BURR - BROWN®

OPA121

Low Cost Precision *Difet*® OPERATIONAL AMPLIFIER

FEATURES

- LOW NOISE: 6nV/√Hz typ at 10kHz
- LOW BIAS CURRENT: 5pA max
- LOW OFFSET: 2mV max
- LOW DRIFT: 3μV/°C typ
- HIGH OPEN-LOOP GAIN: 110dB min
- HIGH COMMON-MODE REJECTION: 86dB min

APPLICATIONS

- OPTOELECTRONICS
- DATA ACQUISITION
- TEST EQUIPMENT
- MEDICAL EQUIPMENT
- RADIATION HARD EQUIPMENT

DESCRIPTION

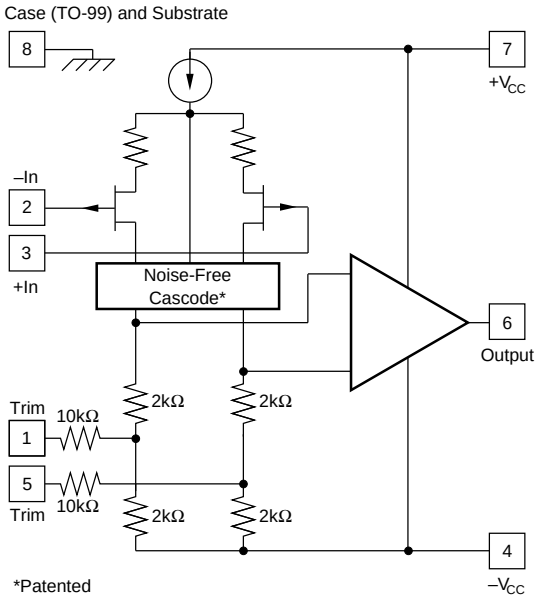
The OPA121 is a precision monolithic dielectrically-isolated FET (***Difet***®) operational amplifier. Outstanding performance characteristics are now available for low-cost applications.

Noise, bias current, voltage offset, drift, open-loop gain, common-mode rejection, and power supply rejection are superior to BIFET® amplifiers.

Very low bias current is obtained by dielectric isolation with on-chip guarding.

Laser-trimming of thin-film resistors gives very low offset and drift. Extremely low noise is achieved with new circuit design techniques (patented). A new cascode design allows high precision input specifications and reduced susceptibility to flicker noise.

Standard 741 pin configuration allows upgrading of existing designs to higher performance levels.



OPA121 Simplified Circuit

Difet®, Burr-Brown Corp.
BIFET®, National Semiconductor Corp.

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PDS-539F
Printed in U.S.A. September, 1993

SPECIFICATIONS

ELECTRICAL

At V_{CC} = ±15VDC and T_A = +25°C unless otherwise noted. Pin 8 connected to ground.

PARAMETER	CONDITIONS	OPA121KM			OPA121KP, KU			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT								
NOISE								
Voltage, f_O = 10Hz	(1)		40			50		nV/√Hz
f_O = 100Hz	(1)		15			18		nV/√Hz
f_O = 1kHz	(1)		8			10		nV/√Hz
f_O = 10kHz	(1)		6			7		nV/√Hz
f_B = 10Hz to 10kHz	(1)		0.7			0.8		µVrms
f_B = 0.1Hz to 10 Hz	(1)		1.6			2		µVp-p
Current, f_B = 0.1Hz to 10Hz	(1)		15			21		fA, p-p
f_O = 0.1Hz thru 20kHz	(1)		0.8			1.1		fA/√Hz
OFFSET VOLTAGE(2)								
Input Offset Voltage	V_{CM} = 0VDC		±0.5	±2		±0.5	±3	mV
Average Drift	$T_A = T_{MIN}$ to T_{MAX}		±3	±10		±3	±10	µV/°C
Supply Rejection		86	104		86	104		dB
			±6	±50		±6	±50	µV/V
BIAS CURRENT(2)								
Input Bias Current	V_{CM} = 0VDC Device Operating		±1	±5		±1	±10	pA
OFFSET CURRENT(2)								
Input Offset Current	V_{CM} = 0VDC Device Operating		±0.7	±4		±0.7	±8	pA
IMPEDANCE								
Differential			10^{13} || 1			10^{13} || 1		Ω || pF
Common-Mode			10^{14} || 3			10^{14} || 3		Ω || pF
VOLTAGE RANGE								
Common-Mode Input Range		±10	±11		±10	±11		V
Common-Mode Rejection	V_{IN} = ±10VDC	86	104		82	100		dB
OPEN-LOOP GAIN, DC								
Open-Loop Voltage Gain	R_L ≥ 2kΩ	110	120		106	114		dB
FREQUENCY RESPONSE								
Unity Gain, Small Signal			2			2		MHz
Full Power Response	20Vp-p, R_L = 2kΩ		32			32		kHz
Slew Rate	V_O = ±10V, R_L = 2kΩ		2			2		V/µs
Settling Time, 0.1%	Gain = –1, R_L = 2kΩ		6			6		µs
0.01%	10V Step		10			10		µs
Overload Recovery, 50% Overdrive(3)	Gain = –1		5			5		µs
RATED OUTPUT								
Voltage Output	R_L = 2kΩ	±11	±12		±11	±12		V
Current Output	V_O = ±10VDC	±5.5	±10		±5.5	±10		mA
Output Resistance	DC, Open Loop		100			100		Ω
Load Capacitance Stability	Gain = +1		1000			1000		pF
Short Circuit Current		10	40		10	40		mA
POWER SUPPLY								
Rated Voltage			±15			±15		VDC
Voltage Range, Derated Performance		±5		±18	±5		±18	VDC
Current, Quiescent	I_O = 0mADC		2.5	4		2.5	4.5	mA
TEMPERATURE RANGE								
Specification	Ambient Temperature	0		+70	0		+70	°C
Operating	Ambient Temperature	–40		+85	–25		+85	°C
Storage	Ambient Temperature	–65		+150	–55		+125	°C
θ Junction-Ambient			200			150(4)		°C/W

