

# OPAx172 36V 单电源 10MHz 轨到轨输出运算放大器

## 1 特性

- 宽电源范围：  
+4.5V 至 +36V， $\pm 2.25V$  至  $\pm 18V$
- 低偏移电压： $\pm 0.2mV$
- 低偏移漂移： $\pm 0.3\mu V/^\circ C$
- 增益带宽：10MHz
- 低输入偏置电流： $\pm 8pA$
- 低静态电流：每放大器 1.6mA
- 低噪声： $7nV/\sqrt{Hz}$
- 已过滤电磁干扰 (EMI) 和射频干扰 (RFI) 的输入
- 输入范围包括负电源
- 输入范围运行至正电源
- 轨到轨输出
- 高共模抑制：120dB
- 行业标准封装：
  - SOIC-8、VSSOP-8、SOIC-14、TSSOP-14
- 微型封装：单电源版本采用 SC70 和 SOT-23 封装；  
双电源版本采用 WSON-8 封装

## 2 应用范围

- 电源模块内的跟踪放大器
- 商用电源
- 变频器放大器
- 桥式放大器
- 温度测量
- 应力计放大器
- 精密积分器
- 测试设备

## 3 说明

OPA172、OPA2172 和 OPA4172 (OPAx172) 属于 36V、单电源、低噪声运算放大器系列，该系列放大器能够在 +4.5V ( $\pm 2.25V$ ) 至 +36V ( $\pm 18V$ ) 的电源范围内运行。这款最新补充的高压 CMOS 运算放大器与 OPAx171 和 OPAx170 搭配，为用户提供了广泛的带宽、噪声和功率选择，可以满足各种应用的需要。OPAx172 采用微型封装并且提供低偏移、漂移和静态电流。这些器件还提供宽带宽、快速转换率和高输出电流驱动能力。单通道、双通道和四通道版本均具有相同的技术规格，可最大程度地提高设计灵活性。

与大多数只在一个电源电压下额定运行的运算放大器不同，OPAx172 系列可在 +4.5 至 +36V 的电压范围内额定运行。超过电源轨的输入信号不会导致相位反向。输入可在负电源轨以下 100mV 以及正电源轨 2V 之内正常运行。请注意这些器件可在正电源轨之上 100mV 的满轨到轨输入上运行，但是在正电源轨 2V 之内运行时性能会受到影响。

OPAx172 系列运算放大器额定运行温度范围为  $-40^\circ C$  至  $+125^\circ C$ 。

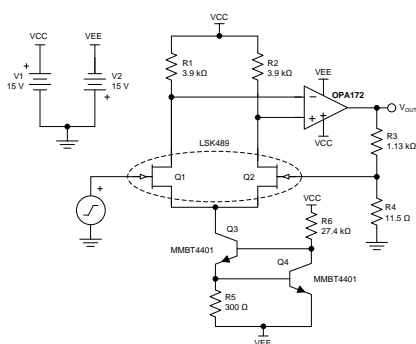
### 器件信息(1)

器件型号	封装	封装尺寸 (标称值)
OPA172	SC70 (5)	2.00mm x 1.25mm
	SOT-23 (5)	2.90mm x 1.60mm
	SOIC (8)	4.90mm x 3.91mm
OPA2172	SOIC (8)	4.90mm x 3.91mm
	VSSOP (8) <sup>(2)</sup>	3.00mm x 3.00mm
	WSON (8)	3.00mm x 3.00mm
OPA4172	SOIC (14)	8.65mm x 3.91mm
	TSSOP (14)	4.40mm x 5.00mm

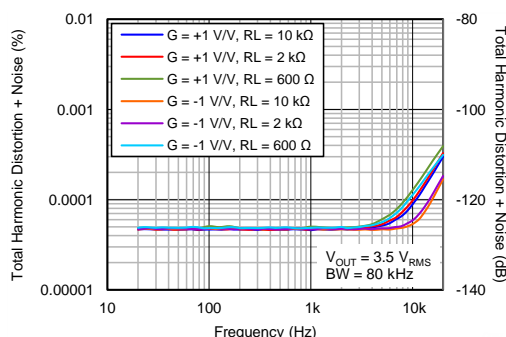
(1) 要了解所有可用封装，请参见数据表末尾的封装选项附录。

(2) VSSOP 封装与 MSOP 封装相同。

### JFET 输入低噪声放大器



### 出色的总谐波失真 (THD) 性能



## 目录

<b>1</b>	特性 .....	<b>1</b>	8.3	Feature Description .....	<b>19</b>
<b>2</b>	应用范围 .....	<b>1</b>	8.4	Device Functional Modes .....	<b>21</b>
<b>3</b>	说明 .....	<b>1</b>	<b>9</b>	<b>Applications and Implementation</b> .....	<b>24</b>
<b>4</b>	修订历史记录 .....	<b>2</b>	9.1	Application Information .....	<b>24</b>
<b>5</b>	<b>Device Comparison</b> .....	<b>4</b>	9.2	Typical Applications .....	<b>24</b>
<b>6</b>	<b>Pin Configuration and Functions</b> .....	<b>5</b>	<b>10</b>	<b>Power-Supply Recommendations</b> .....	<b>27</b>
<b>7</b>	<b>Specifications</b> .....	<b>7</b>	<b>11</b>	<b>Layout</b> .....	<b>28</b>
7.1	Absolute Maximum Ratings .....	<b>7</b>	11.1	Layout Guidelines .....	<b>28</b>
7.2	ESD Ratings .....	<b>7</b>	11.2	Layout Example .....	<b>28</b>
7.3	Recommended Operating Conditions .....	<b>7</b>	<b>12</b>	<b>器件和文档支持</b> .....	<b>29</b>
7.4	Thermal Information: OPA172 .....	<b>7</b>	12.1	器件支持 .....	<b>29</b>
7.5	Thermal Information: OPA2172 .....	<b>8</b>	12.2	文档支持 .....	<b>29</b>
7.6	Thermal Information: OPA4172 .....	<b>8</b>	12.3	相关链接 .....	<b>29</b>
7.7	Electrical Characteristics .....	<b>8</b>	12.4	社区资源 .....	<b>29</b>
7.8	Typical Characteristics: Table of Graphs .....	<b>10</b>	12.5	商标 .....	<b>30</b>
7.9	Typical Characteristics .....	<b>11</b>	12.6	静电放电警告 .....	<b>30</b>
<b>8</b>	<b>Detailed Description</b> .....	<b>18</b>	12.7	术语表 .....	<b>30</b>
8.1	Overview .....	<b>18</b>	<b>13</b>	<b>机械、封装和可订购信息</b> .....	<b>30</b>
8.2	Functional Block Diagram .....	<b>18</b>			

## 4 修订历史记录

<b>Changes from Revision G (June 2015) to Revision H</b>	<b>Page</b>
• 已添加 DRG 封装至 OPA2172 器件 .....	<b>1</b>
• 已添加 WSON 至最后一个特性要点 .....	<b>1</b>
• 已添加 OPA2172 WSON 行至器件信息表 .....	<b>1</b>
• Added WSON-8 to OPA2172 row of <i>Device Comparison</i> table .....	<b>4</b>
• Added DRG pinout drawing .....	<b>5</b>
• Added DRG column to OPA2172 and OPA4172 <i>Pin Functions</i> table .....	<b>6</b>
• Added DRG column to OPA2172 <i>Thermal Information</i> table .....	<b>8</b>

<b>Changes from Revision F (June 2015) to Revision G</b>	<b>Page</b>
• 已添加 input bias current ( $I_B$ ) values for DGK and PW packages .....	<b>8</b>

<b>Changes from Revision E (December 2014) to Revision F</b>	<b>Page</b>
• 已将器件状态从混合状态改为量产数据 .....	<b>1</b>
• 已将 OPA2172 DGK 和 OPA4172 PW 封装改为量产数据 .....	<b>1</b>
• 已添加 OPA2172 VSSOP 和 OPA4172 TSSOP 行至器件信息表 .....	<b>1</b>
• Deleted footnote from <i>Device Comparison</i> table .....	<b>4</b>
• Deleted footnote from OPA2172 DGK and OPA4172 PW pin out drawings .....	<b>5</b>
• Added OPA2172 DGK thermal information .....	<b>8</b>

<b>Changes from Revision D (September 2014) to Revision E</b>	<b>Page</b>
• 已将 OPA2172 D 封装从产品预览改为量产数据 .....	1
• 已更改器件信息表 .....	1
• Changed <i>Device Comparison</i> table note (1) to show preview packages .....	4
• Added note 2 to pin configurations to show preview packages and deleted previous note .....	5
• Changed <i>Handling Ratings</i> table to <i>ESD Ratings</i> table .....	7
<hr/>	
<b>Changes from Revision C (July 2014) to Revision D</b>	<b>Page</b>
• 已更改低噪声 特性 要点值, 从 $6\text{nV}/\sqrt{\text{Hz}}$ 改为 7 .....	1
• 已将 特性 要点中的 MSOP 改为 VSSOP .....	1
• 已添加封装和新的注释 2 至器件信息表 .....	1
• Changed OPAx172 voltage noise density from $6\text{nV}/\sqrt{\text{Hz}}$ to 7 in <i>Device Family Comparison</i> table .....	4
• Changed OPA4172 package from DGK to PW in <i>Pin Functions</i> table .....	6
• Added OPA2172 <i>Thermal Information</i> table .....	8
• Changed input voltage noise value in <i>Electrical Characteristics</i> from $1.2\ \mu\text{V}_{\text{PP}}$ to $2.5\ \mu\text{V}_{\text{PP}}$ .....	8
• Changed input voltage noise density value at 100 Hz in <i>Electrical Characteristics</i> from $8.6\text{nV}/\sqrt{\text{Hz}}$ to 12 .....	8
• Changed input voltage noise density value at 1 kHz in <i>Electrical Characteristics</i> from $6\text{nV}/\sqrt{\text{Hz}}$ to 7 .....	8
• Changed voltage output swing values in the <i>Electrical Characteristics</i> .....	9
• Changed <a href="#">图 13</a> .....	12
• Changed <a href="#">图 14</a> .....	12
• Added new note to <a href="#">Applications and Implementation</a> section .....	24
<hr/>	
<b>Changes from Revision B (May 2014) to Revision C</b>	<b>Page</b>
• 已将 OPA4172 D 封装 (SOIC-14) 从产品预览改为量产数据 .....	1
• Added OPA4172-D Thermal information .....	8
• Added Channel separation parameter to the <i>Electrical Characteristics</i> .....	8
• Added Channel Separation vs Frequency plot .....	16
<hr/>	
<b>Changes from Revision A (April 2014) to Revision B</b>	<b>Page</b>
• 已将 DCK (SC70) 封装从产品预览改为量产数据 .....	1
<hr/>	
<b>Changes from Original (December 2013) to Revision A</b>	<b>Page</b>
• 已更改文档格式以符合最新数据表标准; 已添加处理额定值、建议运行条件以及器件和文档支持部分, 并已移动现有部分 ..	1
• Changed DCK package pin names from IN+ and IN- to +IN and -IN, respectively .....	5
• Changed DBV package from product preview to production data .....	5
• Changed <a href="#">图 9</a> .....	11
• Added <a href="#">Functional Block Diagram</a> section .....	18
• Added <a href="#">Capacitive Load Drive Solution Using an Isolation Resistor</a> section .....	24
• Added <a href="#">Power-Supply Recommendations</a> section .....	27
• Changed <a href="#">Layout Guidelines</a> section .....	28

## 5 Device Comparison

### Device Comparison

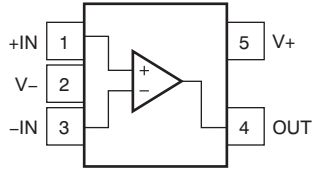
DEVICE	PACKAGE
OPA172 (single)	SC70-5, SOT-23-5, SOIC-8
OPA2172 (dual)	SOIC-8, VSSOP-8, WSON-8
OPA4172 (quad)	SOIC-14, TSSOP-14

### Device Family Comparison

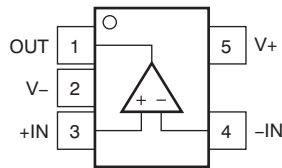
DEVICE	QUIESCENT CURRENT ( $I_Q$ )	GAIN BANDWIDTH PRODUCT (GBP)	VOLTAGE NOISE DENSITY ( $e_n$ )
<a href="#">OPAx172</a>	1600 $\mu$ A	10 MHz	7 nV/ $\sqrt{\text{Hz}}$
<a href="#">OPAx171</a>	475 $\mu$ A	3.0 MHz	14 nV/ $\sqrt{\text{Hz}}$
<a href="#">OPAx170</a>	110 $\mu$ A	1.2 MHz	19 nV/ $\sqrt{\text{Hz}}$

## 6 Pin Configuration and Functions

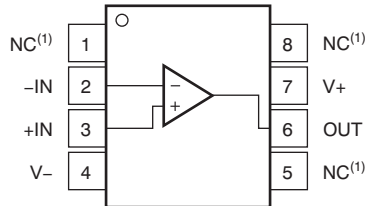
**DCK Package: OPA172  
SC70-5  
Top View**



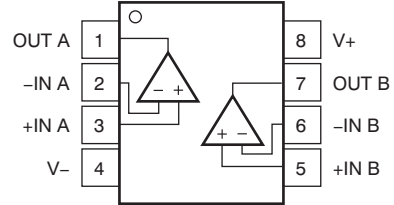
**DBV Package: OPA172  
SOT-23-5  
Top View**



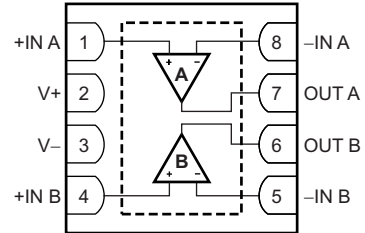
**D Package: OPA172  
SOIC-8  
Top View**



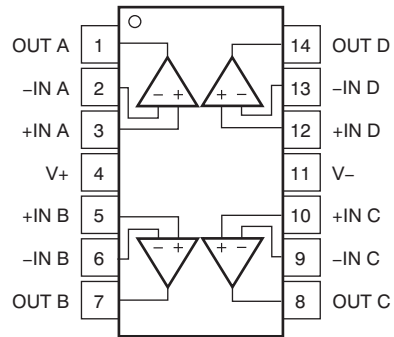
**D and DGK Packages: OPA2172  
SOIC-8 and VSSOP-8  
Top View**



**DRG Package: OPA2172  
WSON-8  
Top View**



**D and PW Packages: OPA4172  
SO-14 and TSSOP-14  
Top View**



(1) No internal connection.

