

# OPAx172 36V、単一電源、10MHz、レール・ツー・レール出力オペアンプ

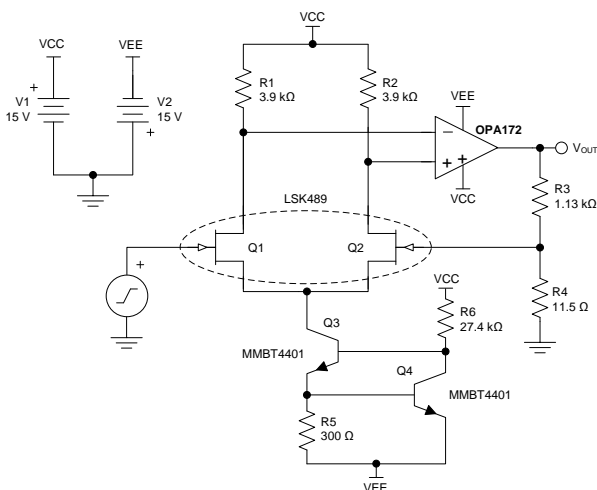
## 1 特長

- 広い電源電圧範囲:  
+4.5V~+36V,  $\pm 2.25V \sim \pm 18V$
- 低いオフセット電圧:  $\pm 0.2mV$
- 低いオフセット・ドリフト:  $\pm 0.3\mu V/^\circ C$
- ゲイン帯域幅: 10MHz
- 低い入力バイアス電流:  $\pm 8pA$
- 低い静止電流: アンプごとに1.6mA
- 低ノイズ:  $7nV/\sqrt{Hz}$
- EMIおよびRFIフィルタ入力
- 入力範囲は負の電源電圧にも対応
- 入力範囲は正の電源電圧まで動作
- レール・ツー・レール出力
- 高い同相除去: 120dB
- 業界標準のパッケージ
  - SOIC-8, VSSOP-8, SOIC-14, TSSOP-14
- *micro*パッケージ: シングルはSC70およびSOT-23、デュアルはWSO-8

## 2 アプリケーション

- 電源モジュールのトラッキング・アンプ
- 商業施設の電源
- トランスデューサ・アンプ
- ブリッジ・アンプ
- 温度計測
- ひずみゲージ・アンプ
- 高精度積分器
- 試験用機器

### JFET入力の低ノイズ・アンプ



## 3 概要

OPA172, OPA2172, OPA4172 (OPAx172)は36V、単一電源、低ノイズのオペアンプのファミリーで、+4.5V ( $\pm 2.25V$ )~+36V ( $\pm 18V$ )の範囲の電源で動作できます。高電圧CMOSオペアンプの新しい追加製品として、OPAx171およびOPAx170シリーズとともに、広範なアプリケーションの要求を満たす帯域幅、ノイズ、電力オプションのファミリーを提供します。OPAx172はマイクロパッケージで供給され、低いオフセット、ドリフト係数、静止電流を実現します。広い帯域幅、高速なスルー・レート、高い出力電流駆動能力も、これらのデバイスの特長です。シングル、デュアル、クワッドの各製品で同一の仕様を備え、設計の柔軟性を高めています。

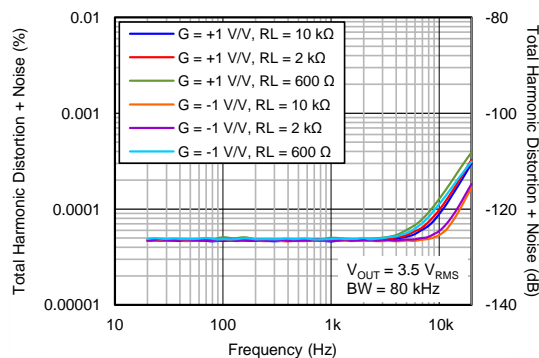
### 製品情報<sup>(1)</sup>

型番	パッケージ	本体サイズ(公称)
OPA172	SC70 (5)	2.00mm×1.25mm
	SOT-23 (5)	2.90mm×1.60mm
	SOIC (8)	4.90mm×3.91mm
OPA2172	SOIC (8)	4.90mm×3.91mm
	VSSOP (8) <sup>(2)</sup>	3.00mm×3.00mm
	WSO (8)	3.00mm×3.00mm
OPA4172	SOIC (14)	8.65mm×3.91mm
	TSSOP (14)	4.40mm×5.00mm

(1) 利用可能なすべてのパッケージについては、このデータシートの末尾にあるパッケージ・オプションについての付録を参照してください。

(2) VSSOPパッケージはMSOPパッケージと同じです。

### 優れたTHD性能



## 目次

1	特長	1	9.1	Overview	20
2	アプリケーション	1	9.2	Functional Block Diagram	20
3	概要	1	9.3	Feature Description	21
4	改訂履歴	2	9.4	Device Functional Modes	23
5	概要(続き)	4	<b>10</b>	<b>Applications and Implementation</b>	<b>26</b>
6	<b>Device Comparison</b>	<b>5</b>	10.1	Application Information	26
6.1	Device Comparison	5	10.2	Typical Applications	26
6.2	Device Family Comparison	5	<b>11</b>	<b>Power-Supply Recommendations</b>	<b>29</b>
7	<b>Pin Configuration and Functions</b>	<b>6</b>	<b>12</b>	<b>Layout</b>	<b>30</b>
8	<b>Specifications</b>	<b>8</b>	12.1	Layout Guidelines	30
8.1	Absolute Maximum Ratings	8	12.2	Layout Example	30
8.2	ESD Ratings	8	<b>13</b>	<b>デバイスおよびドキュメントのサポート</b>	<b>31</b>
8.3	Recommended Operating Conditions	8	13.1	デバイス・サポート	31
8.4	Thermal Information: OPA172	9	13.2	ドキュメントのサポート	31
8.5	Thermal Information: OPA2172	9	13.3	関連リンク	31
8.6	Thermal Information: OPA4172	9	13.4	コミュニティ・リソース	31
8.7	Electrical Characteristics	10	13.5	商標	32
8.8	Typical Characteristics: Table of Graphs	12	13.6	静電気放電に関する注意事項	32
8.9	Typical Characteristics	13	13.7	Glossary	32
9	<b>Detailed Description</b>	<b>20</b>	<b>14</b>	<b>メカニカル、パッケージ、および注文情報</b>	<b>32</b>

## 4 改訂履歴

Revision H (September 2015) から Revision I に変更	Page
• Changed supply voltage values within <i>Absolute Maximum Ratings</i> table	8

Revision G (June 2015) から Revision H に変更	Page
• OPA2172デバイスにDRGパッケージを追加	1
• 「特長」の最後の箇条書き項目にWSONを追加	1
• 「製品情報」表にOPA2172 WSONの行を追加	1
• Added WSON-8 to OPA2172 row of <i>Device Comparison</i> table	5
• Added DRG pinout drawing	7
• Added DRG column to OPA2172 and OPA4172 <i>Pin Functions</i> table	7
• Added DRG column to OPA2172 <i>Thermal Information</i> table	9

Revision F (June 2015) から Revision G に変更	Page
• Added input bias current ( $I_B$ ) values for DGK and PW packages	10

Revision E (December 2014) から Revision F に変更	Page
• デバイスのステータスを「量産データ」から「混在ステータス」に変更	1
• OPA2172 DGKおよびOPA4172 PWパッケージを量産データに変更	1
• 「製品情報」表にOPA2172 VSSOPおよびOPA4172 TSSOPの行を追加	1
• Deleted footnote from <i>Device Comparison</i> table	5
• Deleted footnote from OPA2172 DGK and OPA4172 PW pin out drawings	7
• Added OPA2172 DGK thermal information	9

Revision D (September 2014) から Revision E に変更	Page
• OPA2172 Dパッケージを製品プレビューから量産データに変更 .....	1
• 「製品情報」表を変更 .....	1
• Changed <i>Device Comparison</i> table note (1) to show preview packages .....	5
• Changed <i>Handling Ratings</i> table to <i>ESD Ratings</i> table .....	8
<hr/>	
Revision C (July 2014) から Revision D に変更	Page
• 特長の低ノイズの簡条書き項目を $6\text{nV}/\sqrt{\text{Hz}}$ から7に変更 .....	1
• 特長の簡条書き項目でMSOPをVSSOPに変更 .....	1
• 「製品情報」表にパッケージと新しい注2を追加 .....	1
• Changed OPAx172 voltage noise density from $6\text{ nV}/\sqrt{\text{Hz}}$ to 7 in <i>Device Family Comparison</i> table .....	5
• Changed OPA4172 package from DGK to PW in <i>Pin Functions</i> table .....	7
• Added OPA2172 <i>Thermal Information</i> table .....	9
• Changed input voltage noise value in <i>Electrical Characteristics</i> from $1.2\ \mu\text{V}_{\text{PP}}$ to $2.5\ \mu\text{V}_{\text{PP}}$ .....	10
• Changed input voltage noise density value at 100 Hz in <i>Electrical Characteristics</i> from $8.6\text{ nV}/\sqrt{\text{Hz}}$ to 12 .....	10
• Changed input voltage noise density value at 1 kHz in <i>Electrical Characteristics</i> from $6\text{ nV}/\sqrt{\text{Hz}}$ to 7 .....	10
• Changed voltage output swing values in the <i>Electrical Characteristics</i> .....	11
• Changed <a href="#">図 13</a> .....	14
• Changed <a href="#">図 14</a> .....	14
• Added new note to <a href="#">Applications and Implementation</a> section .....	26
<hr/>	
Revision B (May 2014) から Revision C に変更	Page
• OPA4172 Dパッケージ(SOIC-14)を製品プレビューから量産データに変更 .....	1
• Added OPA4172-D Thermal information .....	9
• Added Channel separation parameter to the <i>Electrical Characteristics</i> .....	10
• Added Channel Separation vs Frequency plot .....	18
<hr/>	
Revision A (April 2014) から Revision B に変更	Page
• DCK (SC70)パッケージを製品プレビューから量産データに変更 .....	1
<hr/>	
2013年12月発行のものから更新	Page
• 最新のデータシート標準に合わせてドキュメントのフォーマットを変更、「取り扱い定格」セクション、「推奨動作条件」セクション、「デバイスおよびドキュメントのサポート」セクションを追加、既存のセクションを移動 .....	1
• Changed DCK package pin names from IN+ and IN- to +IN and -IN, respectively .....	6
• Changed DBV package from product preview to production data .....	6
• Changed <a href="#">図 9</a> .....	13
• Added <a href="#">Functional Block Diagram</a> section .....	20
• Added <a href="#">Capacitive Load Drive Solution Using an Isolation Resistor</a> section .....	26
• Added <a href="#">Power-Supply Recommendations</a> section .....	29
• Changed <a href="#">Layout Guidelines</a> section .....	30

## 5 概要（続き）

ほとんどのオペアンプでは1つの電源電圧でしか動作が規定されていないのに対して、OPAx172ファミリは+4.5V～+36Vでの動作が規定されています。電源レールの範囲外の入力信号が位相反転を起こすことはありません。通常の動作時に、入力は負のレールより100mV下、および上限レールの2V以内で動作できます。これらのデバイスは完全なレール・ツー・レール入力で、上限レールを100mV超えて動作しますが、上限レールから2V以内では性能が低下することに注意してください。

OPAx172シリーズのオペアンプは、-40°C～+125°Cでの動作が規定されています。

## 6 Device Comparison

### 6.1 Device Comparison

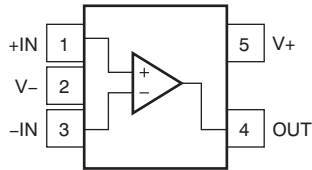
DEVICE	PACKAGE
OPA172 (single)	SC70-5, SOT-23-5, SOIC-8
OPA2172 (dual)	SOIC-8, VSSOP-8, WSON-8
OPA4172 (quad)	SOIC-14, TSSOP-14

