

TSV91x レール・ツー・レール入出力、8MHzオペアンプ

1 特長

- レール・ツー・レールの入出力
- 低ノイズ：18nV/√Hz (1kHz 時)
- 低い消費電力：550μA (標準値)
- 高いゲイン帯域幅：8MHz
- 動作電源電圧範囲：2.5V~5.5V
- 低い入力バイアス電流：1pA (標準値)
- 低い入力オフセット電圧：1.5mV (最大値)
- 低いオフセット電圧ドリフト係数：±0.5μV/°C (標準値)
- 内部 ESD 保護：人体モデル (HBM) ±4kV
- 拡張温度範囲：-40°C~125°C

2 アプリケーション

- バッテリ駆動のアプリケーション
- モータ制御
- パワー・モジュール
- HVAC：暖房、換気、および空調
- 洗濯機
- 冷蔵庫
- 医療用計測装置
- アクティブ・フィルタ
- センサ信号コンディショニング
- オーディオ・レシーバ
- 車載インフォテインメント

3 概要

TSV91xファミリにはシングル、デュアル、クワッド・チャネルのオペアンプが含まれ、汎用アプリケーション向けに特化して設計されています。このファミリは、レール・ツー・レールの入出力(RRIO)スイング、広い帯域幅(8MHz)、低いオフセット電圧(標準値0.3mV)の特長を持ち、速度と消費電力との適切なバランスを必要とする各種のアプリケーション向けに設計されています。オペアンプはユニティ・ゲイン安定で、入力バイアス電流が非常に低い特長があるため、このファミリは高いソース・インピーダンスのアプリケーションに使用できます。入力バイアス電流が低いため、センサ・インターフェイス、バッテリー電源および携帯型アプリケーション、アクティブ・フィルタにデバイスを使用できます。

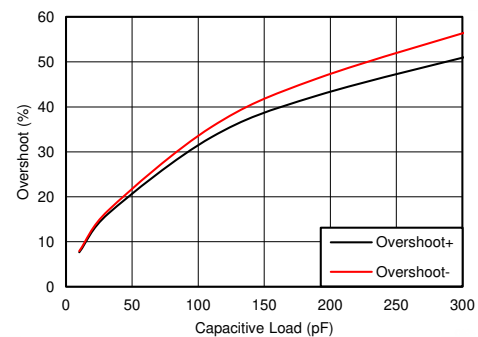
TSV91xは堅牢な設計のため、回路設計者が簡単に使用できます。ユニティ・ゲイン安定、RFI-EMI除去フィルタの内蔵、オーバードライブ状態で位相反転が発生しない、高い静電放電(ESD)保護(4kV HBV)などの特長があります。

製品情報(1)

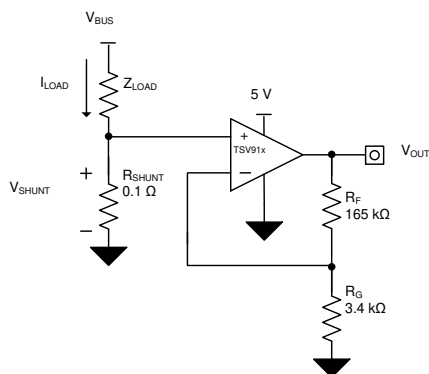
型番	パッケージ	本体サイズ(公称)
TSV911	SOT-23 (5)	1.60mm × 2.90mm
	SC70 (5)	1.25mm×2.00mm
TSV912	SOIC (8)	3.91mm×4.90mm
	WSON (8)	2.00mm×2.00mm
	SOT-23 (8)	1.60mm × 2.90mm
TSV914	SOIC (14)	8.65mm×3.91mm
	TSSOP (14)	4.40mm×5.00mm

(1) 提供されているすべてのパッケージについては、データシートの末尾にある注文情報を参照してください。

小信号のオーバーシュートと負荷容量との関係



ローサイドのモータ制御



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4 改訂履歴

Revision C (January 2019) から Revision D に変更 Page

•	データシートに SOT-23 (8) (DDF) パッケージ情報を追加	1
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Revision B (April 2018) から Revision C に変更 Page

•	TSV911IDBV のプレビュー版表記を削除	1
•	「製品情報」表に SC70 パッケージ情報を追加	1
•	Deleted package preview notation from TSV911 DBV (SOT-23) package	4
•	Added DCK (SC70) package information to <i>Device Comparison Table</i>	4
•	Deleted TSV911 DBV (SOT-23) package preview notation from <i>Pin Configuration and Functions</i> section	5
•	Added TSV911 DCK (SC70) package drawing and pin functions	5
•	Added TSV911 DBV and DCK package thermal information	8

Revision A (October 2017) から Revision B に変更 Page

•	「製品情報」表で、TSV914 14ピンTSSOPパッケージをプレビューから量産データに変更	1
•	「製品情報」表の8ピンWSONパッケージからパッケージのプレビュー版の注を削除	1
•	Deleted package preview note from PW (TSSOP) package from <i>Device Comparison table</i>	4
•	Deleted package preview note from DSG (WSON) package from <i>Device Comparison table</i>	4
•	Deleted package preview note from TSV912 DSG package pinout drawing in <i>Pin Configuration and Functions</i> section	6
•	Added DGK (VSSOP) thermal information to <i>Thermal Information: TSV912 table</i>	9
•	Deleted package preview note to TSV914 PW (TSSOP) package <i>Thermal Information table</i>	9
•	Added PW (TSSOP) package information to <i>Thermal Information: TSV914 table</i>	9
•	Changed TSV914 PW (TSSOP) junction-to-ambient thermal resistance from 135.8°C/W to 205.8°C/W	9
•	Changed TSV914 PW (TSSOP) junction-to-case(top) thermal resistance from 64°C/W to 106.7°C/W	9
•	Changed TSV914 PW (TSSOP) junction-to-board thermal resistance from 79°C/W to 133.9°C/W	9

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- Changed TSV914 PW (TSSOP) junction-to-top characterization parameter from 15.7°C/W to 34.4°C/W 9
 - Changed TSV914 PW (TSSOP) junction-to-board characterization parameter from 78.4°C/W to 132.6°C/W 9
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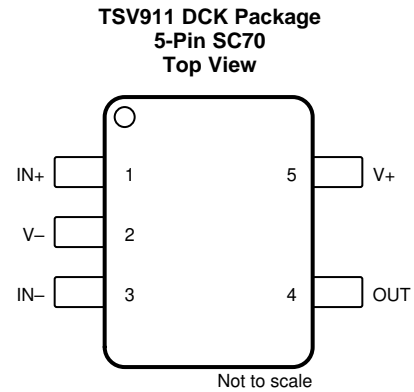
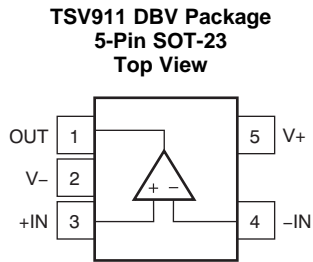
2017年7月発行のものから更新
Page

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- 「製品情報」表で、TSV914 14ピンSOICパッケージをプレビューから量産データに変更 1
 - 「製品情報」表からTSV911のSC70、SOT-553、SOICパッケージを削除 1
 - 「製品情報」表からTSV912 VSSOPパッケージを削除 1
 - Deleted TSV911 SC70 and SOIC packages from pinout drawings and *Pin Functions* table 5
 - Deleted TSV912 DGK and DGS packages from pinout images *Pin Functions* table 6
 - Deleted package preview note from TSV914 pinout drawing and *Pin Functions* table 7
 - Added TSV914 *Thermal Information* table 9
 - 追加 2017 copyright notice to [図 35](#) 20
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5 Device Comparison Table