**OPA172, OPA2172, OPA4172**

ZHCSBX8H – DECEMBER 2013 – REVISED SEPTEMBER 2015

[www.ti.com.cn](http://www.ti.com.cn)
**Pin Functions: OPA172**

PIN				I/O	DESCRIPTION
NAME	OPA172				
	D (SOIC)	DBV (SOT)	DCK (SC70)		
+IN	3	3	1	I	Noninverting input
–IN	2	4	3	I	Inverting input
NC	1, 5, 8	—	—	—	No internal connection
OUT	6	1	4	O	Output
V+	7	5	5	—	Positive (highest) power supply
V–	4	2	2	—	Negative (lowest) power supply

**Pin Functions: OPA2172 and OPA4172**

PIN				I/O	DESCRIPTION
NAME	OPA2172		OPA4172		
	D (SOIC), DGK (VSSOP)	DRG (WSO)	D (SOIC), PW (TSSOP)		
+IN A	3	1	3	I	Noninverting input, channel A
+IN B	5	4	5	I	Noninverting input, channel B
+IN C	—	—	10	I	Noninverting input, channel C
+IN D	—	—	12	I	Noninverting input, channel D
–IN A	2	8	2	I	Inverting input, channel A
–IN B	6	5	6	I	Inverting input, channel B
–IN C	—	—	9	I	Inverting input, channel C
–IN D	—	—	13	I	Inverting input, channel D
OUT A	1	7	1	O	Output, channel A
OUT B	7	6	7	O	Output, channel B
OUT C	—	—	8	O	Output, channel C
OUT D	—	—	14	O	Output, channel D
V+	8	2	4	—	Positive (highest) power supply
V–	4	3	11	—	Negative (lowest) power supply

## 7 Specifications

### 7.1 Absolute Maximum Ratings<sup>(1)</sup>

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
Supply voltage, $V_S$			±20 (+40, single supply)		V
Signal input pins	Voltage <sup>(2)</sup>	Common-mode	(V-) – 0.5	(V+) + 0.5	V
		Differential <sup>(3)</sup>	±0.5		
	Current	±10		mA	
Output short circuit <sup>(4)</sup>			Continuous		
Temperature	Operating		–55	+150	°C
	Junction			+150	
	Storage, $T_{stg}$		–65	+150	

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Transient conditions that exceed these voltage ratings must be current limited to 10 mA or less.
- (3) Refer to the [Electrical Overstress](#) section for more information.
- (4) Short-circuit to ground, one amplifier per package.

### 7.2 ESD Ratings

		VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±4000
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	±1000

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 7.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

	MIN	NOM	MAX	UNIT
Supply voltage ( $V_+ - V_-$ )	4.5 (±2.25)		36 (±18)	V
Specified temperature	–40		125	°C

### 7.4 Thermal Information: OPA172

THERMAL METRIC <sup>(1)</sup>	OPA172			UNIT
	D (SOIC)	DBV (SOT-23)	DCK (SC70)	
	8 PINS	5 PINS	5 PINS	
$R_{\theta JA}$ Junction-to-ambient thermal resistance	126.5	227.9	285.2	°C/W
$R_{\theta JC(top)}$ Junction-to-case(top) thermal resistance	80.6	115.7	60.5	°C/W
$R_{\theta JB}$ Junction-to-board thermal resistance	67.1	65.9	78.9	°C/W
$\Psi_{JT}$ Junction-to-top characterization parameter	31.0	10.7	0.8	°C/W
$\Psi_{JB}$ Junction-to-board characterization parameter	66.6	65.3	77.9	°C/W
$R_{\theta JC(bot)}$ Junction-to-case(bottom) thermal resistance	N/A	N/A	N/A	°C/W

- (1) 有关传统和新热指标的更多信息，请参见《半导体和 IC 封装热指标》应用报告，[SPRA953](#)。

## 7.5 Thermal Information: OPA2172

THERMAL METRIC <sup>(1)</sup>		OPA2172			UNIT
		D (SOIC)	DGK (VSSOP)	DRG (WSON)	
		8 PINS	8 PINS	8 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	116.1	158	63.2	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	69.8	48.6	63.5	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	56.6	78.7	36.5	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	22.5	3.9	1.4	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	56.1	77.3	36.6	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	N/A	N/A	6.3	°C/W

(1) 有关传统和新热指标的更多信息，请参见《半导体和 IC 封装热指标》应用报告，SPRA953。

## 7.6 Thermal Information: OPA4172

THERMAL METRIC <sup>(1)</sup>		OPA4172		UNIT
		D (SOIC)	PW (TSSOP)	
		14 PINS	14 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	82.7	111.1	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	42.3	40.8	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	37.3	54.1	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	8.9	3.8	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	37	53.3	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	N/A	N/A	°C/W

(1) 有关传统和新热指标的更多信息，请参见《半导体和 IC 封装热指标》应用报告，SPRA953。

## 7.7 Electrical Characteristics

At T<sub>A</sub> = +25°C, V<sub>S</sub> = ±2.25 V to ±18 V, V<sub>CM</sub> = V<sub>OUT</sub> = V<sub>S</sub> / 2, and R<sub>L</sub> = 10 kΩ connected to V<sub>S</sub> / 2, unless otherwise noted.

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
<b>OFFSET VOLTAGE</b>							
V <sub>OS</sub>	Input offset voltage				±0.2	±1	mV
		T <sub>A</sub> = -40°C to +125°C				±1.15	
dV <sub>OS</sub> /dT	Drift	T <sub>A</sub> = -40°C to +125°C			±0.3	±1.5	μV/°C
			OPA172, OPA4172			±1.8	
PSRR	vs power supply	T <sub>A</sub> = -40°C to +125°C			±1	±3	μV/V
	Channel separation, dc	At dc			5		μV/V
<b>INPUT BIAS CURRENT</b>							
I <sub>B</sub>	Input bias current	T <sub>A</sub> = -40°C to +125°C			±8	±15	pA
		T <sub>A</sub> = -40°C to +125°C	OPA2172IDGK			±18	nA
			OPA41721PW				
I <sub>OS</sub>	Input offset current	T <sub>A</sub> = -40°C to +125°C			±2	±15	pA
		T <sub>A</sub> = -40°C to +125°C	OPA172, OPA4172			±1	nA
			OPA2172			±3	
<b>NOISE</b>							
E <sub>n</sub>	Input voltage noise	f = 0.1 Hz to 10 Hz			2.5		μV <sub>PP</sub>
e <sub>n</sub>	Input voltage noise density	f = 100 Hz			12		nV/√Hz
		f = 1 kHz			7		
i <sub>n</sub>	Input current noise density	f = 1 kHz			1.6		fA/√Hz



**Electrical Characteristics (接下页)**

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 2.25\text{ V}$  to  $\pm 18\text{ V}$ ,  $V_{CM} = V_{OUT} = V_S / 2$ , and  $R_L = 10\text{ k}\Omega$  connected to  $V_S / 2$ , unless otherwise noted.

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT	
<b>INPUT VOLTAGE</b>								
$V_{CM}$	Common-mode voltage range <sup>(1)</sup>			$(V-) - 0.1\text{ V}$		$(V+) - 2\text{ V}$	V	
CMRR	Common-mode rejection ratio	$V_S = \pm 2.25\text{ V}$ , $(V-) - 0.1\text{ V} < V_{CM} < (V+) - 2\text{ V}$ , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$		90	104		dB	
		$V_S = \pm 18\text{ V}$ , $(V-) - 0.1\text{ V} < V_{CM} < (V+) - 2\text{ V}$ , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$		110	120			
<b>INPUT IMPEDANCE</b>								
Differential				100    4			M $\Omega$    pF	
Common-mode				6    4			10 <sup>13</sup> $\Omega$    pF	
<b>OPEN-LOOP GAIN</b>								
$A_{OL}$	Open-loop voltage gain	$(V-) + 0.35\text{ V} < V_O < (V+) - 0.35\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	OPA172, OPA4172	110	130		dB	
			OPA2172	107	115			
		$(V-) + 0.5\text{ V} < V_O < (V+) - 0.5\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	OPA172, OPA4172			116		
			OPA2172			107		
<b>FREQUENCY RESPONSE</b>								
GBP	Gain bandwidth product			10			MHz	
SR	Slew rate	$G = +1$		10			V/ $\mu\text{s}$	
$t_S$	Settling time	To 0.1%, $V_S = \pm 18\text{ V}$ , $G = +1$ , 10-V step		2			$\mu\text{s}$	
		To 0.01% (12 bit), $V_S = \pm 18\text{ V}$ , $G = +1$ , 10-V step		3.2				
	Overload recovery time	$V_{IN} \times \text{Gain} > V_S$		200			ns	
THD+N	Total harmonic distortion + noise	$V_S = +36\text{ V}$ , $G = +1$ , $f = 1\text{ kHz}$ , $V_O = 3.5\text{ V}_{RMS}$		0.00005%				
<b>OUTPUT</b>								
$V_O$	Voltage output swing from rail	$V_S = +36\text{ V}$	$R_L = 10\text{ k}\Omega$	70	90		mV	
			$R_L = 2\text{ k}\Omega$	330	400			
		$V_S = +36\text{ V}$ , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	$R_L = 10\text{ k}\Omega$	95	120			
			$R_L = 2\text{ k}\Omega$	470	530			
		$V_S = +4.5\text{ V}$	$R_L = 10\text{ k}\Omega$	10	20			
			$R_L = 2\text{ k}\Omega$	40	50			
		$V_S = +4.5\text{ V}$ , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	$R_L = 10\text{ k}\Omega$	10	25			
			$R_L = 2\text{ k}\Omega$	55	70			
$I_{SC}$	Short-circuit current			$\pm 75$			mA	
$C_{LOAD}$	Capacitive load drive			See <a href="#">Typical Characteristics</a>			pF	
$Z_O$	Open-loop output impedance	$f = 1\text{ MHz}$ , $I_O = 0\text{ A}$		60			$\Omega$	
<b>POWER SUPPLY</b>								
$V_S$	Specified voltage range			+4.5		+36	V	
$I_Q$	Quiescent current per amplifier	$I_O = 0\text{ A}$		1.6	1.8		mA	
		$I_O = 0\text{ A}$ , $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$		2				
<b>TEMPERATURE</b>								
Specified range				-40		+125	$^\circ\text{C}$	

(1) The input range can be extended beyond  $(V+) - 2\text{ V}$  up to  $(V+) + 0.1\text{ V}$ . See the [Typical Characteristics](#) and [Application Information](#) sections for additional information.

## 7.8 Typical Characteristics: Table of Graphs

**表 1. List of Typical Characteristics**

DESCRIPTION	FIGURE
Offset Voltage Production Distribution	图 1
Offset Voltage Drift Distribution	图 2
Offset Voltage vs Temperature ( $V_S = \pm 18\text{ V}$ )	图 3
Offset Voltage vs Common-Mode Voltage ( $V_S = \pm 18\text{ V}$ )	图 4
Offset Voltage vs Common-Mode Voltage (Upper Stage)	图 5
Offset Voltage vs Power Supply	图 6
$I_B$ vs Common-Mode Voltage	图 7
Input Bias Current vs Temperature	图 8
Output Voltage Swing vs Output Current (Maximum Supply)	图 9
CMRR and PSRR vs Frequency (Referred-to Input)	图 10
CMRR vs Temperature	图 11
PSRR vs Temperature	图 12
0.1-Hz to 10-Hz Noise	图 13
Input Voltage Noise Spectral Density vs Frequency	图 14
THD+N Ratio vs Frequency	图 15
THD+N vs Output Amplitude	图 16
Quiescent Current vs Temperature	图 17
Quiescent Current vs Supply Voltage	图 18
Open-Loop Gain and Phase vs Frequency	图 19
Closed-Loop Gain vs Frequency	图 20
Open-Loop Gain vs Temperature	图 21
Open-Loop Output Impedance vs Frequency	图 22
Small-Signal Overshoot vs Capacitive Load (100-mV Output Step)	图 23, 图 24
Positive Overload Recovery	图 25, 图 26
Negative Overload Recovery	图 27, 图 28
Small-Signal Step Response (10 mV)	图 29, 图 30
Small-Signal Step Response (100 mV)	图 31, 图 32
Large-Signal Step Response (1 V)	图 33, 图 34
Large-Signal Settling Time (10-V Positive Step)	图 35
Large-Signal Settling Time (10-V Negative Step)	图 36
No Phase Reversal	图 37
Short-Circuit Current vs Temperature	图 38
Maximum Output Voltage vs Frequency	图 39
EMIRR vs Frequency	图 40
Channel Separation vs Frequency	图 41

### 7.9 Typical Characteristics

At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.

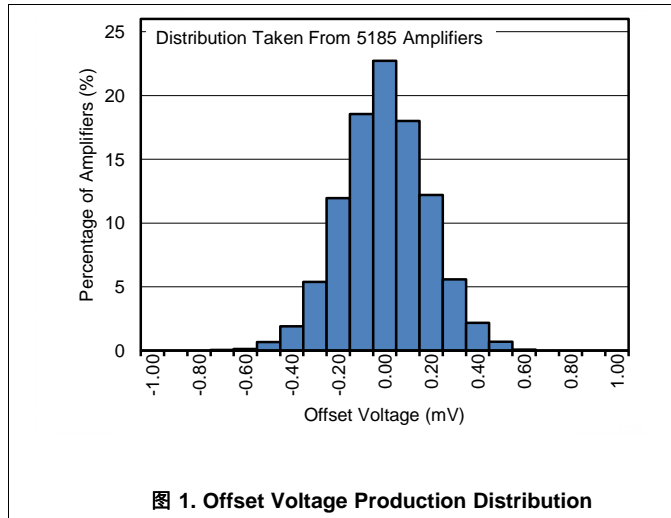


图 1. Offset Voltage Production Distribution

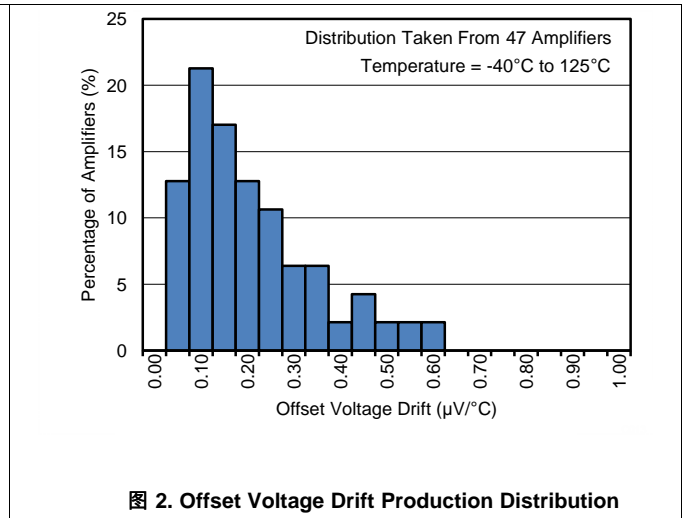


图 2. Offset Voltage Drift Production Distribution

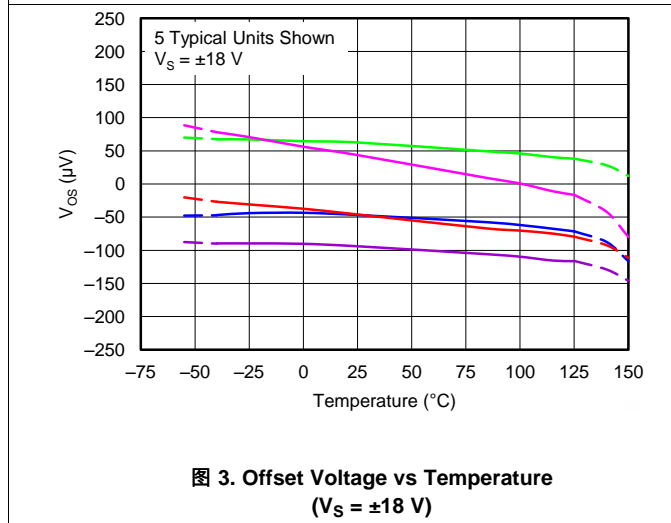


图 3. Offset Voltage vs Temperature  
( $V_S = \pm 18\text{ V}$ )