### 6.2 Device Family Comparison

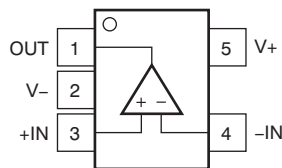
DEVICE	QUIESCENT CURRENT ( $I_Q$ )	GAIN BANDWIDTH PRODUCT (GBP)	VOLTAGE NOISE DENSITY ( $e_n$ )
<a href="#">OPAx172</a>	1600 $\mu$ A	10 MHz	7 nV/ $\sqrt{\text{Hz}}$
<a href="#">OPAx171</a>	475 $\mu$ A	3.0 MHz	14 nV/ $\sqrt{\text{Hz}}$
<a href="#">OPAx170</a>	110 $\mu$ A	1.2 MHz	19 nV/ $\sqrt{\text{Hz}}$

## 7 Pin Configuration and Functions

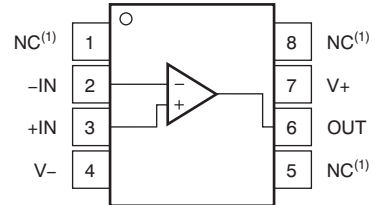
**DCK Package: OPA172  
SC70-5  
Top View**



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



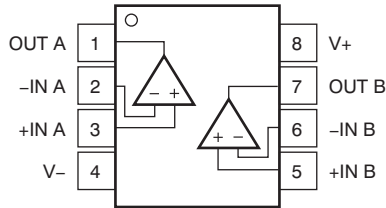
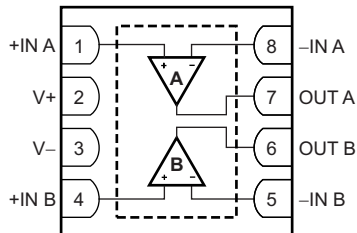
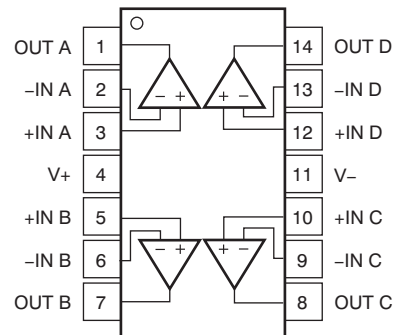
**D Package: OPA172  
SOIC-8  
Top View**



(1) No internal connection.

**Pin Functions: OPA172**

NAME	PIN			I/O	DESCRIPTION
	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

**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**

**Pin Functions: OPA2172 and OPA4172**

NAME	PIN			I/O	DESCRIPTION
	OPA2172		OPA4172		
	D (SOIC), DGK (VSSOP)	DRG (WSON)	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

## 8 Specifications

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

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

			MIN	MAX	UNIT	
Supply voltage, [(V+) – (V-)]			40		V	
Signal input pins	Voltage <sup>(2)</sup>	Common-mode	(V-) – 0.5	(V+) + 0.5	V	
		Differential <sup>(3)</sup>	±0.5			
Signal input pins	Current		±10		mA	
Output short circuit <sup>(4)</sup>			Continuous			
Operating temperature			–55	+150	°C	
Junction temperature, T <sub>J</sub>					+150	°C
Storage temperature, T <sub>stg</sub>			–65	+150	°C	

(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.

### 8.2 ESD Ratings

			VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±4000	V
		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.

### 8.3 Recommended Operating Conditions

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

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



### 8.4 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) For more information about traditional and new thermal metrics, see the [Semiconductor and IC package Thermal Metrics](#) application report.

### 8.5 Thermal Information: OPA2172

THERMAL METRIC <sup>(1)</sup>		OPA2172			UNIT
		D (SOIC)	DGK (VSSOP)	DRG (WSON)	
		8 PINS	8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	116.1	158	63.2	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	69.8	48.6	63.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	56.6	78.7	36.5	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	22.5	3.9	1.4	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	56.1	77.3	36.6	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	6.3	°C/W

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC package Thermal Metrics](#) application report.

### 8.6 Thermal Information: OPA4172

THERMAL METRIC <sup>(1)</sup>		OPA4172		UNIT
		D (SOIC)	PW (TSSOP)	
		14 PINS	14 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	82.7	111.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	42.3	40.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	37.3	54.1	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	8.9	3.8	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	37	53.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	N/A	°C/W

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC package Thermal Metrics](#) application report.

## 8.7 Electrical Characteristics

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>OFFSET VOLTAGE</b>								
$V_{OS}$	Input offset voltage	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			$\pm 0.2$	$\pm 1$	mV	
						$\pm 1.15$		
$dV_{OS}/dT$	Drift	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			$\pm 0.3$	$\pm 1.5$	$\mu\text{V}/^\circ\text{C}$	
						$\pm 1.8$		
PSRR	vs power supply	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			$\pm 1$	$\pm 3$	$\mu\text{V}/\text{V}$	
	Channel separation, dc	At dc			5		$\mu\text{V}/\text{V}$	
<b>INPUT BIAS CURRENT</b>								
$I_B$	Input bias current	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$				$\pm 8$	$\pm 15$	pA
						$\pm 14$		
							OPA2172IDGK	
		OPA41721PW						
$I_{OS}$	Input offset current	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$				$\pm 2$	$\pm 15$	pA
							$\pm 1$	nA
							OPA2172	
<b>NOISE</b>								
$E_n$	Input voltage noise	f = 0.1 Hz to 10 Hz			2.5		$\mu\text{V}_{PP}$	
$e_n$	Input voltage noise density	f = 100 Hz			12		$\text{nV}/\sqrt{\text{Hz}}$	
		f = 1 kHz			7			
$i_n$	Input current noise density	f = 1 kHz			1.6		$\text{fA}/\sqrt{\text{Hz}}$	

**Electrical Characteristics (continued)**

 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 V		(V+) – 2 V	V
CMRR	Common-mode rejection ratio	$V_S = \pm 2.25\text{ V}$ , (V-) – 0.1 V < $V_{CM}$ < (V+) – 2 V, $T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$	90	104		dB
		$V_S = \pm 18\text{ V}$ , (V-) – 0.1 V < $V_{CM}$ < (V+) – 2 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		$10^{13}\Omega$    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	$V_S = +36\text{ V}$ , $G = +1$ , $f = 1\text{ kHz}$ , $V_O = 3.5 V_{RMS}$		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 V up to (V+) + 0.1 V. For additional information, see the [Typical Characteristics](#) and [Application Information](#) sections.

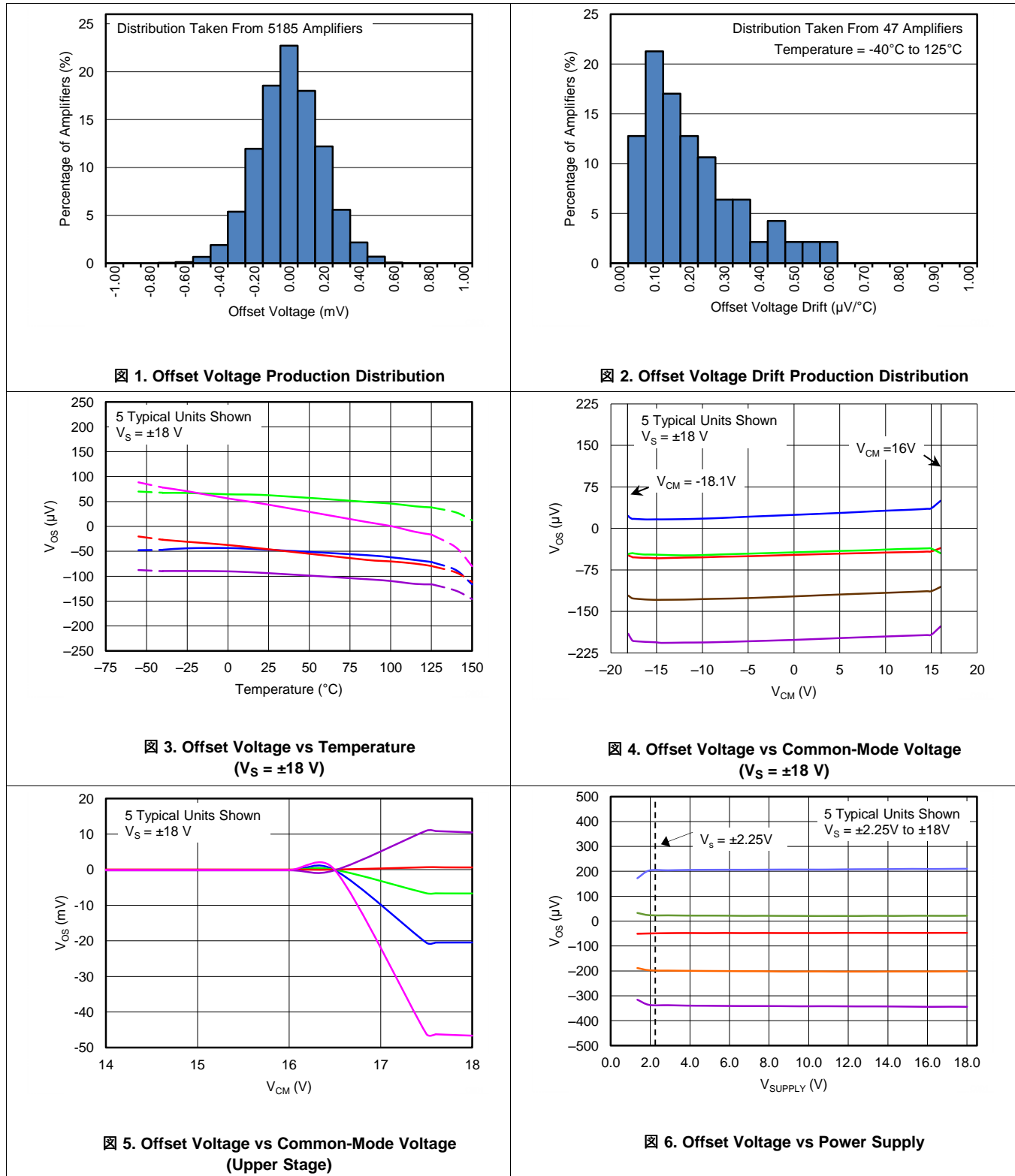
## 8.8 Typical Characteristics: Table of Graphs