DEVICE	NO. OF CHANNELS	PACKAGE LEADS					
		DBV	DCK	D	DSG	PW	DDF
TSV911	1	5	5	—	—	—	—
TSV912	2	—	—	8	8	—	8
TSV914	4	—	—	14	—	14	—

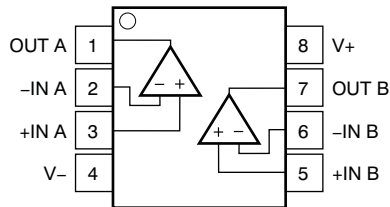
6 Pin Configuration and Functions



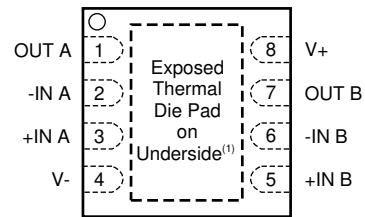
Pin Functions: TSV911

NAME	PIN NO.		I/O	DESCRIPTION
	DBV (SOT-23)	DCK (SC70)		
-IN	4	3	I	Inverting input
+IN	3	1	I	Noninverting input
OUT	1	4	O	Output
V-	2	2	—	Negative (lowest) supply or ground (for single-supply operation)
V+	5	5	—	Positive (highest) supply

**TSV912 D, DGK, DDF Packages
8-Pin SOIC, VSSOP
Top View**



**TSV912 DSG Package (1)
8-Pin WSON With Exposed Thermal Pad
Top View**

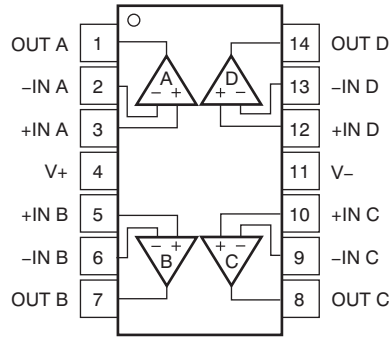


(1) Connect exposed thermal pad to V-. See [Packages with an Exposed Thermal Pad](#) section for more information.

Pin Functions: TSV912

PIN		I/O	DESCRIPTION
NAME	NO.		
-IN A	2	I	Inverting input, channel A
+IN A	3	I	Noninverting input, channel A
-IN B	6	I	Inverting input, channel B
+IN B	5	I	Noninverting input, channel B
OUT A	1	O	Output, channel A
OUT B	7	O	Output, channel B
V-	4	—	Negative (lowest) supply or ground (for single-supply operation)
V+	8	—	Positive (highest) supply

**TSV914 D, PW Packages
14-Pin SOIC, TSSOP
Top View**



Pin Functions: TSV914

PIN		I/O	DESCRIPTION
NAME	NO.		
-IN A	2	I	Inverting input, channel A
+IN A	3	I	Noninverting input, channel A
-IN B	6	I	Inverting input, channel B
+IN B	5	I	Noninverting input, channel B
-IN C	9	I	Inverting input, channel C
+IN C	10	I	Noninverting input, channel C
-IN D	13	I	Inverting input, channel D
+IN D	12	I	Noninverting input, channel D
OUT A	1	O	Output, channel A
OUT B	7	O	Output, channel B
OUT C	8	O	Output, channel C
OUT D	14	O	Output, channel D
V-	11	—	Negative (lowest) supply or ground (for single-supply operation)
V+	4	—	Positive (highest) supply

7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature (unless otherwise noted)⁽¹⁾

			MIN	MAX	UNIT	
Supply voltage			6		V	
Signal input pins	Voltage ⁽²⁾	Common-mode	(V-) – 0.5	(V+) + 0.5	V	
		Differential	(V+) – (V-) + 0.2			
Current ⁽²⁾			–10	10	mA	
Output short-circuit ⁽³⁾			Continuous		mA	
Specified, T _A			–40	125	°C	
Junction, T _J					150	°C
Storage, T _{stg}			–65	150	°C	

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Input pins are diode-clamped to the power-supply rails. Current limit input signals that can swing more than 0.5 V beyond the supply rails to 10 mA or less.
- (3) Short-circuit to ground, one amplifier per package.

7.2 ESD Ratings

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

			VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±4000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±1500	

- (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	MAX	UNIT
V _S	Supply voltage		2.5	5.5	V
	Specified temperature		–40	125	°C

7.4 Thermal Information: TSV911

THERMAL METRIC ⁽¹⁾		TSV911		UNIT
		DBV (SOT-23)	DCK (SC70)	
		5 PINS	5 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	221.7	263.3	°C/W
R _{θJC(top)}	Junction-to-case(top) thermal resistance	144.7	75.5	°C/W
R _{θJB}	Junction-to-board thermal resistance	49.7	51.0	°C/W
ψ _{JT}	Junction-to-top characterization parameter	26.1	1.0	°C/W
ψ _{JB}	Junction-to-board characterization parameter	49.0	50.3	°C/W

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

7.5 Thermal Information: TSV912

THERMAL METRIC ⁽¹⁾		TSV912				UNIT
		D (SOIC)	DGK (VSSOP)	DSG (WSON)	DDF (SOT-23)	
		8 PINS	8 PINS	8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	157.6	201.2	94.4	184.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case(top) thermal resistance	104.6	85.7	116.5	112.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	99.7	122.9	61.3	99.9	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	55.6	21.2	13	18.7	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	99.2	121.4	61.7	99.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case(bottom) thermal resistance	N/A	N/A	34.4	N/A	°C/W

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

7.6 Thermal Information: TSV914

THERMAL METRIC ⁽¹⁾		TSV914		UNIT
		D (SOIC)	PW (TSSOP)	
		14 PINS	14 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	106.9	205.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	69	106.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	63	133.9	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	25.9	34.4	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	62.7	132.6	°C/W