NOTES: (1) Sample tested. (2) Offset voltage, offset current, and bias current are specified with the units fully warmed up. (3) Overload recovery is defined as the time required for the output to return from saturation to linear operation following the removal of a 50% input overdrive. (4) 100°C/W for KU grade.

ELECTRICAL (FULL TEMPERATURE RANGE SPECIFICATIONS)

At V_{CC} = ±15VDC and $T_A = T_{MIN}$ to T_{MAX} unless otherwise noted.

PARAMETER	CONDITIONS	OPA121KM			OPA121KP, KU			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
TEMPERATURE RANGE								
Specification Range	Ambient Temperature	0		+70	0		+70	°C
INPUT								
OFFSET VOLTAGE(1)								
Input Offset Voltage	V_{CM} = 0VDC		±1	±3		±1	±5	mV
Average Drift			±3	±10		±3	±10	µV/°C
Supply Rejection		82	94		82	94		dB
			±20	±80		±20	±80	µV/V
BIAS CURRENT(1)								
Input Bias Current	V_{CM} = 0VDC Device Operating		±23	±115		±23	±250	pA
OFFSET CURRENT(1)								
Input Offset Current	V_{CM} = 0VDC Device Operating		±16	±100		±16	±200	pA
VOLTAGE RANGE								
Common-Mode Input Range		±10	±11		±10	±11		V
Common-Mode Rejection	V_{IN} = ±10VDC	82	98		80	96		dB
OPEN-LOOP GAIN, DC								
Open-Loop Voltage Gain	$R_L \geq 2k\Omega$	106	116		100	110		dB
RATED OUTPUT								
Voltage Output	R_L = 2kΩ	±10.5	±11		±10.5	±11		V
Current Output	V_O = ±10VDC	±5.25	±10		±5.25	±10		mA
Short Circuit Current	V_O = 0VDC	10	40		10	40		mA
POWER SUPPLY								
Current, Quiescent	I_O = 0mADC		2.5	4.5		2.5	5	mA

NOTE: (1) Offset voltage, offset current, and bias current are measured with the units fully warmed up.

ABSOLUTE MAXIMUM RATINGS

Supply ..... ±18VDC
Internal Power Dissipation(1) 500mW
Differential Input Voltage ..... ±36VDC
Input Voltage Range ..... ±18VDC
Storage Temperature Range
  M package ..... –65°C to +150°C
  P, U packages ..... –55°C to +125°C
Operating Temperature Range
  M package ..... –40°C to +85°C
  P, U packages ..... –25°C to +85°C
Lead Temperature
  M, P packages (soldering, 10s) ..... +300°C
  U package (soldering, 3s) ..... +260°C
Output Short-Circuit Duration(2) ..... Continuous
Junction Temperature ..... +175°C

NOTES: (1) Packages must be derated based on θ_{JA} = 150°C/W (P package); θ_{JA} = 200°C/W (M package); θ_{JA} = 100°C/W (U package). (2) Short circuit may be to power supply common only. Rating applies to +25°C ambient. Observe dissipation limit and T_J.