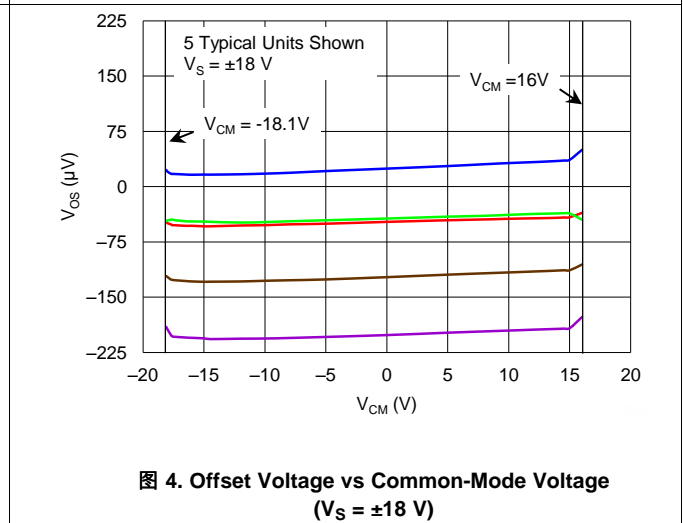


图 4. Offset Voltage vs Common-Mode Voltage  
( $V_S = \pm 18\text{ V}$ )

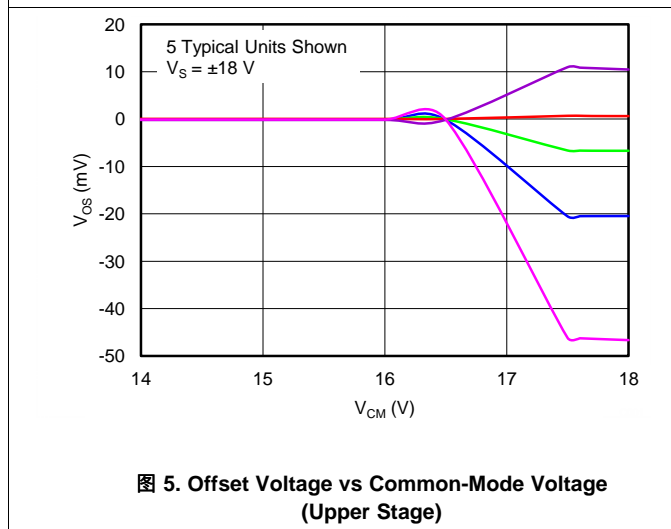


图 5. Offset Voltage vs Common-Mode Voltage  
(Upper Stage)

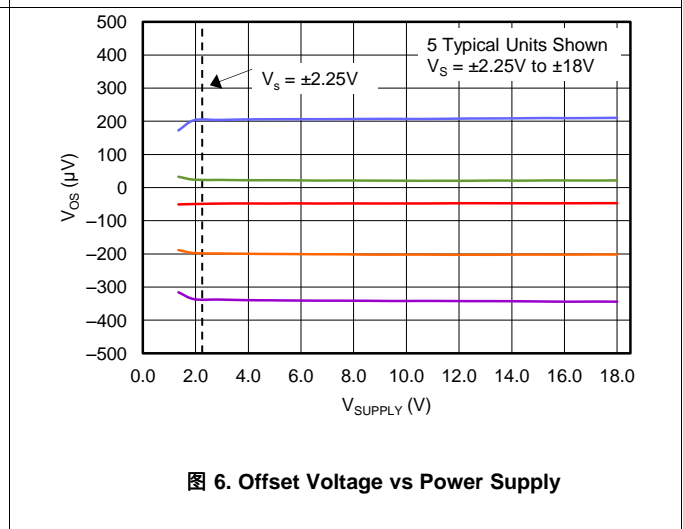


图 6. Offset Voltage vs Power Supply

Typical Characteristics (接下页)

At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.

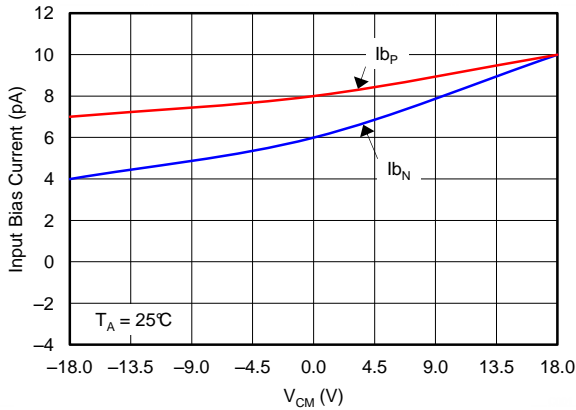


图 7. Input Bias Current vs Common-Mode Voltage

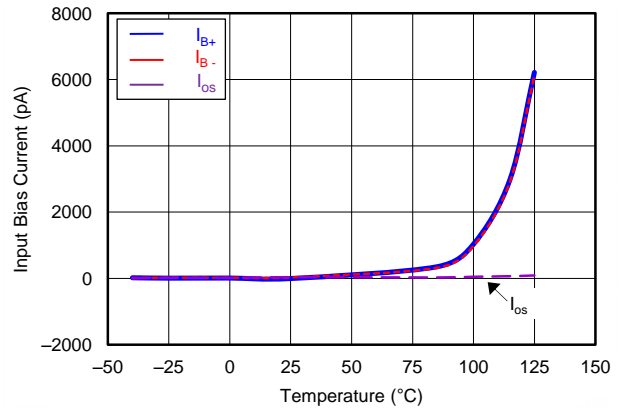


图 8. Input Bias Current vs Temperature

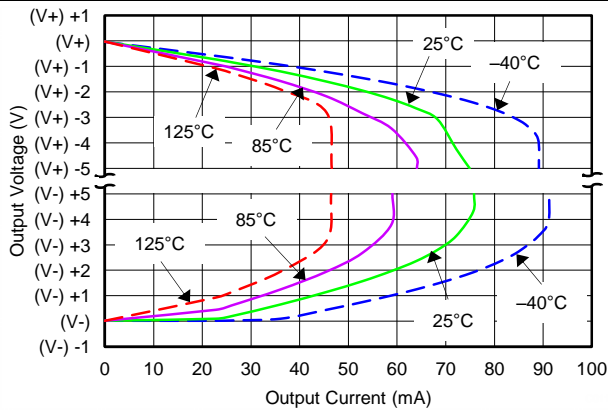


图 9. Output Voltage Swing vs Output Current (Maximum Supply)

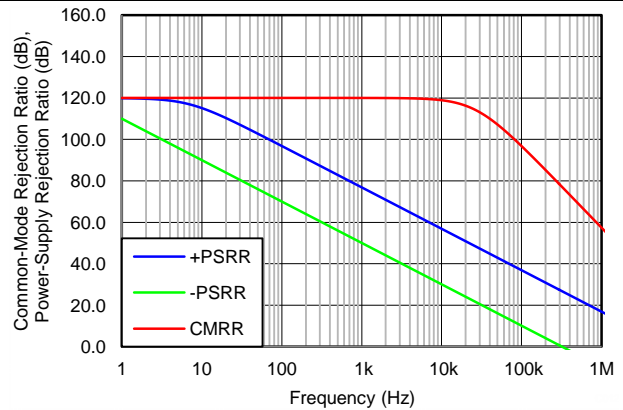


图 10. CMRR and PSRR vs Frequency (Referred-To-Input)

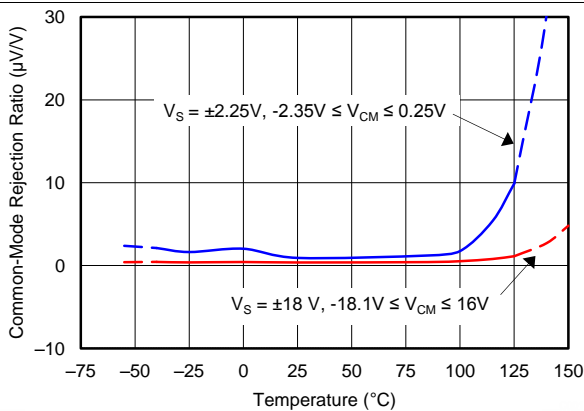


图 11. CMRR vs Temperature

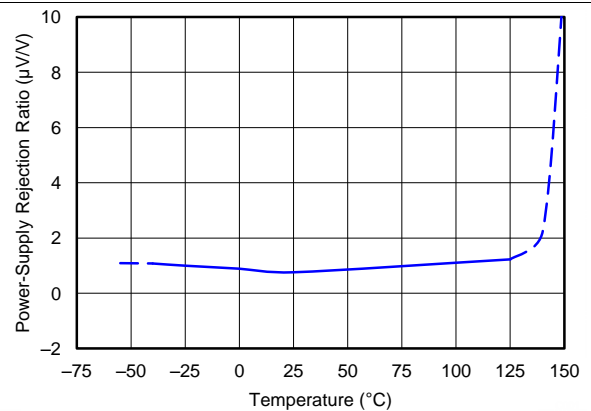


图 12. PSRR vs Temperature

Typical Characteristics (接下页)

At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.

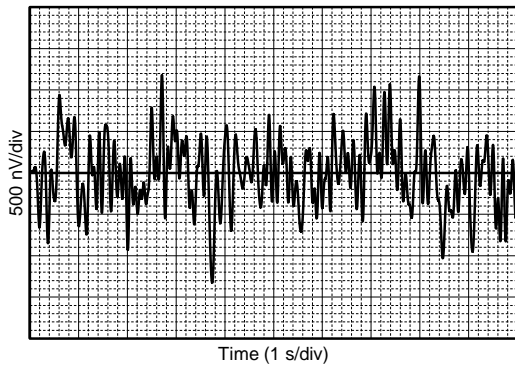


图 13. 0.1-Hz to 10-Hz Noise

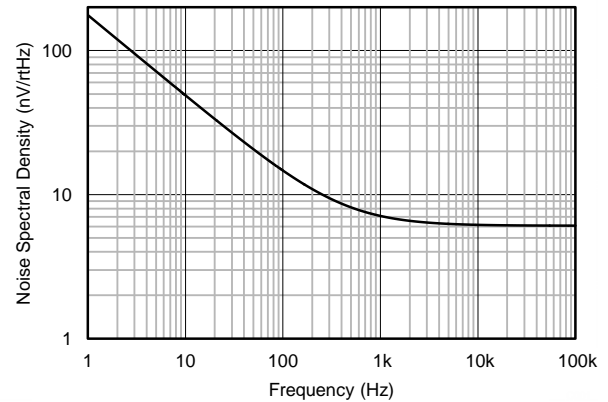


图 14. Input Voltage Noise Spectral Density vs Frequency

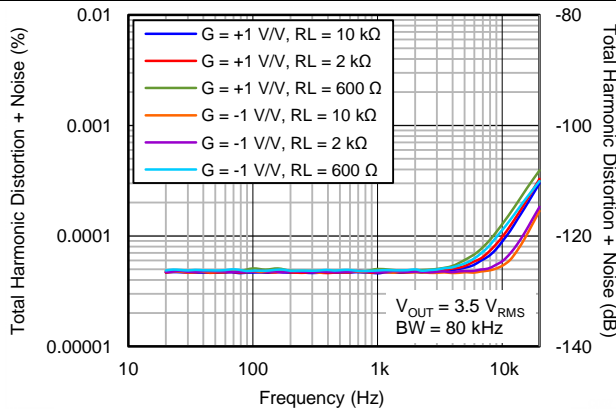


图 15. THD+N Ratio vs Frequency

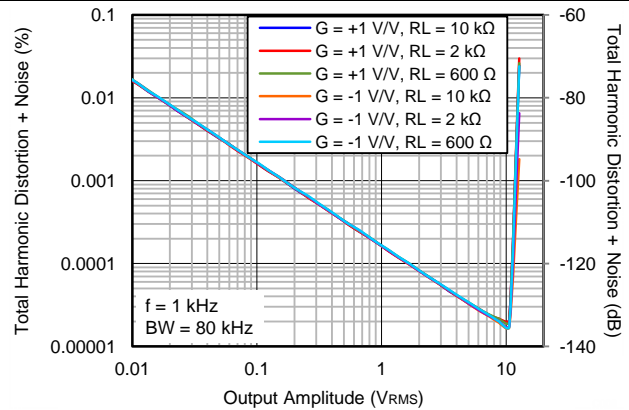


图 16. THD+N vs Output Amplitude

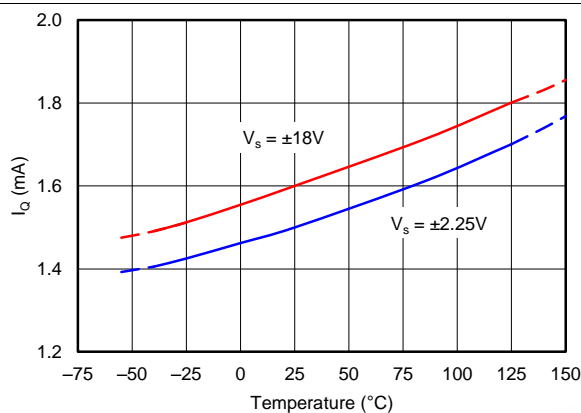


图 17. Quiescent Current vs Temperature

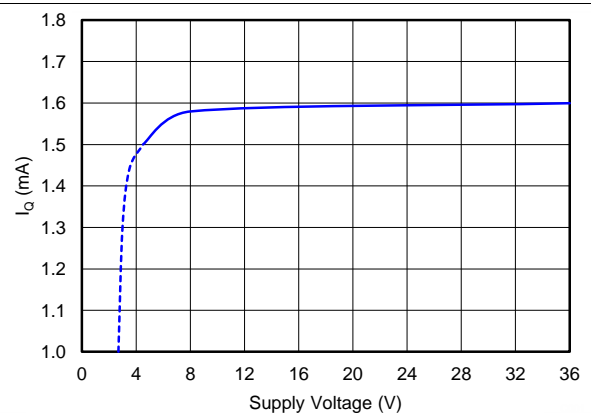


图 18. Quiescent Current vs Supply Voltage

Typical Characteristics (接下页)

At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.