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

7.7 Electrical Characteristics: V_S (Total Supply Voltage) = $(V_+) - (V_-) = 2.5\text{ V to }5.5\text{ V}$

 at $T_A = 25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OFFSET VOLTAGE						
V_{OS}	Input offset voltage	$V_S = 5\text{ V}$		± 0.3	± 1.5	mV
		$V_S = 5\text{ V}$ $T_A = -40^\circ\text{C to }125^\circ\text{C}$			± 3	
dV_{OS}/dT	Drift	$V_S = 5\text{ V}$ $T_A = -40^\circ\text{C to }125^\circ\text{C}$		± 0.5		$\mu\text{V}/^\circ\text{C}$
PSRR	Power-supply rejection ratio	$V_S = 2.5\text{ V} - 5.5\text{ V}$, $V_{CM} = (V_-)$		± 7		$\mu\text{V/V}$
	Channel separation, DC	At DC		100		dB
INPUT VOLTAGE RANGE						
V_{CM}	Common-mode voltage range	$V_S = 2.5\text{ V to }5.5\text{ V}$	$(V_-) - 0.1$		$(V_+) + 0.1$	V
CMRR	Common-mode rejection ratio	$V_S = 5.5\text{ V}$ $(V_-) - 0.1\text{ V} < V_{CM} < (V_+) - 1.4\text{ V}$ $T_A = -40^\circ\text{C to }125^\circ\text{C}$	80	103		dB
		$V_S = 5.5\text{ V}$, $V_{CM} = -0.1\text{ V to }5.6\text{ V}$ $T_A = -40^\circ\text{C to }125^\circ\text{C}$	57	87		
		$V_S = 2.5\text{ V}$, $(V_-) - 0.1\text{ V} < V_{CM} < (V_+) - 1.4\text{ V}$ $T_A = -40^\circ\text{C to }125^\circ\text{C}$		88		
		$V_S = 2.5\text{ V}$, $V_{CM} = -0.1\text{ V to }1.9\text{ V}$ $T_A = -40^\circ\text{C to }125^\circ\text{C}$		81		
INPUT BIAS CURRENT						
I_B	Input bias current			± 1		pA
I_{OS}	Input offset current			± 0.05		pA
NOISE						
E_n	Input voltage noise (peak-to-peak)	$V_S = 5\text{ V}$, $f = 0.1\text{ Hz to }10\text{ Hz}$		4.77		μV_{PP}
e_n	Input voltage noise density	$V_S = 5\text{ V}$, $f = 10\text{ kHz}$		12		$\text{nV}/\sqrt{\text{Hz}}$
		$V_S = 5\text{ V}$, $f = 1\text{ kHz}$		18		
i_n	Input current noise density	$f = 1\text{ kHz}$		10		$\text{fA}/\sqrt{\text{Hz}}$
INPUT CAPACITANCE						
C_{ID}	Differential			2		pF
C_{IC}	Common-mode			4		pF
OPEN-LOOP GAIN						
A_{OL}	Open-loop voltage gain	$V_S = 2.5\text{ V}$, $(V_-) + 0.04\text{ V} < V_O < (V_+) - 0.04\text{ V}$ $R_L = 10\text{ k}\Omega$		100		dB
		$V_S = 5.5\text{ V}$, $(V_-) + 0.05\text{ V} < V_O < (V_+) - 0.05\text{ V}$ $R_L = 10\text{ k}\Omega$	104	130		
		$V_S = 2.5\text{ V}$, $(V_-) + 0.06\text{ V} < V_O < (V_+) - 0.06\text{ V}$ $R_L = 2\text{ k}\Omega$		100		
		$V_S = 5.5\text{ V}$, $(V_-) + 0.15\text{ V} < V_O < (V_+) - 0.15\text{ V}$ $R_L = 2\text{ k}\Omega$		130		
FREQUENCY RESPONSE						
GBP	Gain bandwidth product	$V_S = 5\text{ V}$, $G = 1$		8		MHz
ϕ_m	Phase margin	$V_S = 5\text{ V}$, $G = 1$		55		$^\circ$
SR	Slew rate	$V_S = 5\text{ V}$, $G = 1$ $R_L = 2\text{ k}\Omega$ $C_L = 100\text{ pF}$		4.5		$\text{V}/\mu\text{s}$
t_s	Settling time	To 0.1%, $V_S = 5\text{ V}$, 2-V step, $G = 1$ $C_L = 100\text{ pF}$		0.5		μs
		To 0.01%, $V_S = 5\text{ V}$, 2-V step, $G = 1$ $C_L = 100\text{ pF}$		1		
t_{OR}	Overload recovery time	$V_S = 5\text{ V}$, $V_{IN} \times \text{gain} > V_S$		0.2		μs
THD + N	Total harmonic distortion + noise ⁽¹⁾	$V_S = 5\text{ V}$, $V_O = 1\text{ V}_{RMS}$, $G = 1$, $f = 1\text{ kHz}$		0.0008%		
OUTPUT						
V_O	Voltage output swing from supply rails	$V_S = 5.5\text{ V}$, $R_L = 10\text{ k}\Omega$			15	mV
		$V_S = 5.5\text{ V}$, $R_L = 2\text{ k}\Omega$			50	

(1) Third-order filter; bandwidth = 80 kHz at -3 dB.

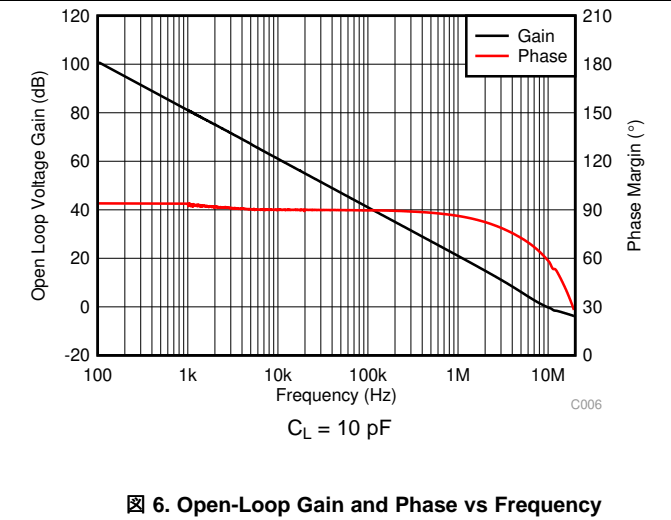
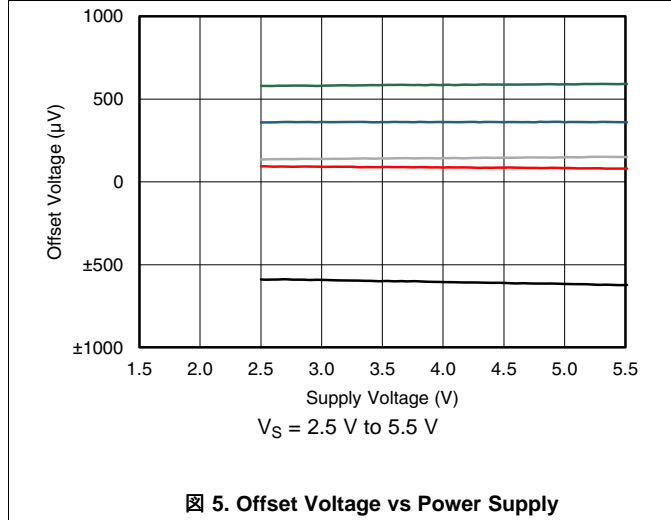
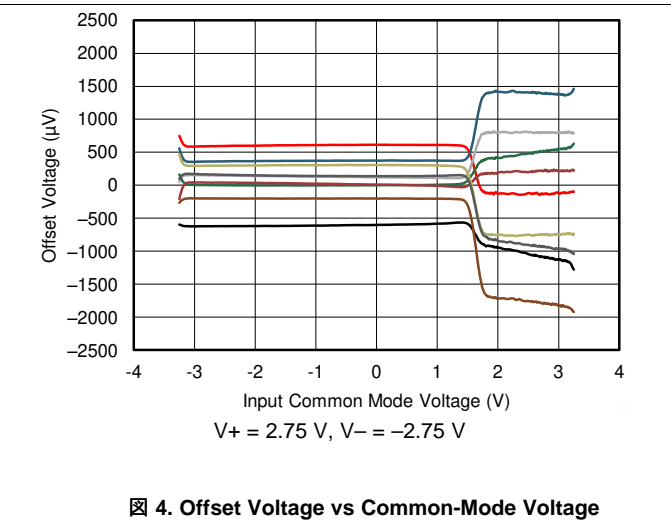
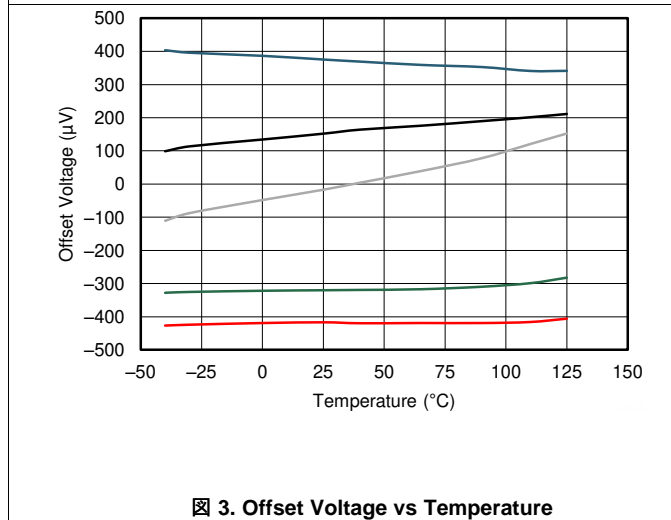
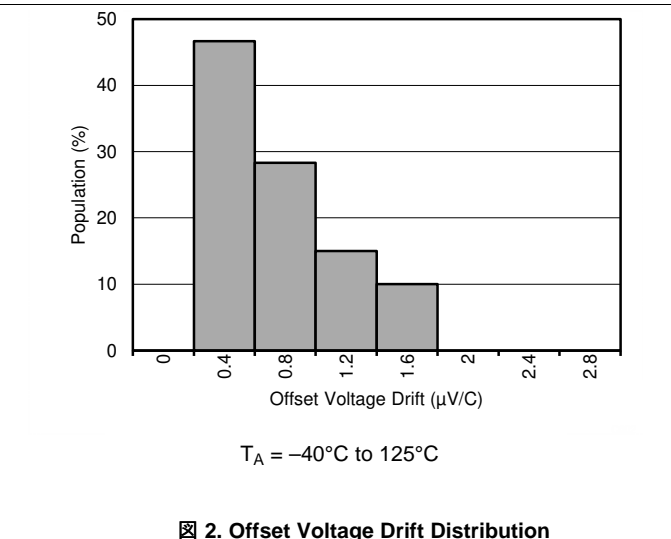
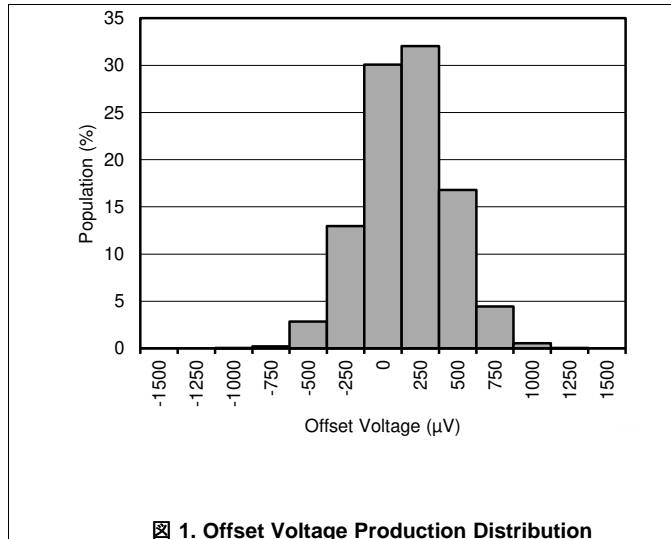
Electrical Characteristics: V_S (Total Supply Voltage) = (V+) – (V–) = 2.5 V to 5.5 V (continued)