PACKAGE INFORMATION

MODEL	PACKAGE	PACKAGE DRAWING NUMBER(1)
OPA121KM	TO-99	001
OPA121KP	8-Pin Plastic DIP	006
OPA121KU	8-Pin SOIC	182

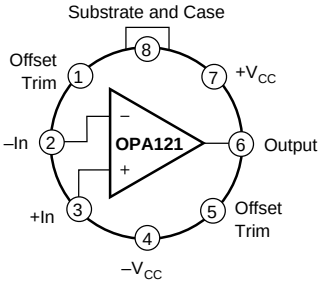
NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

ORDERING INFORMATION

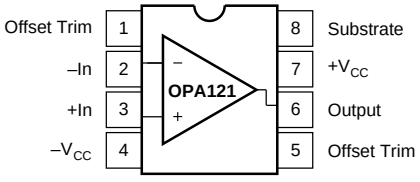
MODEL	PACKAGE	TEMPERATURE RANGE
OPA121KM	TO-99	0°C to +70°C
OPA121KP	8-Pin Plastic DIP	0°C to +70°C
OPA121KU	8-Pin SOIC	0°C to +70°C

CONNECTION DIAGRAMS

Top View **M-Package** TO-99 (Hermetic)



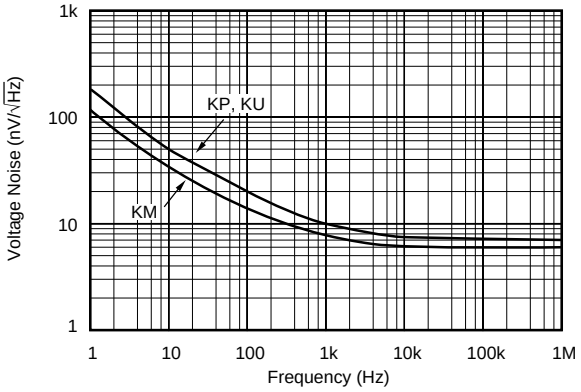
Top View **P-Package** Plastic Mini-DIP
U-Package Plastic SOIC



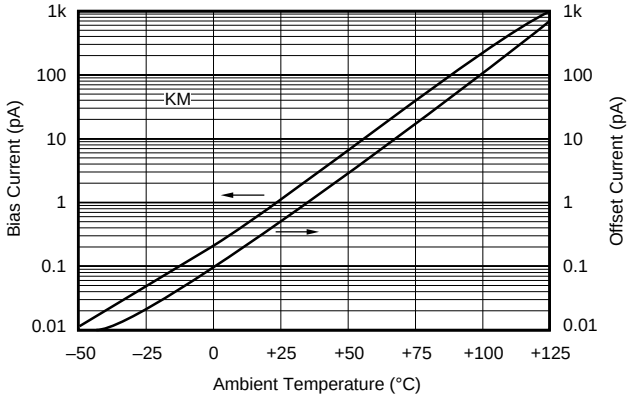
TYPICAL PERFORMANCE CURVES

T_A = +25°C, V_{CC} = ±15VDC unless otherwise noted.