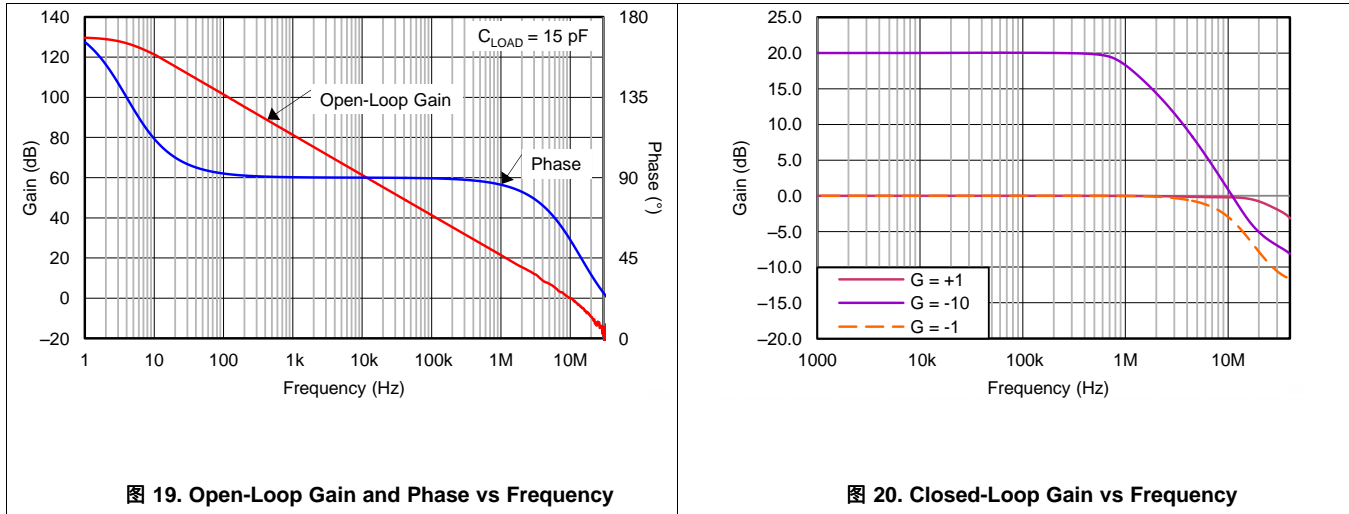


图 19. Open-Loop Gain and Phase vs Frequency

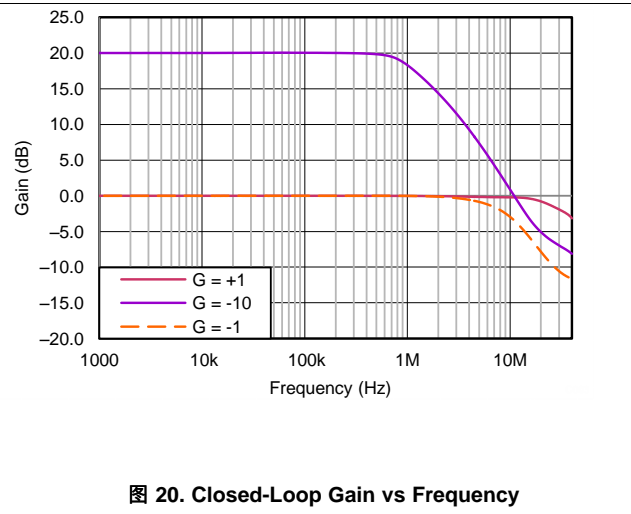


图 20. Closed-Loop Gain vs Frequency

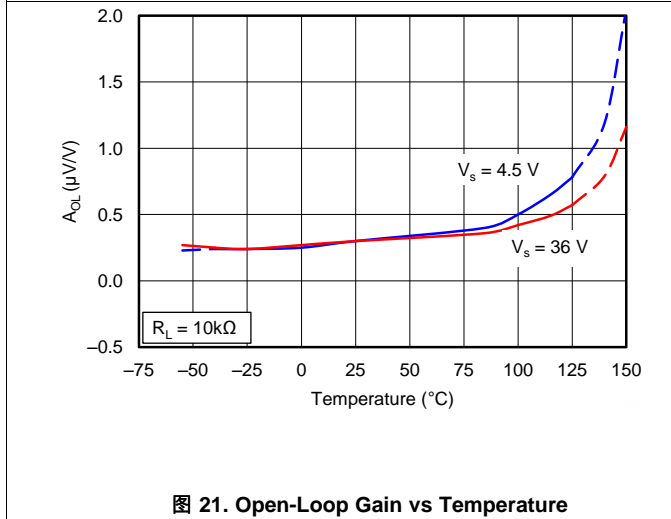


图 21. Open-Loop Gain vs Temperature

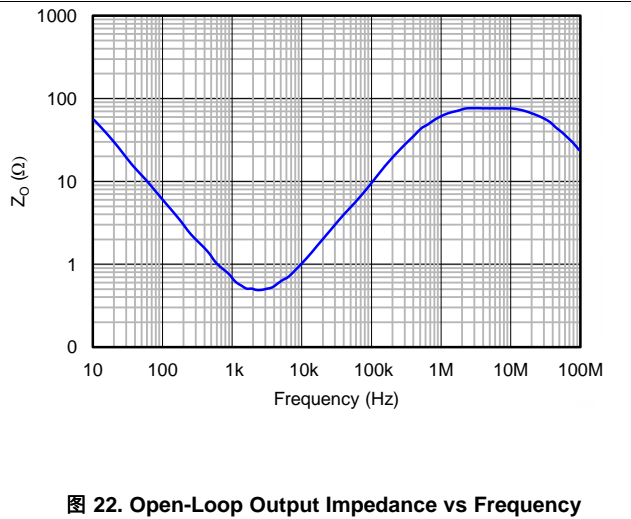


图 22. Open-Loop Output Impedance vs Frequency

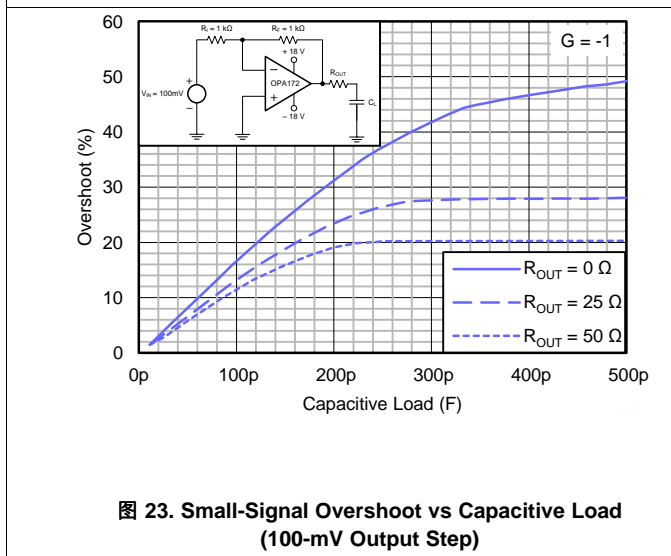


图 23. Small-Signal Overshoot vs Capacitive Load (100-mV Output Step)

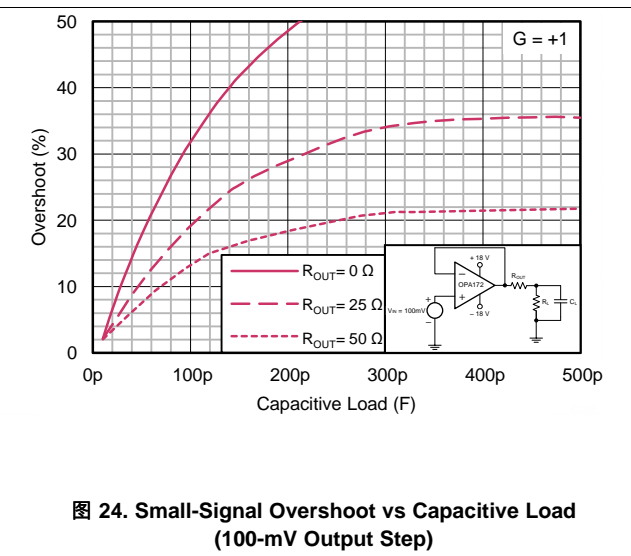


图 24. Small-Signal Overshoot vs Capacitive Load (100-mV Output Step)

Typical Characteristics (接下页)

At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.

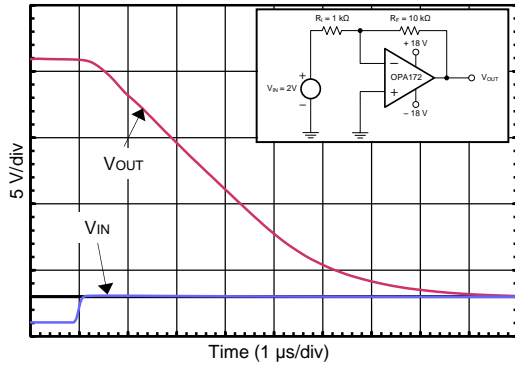


图 25. Positive Overload Recovery

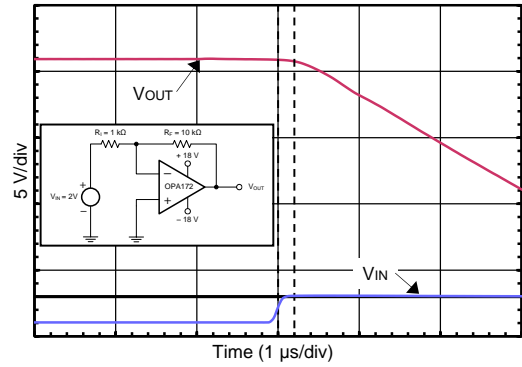


图 26. Positive Overload Recovery (Zoomed In)

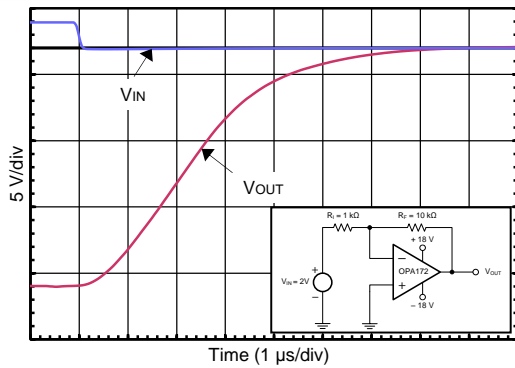


图 27. Negative Overload Recovery

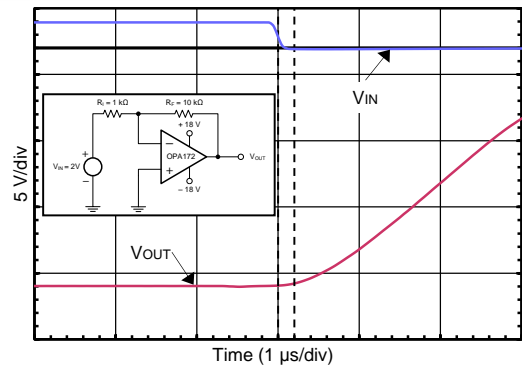


图 28. Negative Overload Recovery (Zoomed In)

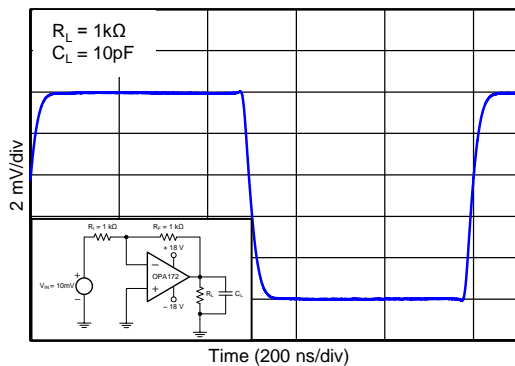


图 29. Small-Signal Step Response (10 mV, G = -1)

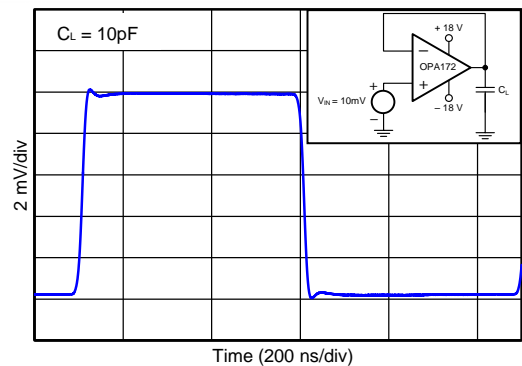
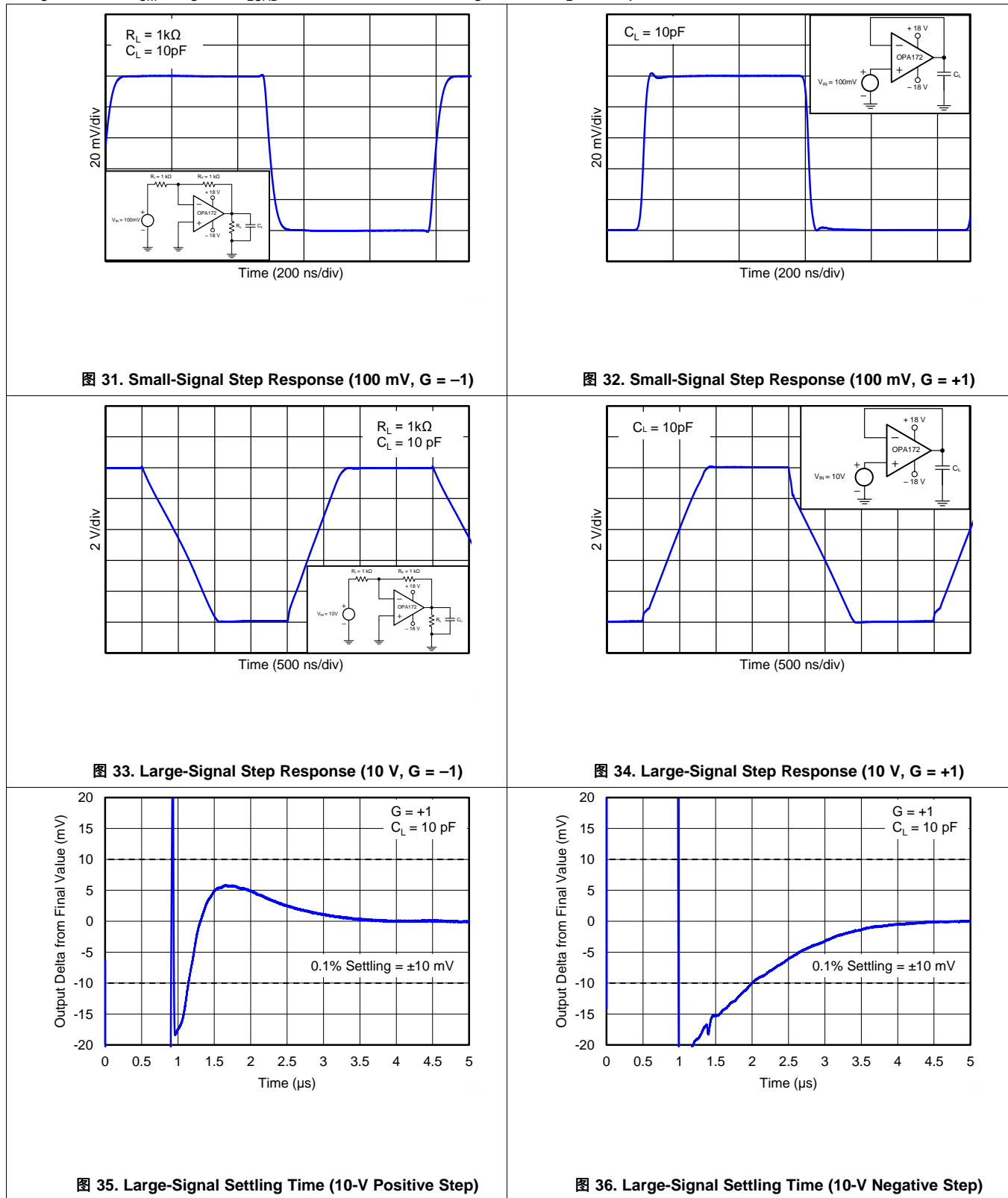


图 30. Small-Signal Step Response (10 mV, G = +1)

### Typical Characteristics (接下页)

At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.





Typical Characteristics (接下页)

At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.