 at $T_A = 25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{SC}	Short-circuit current	$V_S = 5\text{ V}$		± 50		mA
Z_O	Open-loop output impedance	$V_S = 5\text{ V}$, $f = 10\text{ MHz}$		100		Ω
POWER SUPPLY						
I_Q	Quiescent current per amplifier	$V_S = 5.5\text{ V}$, $I_O = 0\text{ mA}$		550	750	μA
		$V_S = 5.5\text{ V}$, $I_O = 0\text{ mA}$, $T_A = -40^\circ\text{C}$ to 125°C			1100	

7.8 Typical Characteristics

at $T_A = 25^\circ\text{C}$, $V_S = 5.5\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)



Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = 5.5\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)

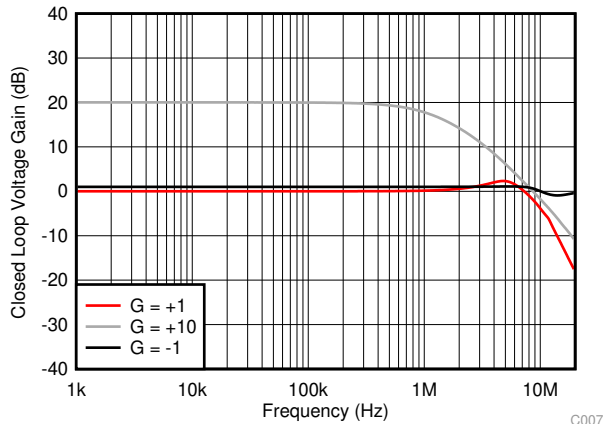


Figure 7. Closed-Loop Gain vs Frequency

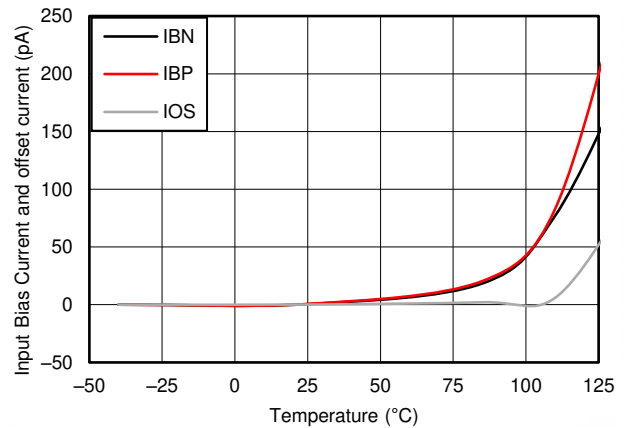


Figure 8. Input Bias Current vs Temperature

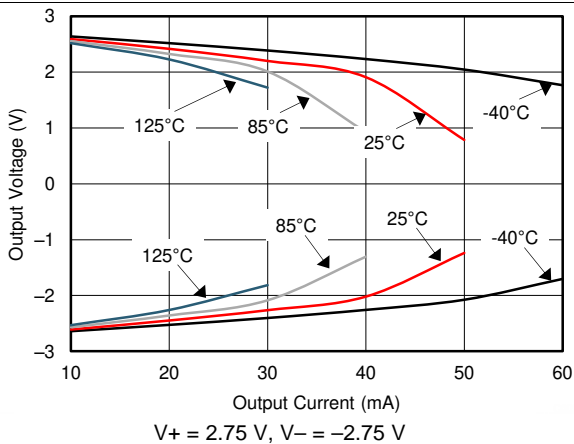


Figure 9. Output Voltage Swing vs Output Current

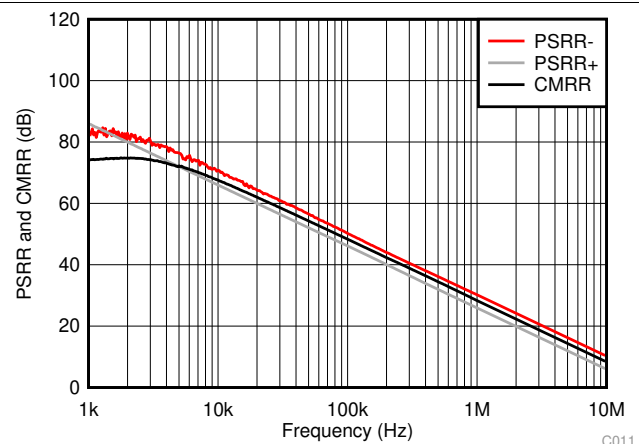
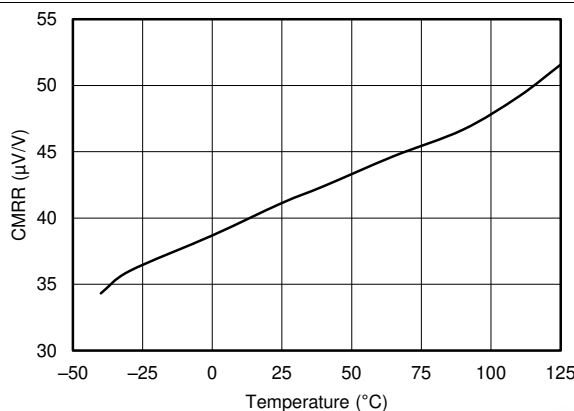
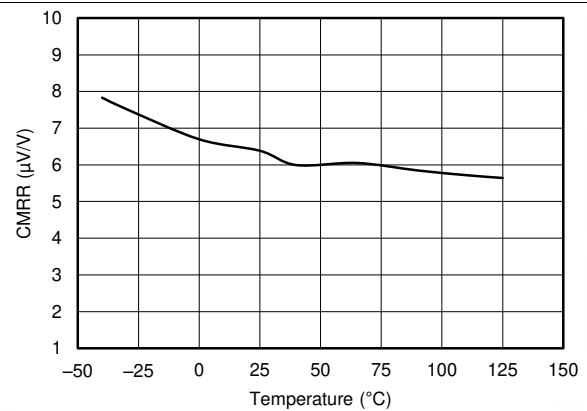