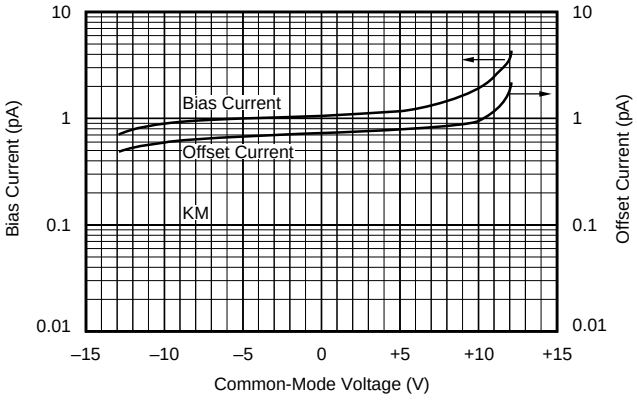
INPUT VOLTAGE NOISE SPECTRAL DENSITY



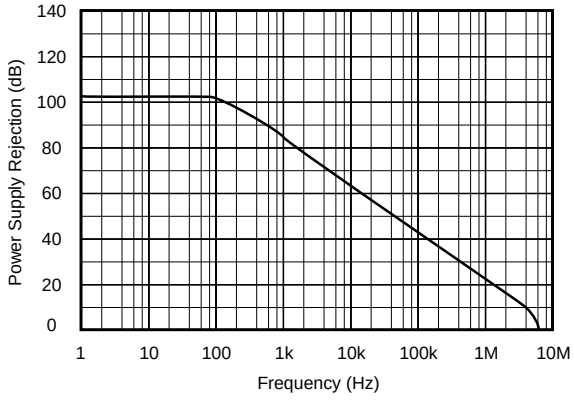
BIAS AND OFFSET CURRENT
vs TEMPERATURE



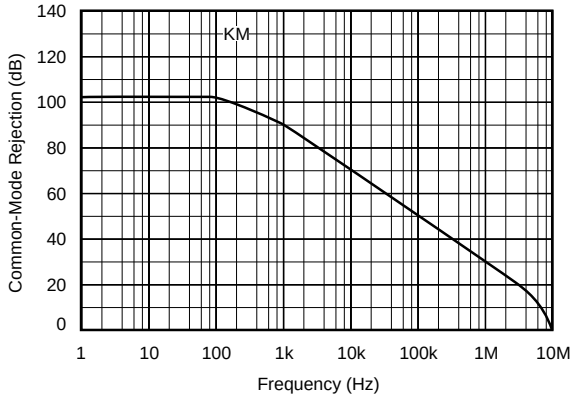
BIAS AND OFFSET CURRENT
vs INPUT COMMON-MODE VOLTAGE



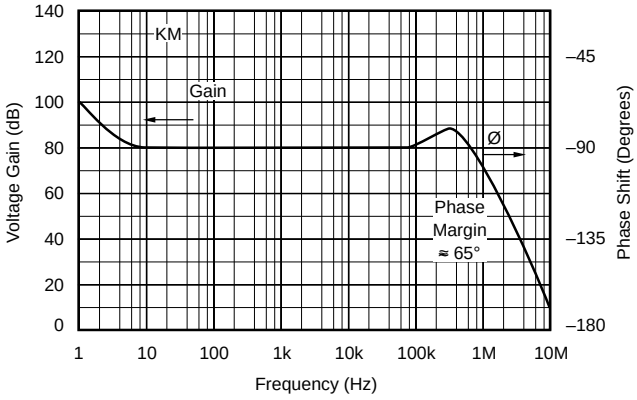
POWER SUPPLY REJECTION
vs FREQUENCY



COMMON-MODE REJECTION
vs FREQUENCY



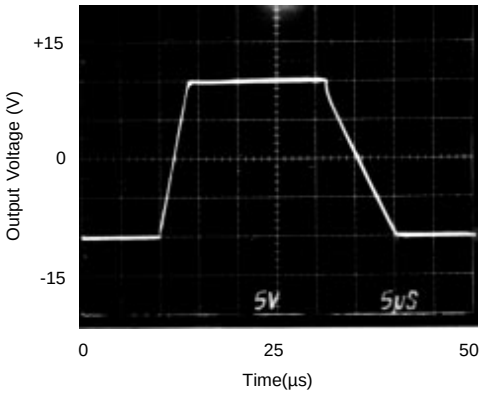
OPEN-LOOP FREQUENCY RESPONSE



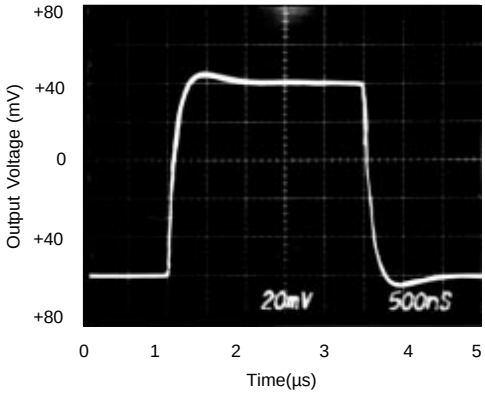
TYPICAL PERFORMANCE CURVES (CONT)

T_A = +25°C, V_{CC} = ±15VDC unless otherwise noted.