**表 1. List of Typical Characteristics**

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

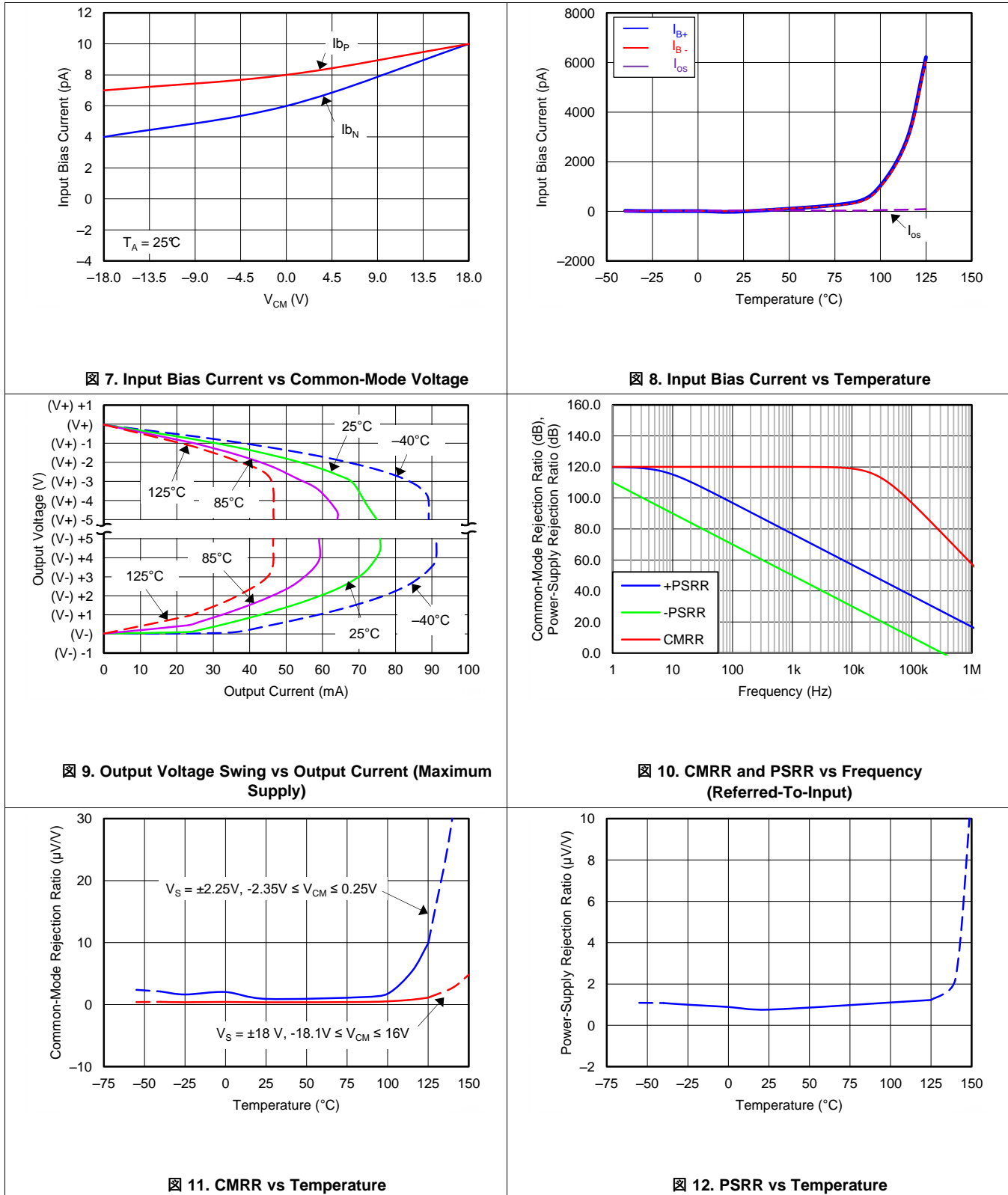
### 8.9 Typical Characteristics

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.



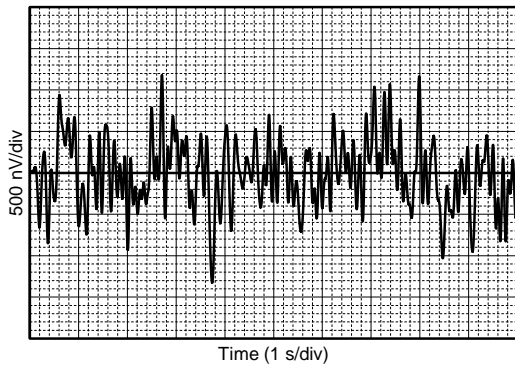
**Typical Characteristics (continued)**

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.

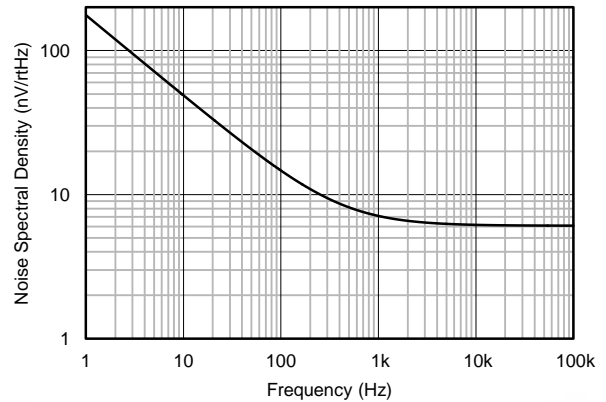


Typical Characteristics (continued)

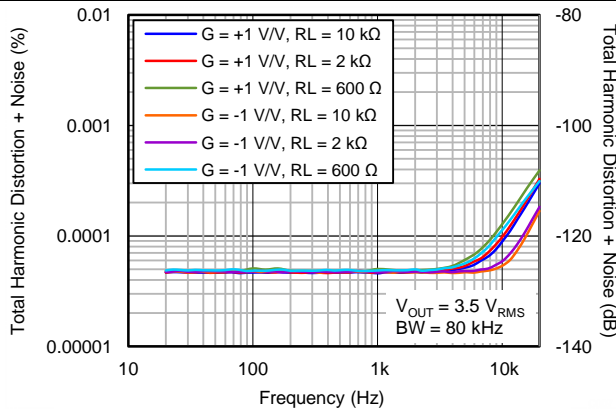
At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.



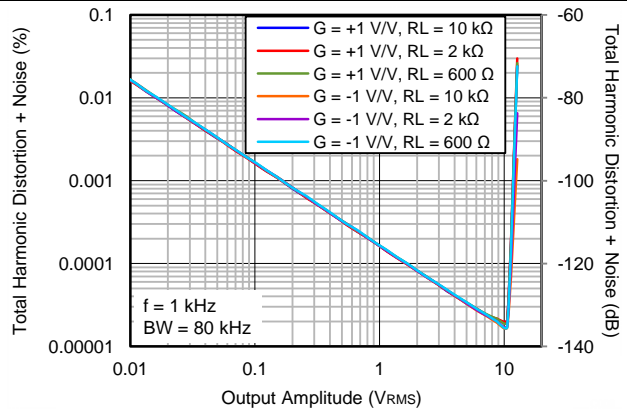
13. 0.1-Hz to 10-Hz Noise



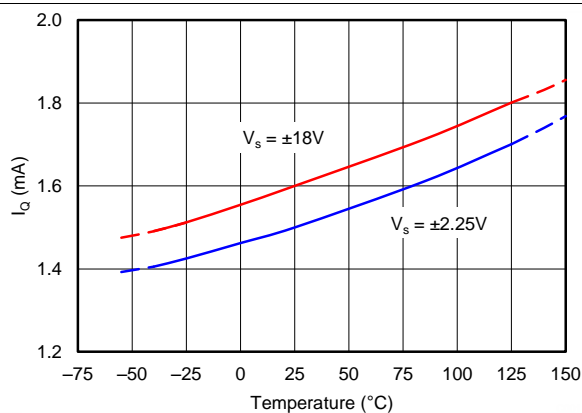
14. Input Voltage Noise Spectral Density vs Frequency



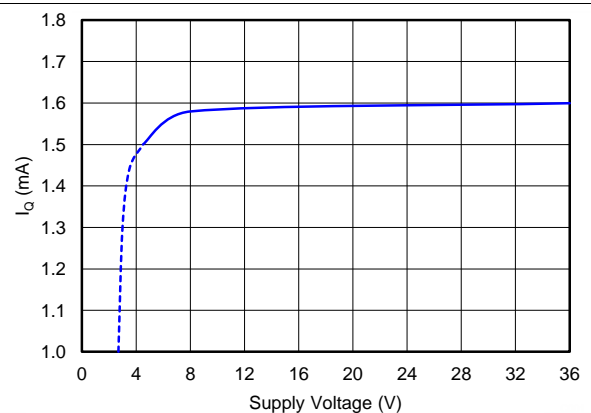
15. THD+N Ratio vs Frequency



16. THD+N vs Output Amplitude



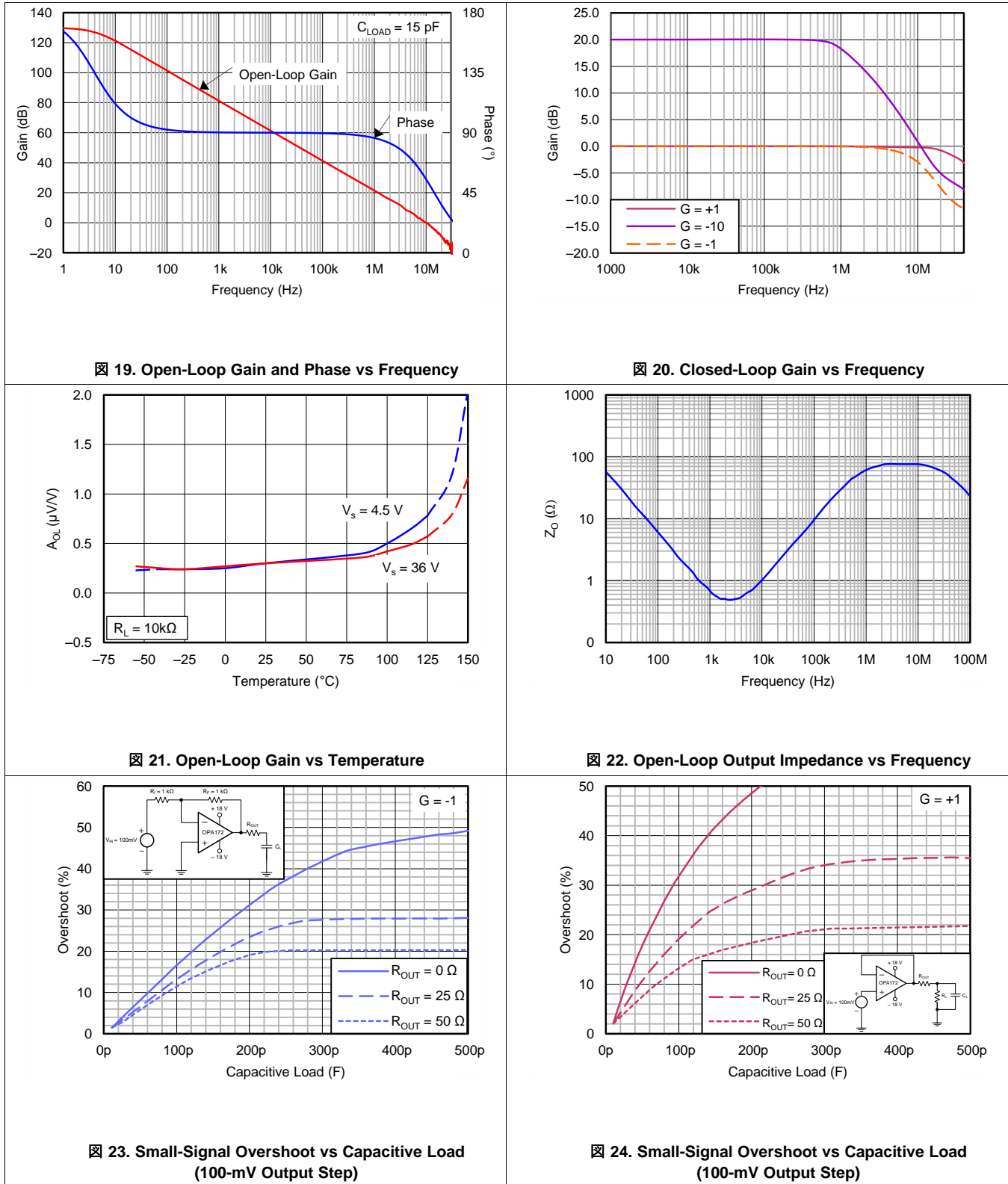
17. Quiescent Current vs Temperature



18. Quiescent Current vs Supply Voltage

Typical Characteristics (continued)

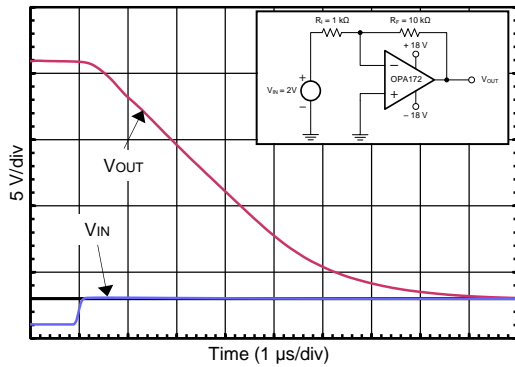
At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.