Figure 10. CMRR and PSRR vs Frequency (Referred to Input)



$V_S = 5.5\text{ V}$ $V_{CM} = (V_-) - 0.1\text{ V to } (V_+) + 0.1\text{ V}$ $R_L = 10\text{ k}\Omega$
 $T_A = -40^\circ\text{C to } 125^\circ\text{C}$

Figure 11. CMRR vs Temperature

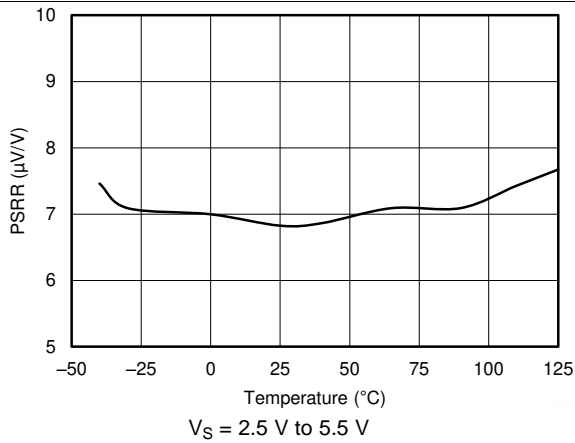


$V_S = 5.5\text{ V}$ $V_{CM} = (V_-) - 0.1\text{ V to } (V_+) - 1.4\text{ V}$ $R_L = 10\text{ k}\Omega$
 $T_A = -40^\circ\text{C to } 125^\circ\text{C}$

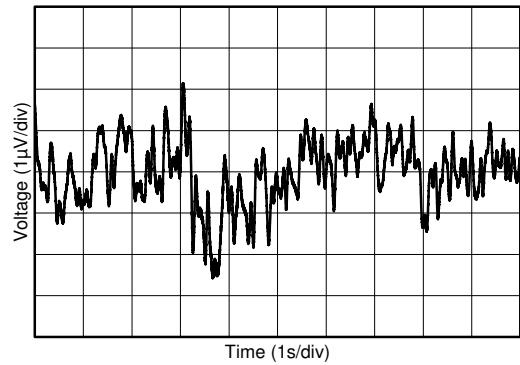
Figure 12. CMRR vs Temperature

Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = 5.5\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)

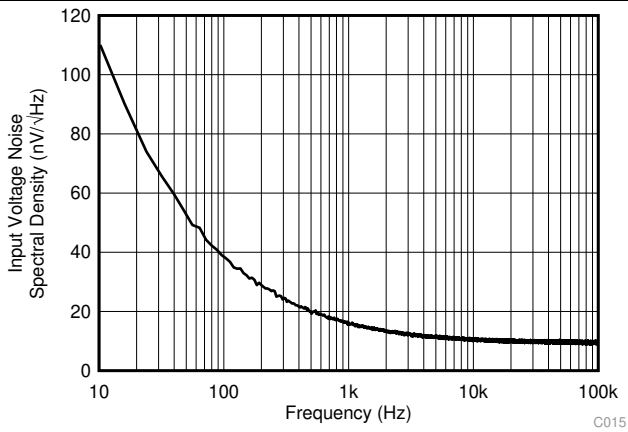


⊠ 13. PSRR vs Temperature

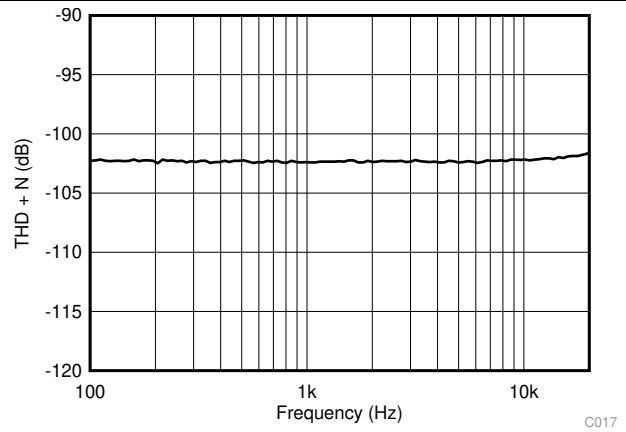


$V_S = 2.5\text{ V to } 5.5\text{ V}$

⊠ 14. 0.1-Hz to 10-Hz Input Voltage Noise

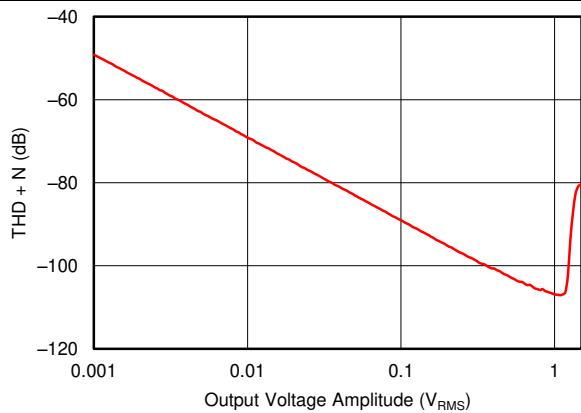


⊠ 15. Input Voltage Noise Spectral Density vs Frequency



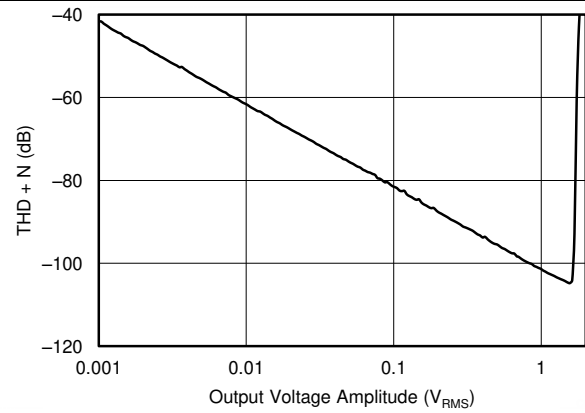
$V_S = 5.5\text{ V}$ $V_{CM} = 2.5\text{ V}$ $R_L = 2\text{ k}\Omega$
 $G = 1$ $V_{OUT} = 0.5 V_{RMS}$ $BW = 80\text{ kHz}$

⊠ 16. THD + N vs Frequency



$V_S = 5.5\text{ V}$ $V_{CM} = 2.5\text{ V}$ $R_L = 2\text{ k}\Omega$
 $G = 1$ $BW = 80\text{ kHz}$ $f = 1\text{ kHz}$