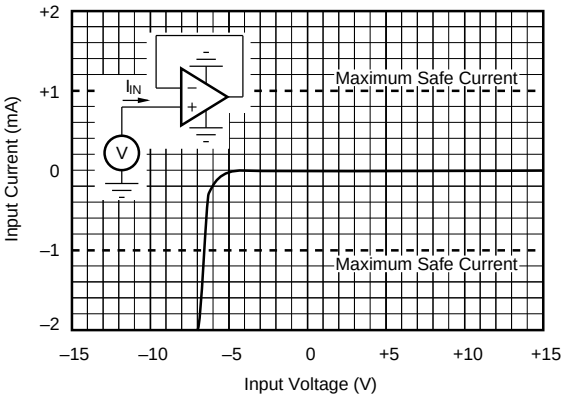
LARGE SIGNAL TRANSIENT RESPONSE



SMALL SIGNAL TRANSIENT RESPONSE



INPUT CURRENTS vs INPUT VOLTAGE
WITH ±V_{CC} PINS GROUNDED



APPLICATIONS INFORMATION

OFFSET VOLTAGE ADJUSTMENT

The OPA121 offset voltage is laser-trimmed and will require no further trim for most applications. As with most amplifiers, externally trimming the remaining offset can change drift performance by about 0.3µV/°C for each 100µV of adjusted offset. Note that the trim (Figure 1) is similar to operational amplifiers such as 741 and AD547. The OPA121 can replace most BIFET amplifiers by leaving the external null circuit unconnected.

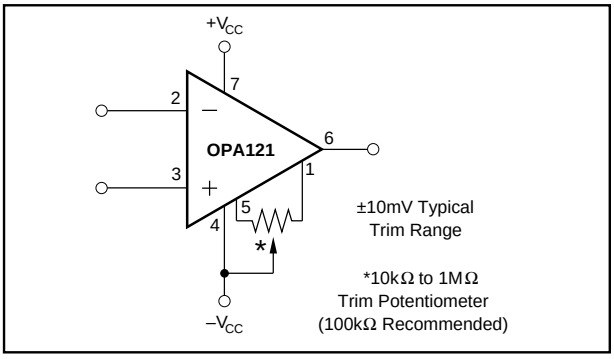


FIGURE 1. Offset Voltage Trim.

INPUT PROTECTION

Conventional monolithic FET operational amplifiers require external current-limiting resistors to protect their inputs against destructive currents that can flow when input FET gate-to-substrate isolation diodes are forward-biased. Most BIFET amplifiers can be destroyed by the loss of $-V_{CC}$.

Unlike BIFET amplifiers, the ***Difet*** OPA121 requires input current limiting resistors only if its input voltage is greater than 6V more negative than $-V_{CC}$. A 10kΩ series resistor will limit input current to a safe level with up to ±15V input levels even if both supply voltages are lost.

Static damage can cause subtle changes in amplifier input characteristics without necessarily destroying the device. In precision operational amplifiers (both bipolar and FET types),

this may cause a noticeable degradation of offset voltage and drift.

Static protection is recommended when handling any precision IC operational amplifier.

GUARDING AND SHIELDING

As in any situation where high impedances are involved, careful shielding is required to reduce "hum" pickup in input leads. If large feedback resistors are used, they should also be shielded along with the external input circuitry.

Leakage currents across printed circuit boards can easily exceed the bias current of the OPA121. To avoid leakage problems, it is recommended that the signal input lead of the OPA121 be wired to a Teflon™ standoff. If the OPA121 is to be soldered directly into a printed circuit board, utmost care must be used in planning the board layout. A "guard" pattern should completely surround the high-impedance input leads and should be connected to a low-impedance point which is at the signal input potential.

The amplifier case should be connected to any input shield or guard via pin 8. This insures that the amplifier itself is fully surrounded by guard potential, minimizing both leakage and noise pickup (see Figure #2).

If guarding is not required, pin 8 (case) should be connected to ground.

BIAS CURRENT CHANGE VERSUS COMMON-MODE VOLTAGE

The input bias currents of most popular BIFET operational amplifiers are affected by common-mode voltage (Figure 3). Higher input FET gate-to-drain voltage causes leakage and ionization (bias) currents to increase. Due to its cascode input stage, the extremely-low bias current of the OPA121 is not compromised by common-mode voltage.

Teflon™ E.I. du Pont de Nemours & Co.

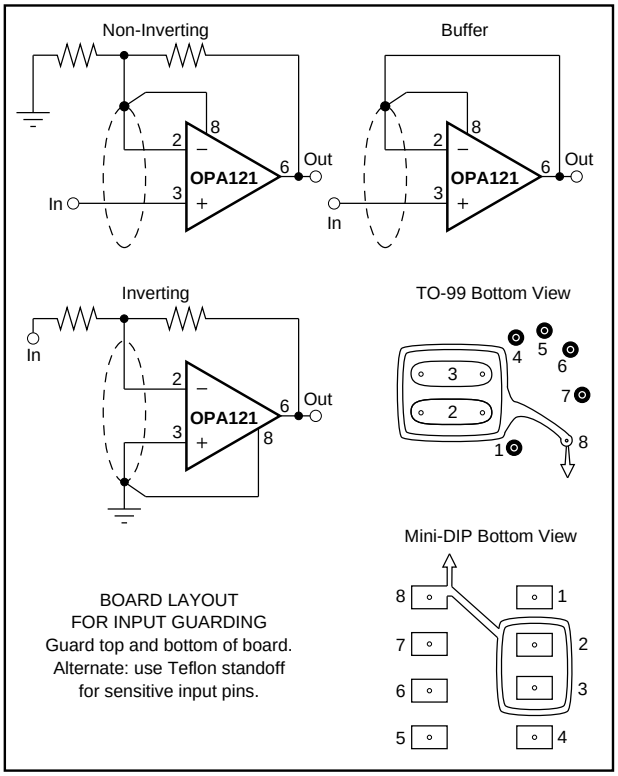


FIGURE 2. Connection of Input Guard.