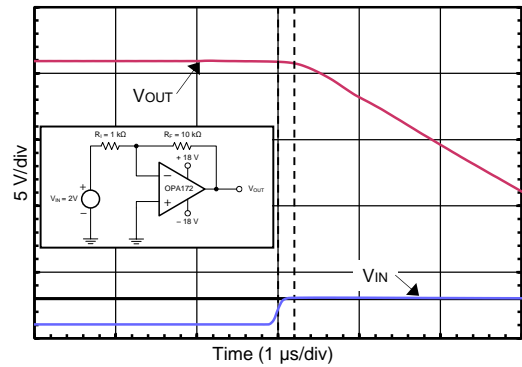


Typical Characteristics (continued)

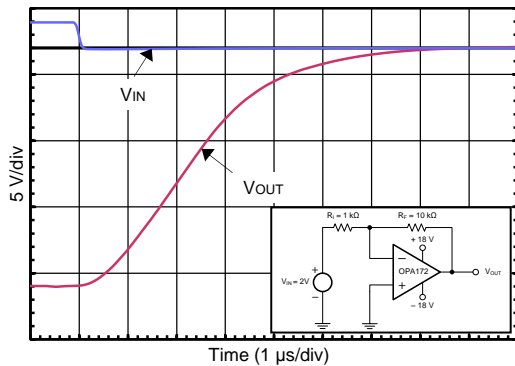
At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.



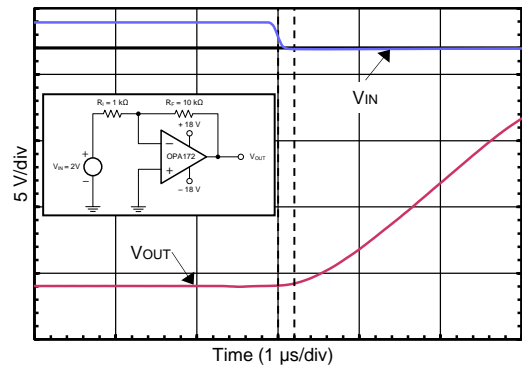
25. Positive Overload Recovery



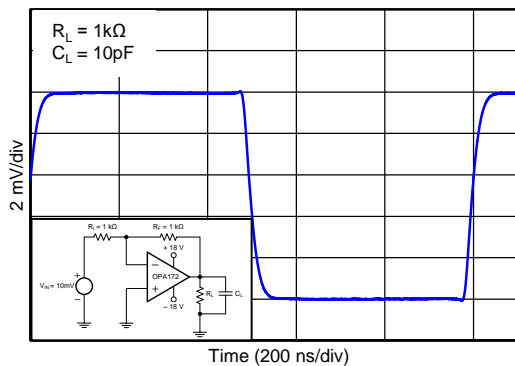
26. Positive Overload Recovery (Zoomed In)



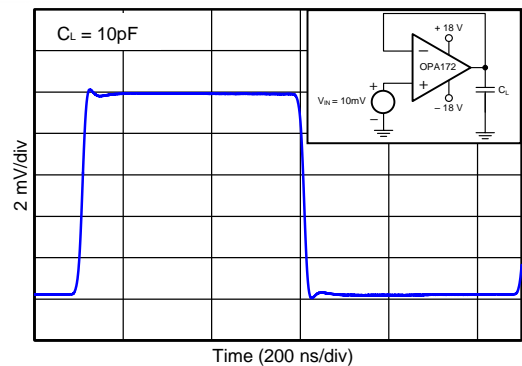
27. Negative Overload Recovery



28. Negative Overload Recovery (Zoomed In)



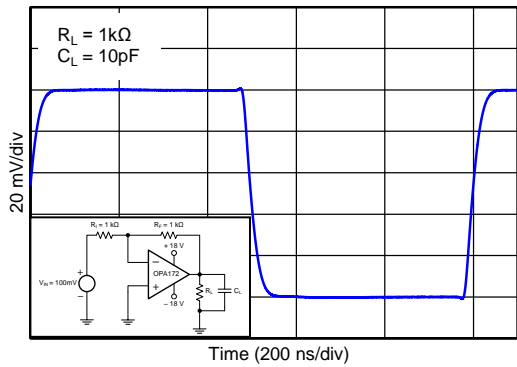
29. Small-Signal Step Response (10 mV, G = -1)



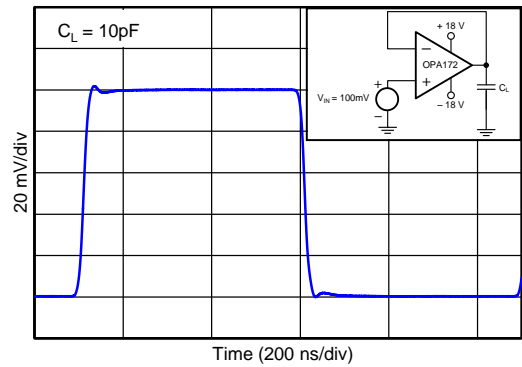
30. Small-Signal Step Response (10 mV, G = +1)

Typical Characteristics (continued)

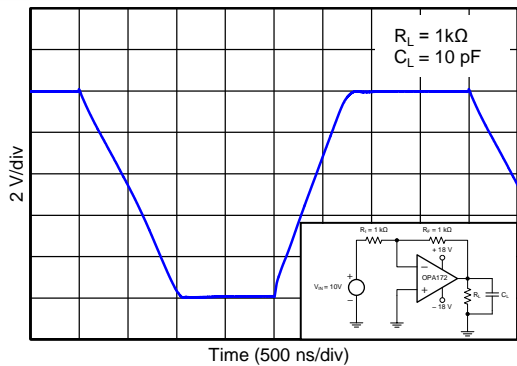
At  $V_S = \pm 18\text{ V}$ ,  $V_{CM} = V_S / 2$ ,  $R_{LOAD} = 10\text{ k}\Omega$  connected to  $V_S / 2$ , and  $C_L = 100\text{ pF}$ , unless otherwise noted.



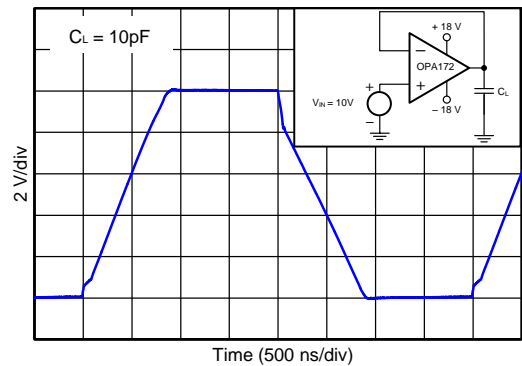
31. Small-Signal Step Response (100 mV, G = -1)



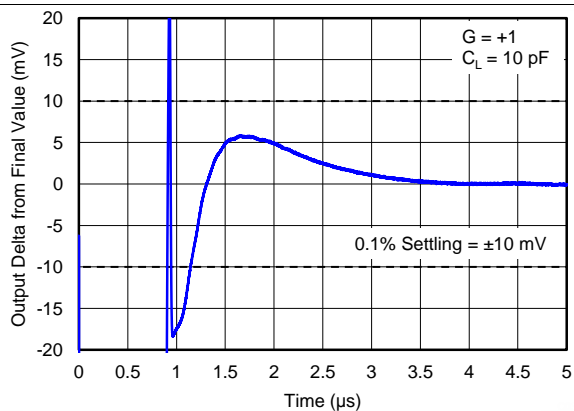
32. Small-Signal Step Response (100 mV, G = +1)



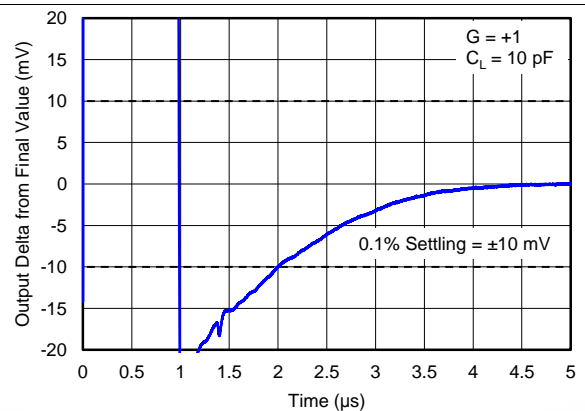
33. Large-Signal Step Response (10 V, G = -1)



34. Large-Signal Step Response (10 V, G = +1)



35. Large-Signal Settling Time (10-V Positive Step)



36. Large-Signal Settling Time (10-V Negative Step)

Typical Characteristics (continued)

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.