⊠ 17. THD + N vs Amplitude

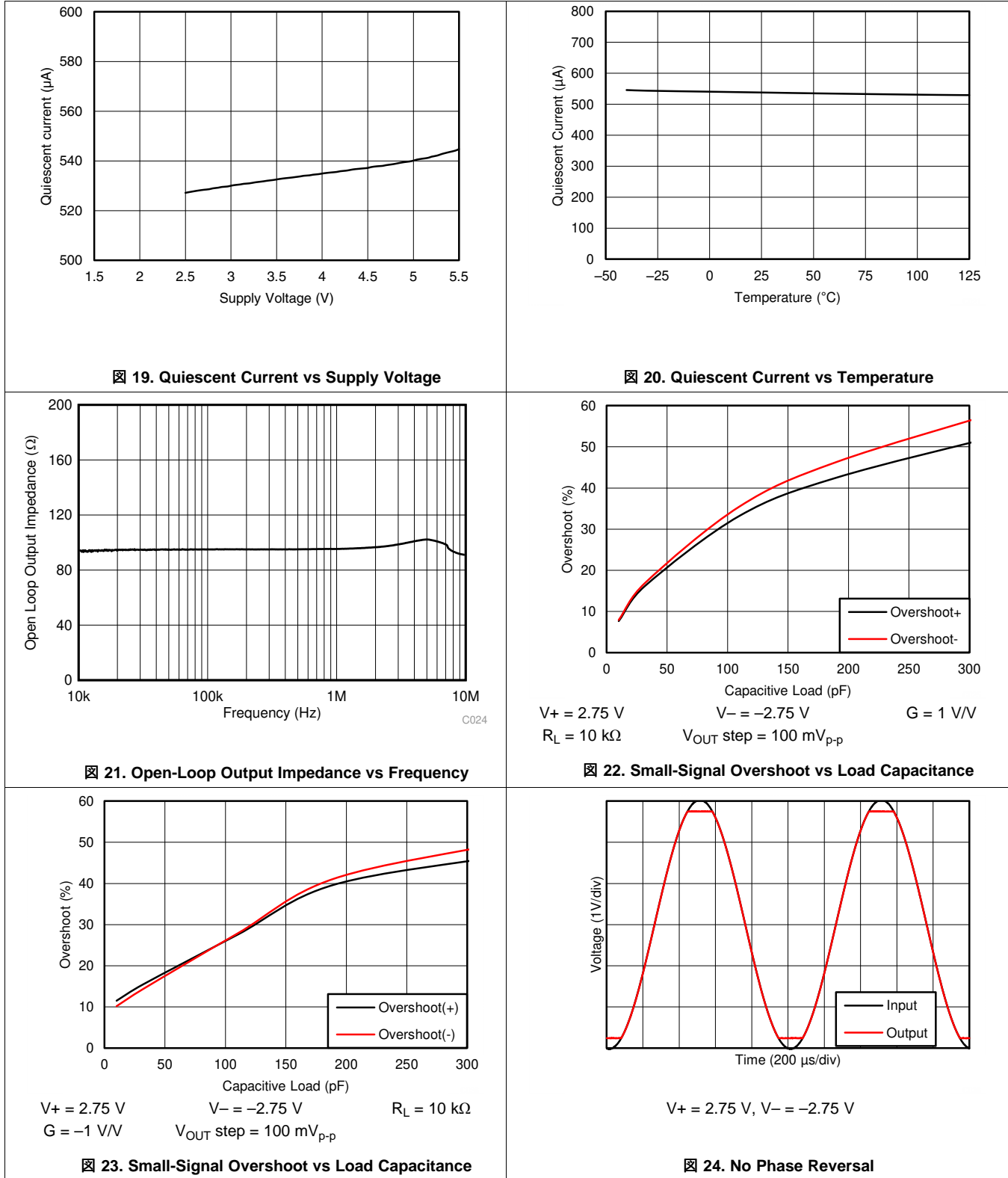


$V_S = 5.5\text{ V}$ $V_{CM} = 2.5\text{ V}$ $R_L = 2\text{ k}\Omega$
 $G = -1$ $BW = 80\text{ kHz}$ $f = 1\text{ kHz}$

⊠ 18. THD + N vs Amplitude

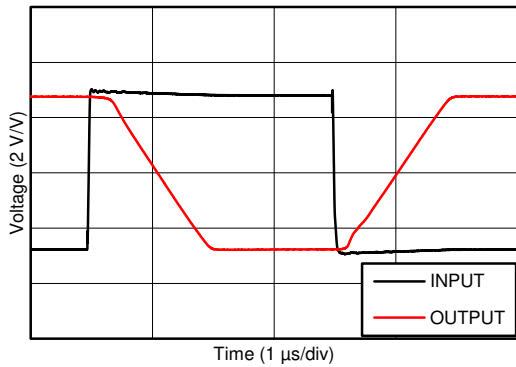
Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = 5.5\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)



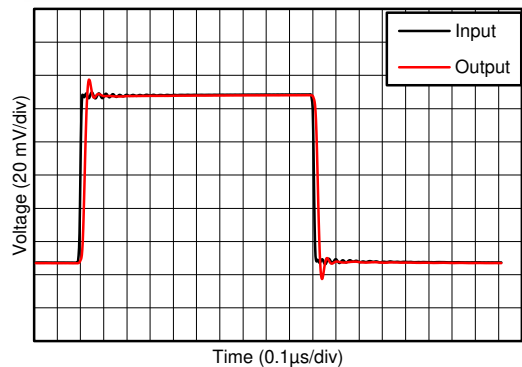
Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = 5.5\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)



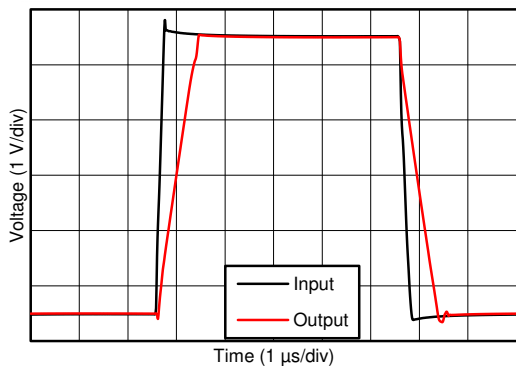
$V_+ = 2.75\text{ V}$, $V_- = -2.75\text{ V}$, $G = -10\text{ V/V}$

25. Overload Recovery



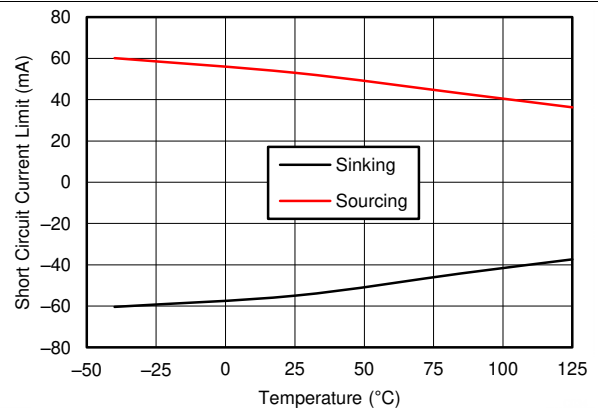
$V_+ = 2.75\text{ V}$, $V_- = -2.75\text{ V}$, $G = 1\text{ V/V}$

26. Small-Signal Step Response

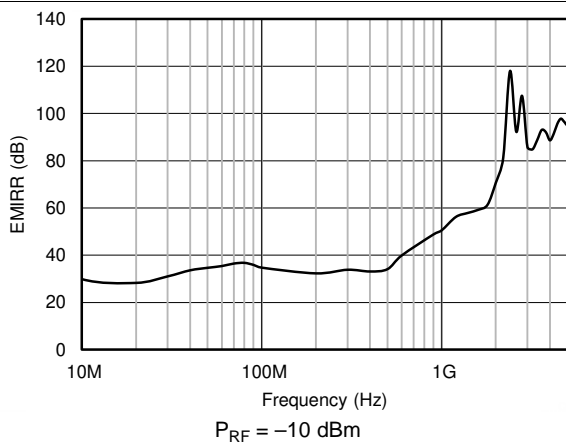


$V_+ = 2.75\text{ V}$ $V_- = -2.75\text{ V}$ $C_L = 100\text{ pF}$
 $G = 1\text{ V/V}$