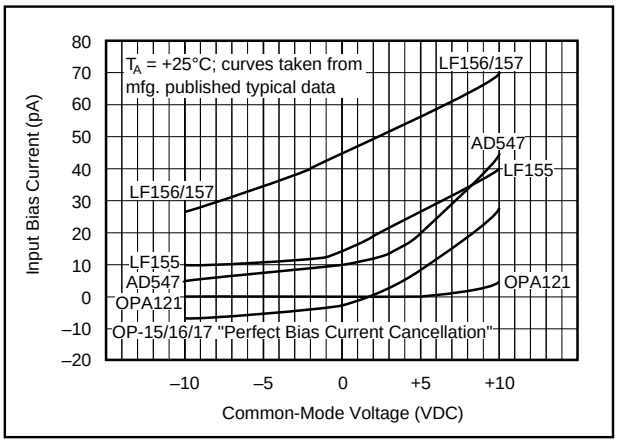


FIGURE 3. Input Bias Current vs Common-Mode Voltage.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
OPA121KU	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	0 to 70	OPA 121KU	Samples
OPA121KU/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	0 to 70	OPA 121KU	Samples
OPA121KUE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	0 to 70	OPA 121KU	Samples

(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.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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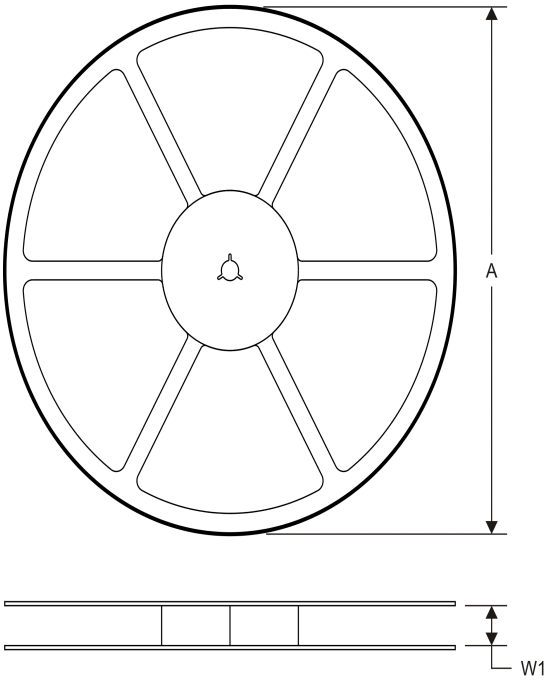
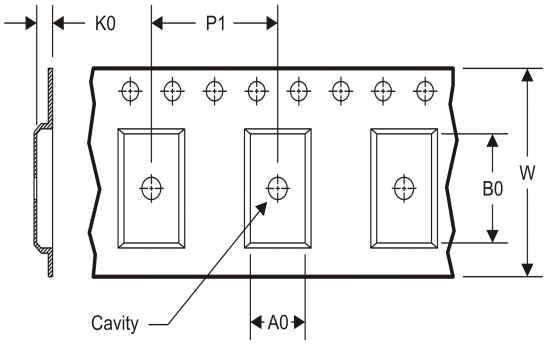
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