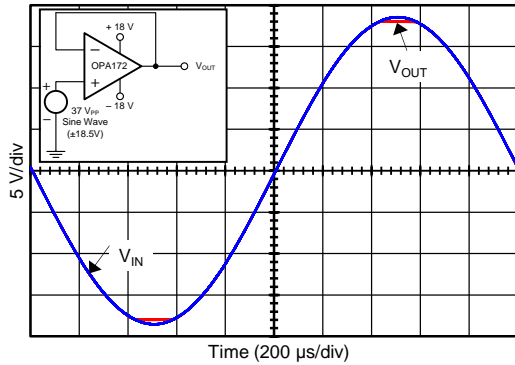


Figure 37. No Phase Reversal

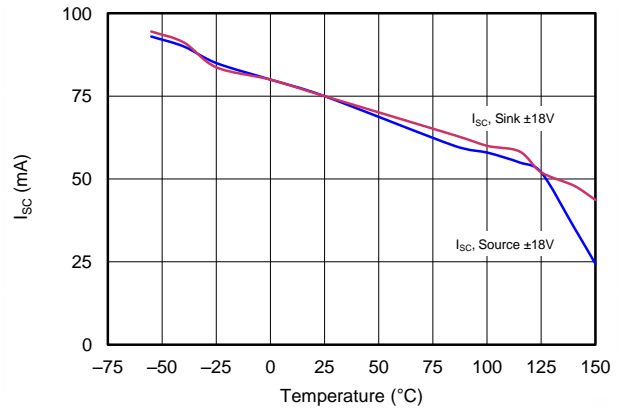


Figure 38. Short-Circuit Current vs Temperature

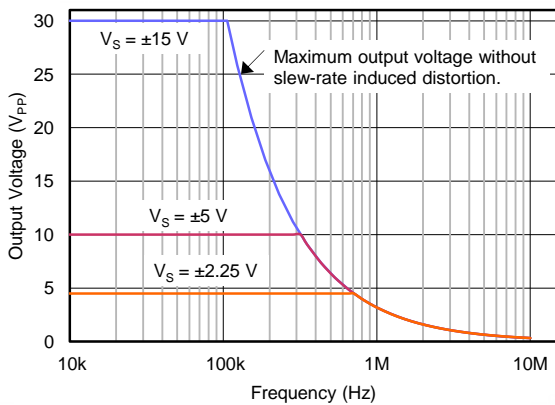


Figure 39. Maximum Output Voltage vs Frequency

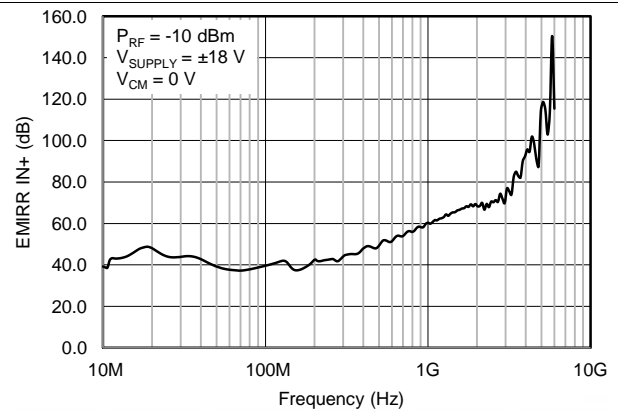


Figure 40. EMIRR vs Frequency

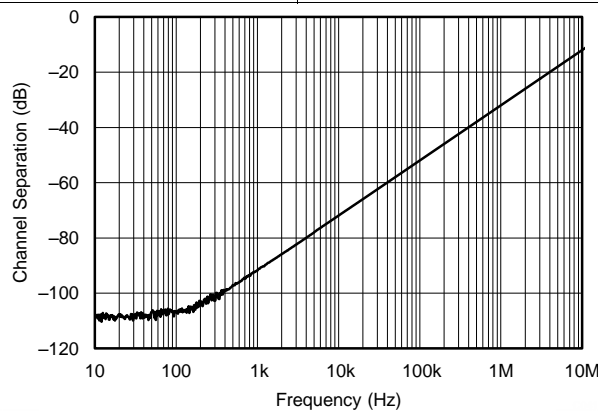


Figure 41. Channel Separation vs Frequency

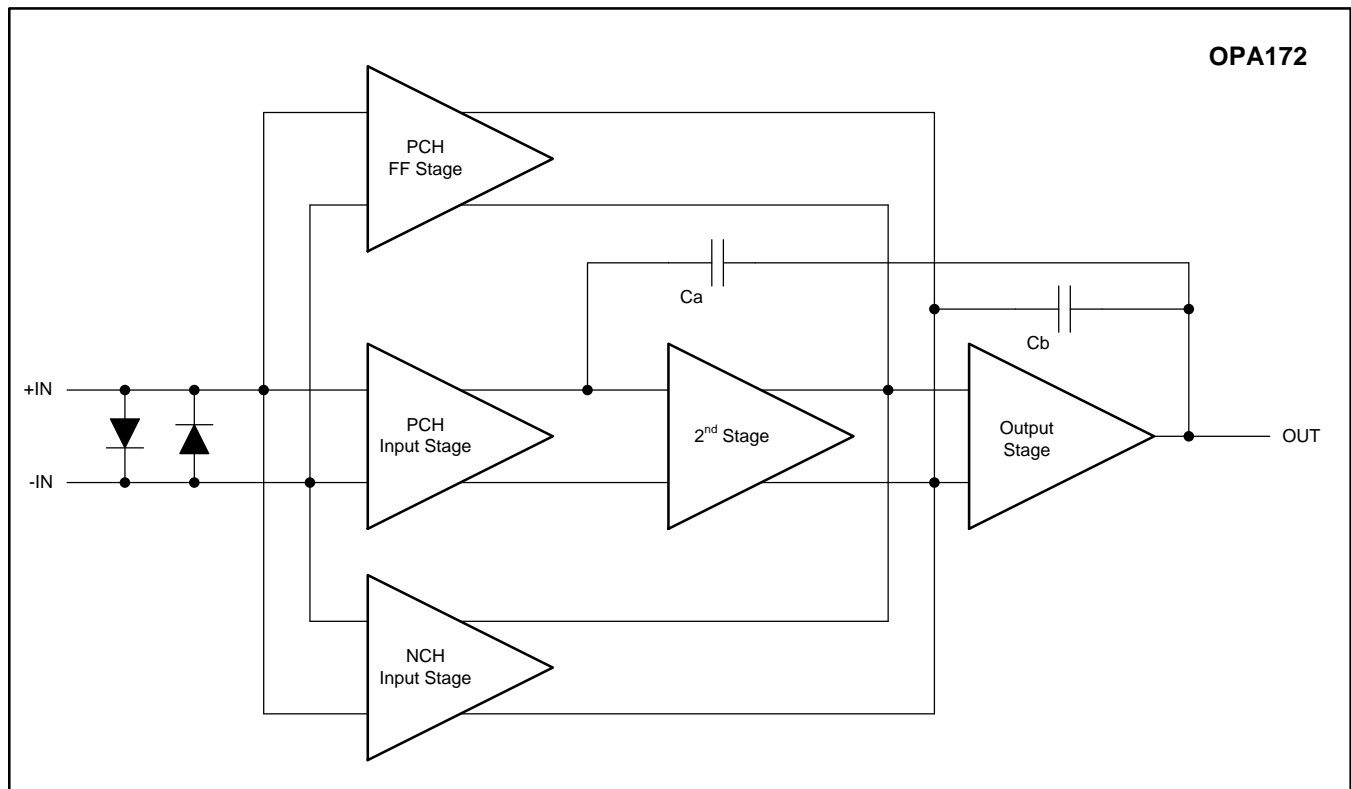
## 9 Detailed Description

### 9.1 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.

### 9.2 Functional Block Diagram



### 9.3 Feature Description

#### 9.3.1 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).

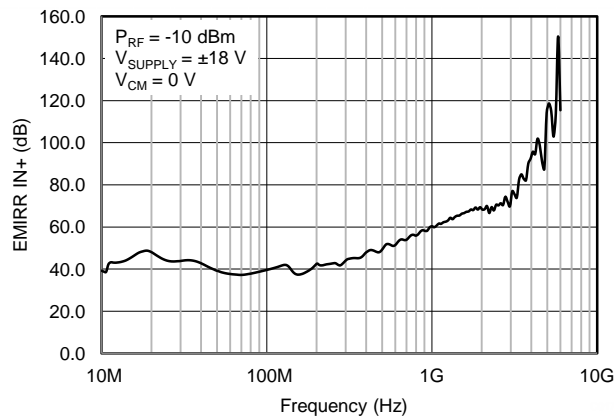


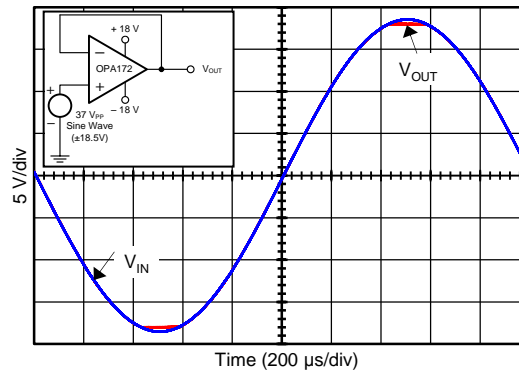
图 42. EMIRR Testing

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

### 9.3.2 Phase-Reversal Protection

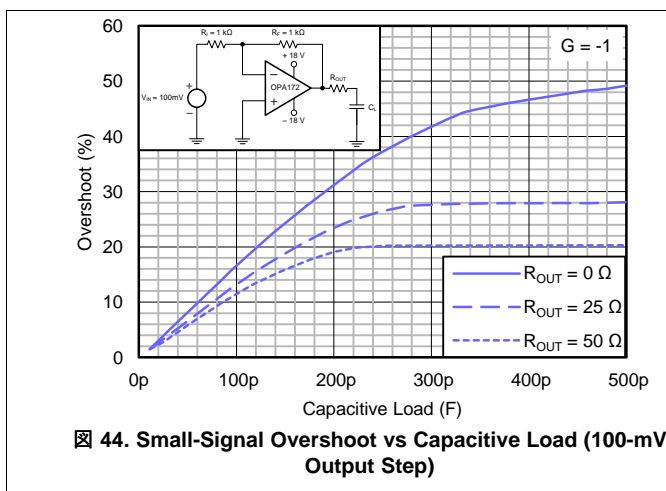
The OPAx172 family has internal phase-reversal protection. Many op amps exhibit a phase reversal when the input is driven beyond the linear common-mode range. This condition is most often encountered in noninverting circuits when the input is driven beyond the specified common-mode voltage range, causing 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 [Figure 43](#).



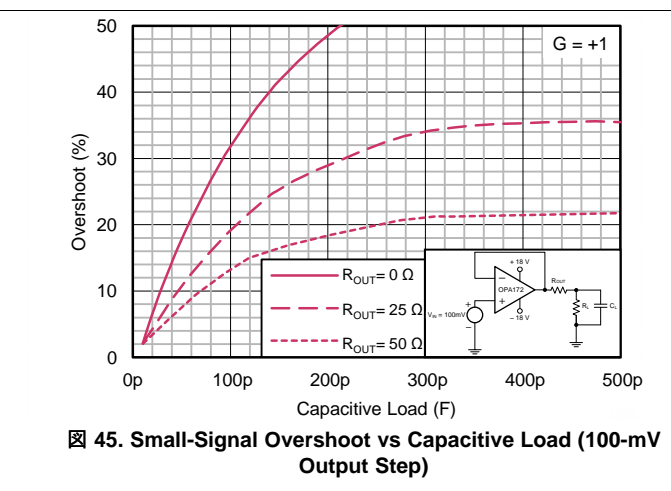
**Figure 43. No Phase Reversal**

### 9.3.3 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. [Figure 44](#) and [Figure 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.



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



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

## 9.4 Device Functional Modes

### 9.4.1 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](#).

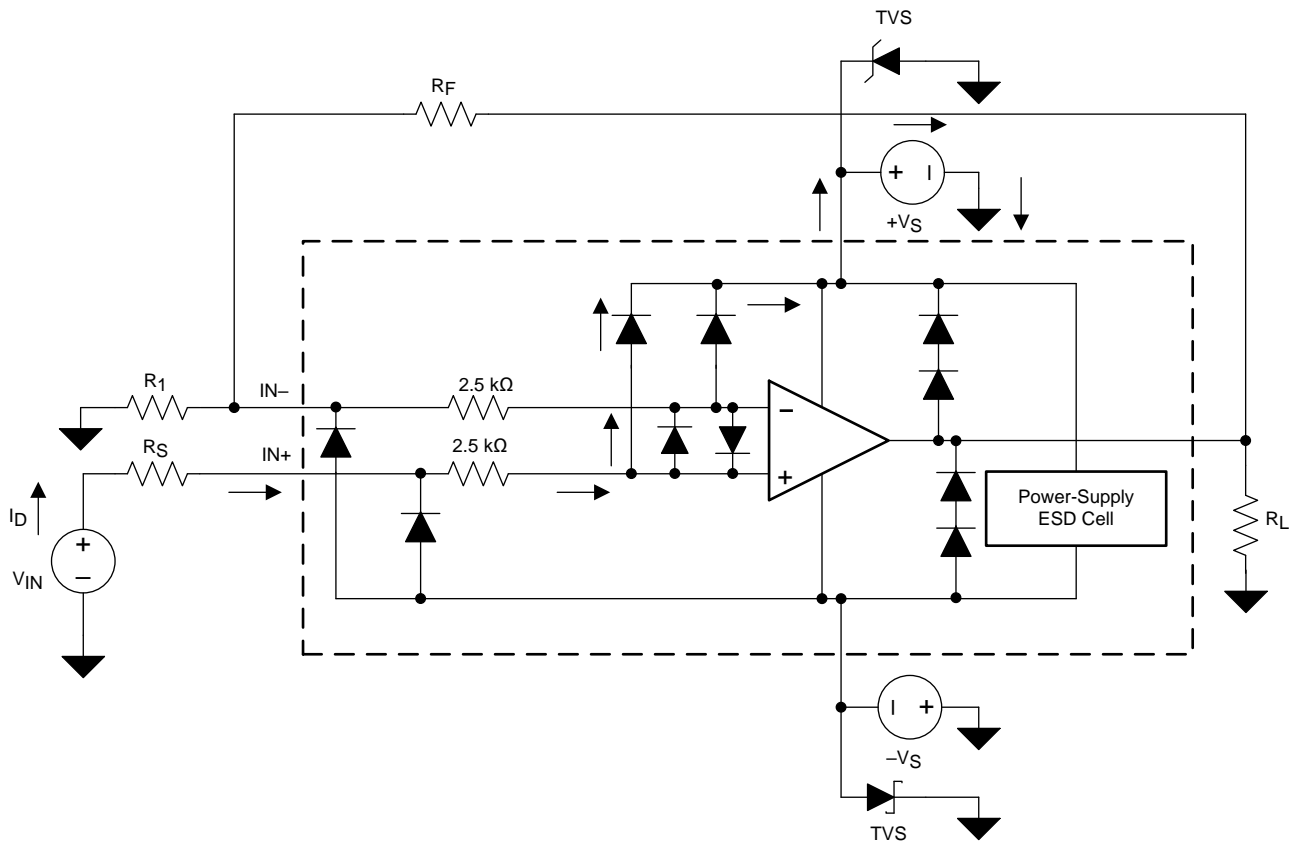
**表 3. Typical Performance Range ( $V_S = \pm 18\text{ V}$ )**

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		$\text{nV}/\sqrt{\text{Hz}}$

### 9.4.2 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.



**FIG 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 FIG 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.

FIG 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.