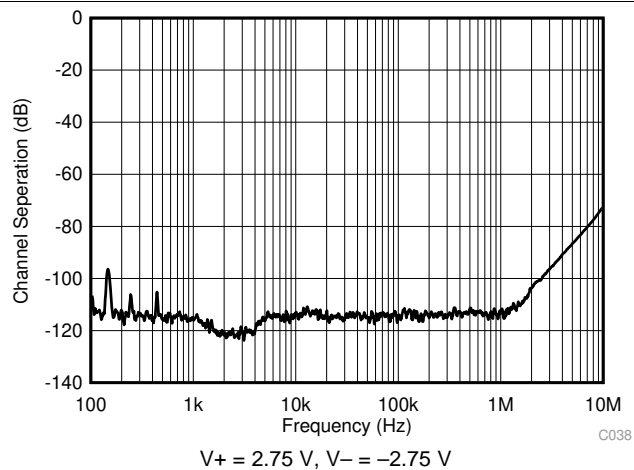
27. Large-Signal Step Response



28. Short-Circuit Current vs Temperature



29. Electromagnetic Interference Rejection Ratio Referred to Noninverting Input (EMIRR+) vs Frequency
 $P_{RF} = -10\text{ dBm}$

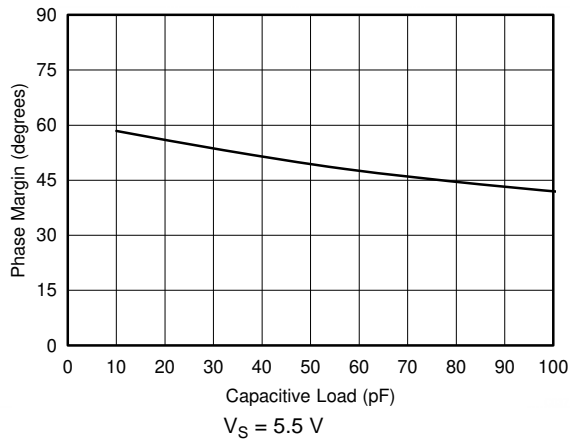


30. Channel Separation vs Frequency
 $V_+ = 2.75\text{ V}$, $V_- = -2.75\text{ V}$

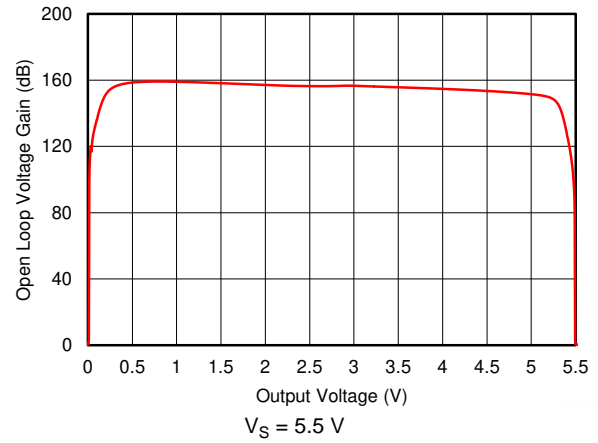
C038

Typical Characteristics (continued)

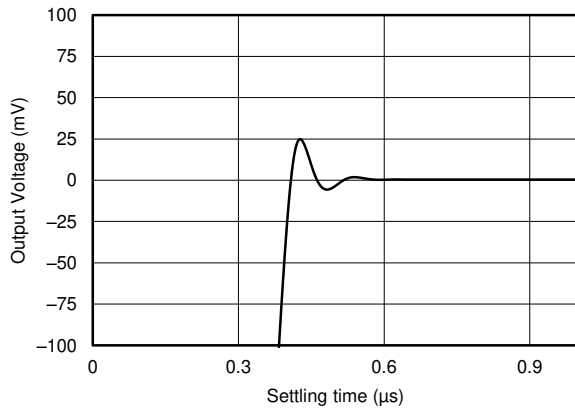
at $T_A = 25^\circ\text{C}$, $V_S = 5.5\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$ (unless otherwise noted)



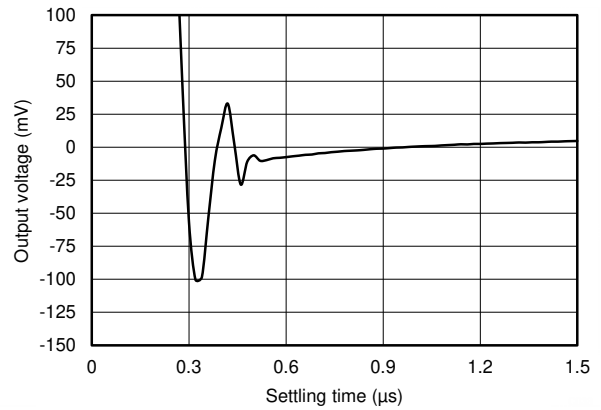
☒ 31. Phase Margin vs Capacitive Load



☒ 32. Open Loop Voltage Gain vs Output Voltage



☒ 33. Large Signal Settling Time (Positive)



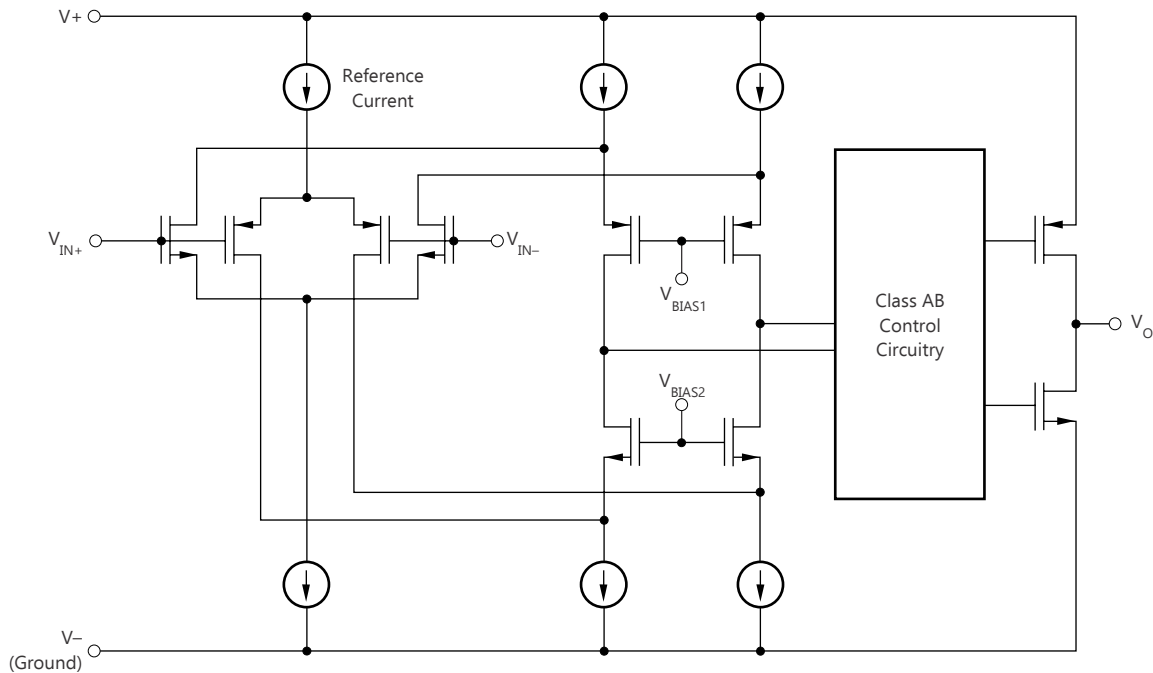
☒ 34. Large Signal Settling Time (Negative)

8 Detailed Description

8.1 Overview

The TSV91x series is a family of low-power, rail-to-rail input and output op amps. These devices operate from 2.5 V to 5.5 V, are unity-gain stable, and are designed for a wide range of general-purpose applications. The input common-mode voltage range includes both rails and allows the TSV91x series to be used in virtually any single-supply application. Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications and are designed for driving sampling analog-to-digital converters (ADCs).