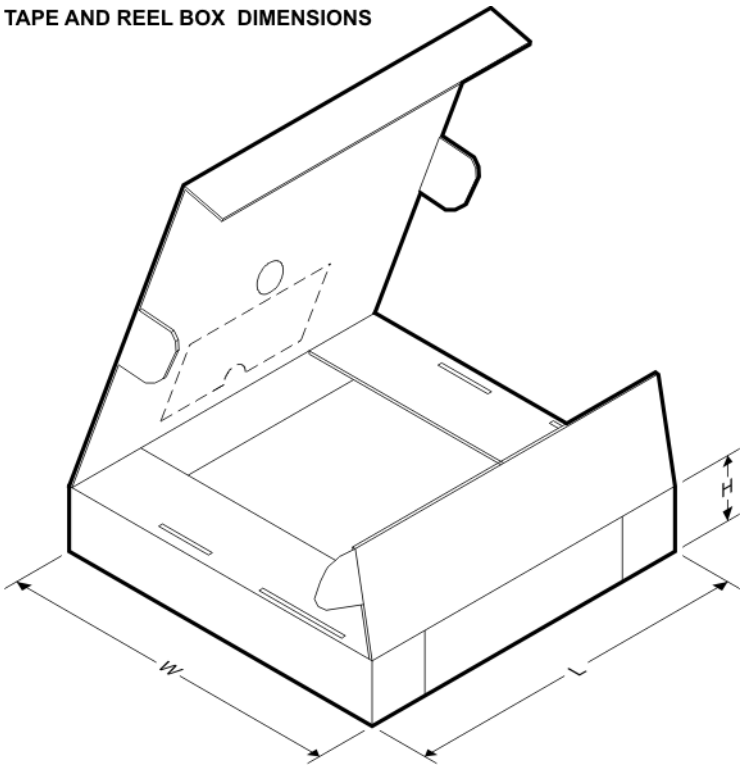
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
OPA121KU/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

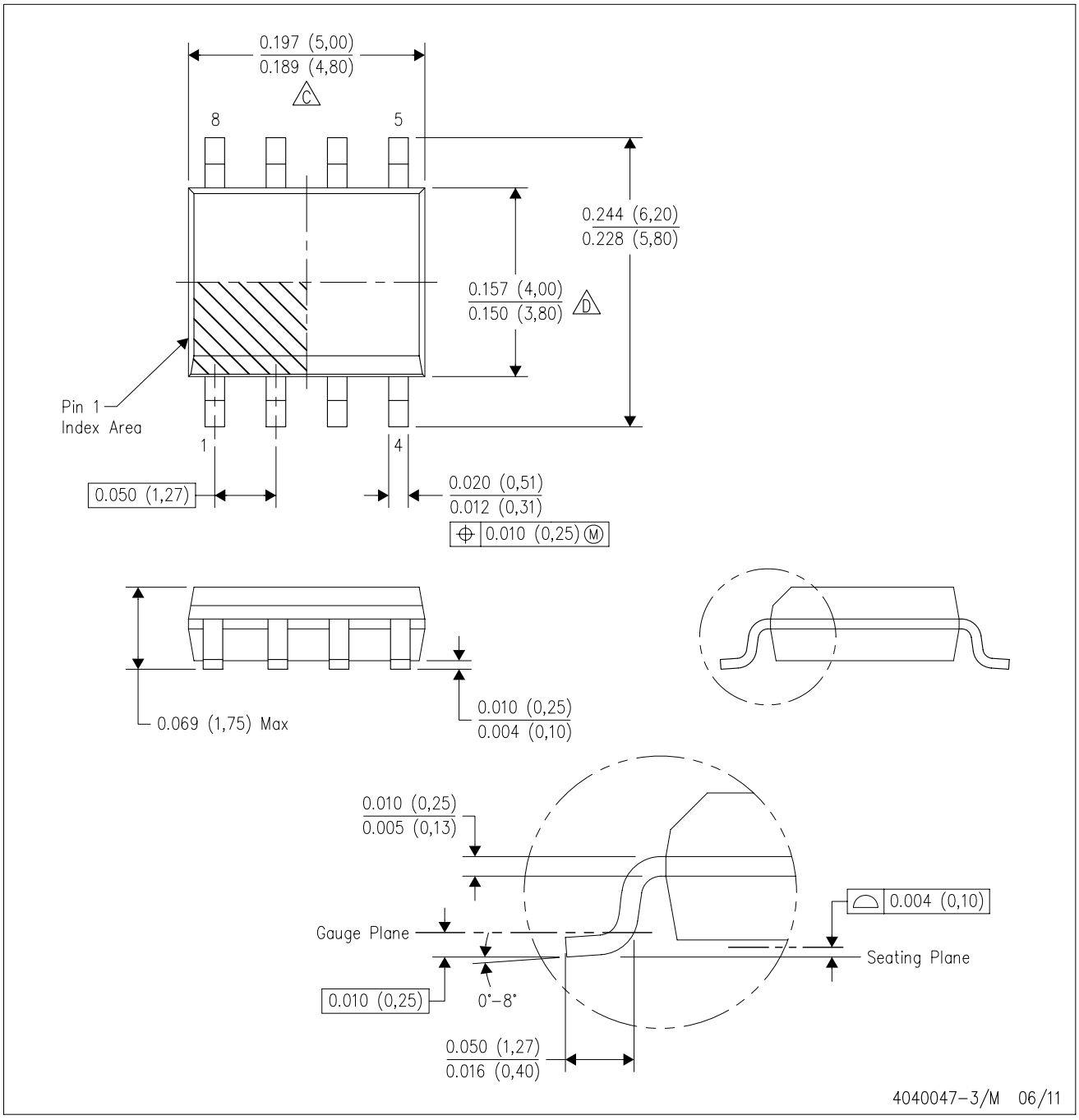
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