### 9.4.3 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.

## 10 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.

### 10.1 Application Information

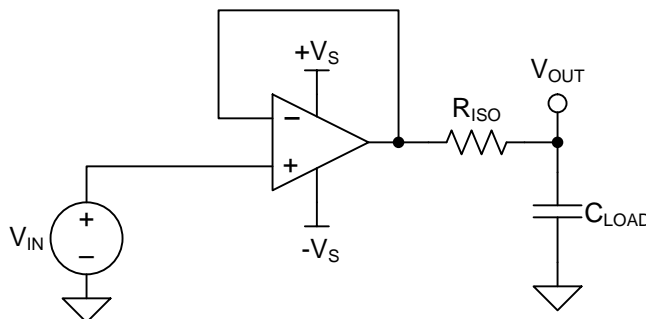
The OPAx172 family of amplifiers is specified for operation from 4.5 V to 36 V ( $\pm 2.25$  V to  $\pm 18$  V). Many of the specifications apply from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . Parameters that can exhibit significant variance with regard to operating voltage or temperature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

### 10.2 Typical Applications

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

#### 10.2.1 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.



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

##### 10.2.1.1 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 (continued)

### 10.2.1.2 Detailed Design Procedure

Figure 47 depicts a unity-gain buffer driving a capacitive load. Equation 1 shows the transfer function for the circuit in Figure 47. Not depicted in Figure 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 Equation 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. Figure 48 shows the concept. Note that the  $1 / \beta$  curve for a unity-gain buffer is 0 dB.

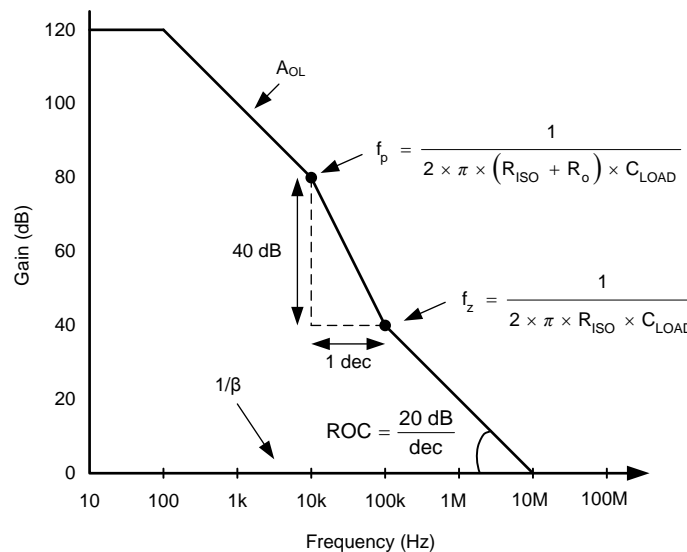


Figure 48. Unity-Gain Amplifier with  $R_{ISO}$  Compensation

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. Table 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).

Table 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

### 10.2.1.3 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 the these tests are summarized in 图 49.

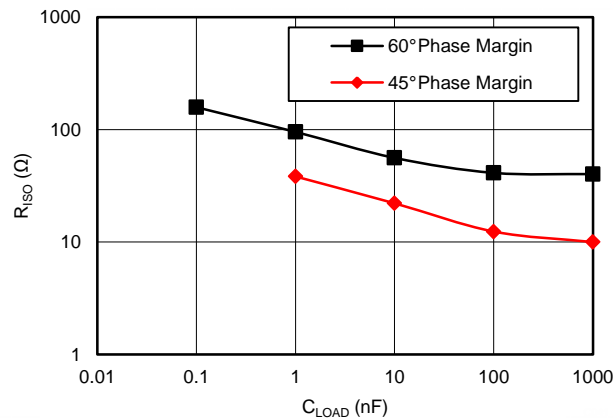


图 49.  $R_{ISO}$  VS  $C_{LOAD}$

### 10.2.2 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 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.

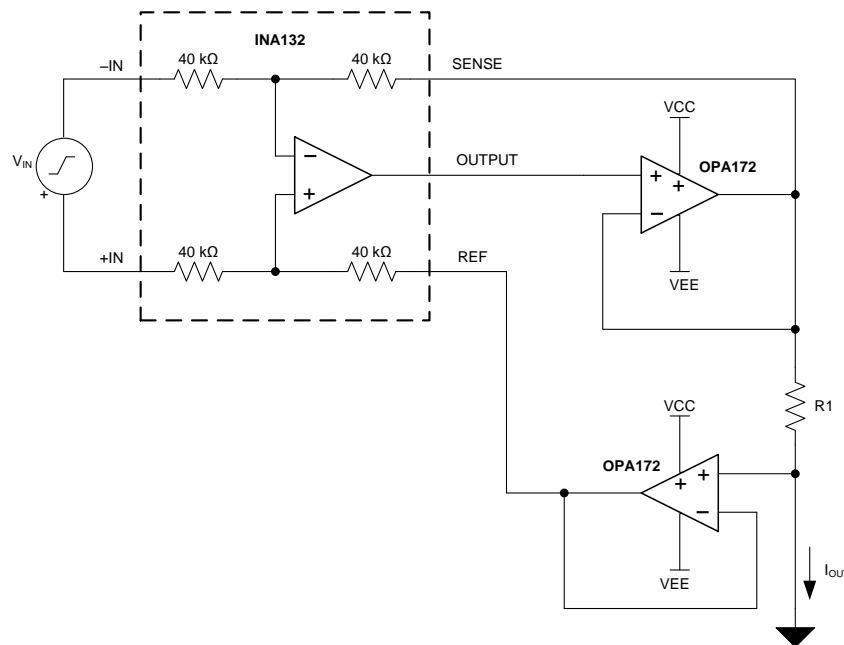


图 50. Bidirectional Current Source

### 10.2.3 JFET-Input Low-Noise Amplifier

Figure 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 Equation 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.

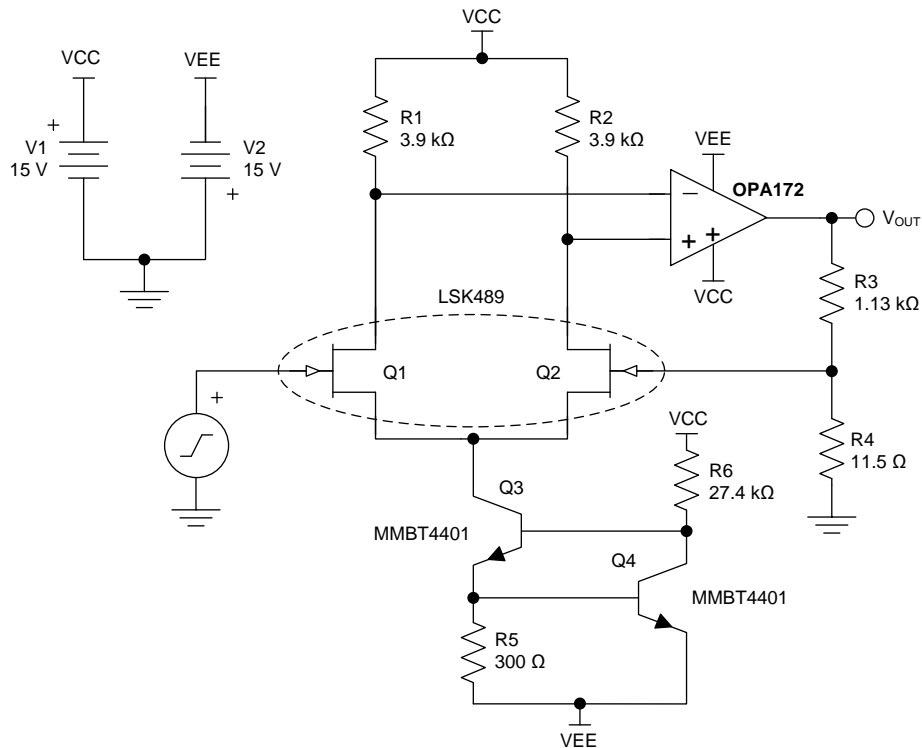


Figure 51. JFET-Input Low-Noise Amplifier

## 11 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](#).

### 注意

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.

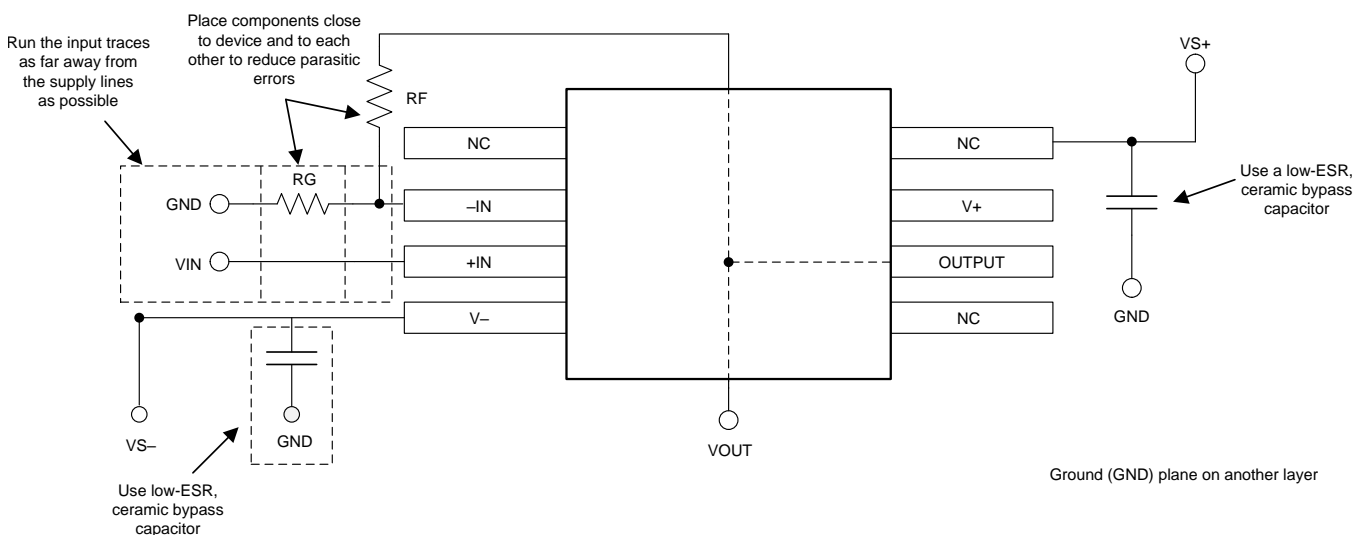
## 12 Layout

### 12.1 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- $\mu\text{F}$  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.