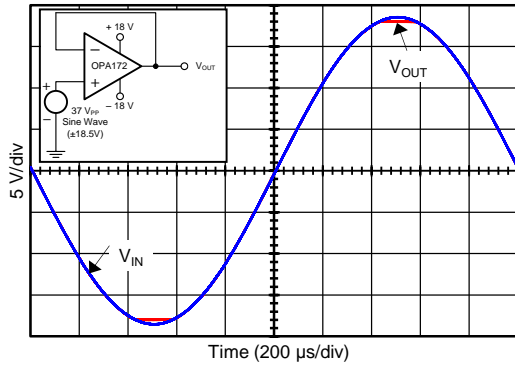


图 37. No Phase Reversal

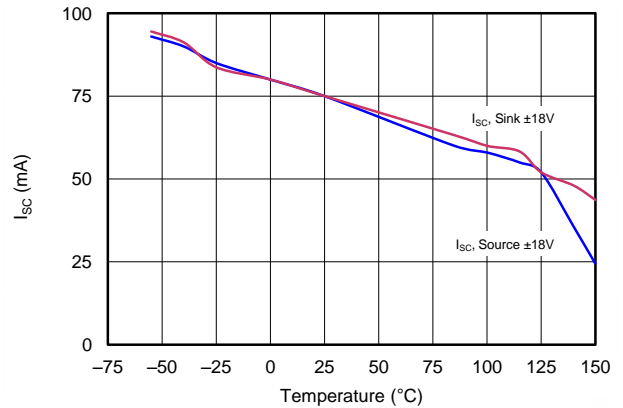


图 38. Short-Circuit Current vs Temperature

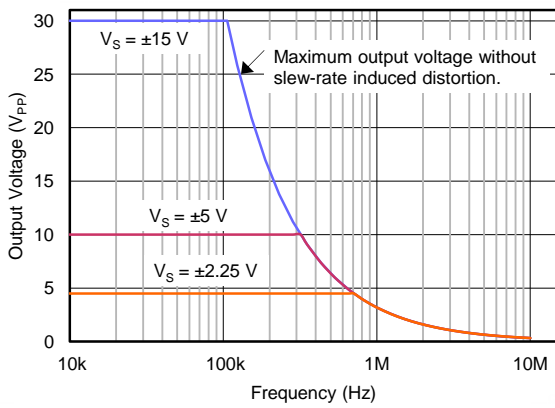


图 39. Maximum Output Voltage vs Frequency

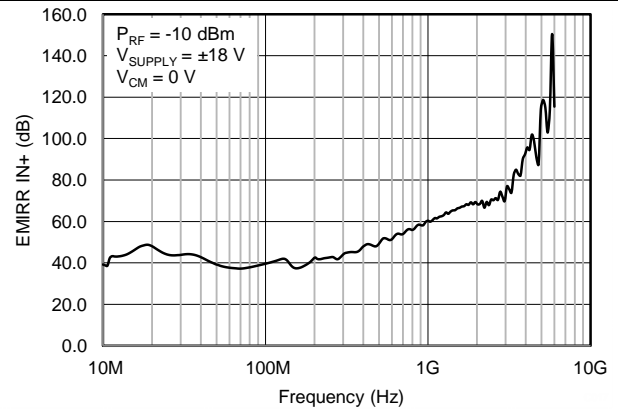


图 40. EMIRR vs Frequency

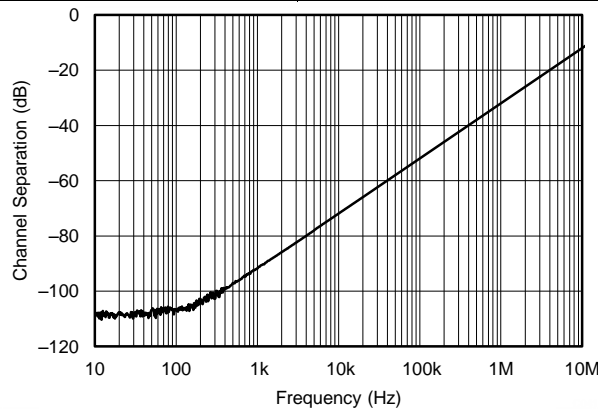


图 41. Channel Separation vs Frequency

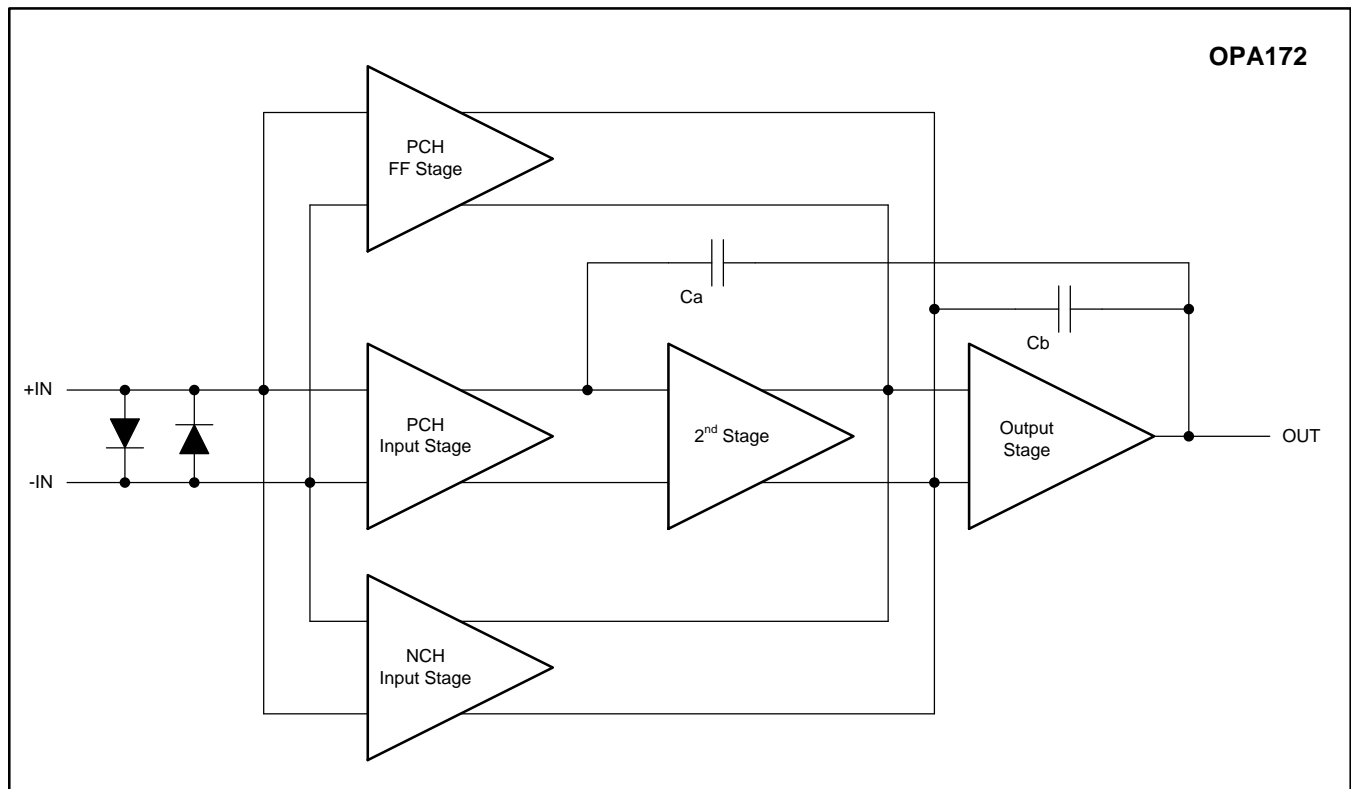
## 8 Detailed Description

### 8.1 Overview

The OPAx172 family of operational amplifiers provide high overall performance, making them ideal for many general-purpose applications. The excellent offset drift of only  $1.5 \mu\text{V}/^\circ\text{C}$  (max) provides excellent stability over the entire temperature range. In addition, the device offers very good overall performance with high CMRR, PSRR,  $A_{OL}$ , and superior THD.

The [Functional Block Diagram](#) section shows the simplified diagram of the OPA172 design. The design topology is a highly-optimized, three-stage amplifier with an active-feedforward gain stage.

### 8.2 Functional Block Diagram



## 8.3 Feature Description

### 8.3.1 EMI Rejection

The OPAx172 uses integrated electromagnetic interference (EMI) filtering to reduce the effects of EMI from sources such as wireless communications and densely-populated boards with a mix of analog signal chain and digital components. EMI immunity can be improved with circuit design techniques; the OPAx172 benefits from these design improvements. Texas Instruments has developed the ability to accurately measure and quantify the immunity of an operational amplifier over a broad frequency spectrum extending from 10 MHz to 6 GHz. 图 42 shows the results of this testing on the OPAx172. 表 2 shows the EMIRR IN+ values for the OPAx172 at particular frequencies commonly encountered in real-world applications. Applications listed in 表 2 can be centered on or operated near the particular frequency shown. Detailed information can also be found in Application Report [SBOA128](#), *EMI Rejection Ratio of Operational Amplifiers*, available for download from [www.ti.com](http://www.ti.com).

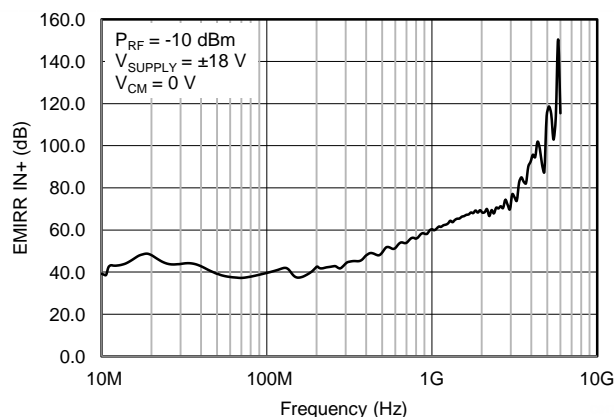


图 42. EMIRR Testing

表 2. OPAx172 EMIRR IN+ for Frequencies of Interest

FREQUENCY	APPLICATION OR ALLOCATION	EMIRR IN+
400 MHz	Mobile radio, mobile satellite, space operation, weather, radar, ultrahigh frequency (UHF) applications	47.6 dB
900 MHz	Global system for mobile communications (GSM) applications, radio communication, navigation, GPS (to 1.6 GHz), GSM, aeronautical mobile, UHF applications	58.5 dB
1.8 GHz	GSM applications, mobile personal communications, broadband, satellite, L-band (1 GHz to 2 GHz)	68 dB
2.4 GHz	802.11b, 802.11g, 802.11n, Bluetooth®, mobile personal communications, industrial, scientific and medical (ISM) radio band, amateur radio and satellite, S-band (2 GHz to 4 GHz)	69.2 dB
3.6 GHz	Radiolocation, aero communication and navigation, satellite, mobile, S-band	82.9 dB
5.0 GHz	802.11a, 802.11n, aero communication and navigation, mobile communication, space and satellite operation, C-band (4 GHz to 8 GHz)	114 dB

### 8.3.2 Phase-Reversal Protection

The OPAx172 family has internal phase-reversal protection. Many op amps exhibit a phase reversal when the input is driven beyond the linear common-mode range. This condition is most often encountered in noninverting circuits when the input is driven beyond the specified common-mode voltage range, causing the output to reverse into the opposite rail. The input of the OPAx172 prevents phase reversal with excessive common-mode voltage. Instead, the appropriate rail limits the output voltage. This performance is shown in [图 43](#).

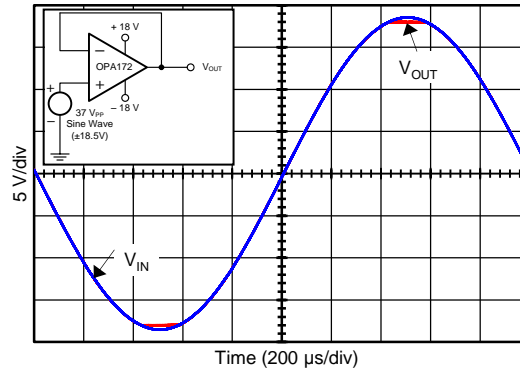


图 43. No Phase Reversal

### 8.3.3 Capacitive Load and Stability

The dynamic characteristics of the OPAx172 are optimized for commonly-used operating conditions. The combination of low closed-loop gain and high capacitive loads decreases the phase margin of the amplifier and may lead to gain peaking or oscillations. As a result, heavier capacitive loads must be isolated from the output. The simplest way to achieve this isolation is to add a small resistor (for example,  $R_{OUT} = 50 \Omega$ ) in series with the output. [图 44](#) and [图 45](#) show graphs of small-signal overshoot versus capacitive load for several values of  $R_{OUT}$ . Refer to Application Bulletin [SBOA015 \(AB-028\)](#), *Feedback Plots Define Op Amp AC Performance*, available for download from [www.ti.com](http://www.ti.com), for details of analysis techniques and application circuits.

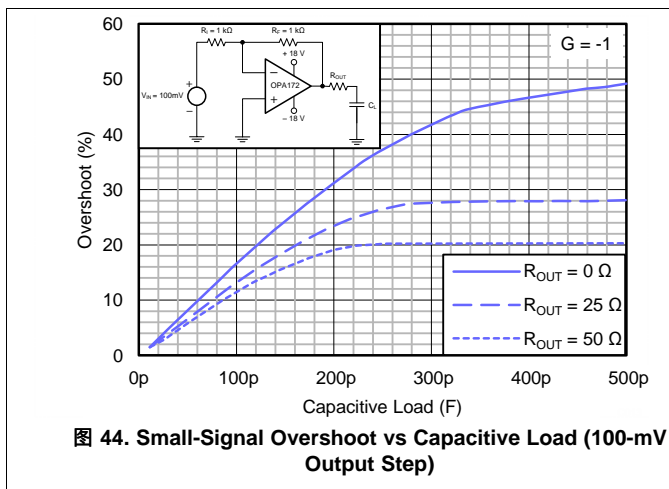


图 44. Small-Signal Overshoot vs Capacitive Load (100-mV Output Step)

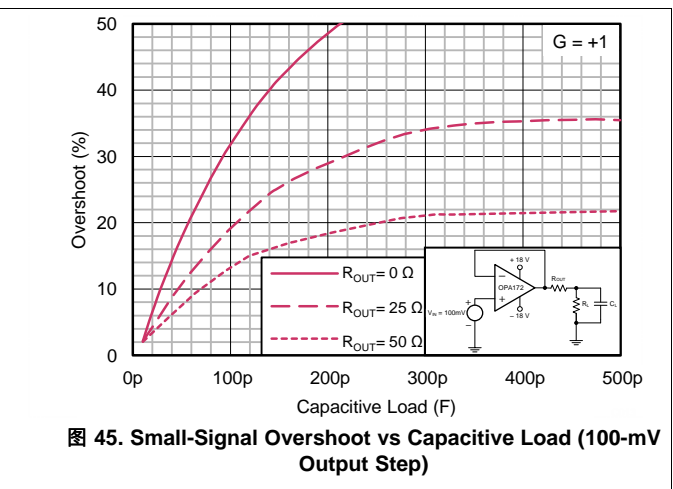


图 45. Small-Signal Overshoot vs Capacitive Load (100-mV Output Step)

## 8.4 Device Functional Modes

### 8.4.1 Common-Mode Voltage Range

The input common-mode voltage range of the OPAx172 series extends 100 mV below the negative rail and within 2 V of the top rail for normal operation.

This device can operate with full rail-to-rail input 100 mV beyond the top rail, but with reduced performance within 2 V of the top rail. The typical performance in this range is summarized in [表 3](#).