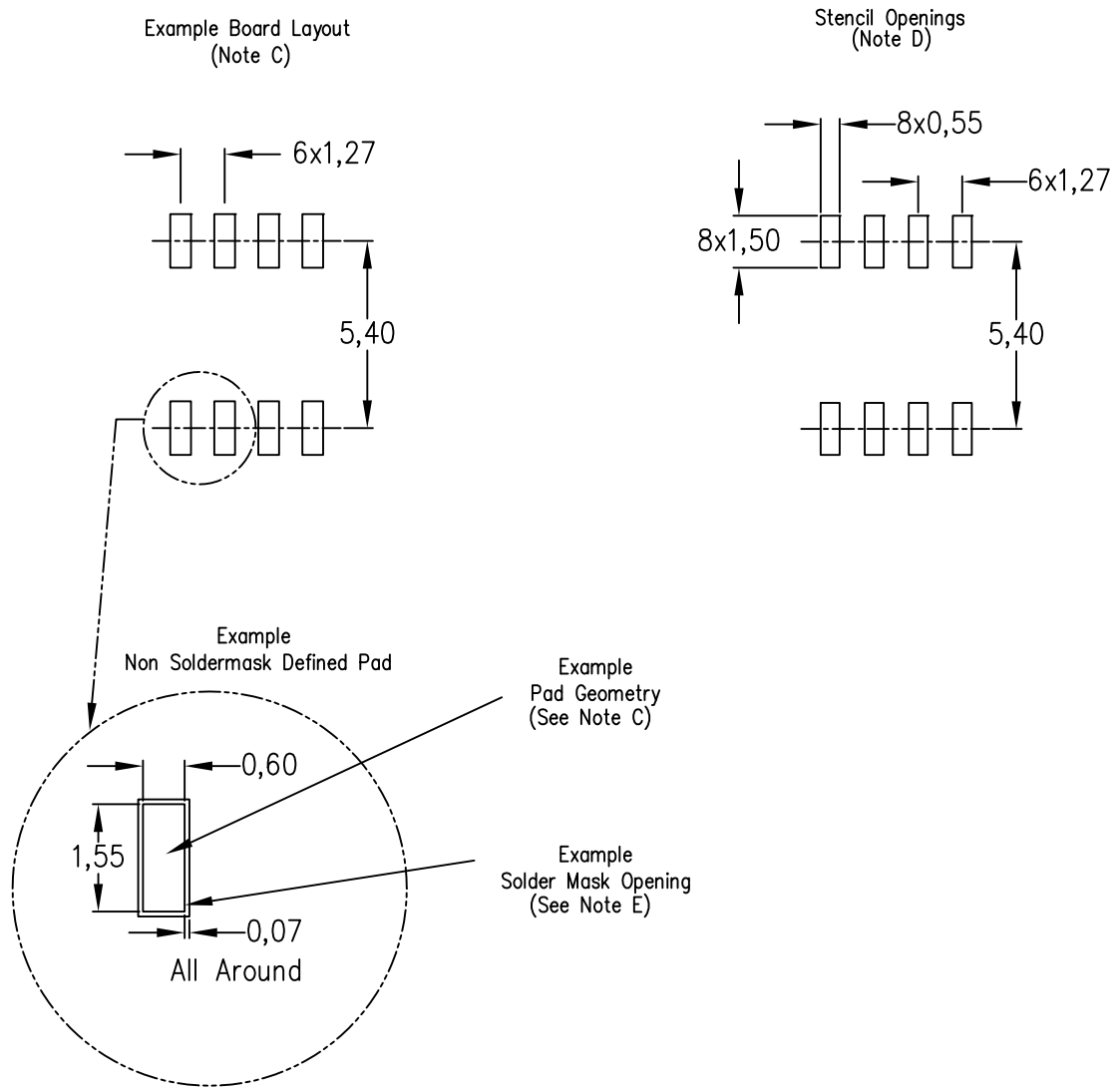
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA121KU/2K5	SOIC	D	8	2500	367.0	367.0	35.0

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AA.

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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