rms 1mV rms	50µV rms 1mV rms
±11V ±11mA 0.01µF	±11V ±11mA 0.001µF	±10V ±7mA 0.01µF	±10.2V ±7mA 0.01µF
10kΩ/11kΩ/13kΩ	25kΩ/25kΩ/200kΩ	10kΩ/11kΩ/N/A	10kΩ/10kΩ/33kΩ
+100nA/+100nA/±40nA	+100nA/+100nA/−50µA	±3µA each	±3µA/±3µA/±10µA
±10.5V ±16V	±10.5V ±18V	±10.5V ±16V	±10.5V ±16V
±14.7 to ±15.3V ±14 to ±16V ±12mA	±14.7 to ±15.3V ±11.5 to ±18V ±5mA	±14.8 to ±16V ±14.8 to ±16V ±16mA	±14.8 to ±15.3V ±14.8 to ±16V ±16mA
−25°C to +85°C −25°C to +85°C −55°C to +125°C	0°C to +70°C −25°C to +85°C −55°C to +125°C	0°C to +70°C −25°C to +85°C −55°C to +125°C	0°C to +70°C −25°C to +85°C −55°C to +125°C
FA-4 1.5" x 1.5" x 0.6"	FA-4 1.5" x 1.5" x 0.6"	D-1 1.6" x 3.0" x 0.6"	D-2 1.6" x 3.0" x 0.6"
$109 ($139) **$104 ($129)**	**$89 ($109)** **$79 ($98)**	**$139 ($174)** **$126 ($157)**	**$159 ($210)** **$143 ($189)**

[4] All models are short-circuit-proof, from output to ground. Multipliers are not guaranteed short-circuit-proof from output to $+V_S$ or $-V_S$.

[5] Most models designated 'J' or 'K' are available with extended temperature range operation to stated accuracy. Consult factory or your nearest Analog sales office.

MULTIPLIERS/DIVIDERS (Monolithic)
SPECIFICATION SUMMARY (Typical @ +25°C and ±15VDC, unless otherwise specified.)

Models	VARIABLE TRANSCONDUCTANCE TYPES		
	530J (530K) (530L) (530S)	**531J (531K) (531L) (531S)**	**532J (532K) (532S)**
Price 1-24 Price 25-99	$22.50($33.50)($45.00)($51.00) $18.00($27.00)($36.00)($41.00)	$30.00($45.00)($54.00)($54.00) $24.00($36.00)($44.00)($44.00)	$26.00($36.00)($49.00) $21.00($30.00)($40.00)
Full Scale Accuracy	2% (1%) (0.5%) (1%)	2% (1%) (0.5%) (1%)	2% (1%) (1%)
Divides and Square Roots	YES	YES	YES
Multiplication Characteristics Output Function Error, Internal Trim (±) Error, External Trim (±) max Accuracy vs. Temperature (±) Accuracy vs. Supply (±) Warm up Time to Specifications	 XY/10 N/A 2% (1%) (0.5%) (1%) 0.06(0.03)(0.01)(0.02 max)%/°C 0.2%/% 1 sec	 XY/I_{REF} N/A 2% (1%) (0.5%) (1%) 0.06(0.03)(0.01)(0.02 max)%/°C 0.2%/% 1 sec	 $(X_1 - X_2)(Y_1 - Y_2)/10$ 2% (1%) (1%) N/A 0.06(0.03)(0.02)%/°C 0.2%/% 1 sec
Output Offset (±) Initial Average vs. Temperature 0 to +70°C Average vs. Supply	 Adj. to zero 0.2mV/°C 70mV/V	 Adj. to zero 0.2mV/°C 70mV/V	 ±50mV max(±20mV max)(±20mV max) 0.7(0.7)(2.0 max)mV/°C 60mV/V
Scale Factor (±) Initial Error	Fixed Adj. to 1%(0.5%)(0.2%)(0.5%)	Dynamically Variable Adj. to 1%(0.5%)(0.2%)(0.5%)	Fixed Adj. to 1%(0.5%)(0.5%)
Non Linearity (±) X Input (X = 20V p-p, Y = ±10VDC) Y Input (Y = 20V p-p, X = ±10VDC)	 0.8%(0.5%)(0.3%)(0.5%) 0.3%(0.2%)(0.2%)(0.2%)	 0.8%(0.5%)(0.3%)(0.5%)(1) 0.3%(0.2%)(0.2%)(0.2%)(1)	 0.8%(0.5%)(0.5%) 0.3%(0.2%)(0.2%)
Feedthrough X = 0, Y = 20V p-p 50Hz with external trim Y = 0, X = 20V p-p 50Hz with external trim Feedthrough vs. Temperature, each input	 150mV(80mV)(40mV)(80mV)p-p max 100mV(60mV)(30mV)(60mV)p-p max 2mV p-p/°C	 150mV(80mV)(40mV)(80mV)p-p max(1) 100mV(60mV)(30mV)(60mV)p-p max(1) 2mV p-p/°C	 200mV(100mV)(100mV)p-p max 200mV(100mV)(100mV)p-p max 2mV p-p/°C
Bandwidth -3dB Small Signal Full Power Response Slew Rate Small Signal Amplitude Error (±) Small Signal Vector Error (±) Settling Time for ±10V Step Overload Recovery	 1MHz 750kHz 45V/μsec 1% @ 100kHz 1% @ 10kHz 1μsec to 2% 1μsec	 1MHz 750kHz 45V/μsec 1% @ 100kHz 1% @ 10kHz 1μsec to 2% 1μsec	 1MHz 750kHz 45V/μsec 1% @ 100kHz 1% @ 10kHz 1μsec to 2% 1μsec
Output Noise 5Hz to 10kHz 5Hz to 5MHz	 600μV rms 3mV rms	 600μV rms 3mV rms	 600μV rms 3mV rms
Output Characteristics Voltage at Rated Load (min) Current (min) Load Capacitance Limit	 ±10V ±5mA 0.001μF	 ±10V ±5mA 0.001μF	 ±10V ±5mA 0.001μF
Input Resistance X/Y/Z Input[2]	 10MΩ/6MΩ/36kΩ	 10MΩ/6MΩ/36kΩ	 10MΩ/10MΩ/36kΩ
Input Bias Current X/Y/Z Input	 2μA/2μA/5μA	 2μA/2μA/5μA	 2μA/3μA/5μA
Maximum Input Voltage For Rated Accuracy Safe Level	 ±10.1V $\pm V_S$	 ±10.1V $\pm V_S$	 ±10.1V $\pm V_S$
Power Supply (V_S) Rated Performance Operating Quiescent Current	 ±15V ±12 to ±18V ±4mA	 ±15V ±12 to ±18V ±4.5mA	 ±15V ±10 to ±18V ±4mA
Temperature Range Rated Performance Operating Storage	 J – 0 to +70°C K – 0 to +70°C L – 0 to +70°C S – -55°C to +125°C -55°C to +125°C -65°C to +125°C	 J – 0 to +70°C K – 0 to +70°C L – 0 to +70°C S – -55°C to +125°C -55°C to +125°C -65°C to +125°C	 0 to +70°C(0 to +70°C)(-55°C to +125°C) -55°C to +125°C -65°C to +125°C
Package Outline	TO-100 + TO-116	TO-116	TO-100 + TO-116

(1)I_{REF} = full scale.
(2)Z input current is proportional to Z input voltage.