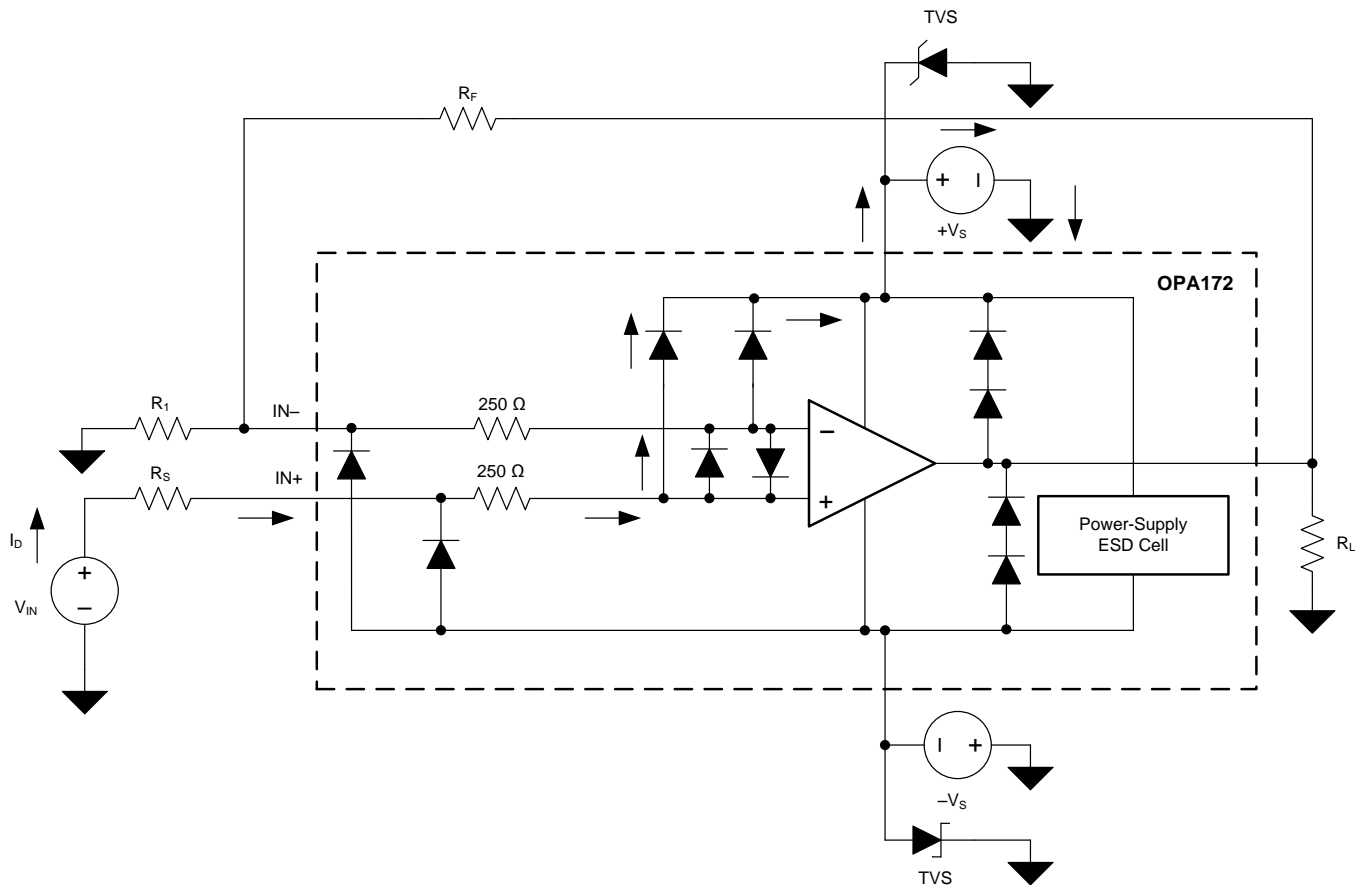
**表 3. Typical Performance Range ( $V_S = \pm 18\text{ V}$ )**

PARAMETER	MIN	TYP	MAX	UNIT
Input Common-Mode Voltage	$(V+) - 2$		$(V+) + 0.1$	V
Offset voltage		5		mV
Offset voltage vs temperature ( $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$ )		10		$\mu\text{V}/^\circ\text{C}$
Common-mode rejection		70		dB
Open-loop gain		60		dB
Gain bandwidth product (GBP)		4		MHz
Slew rate		4		$\text{V}/\mu\text{s}$
Noise at $f = 1\text{ kHz}$		22		$\text{nV}/\sqrt{\text{Hz}}$

### 8.4.2 Electrical Overstress

Designers often ask questions about the capability of an operational amplifier to withstand electrical overstress. These questions tend to focus on the device inputs, but may involve the supply voltage terminals or even the output terminal. Each of these different terminal functions have electrical stress limits determined by the voltage breakdown characteristics of the particular semiconductor fabrication process and specific circuits connected to the terminal. Additionally, internal electrostatic discharge (ESD) protection is built into these circuits to protect them from accidental ESD events both before and during product assembly.

A good understanding of this basic ESD circuitry and its relevance to an electrical overstress event is helpful. [图 46](#) illustrates the ESD circuits contained in the OPAx172 (indicated by the dashed line area). The ESD protection circuitry involves several current-steering diodes connected from the input and output terminals and routed back to the internal power-supply lines, where the diodes meet at an absorption device internal to the operational amplifier. This protection circuitry is intended to remain inactive during normal circuit operation.



**图 46. Equivalent Internal ESD Circuitry Relative to a Typical Circuit Application**

An ESD event produces a short-duration, high-voltage pulse that is transformed into a short-duration, high-current pulse while discharging through a semiconductor device. The ESD protection circuits are designed to provide a current path around the operational amplifier core to prevent damage. The energy absorbed by the protection circuitry is then dissipated as heat.

When an ESD voltage develops across two or more amplifier device terminals, current flows through one or more steering diodes. Depending on the path that the current takes, the absorption device may activate. The absorption device has a trigger, or threshold voltage, that is above the normal operating voltage of the OPAx172 but below the device breakdown voltage level. When this threshold is exceeded, the absorption device quickly activates and clamps the voltage across the supply rails to a safe level.

When the operational amplifier connects into a circuit (as shown in [图 46](#)), the ESD protection components are intended to remain inactive and do not become involved in the application circuit operation. However, circumstances may arise where an applied voltage exceeds the operating voltage range of a given terminal. If this condition occurs, there is a risk that some internal ESD protection circuits can turn on and conduct current. Any such current flow occurs through steering-diode paths and rarely involves the absorption device.

[图 46](#) shows a specific example where the input voltage ( $V_{IN}$ ) exceeds the positive supply voltage ( $+V_S$ ) by 500 mV or more. Much of what happens in the circuit depends on the supply characteristics. If  $+V_S$  can sink the current, one of the upper input steering diodes conducts and directs current to  $+V_S$ . Excessively high current levels can flow with increasingly higher  $V_{IN}$ . As a result, the data sheet specifications recommend that applications limit the input current to 10 mA.

If the supply is not capable of sinking the current,  $V_{IN}$  can begin sourcing current to the operational amplifier, and then take over as the source of positive supply voltage. The danger in this case is that the voltage can rise to levels that exceed the operational amplifier absolute maximum ratings.

Another common question involves what happens to the amplifier if an input signal is applied to the input while the power supplies  $+V_S$  or  $-V_S$  are at 0 V. Again, this question depends on the supply characteristic while at 0 V, or at a level below the input-signal amplitude. If the supplies appear as high impedance, then the input source supplies the operational amplifier current through the current-steering diodes. This state is not a normal bias condition; most likely, the amplifier will not operate normally. If the supplies are low impedance, then the current through the steering diodes can become quite high. The current level depends on the ability of the input source to deliver current, and any resistance in the input path.

If there is any uncertainty about the ability of the supply to absorb this current, add external zener diodes to the supply terminals; see [Figure 46](#). Select the zener voltage so that the diode does not turn on during normal operation. However, the zener voltage must be low enough so that the zener diode conducts if the supply terminal begins to rise above the safe-operating, supply-voltage level.

The OPAx172 input terminals are protected from excessive differential voltage with back-to-back diodes; see [Figure 46](#). In most circuit applications, the input protection circuitry has no effect. However, in low-gain or  $G = 1$  circuits, fast-ramping input signals can forward-bias these diodes because the output of the amplifier cannot respond rapidly enough to the input ramp. If the input signal is fast enough to create this forward-bias condition, limit the input signal current to 10 mA or less. If the input signal current is not inherently limited, an input series resistor can be used to limit the input signal current. This input series resistor degrades the low-noise performance of the OPAx172. [Figure 46](#) illustrates an example configuration that implements a current-limiting feedback resistor.

### 8.4.3 Overload Recovery

Overload recovery is defined as the time it takes for the op amp output to recover from the saturated state to the linear state. The output devices of the op amp enter the saturation region when the output voltage exceeds the rated operating voltage, either due to the high input voltage or the high gain. After the device enters the saturation region, the charge carriers in the output devices need time to return back to the normal state. After the charge carriers return back to the equilibrium state, the device begins to slew at the normal slew rate. Thus, the propagation delay in case of an overload condition is the sum of the overload recovery time and the slew time. The overload recovery time for the OPAx172 is approximately 200 ns.

## 9 Applications and Implementation

### 注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 9.1 Application Information

The OPAx172 family of amplifiers is specified for operation from 4.5 V to 36 V ( $\pm 2.25$  V to  $\pm 18$  V). Many of the specifications apply from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . Parameters that can exhibit significant variance with regard to operating voltage or temperature are presented in the [Typical Characteristics](#).

### 9.2 Typical Applications

The following application examples highlight only a few of the circuits where the OPAx172 can be used.

#### 9.2.1 Capacitive Load Drive Solution Using an Isolation Resistor

The OPA172 can be used capacitive loads such as cable shields, reference buffers, MOSFET gates, and diodes. The circuit uses an isolation resistor ( $R_{\text{ISO}}$ ) to stabilize the output of an op amp.  $R_{\text{ISO}}$  modifies the open-loop gain of the system to ensure the circuit has sufficient phase margin.

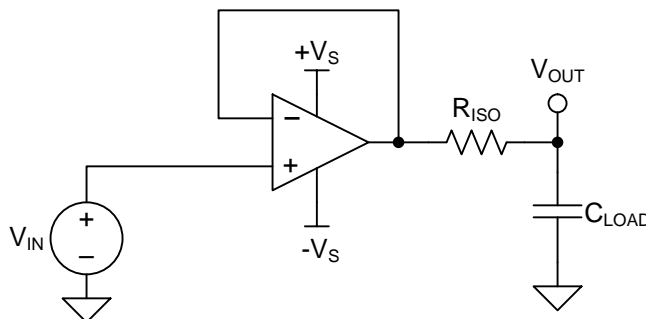


图 47. Unity-Gain Buffer with  $R_{\text{ISO}}$  Stability Compensation

#### 9.2.1.1 Design Requirements

The design requirements are:

- Supply voltage: 30 V ( $\pm 15$  V)
- Capacitive loads: 100 pF, 1000 pF, 0.01  $\mu\text{F}$ , 0.1  $\mu\text{F}$ , and 1  $\mu\text{F}$
- Phase margin:  $45^{\circ}$  and  $60^{\circ}$



## Typical Applications (接下页)

### 9.2.1.2 Detailed Design Procedure

图 47 depicts a unity-gain buffer driving a capacitive load. 公式 1 shows the transfer function for the circuit in 图 47. Not depicted in 图 47 is the open-loop output resistance of the op amp,  $R_o$ .

$$T(s) = \frac{1 + C_{LOAD} \times R_{ISO} \times s}{1 + (R_o + R_{ISO}) \times C_{LOAD} \times s} \quad (1)$$

The transfer function in 公式 1 has a pole and a zero. The frequency of the pole ( $f_p$ ) is determined by  $(R_o + R_{ISO})$  and  $C_{LOAD}$ . Components  $R_{ISO}$  and  $C_{LOAD}$  determine the frequency of the zero ( $f_z$ ). A stable system is obtained by selecting  $R_{ISO}$  such that the rate of closure (ROC) between the open-loop gain ( $A_{OL}$ ) and  $1 / \beta$  is 20 dB per decade. 图 48 shows the concept. Note that the  $1 / \beta$  curve for a unity-gain buffer is 0 dB.

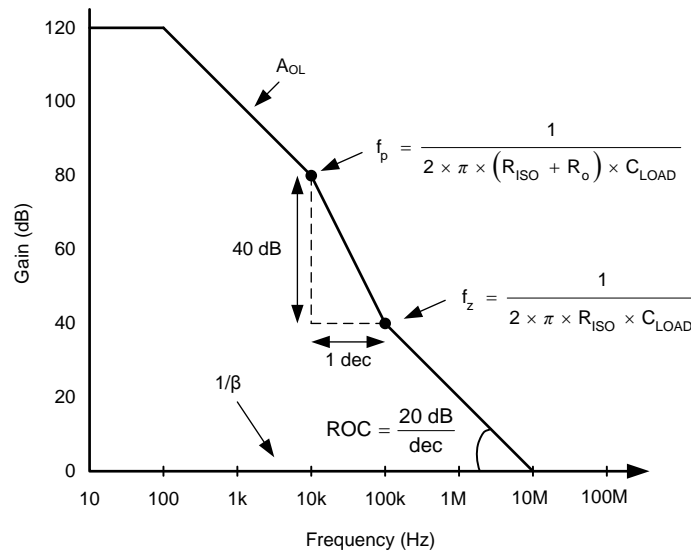


图 48. Unity-Gain Amplifier with  $R_{ISO}$  Compensation

ROC stability analysis is typically simulated. The validity of the analysis depends on multiple factors, especially the accurate modeling of  $R_o$ . In addition to simulating the ROC, a robust stability analysis includes a measurement of overshoot percentage and ac gain peaking of the circuit using a function generator, oscilloscope, and gain and phase analyzer. Phase margin is then calculated from these measurements. 表 4 shows the overshoot percentage and ac gain peaking that correspond to phase margins of 45° and 60°. For more details on this design and other alternative devices that can be used in place of the OPA172, refer to the precision design, *Capacitive Load Drive Solution using an Isolation Resistor* (TIPD128).

表 4. Phase Margin versus Overshoot and AC Gain Peaking

PHASE MARGIN	OVERSHOOT	AC GAIN PEAKING
45°	23.3%	2.35 dB
60°	8.8%	0.28 dB

### 9.2.1.3 Application Curve

The OPA172 meets the supply voltage requirements of 30 V. The OPA172 is tested for various capacitive loads and  $R_{ISO}$  is adjusted to get an overshoot corresponding to 表 4. The results of these tests are summarized in 图 49.

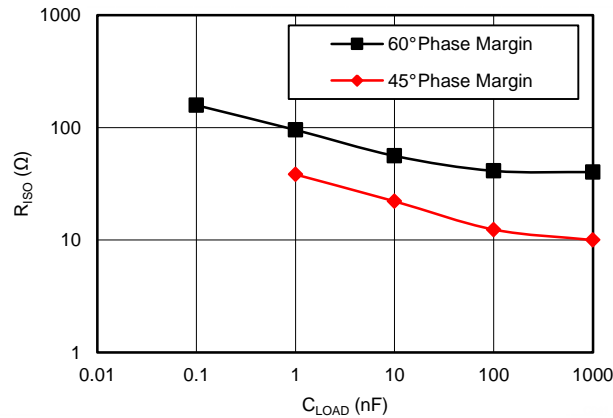


图 49.  $R_{ISO}$  VS  $C_{LOAD}$

### 9.2.2 Bidirectional Current Source

The improved Howland current-pump topology shown in 图 50 provides excellent performance because of the extremely tight tolerances of the on-chip resistors of the INA132. By buffering the output using an OPA172, the output current the circuit is able to deliver is greatly extended.

The circuit dc transfer function is shown in 公式 2:

$$I_{OUT} = V_{IN} / R1 \tag{2}$$

The OPA172 can also be used as the feedback amplifier because the low bias current minimizes error voltages produced across R1. However, for improved performance, select a FET-input device with extremely low offset, such as the OPA192, OPA140, or OPA188 as the feedback amplifier.