### 12.2 Layout Example



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

## 13 デバイスおよびドキュメントのサポート

### 13.1 デバイス・サポート

#### 13.1.1 開発サポート

##### 13.1.1.1 TINA-TI™(無料のダウンロード・ソフトウェア)

TINA™は、SPICEエンジンをベースにした単純かつ強力な、使いやすい回路シミュレーション・プログラムです。また、TINA-TIは、TINAソフトウェアの完全な機能を持つ無償バージョンで、パッシブ・モデルとアクティブ・モデルに加えて、マクロ・モデルのライブラリがプリロードされています。TINA-TIには、SPICEの標準的なDC解析、過渡解析、周波数ドメイン解析などの全機能に加え、追加の設計機能が搭載されています。

TINA-TIはAnalog eLab Design Centerから無料でダウンロードでき、ユーザーが結果をさまざまな方法でフォーマットできる、広範な後処理機能を備えています。仮想計測器により、入力波形を選択し、回路ノード、電圧、および波形をプローブして、動的なクイック・スタート・ツールを作成できます。

#### 注

これらのファイルを使用するには、TINA ソフトウェア ( DesignSoft™製) またはTINA-TIソフトウェアがインストールされている必要があります。TINA-TIフォルダから、無料のTINA-TIソフトウェアをダウンロードしてください。

### 13.2 ドキュメントのサポート

#### 13.2.1 関連資料

[SBOA015 \(AB-028\)](#) - 『フィードバック・プロットによるオペアンプAC性能の定義』

[SLOA089](#) - 『基板のレイアウト技法』

[SLOD006](#) - 『誰でも使えるオペアンプ』

[SBOA128](#) - 『オペアンプのEMI除去率』

[TIPD128](#) - 『絶縁抵抗の使用による容量性負荷駆動のソリューション』

#### 13.3 関連リンク

表 5 に、クイック・アクセス・リンクの一覧を示します。カテゴリには、技術資料、サポートおよびコミュニティ・リソース、ツールとソフトウェア、およびサンプル注文またはご購入へのクイック・アクセスが含まれます。

表 5. 関連リンク

製品	プロダクト・フォルダ	サンプルとご購入	技術資料	ツールとソフトウェア	サポートとコミュニティ
OPA172	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>
OPA2172	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>
OPA4172	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>	<a href="#">ここをクリック</a>

#### 13.4 コミュニティ・リソース

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™オンライン・コミュニティ TIのE2E ( Engineer-to-Engineer )** コミュニティ。エンジニア間の共同作業を促進するために開設されたものです。e2e.ti.comでは、他のエンジニアに質問し、知識を共有し、アイデアを検討して、問題解決に役立てることができます。

**設計サポート** TIの設計サポート役に立つE2Eフォーラムや、設計サポート・ツールをすばやく見つけることができます。技術サポート用の連絡先情報も参照できます。

### 13.5 商標

E2E is a trademark of Texas Instruments.

TINA-TI is a trademark of Texas Instruments, Inc and DesignSoft, Inc.

Bluetooth is a registered trademark of Bluetooth SIG, Inc.

TINA, DesignSoft are trademarks of DesignSoft, Inc.

All other trademarks are the property of their respective owners.

### 13.6 静電気放電に関する注意事項



すべての集積回路は、適切なESD保護方法を用いて、取扱いと保存を行うようにして下さい。

静電気放電はわずかな性能の低下から完全なデバイスの故障に至るまで、様々な損傷を与えます。高精度の集積回路は、損傷に対して敏感であり、極めてわずかなパラメータの変化により、デバイスに規定された仕様に適合しなくなる場合があります。

### 13.7 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 14 メカニカル、パッケージ、および注文情報

以降のページには、メカニカル、パッケージ、および注文に関する情報が記載されています。これらの情報は、指定のデバイスに対して提供されている最新のデータです。このデータは予告なく変更されることがあり、ドキュメントが改訂される場合もあります。本データシートのブラウザ版を使用されている場合は、画面左側の説明をご覧ください。



**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
OPA172ID	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA172	<a href="#">Samples</a>
OPA172IDBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OUWQ	<a href="#">Samples</a>
OPA172IDBVT	ACTIVE	SOT-23	DBV	5	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OUWQ	<a href="#">Samples</a>
OPA172IDCKR	ACTIVE	SC70	DCK	5	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	SIU	<a href="#">Samples</a>
OPA172IDCKT	ACTIVE	SC70	DCK	5	250	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	SIU	<a href="#">Samples</a>
OPA172IDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA172	<a href="#">Samples</a>
OPA2172ID	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	O2172A	<a href="#">Samples</a>
OPA2172IDGK	ACTIVE	VSSOP	DGK	8	80	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	OVJQ	<a href="#">Samples</a>
OPA2172IDGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAUAG   SN	Level-2-260C-1 YEAR	-40 to 125	OVJQ	<a href="#">Samples</a>
OPA2172IDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	O2172A	<a href="#">Samples</a>
OPA2172IDRGR	ACTIVE	SON	DRG	8	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OP2172	<a href="#">Samples</a>
OPA2172IDRGT	ACTIVE	SON	DRG	8	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OP2172	<a href="#">Samples</a>
OPA4172ID	ACTIVE	SOIC	D	14	50	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 125	OPA4172	<a href="#">Samples</a>
OPA4172IDR	ACTIVE	SOIC	D	14	2500	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-40 to 125	OPA4172	<a href="#">Samples</a>
OPA4172IPW	ACTIVE	TSSOP	PW	14	90	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA4172	<a href="#">Samples</a>
OPA4172IPWR	ACTIVE	TSSOP	PW	14	2000	RoHS & Green	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.

**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.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of  $\leq 1000$ ppm threshold. Antimony trioxide based flame retardants must also meet the  $\leq 1000$ ppm threshold requirement.

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

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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.

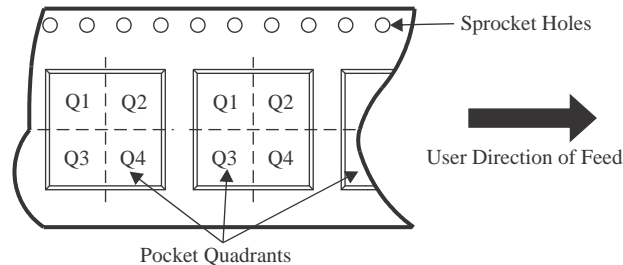
#### OTHER QUALIFIED VERSIONS OF OPA2172, OPA4172 :

- Automotive : [OPA2172-Q1](#), [OPA4172-Q1](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

**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	356.0	356.0	35.0
OPA2172IDGKR	VSSOP	DGK	8	2500	366.0	364.0	50.0
OPA2172IDR	SOIC	D	8	2500	356.0	356.0	35.0
OPA2172IDRGR	SON	DRG	8	3000	346.0	346.0	33.0
OPA2172IDRGT	SON	DRG	8	250	210.0	185.0	35.0
OPA4172IDR	SOIC	D	14	2500	356.0	356.0	35.0
OPA4172IPWR	TSSOP	PW	14	2000	356.0	356.0	35.0

**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
OPA172ID	D	SOIC	8	75	506.6	8	3940	4.32
OPA2172ID	D	SOIC	8	75	506.6	8	3940	4.32
OPA2172IDGK	DGK	VSSOP	8	80	330	6.55	500	2.88
OPA4172ID	D	SOIC	14	50	506.6	8	3940	4.32
OPA4172IPW	PW	TSSOP	14	90	530	10.2	3600	3.5

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.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153





D0008A

# PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

### NOTES:

- Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed  $.006$  [0.15] per side.
- This dimension does not include interlead flash.
- Reference JEDEC registration MS-012, variation AA.

# EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

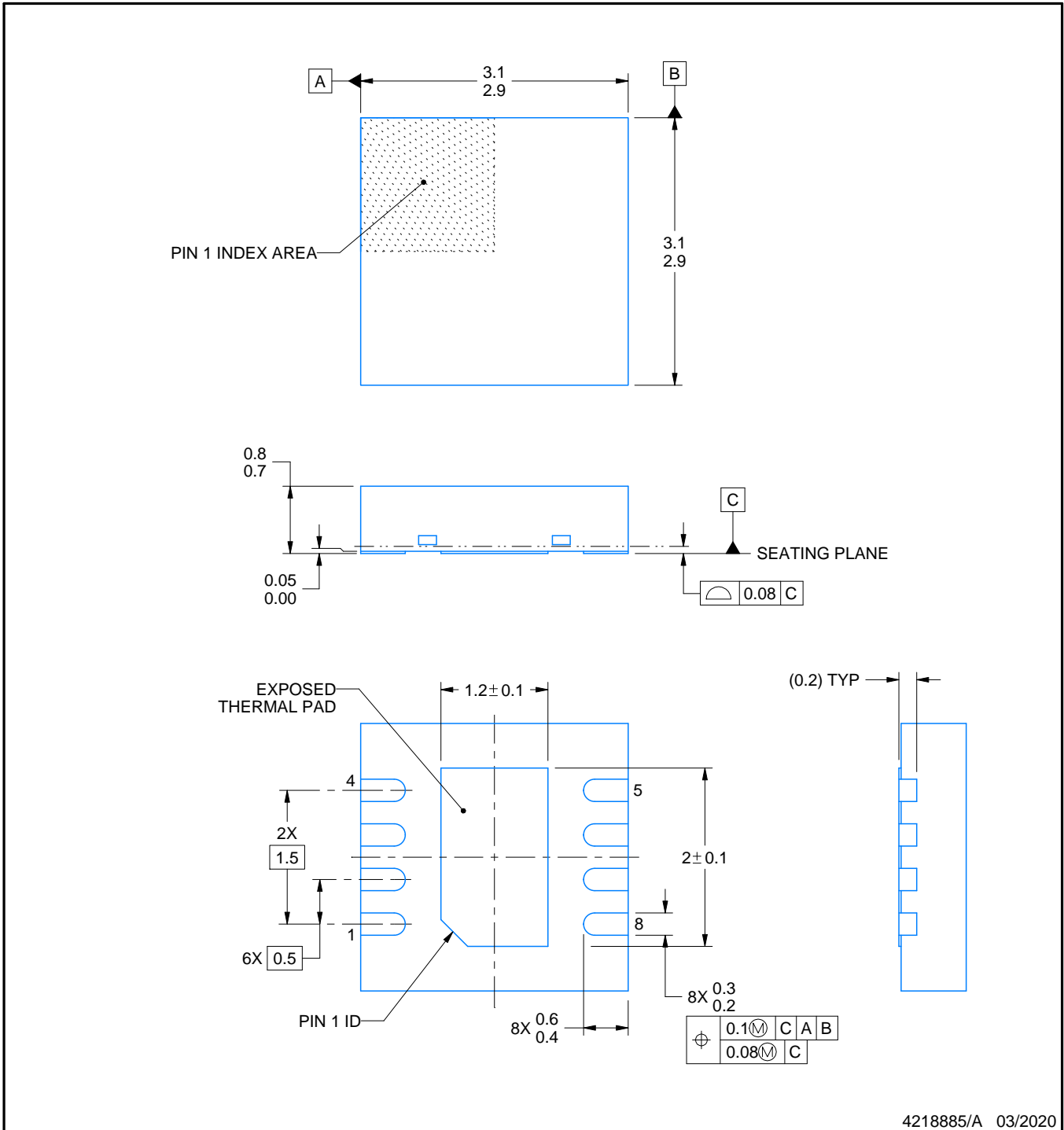
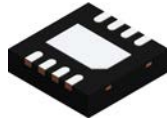
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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.