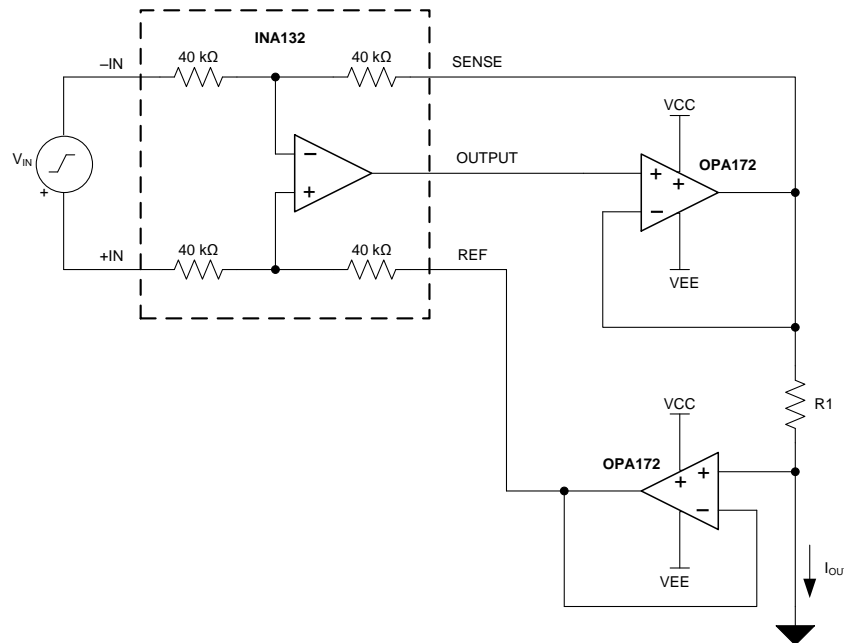


图 50. Bidirectional Current Source

### 9.2.3 JFET-Input Low-Noise Amplifier

图 51 shows a low-noise composite amplifier built by adding a low noise JFET pair (Q1 and Q2) as an input preamplifier for the OPA172. Transistors Q3 and Q4 form a 2-mA current sink that biases each JFET with 1 mA of drain current. Using 3.9-k $\Omega$  drain resistors produces a gain of approximately 10 in the input amplifier, making the extremely-low, broadband-noise spectral density of the JFET pair, Q1 and Q2, the dominant noise source of the amplifier. The output impedance of the input differential amplifier is large enough that a FET-input amplifier such as the OPA172 provides superior noise performance over bipolar-input amplifiers.

The gain of the composite amplifier is given by 公式 3:

$$A_V = (1 + R_3 / R_4) \quad (3)$$

The resistances shown are standard 1% resistor values that produce a gain of approximately 100 (99.26) with 68° of phase margin. Gains less than 10 may require additional compensation methods to provide stability. Select low resistor values to minimize the resistor thermal noise contribution to the total output noise.

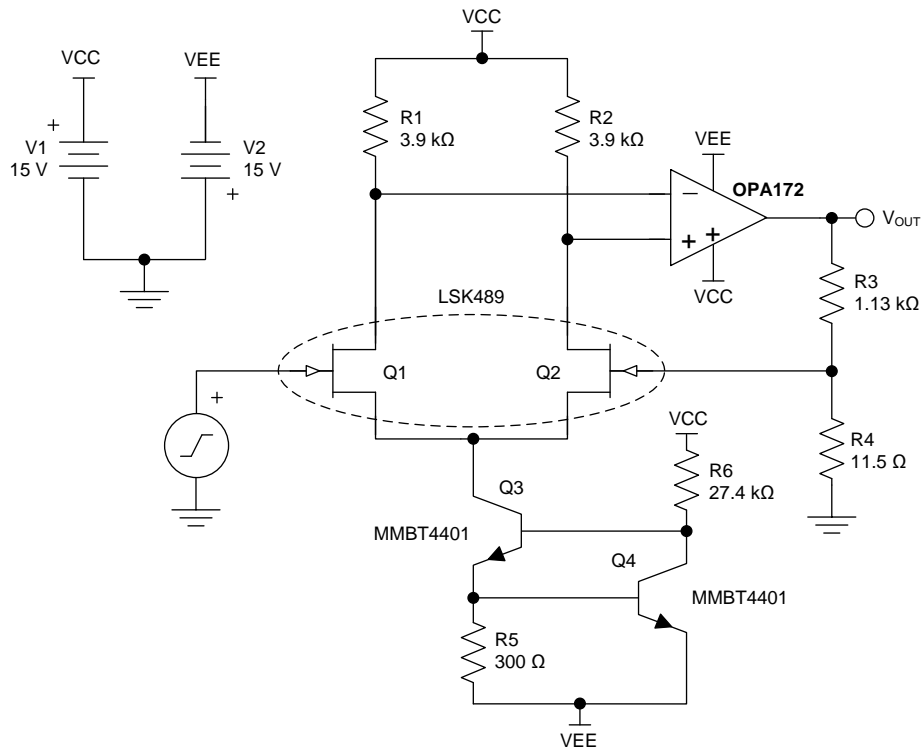


图 51. JFET-Input Low-Noise Amplifier

## 10 Power-Supply Recommendations

The OPA172 is specified for operation from 4.5 V to 36 V ( $\pm 2.25$  V to  $\pm 18$  V); many specifications apply from  $-40^\circ\text{C}$  to  $+125^\circ\text{C}$ . Parameters that can exhibit significant variance with regard to operating voltage or temperature are presented in the [Typical Characteristics](#).

### CAUTION

Supply voltages larger than 40 V can permanently damage the device; see the [Absolute Maximum Ratings](#).

Place 0.1- $\mu\text{F}$  bypass capacitors close to the power-supply terminals to reduce errors coupling in from noisy or high-impedance power supplies. For more detailed information on bypass capacitor placement, see the [Layout](#) section.

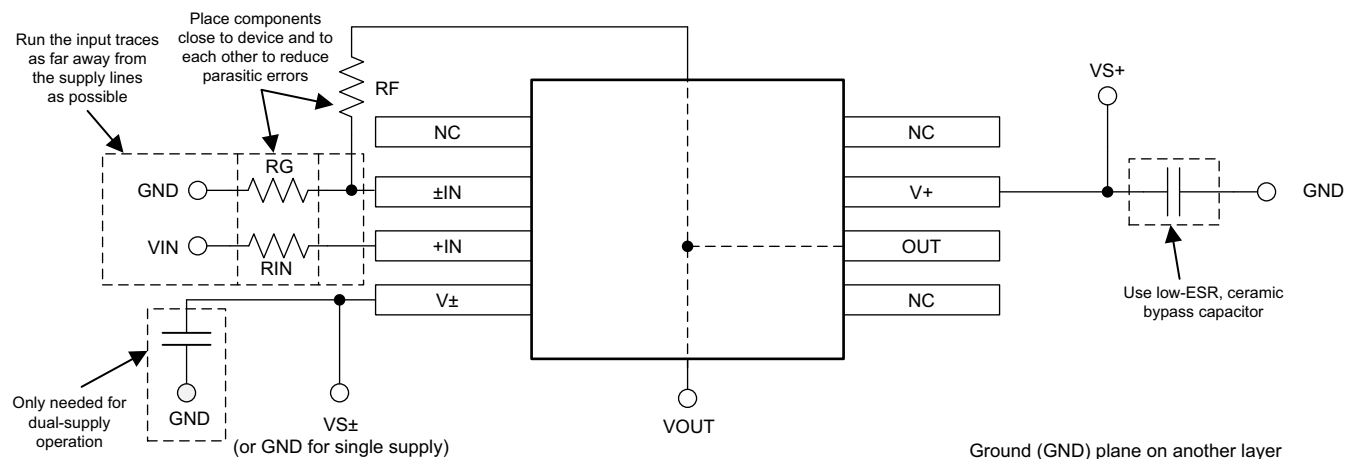
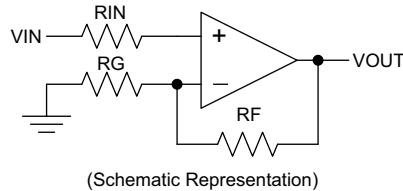
## 11 Layout

### 11.1 Layout Guidelines

For best operational performance of the device, use good printed circuit board (PCB) layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole and op amp itself. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
  - Connect low-ESR, 0.1- $\mu$ F ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single-supply applications.
- Separate grounding for analog and digital portions of circuitry is one of the simplest and most-effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds paying attention to the flow of the ground current. For more detailed information refer to [SLOA089](#), *Circuit Board Layout Techniques*.
- In order to reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicular as opposed to in parallel with the noisy trace is preferable.
- Place the external components as close to the device as possible. As shown in [Figure 52](#), keeping RF and RG close to the inverting input minimizes parasitic capacitance.
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

### 11.2 Layout Example



**图 52. Operational Amplifier Board Layout for Noninverting Configuration**

## 12 器件和文档支持

### 12.1 器件支持

#### 12.1.1 开发支持

##### 12.1.1.1 TINA-TI™ (免费软件下载)

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TINA-TI 可从 Analog eLab Design Center (模拟电子实验室设计中心) [免费下载](#)，它提供全面的后续处理能力，使得用户能够以多种方式形成结果。虚拟仪器提供选择输入波形和探测电路节点、电压和波形的功能，从而创建一个动态的快速入门工具。

**注**

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### 12.2 文档支持

#### 12.2.1 相关文档

[SBOA015 \(AB-028\)](#) — 《反馈曲线图定义运算放大器交流性能》。

[SLOA089](#) — 《电路板布局布线技巧》。

[SLOD006](#) — 《适用于所有人的运算放大器》。

[SBOA128](#) — 《运算放大器的电磁干扰 (EMI) 抑制比》。

[TIPD128](#) — 《使用隔离电阻器实现的电容负载驱动解决方案》。

### 12.3 相关链接

**表 5** 列出了快速访问链接。范围包括技术文档、支持与社区资源、工具和软件，并且可以快速访问样片或购买链接。

**表 5. 相关链接**

器件	产品文件夹	样片与购买	技术文档	工具与软件	支持与社区
OPA172	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>
OPA2172	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>
OPA4172	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>

### 12.4 社区资源

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**设计支持** **TI 参考设计支持** 可帮助您快速查找有帮助的 E2E 论坛、设计支持工具以及技术支持的联系信息。

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ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

## 12.7 术语表

[SLYZ022](#) — *TI* 术语表。

这份术语表列出并解释术语、缩写和定义。

## 13 机械、封装和可订购信息

以下页中包括机械、封装和可订购信息。这些信息是针对指定器件可提供的最新数据。这些数据会在无通知且不对本文档进行修订的情况下发生改变。欲获得该数据表的浏览器版本，请查阅左侧的导航栏。

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放大器和线性器件	<a href="http://www.ti.com.cn/amplifiers">www.ti.com.cn/amplifiers</a>	计算机及周边	<a href="http://www.ti.com.cn/computer">www.ti.com.cn/computer</a>
数据转换器	<a href="http://www.ti.com.cn/dataconverters">www.ti.com.cn/dataconverters</a>	消费电子	<a href="http://www.ti.com.cn/consumer-apps">www.ti.com.cn/consumer-apps</a>
DLP® 产品	<a href="http://www.dlp.com">www.dlp.com</a>	能源	<a href="http://www.ti.com.cn/energy">www.ti.com.cn/energy</a>
DSP - 数字信号处理器	<a href="http://www.ti.com.cn/dsp">www.ti.com.cn/dsp</a>	工业应用	<a href="http://www.ti.com.cn/industrial">www.ti.com.cn/industrial</a>
时钟和计时器	<a href="http://www.ti.com.cn/clockandtimers">www.ti.com.cn/clockandtimers</a>	医疗电子	<a href="http://www.ti.com.cn/medical">www.ti.com.cn/medical</a>
接口	<a href="http://www.ti.com.cn/interface">www.ti.com.cn/interface</a>	安防应用	<a href="http://www.ti.com.cn/security">www.ti.com.cn/security</a>
逻辑	<a href="http://www.ti.com.cn/logic">www.ti.com.cn/logic</a>	汽车电子	<a href="http://www.ti.com.cn/automotive">www.ti.com.cn/automotive</a>
电源管理	<a href="http://www.ti.com.cn/power">www.ti.com.cn/power</a>	视频和影像	<a href="http://www.ti.com.cn/video">www.ti.com.cn/video</a>
微控制器 (MCU)	<a href="http://www.ti.com.cn/microcontrollers">www.ti.com.cn/microcontrollers</a>		
RFID 系统	<a href="http://www.ti.com.cn/rfidsys">www.ti.com.cn/rfidsys</a>		
OMAP应用处理器	<a href="http://www.ti.com/omap">www.ti.com/omap</a>		
无线连通性	<a href="http://www.ti.com.cn/wirelessconnectivity">www.ti.com.cn/wirelessconnectivity</a>	德州仪器在线技术支持社区	<a href="http://www.deyisupport.com">www.deyisupport.com</a>

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**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
OPA172ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA172	<a href="#">Samples</a>
OPA172IDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OUWQ	<a href="#">Samples</a>
OPA172IDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OUWQ	<a href="#">Samples</a>
OPA172IDCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	SIU	<a href="#">Samples</a>
OPA172IDCKT	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 125	SIU	<a href="#">Samples</a>
OPA172IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA172	<a href="#">Samples</a>
OPA2172ID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	O2172A	<a href="#">Samples</a>
OPA2172IDGK	ACTIVE	VSSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	OVJQ	<a href="#">Samples</a>
OPA2172IDGKR	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	OVJQ	<a href="#">Samples</a>
OPA2172IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	O2172A	<a href="#">Samples</a>
OPA2172IDRGR	ACTIVE	SON	DRG	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OP2172	<a href="#">Samples</a>
OPA2172IDRGT	ACTIVE	SON	DRG	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OP2172	<a href="#">Samples</a>
OPA4172ID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 125	OPA4172	<a href="#">Samples</a>
OPA4172IDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 125	OPA4172	<a href="#">Samples</a>
OPA4172IPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA4172	<a href="#">Samples</a>
OPA4172IPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA4172	<a href="#">Samples</a>

(1) The marketing status values are defined as follows:  
**ACTIVE:** Product device recommended for new designs.



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**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.

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

<sup>(2)</sup> 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)

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

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

<sup>(5)</sup> 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.

<sup>(6)</sup> 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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## TAPE AND REEL INFORMATION



### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*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
OPA172IDBVR	SOT-23	DBV	5	3000	180.0	8.4	3.23	3.17	1.37	4.0	8.0	Q3
OPA172IDBVT	SOT-23	DBV	5	250	180.0	8.4	3.23	3.17	1.37	4.0	8.0	Q3
OPA172IDCKR	SC70	DCK	5	3000	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
OPA172IDCKT	SC70	DCK	5	250	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
OPA172IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA2172IDGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2172IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA2172IDRGR	SON	DRG	8	3000	330.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
OPA2172IDRGT	SON	DRG	8	250	180.0	12.4	3.3	3.3	1.1	8.0	12.0	Q2
OPA4172IDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
OPA4172IPWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	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)
OPA172IDBVR	SOT-23	DBV	5	3000	223.0	270.0	35.0
OPA172IDBVT	SOT-23	DBV	5	250	223.0	270.0	35.0
OPA172IDCKR	SC70	DCK	5	3000	180.0	180.0	18.0
OPA172IDCKT	SC70	DCK	5	250	180.0	180.0	18.0
OPA172IDR	SOIC	D	8	2500	367.0	367.0	35.0
OPA2172IDGKR	VSSOP	DGK	8	2500	366.0	364.0	50.0
OPA2172IDR	SOIC	D	8	2500	367.0	367.0	35.0
OPA2172IDRGR	SON	DRG	8	3000	367.0	367.0	35.0
OPA2172IDRGT	SON	DRG	8	250	210.0	185.0	35.0
OPA4172IDR	SOIC	D	14	2500	367.0	367.0	38.0
OPA4172IPWR	TSSOP	PW	14	2000	367.0	367.0	35.0

DCK (R-PDSO-G5)

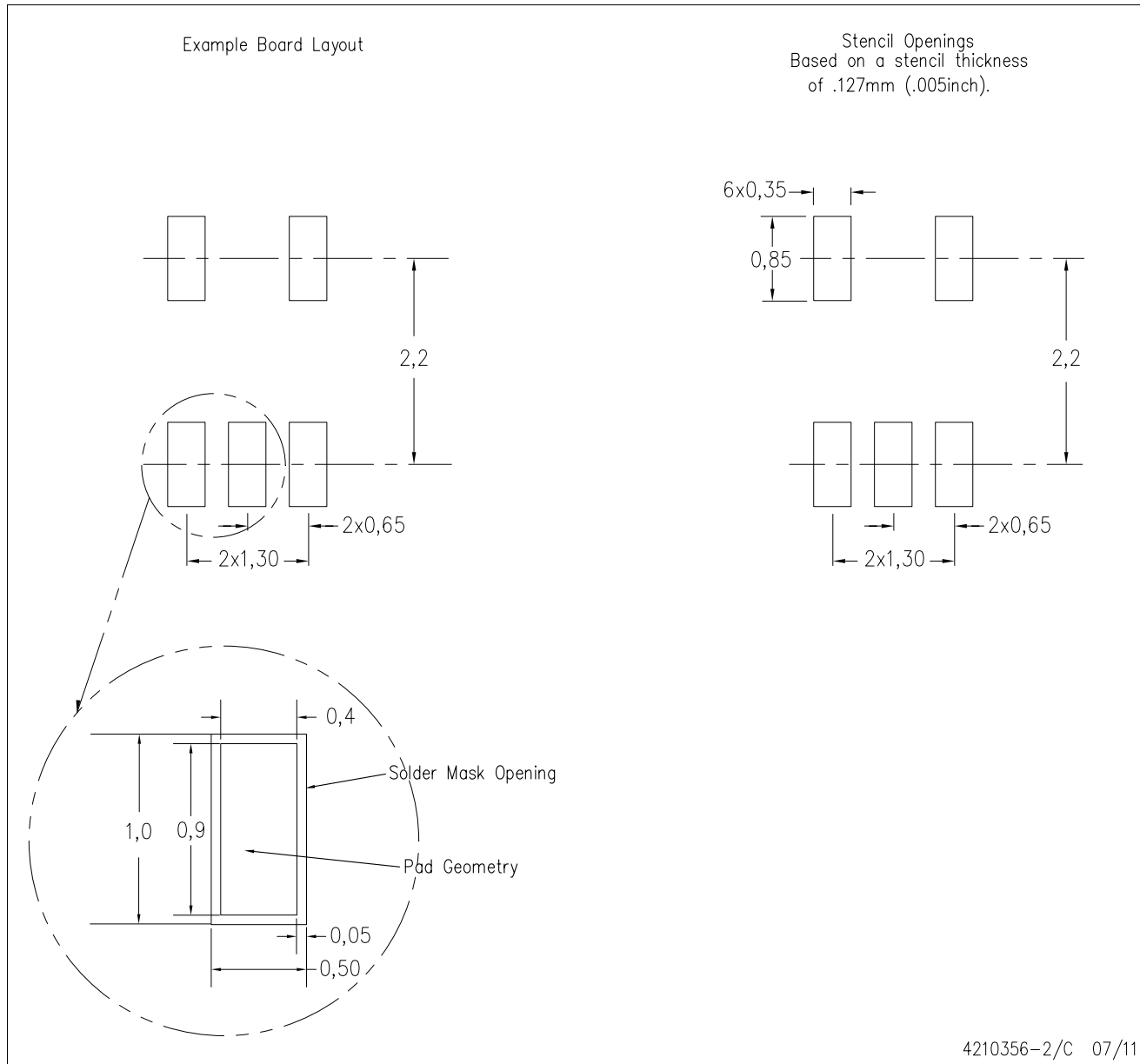
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
  - D. Falls within JEDEC MO-203 variation AA.

DCK (R-PDSO-G5)

PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
  - Publication IPC-7351 is recommended for alternate designs.
  - 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. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

## GENERIC PACKAGE VIEW

DBV 5

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

4073253/P

DBV0005A



# PACKAGE OUTLINE

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



4214839/C 04/2017

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC MO-178.

# EXAMPLE BOARD LAYOUT

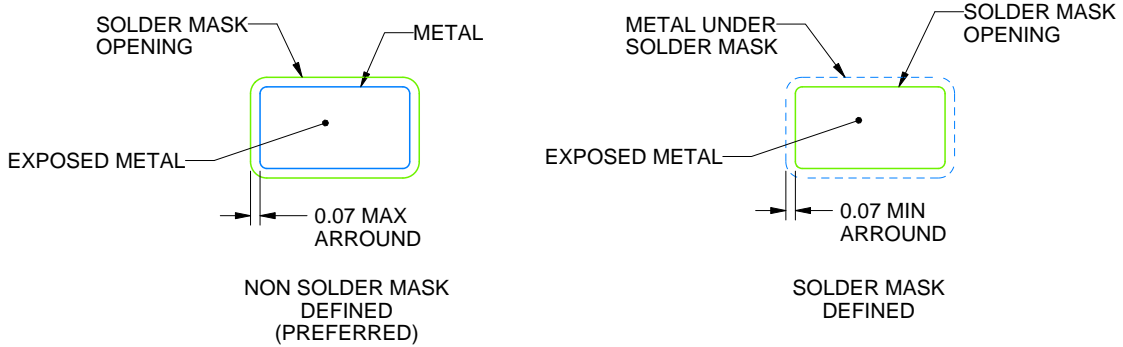
DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4214839/C 04/2017

NOTES: (continued)

- 4. Publication IPC-7351 may have alternate designs.
- 5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



# EXAMPLE STENCIL DESIGN

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:15X

4214839/C 04/2017

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
7. Board assembly site may have different recommendations for stencil design.

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  -  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.
  -  Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
  - E. Reference JEDEC MS-012 variation AB.

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE





4211283-3/E 08/12

- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - 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.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  -  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
  -  Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4211284-2/G 08/15

- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - 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.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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



4211283-2/E 08/12

- 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.

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in 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 0.15 per end.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
  - E. Falls within JEDEC MO-187 variation AA, except interlead flash.

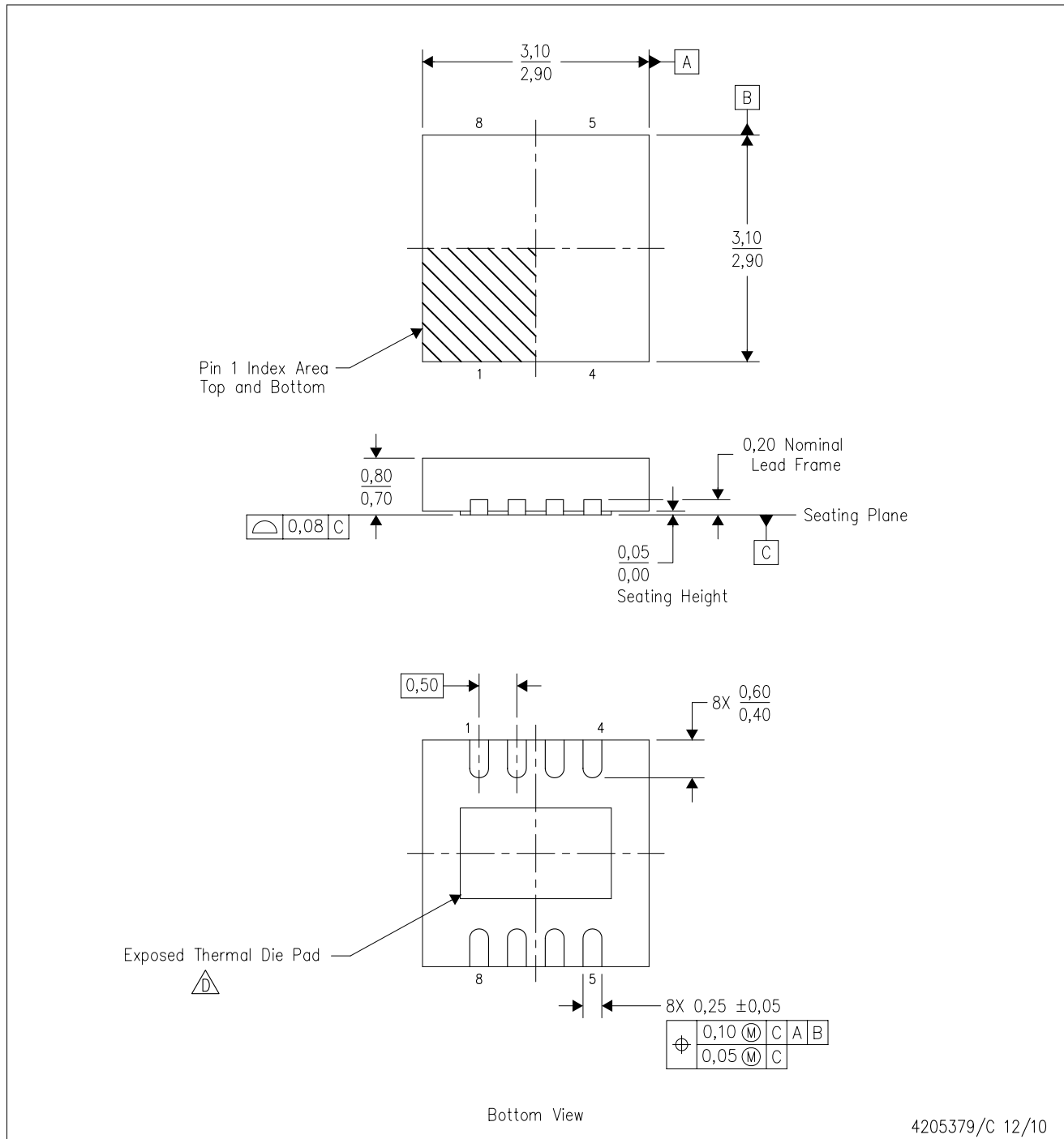




- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers 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.

DRG (S-PWSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. SON (Small Outline No-Lead) package configuration.
  - D. The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.
  - E. JEDEC MO-229 package registration pending.

# THERMAL PAD MECHANICAL DATA

DRG (S-PWSON-N8)

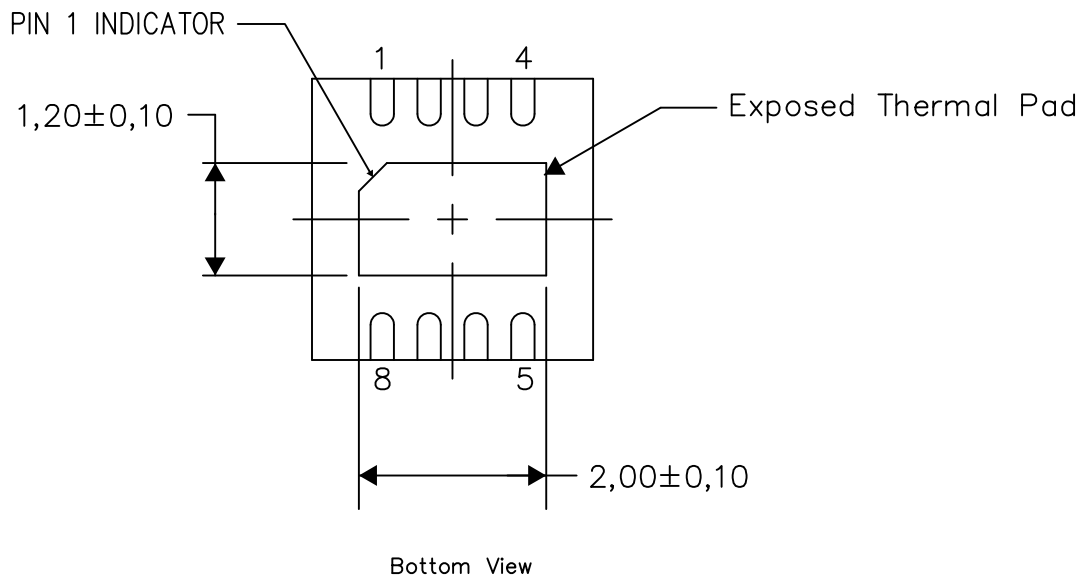
PLASTIC SMALL OUTLINE NO-LEAD

## THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



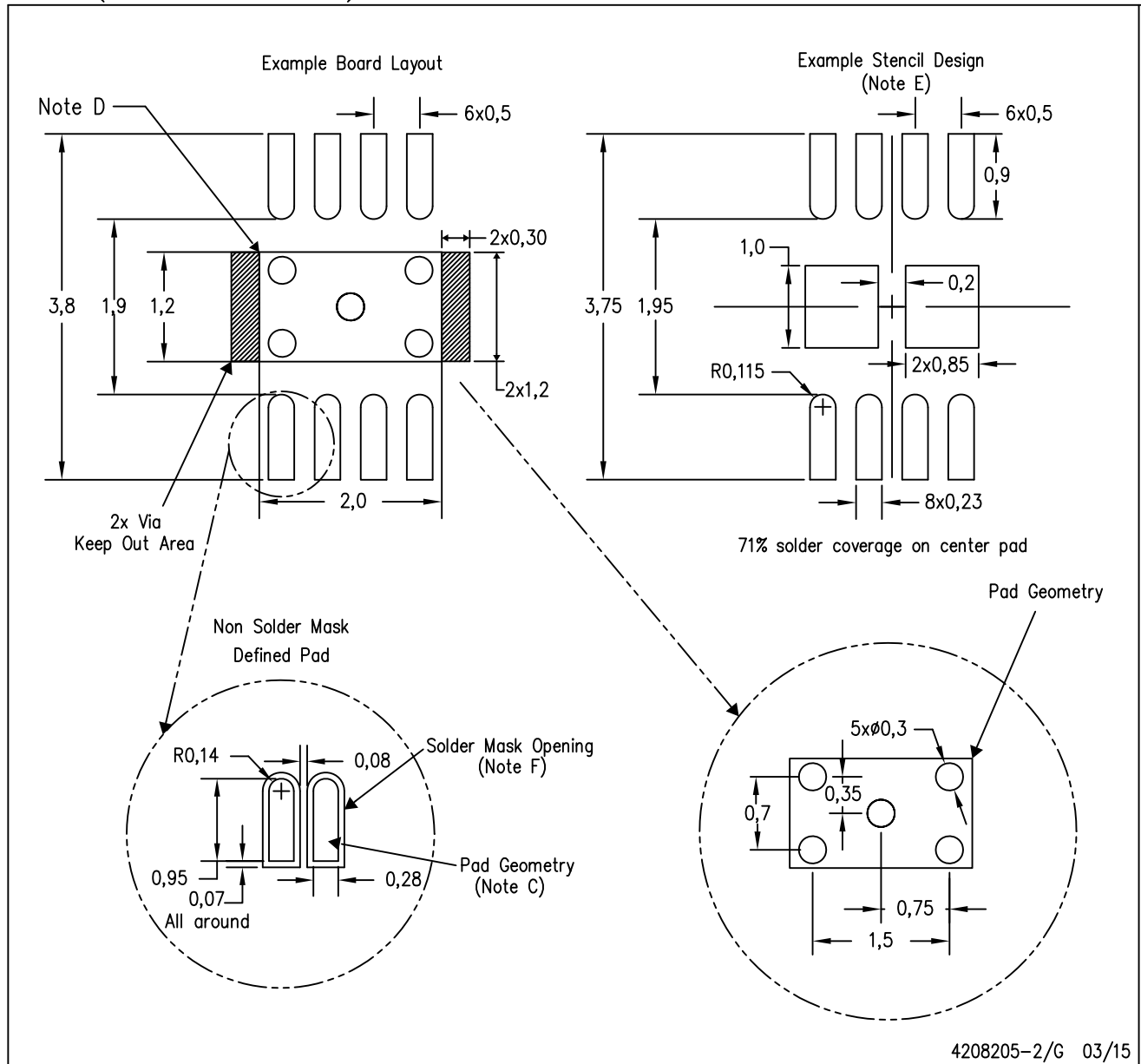
Exposed Thermal Pad Dimensions

4206881-2/1 03/15

NOTE: All linear dimensions are in millimeters

DRG (S-PWSON-N8)

PLASTIC SMALL OUTLINE NO-LEAD



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