4218885/A 03/2020

NOTES:

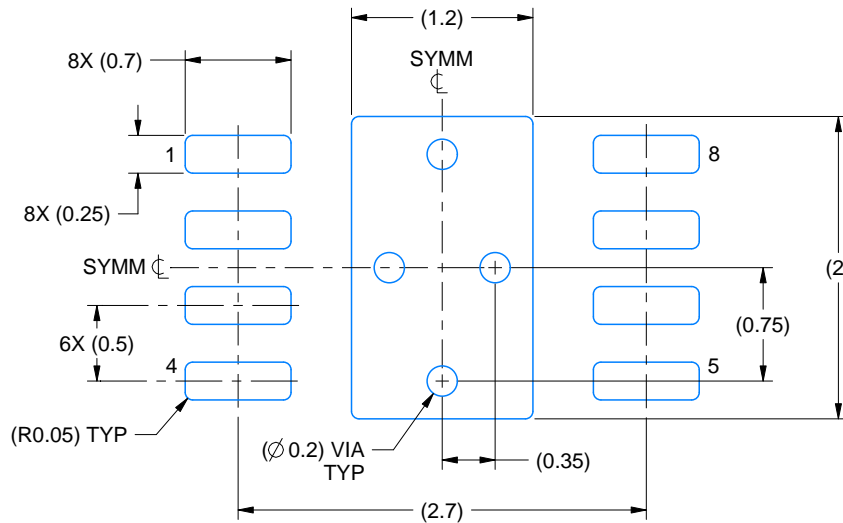
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

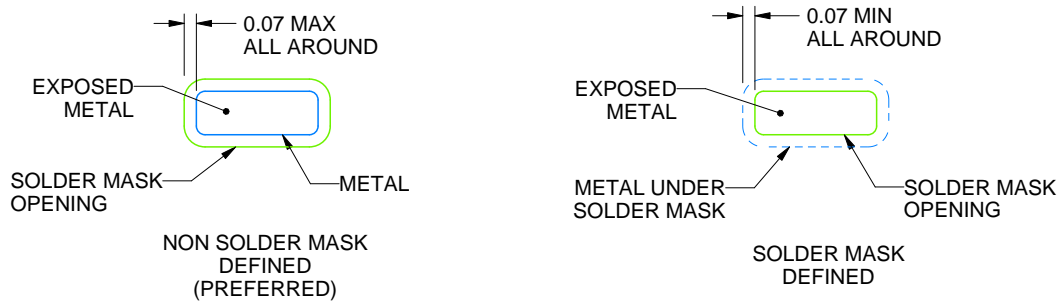
DRG0008A

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:20X



SOLDER MASK DETAILS

4218885/A 03/2020

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

DRG0008A

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD  
84% PRINTED SOLDER COVERAGE BY AREA  
SCALE:25X

4218885/A 03/2020

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

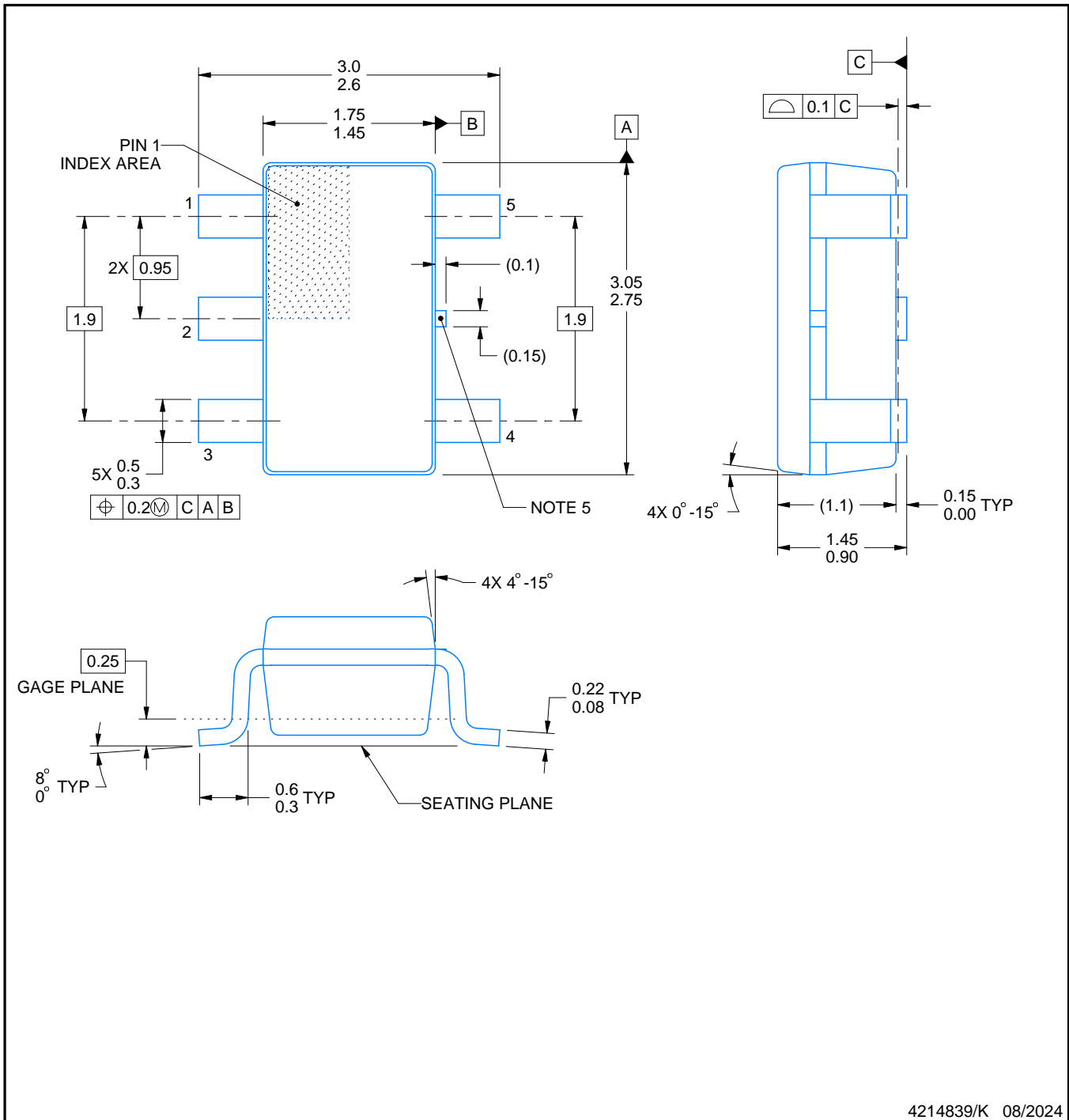
# DBV0005A



# PACKAGE OUTLINE

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



4214839/K 08/2024

### 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.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.



# 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/K 08/2024

NOTES: (continued)

- 6. Publication IPC-7351 may have alternate designs.
- 7. 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/K 08/2024

NOTES: (continued)

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

# DCK0005A



# PACKAGE OUTLINE

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



4214834/E 06/2024

**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-203.
4. Support pin may differ or may not be present.
5. Lead width does not comply with JEDEC.
6. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side

# EXAMPLE BOARD LAYOUT

DCK0005A

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:18X



SOLDER MASK DETAILS

4214834/E 06/2024

NOTES: (continued)

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

# EXAMPLE STENCIL DESIGN

DCK0005A

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE  
BASED ON 0.125 THICK STENCIL  
SCALE: 18X

4214834/E 06/2024

NOTES: (continued)

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

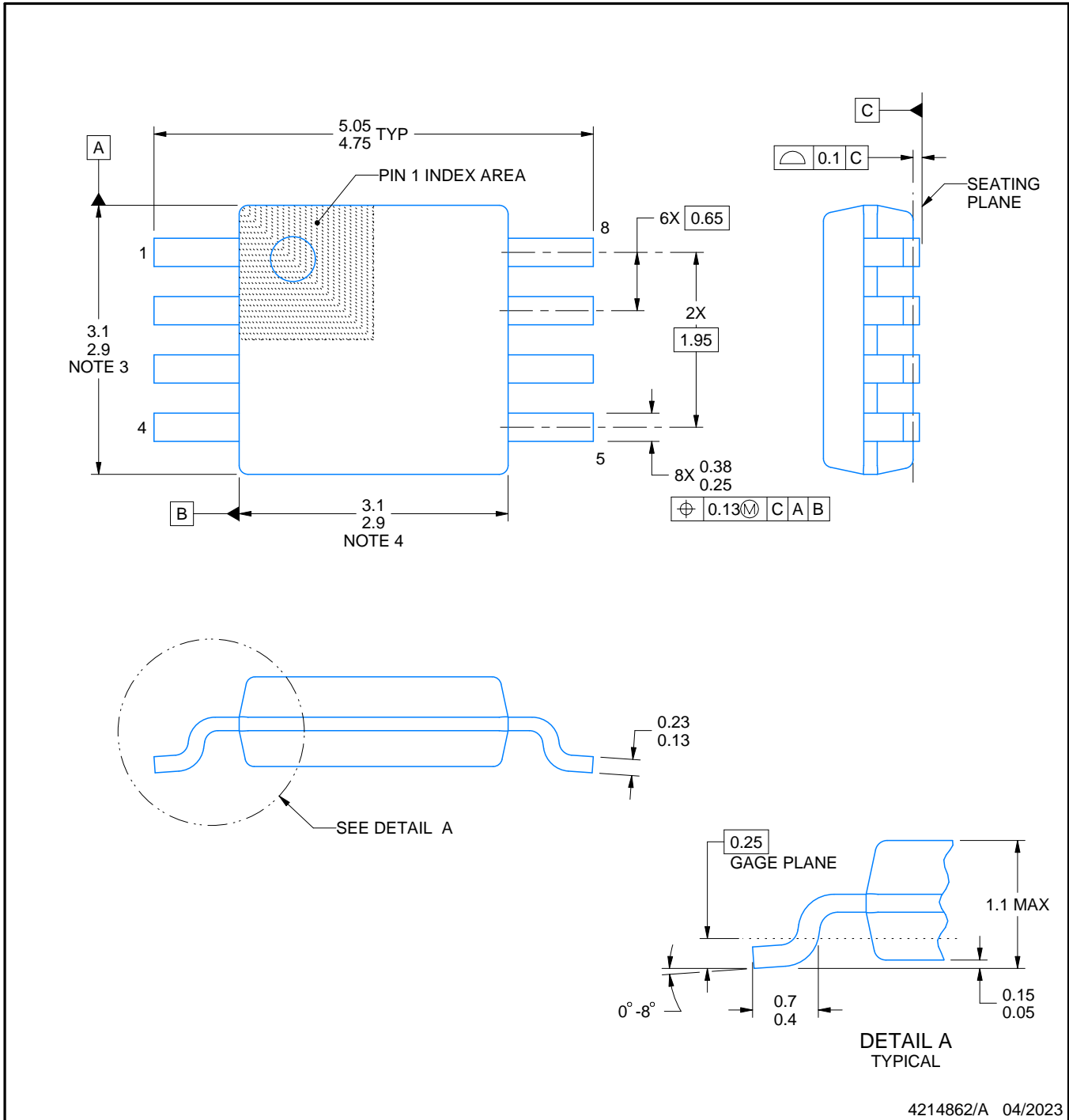
DGK0008A



PACKAGE OUTLINE

VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



NOTES:

PowerPAD is a trademark of Texas Instruments.

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. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187.

# EXAMPLE BOARD LAYOUT

DGK0008A

™ VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 15X



SOLDER MASK DETAILS

4214862/A 04/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
9. Size of metal pad may vary due to creepage requirement.

# EXAMPLE STENCIL DESIGN

DGK0008A

<sup>TM</sup> VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
SCALE: 15X

4214862/A 04/2023

NOTES: (continued)

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



## 重要なお知らせと免責事項

TI は、技術データと信頼性データ (データシートを含みます)、設計リソース (リファレンス・デザインを含みます)、アプリケーションや設計に関する各種アドバイス、Web ツール、安全性情報、その他のリソースを、欠陥が存在する可能性のある「現状のまま」提供しており、商品性および特定目的に対する適合性の黙示保証、第三者の知的財産権の非侵害保証を含むいかなる保証も、明示的または黙示的にかかわらず拒否します。

これらのリソースは、TI 製品を使用する設計の経験を積んだ開発者への提供を意図したものです。(1) お客様のアプリケーションに適した TI 製品の選定、(2) お客様のアプリケーションの設計、検証、試験、(3) お客様のアプリケーションに該当する各種規格や、その他のあらゆる安全性、セキュリティ、規制、または他の要件への確実な適合に関する責任を、お客様のみが単独で負うものとし、

上記の各種リソースは、予告なく変更される可能性があります。これらのリソースは、リソースで説明されている TI 製品を使用するアプリケーションの開発の目的でのみ、TI はその使用をお客様に許諾します。これらのリソースに関して、他の目的で複製することや掲載することは禁止されています。TI や第三者の知的財産権のライセンスが付与されている訳ではありません。お客様は、これらのリソースを自身で使用した結果発生するあらゆる申し立て、損害、費用、損失、責任について、TI およびその代理人を完全に補償するものとし、TI は一切の責任を拒否します。

TI の製品は、[TI の販売条件](#)、または [ti.com](#) やかかる TI 製品の関連資料などのいずれかを通じて提供する適用可能な条項の下で提供されています。TI がこれらのリソースを提供することは、適用される TI の保証または他の保証の放棄の拡大や変更を意味するものではありません。

お客様がいかなる追加条項または代替条項を提案した場合でも、TI はそれらに異議を唱え、拒否します。

郵送先住所 : Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2024, Texas Instruments Incorporated