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Rail-to-Rail Input

The input common-mode voltage range of the TSV91x family extends 100 mV beyond the supply rails for the full supply voltage range of 2.5 V to 5.5 V. This performance is achieved with a complementary input stage: an N-channel input differential pair in parallel with a P-channel differential pair, as shown in the [Functional Block Diagram](#). The N-channel pair is active for input voltages close to the positive rail, typically $(V+) - 1.4$ V to 100 mV above the positive supply, whereas the P-channel pair is active for inputs from 100 mV below the negative supply to approximately $(V+) - 1.4$ V. There is a small transition region, typically $(V+) - 1.2$ V to $(V+) - 1$ V, in which both pairs are on. This 200-mV transition region can vary up to 200 mV with process variation. Thus, the transition region (with both stages on) can range from $(V+) - 1.4$ V to $(V+) - 1.2$ V on the low end, and up to $(V+) - 1$ V to $(V+) - 0.8$ V on the high end. Within this transition region, PSRR, CMRR, offset voltage, offset drift, and THD can degrade compared to device operation outside this region.

8.3.2 Rail-to-Rail Output

Designed as a low-power, low-voltage operational amplifier, the TSV91x series delivers a robust output drive capability. A class AB output stage with common-source transistors achieves full rail-to-rail output swing capability. For resistive loads of 10 k Ω , the output swings to within 15 mV of either supply rail, regardless of the applied power-supply voltage. Different load conditions change the ability of the amplifier to swing close to the rails.

8.3.3 Packages with an Exposed Thermal Pad

The TSV91x family is available in packages such as the WSON-8 (DSG) which feature an exposed thermal pad. Inside the package, the die is attached to this thermal pad using an electrically conductive compound. For this reason, when using a package with an exposed thermal pad, the thermal pad must either be connected to $V-$ or left floating. Attaching the thermal pad to a potential other than $V-$ is not allowed, and the performance of the device is not assured when doing so.

8.3.4 Overload Recovery

Overload recovery is defined as the time required for the operational amplifier output to recover from a saturated state to a linear state. The output devices of the operational amplifier enter a saturation region when the output voltage exceeds the rated operating voltage, because of the high input voltage or the high gain. After the device enters the saturation region, the charge carriers in the output devices require time to return to the linear state. After the charge carriers return to the linear state, the device begins to slew at the specified slew rate. Therefore, 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 TSV91x series is approximately 200 ns.

8.4 Device Functional Modes

The TSV91x family has a single functional mode. These devices are powered on as long as the power-supply voltage is between 2.5 V (± 1.25 V) and 5.5 V (± 2.75 V).

9 Application 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 TSV91x series features 8-MHz bandwidth and 4.5-V/ μ s slew rate with only 550 μ A of supply current per channel, providing good AC performance at low power consumption. DC applications are well served with a low input noise voltage of 18 nV / $\sqrt{\text{Hz}}$ at 1 kHz, low input bias current, and a typical input offset voltage of 0.3 mV.

9.2 Typical Application

Figure 35 shows the TSV91x configured in a low-side, motor-control application.

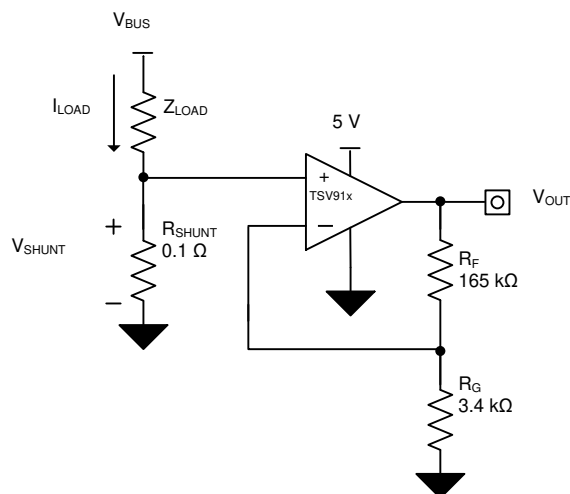


Figure 35. TSV91x in a Low-Side, Motor-Control Application

9.2.1 Design Requirements

The design requirements for this design are:

- Load current: 0 A to 1 A
- Output voltage: 4.95 V
- Maximum shunt voltage: 100 mV

Typical Application (continued)

9.2.2 Detailed Design Procedure

The transfer function of the circuit in [Figure 35](#) is shown in [Equation 1](#).

$$V_{OUT} = I_{LOAD} \times R_{SHUNT} \times \text{Gain} \quad (1)$$

The load current (I_{LOAD}) produces a voltage drop across the shunt resistor (R_{SHUNT}). The load current is set from 0 A to 1 A. To keep the shunt voltage below 100 mV at maximum load current, the largest shunt resistor is defined using [Equation 2](#).

$$R_{SHUNT} = \frac{V_{SHUNT_MAX}}{I_{LOAD_MAX}} = \frac{100\text{mV}}{1\text{A}} = 100\text{m}\Omega \quad (2)$$

Using [Equation 2](#), R_{SHUNT} is 100 mΩ. The voltage drop produced by I_{LOAD} and R_{SHUNT} is amplified by the TSV91x to produce an output voltage of approximately 0 V to 4.95 V. The gain required by the TSV91x to produce the necessary output voltage is calculated using [Equation 3](#):

$$\text{Gain} = \frac{(V_{OUT_MAX} - V_{OUT_MIN})}{(V_{IN_MAX} - V_{IN_MIN})} \quad (3)$$

Using [Equation 3](#), the required gain is calculated to be 49.5 V/V, which is set with resistors R_F and R_G . [Equation 4](#) is used to size the resistors, R_F and R_G , to set the gain of the TSV91x to 49.5 V/V.

$$\text{Gain} = 1 + \frac{(R_F)}{(R_G)} \quad (4)$$

Selecting R_F as 165 kΩ and R_G as 3.4 kΩ provides a combination that equals roughly 49.5 V/V. [Figure 36](#) shows the measured transfer function of the circuit shown in [Figure 35](#).

9.2.3 Application Curve

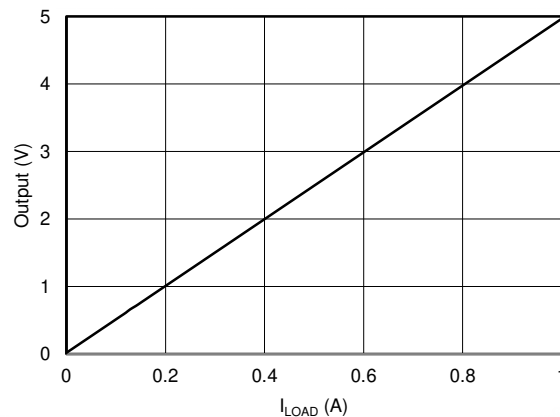


Figure 36. Low-Side, Current-Sense, Transfer Function

10 Power Supply Recommendations

The TSV91x series is specified for operation from 2.5 V to 5.5 V (± 1.25 V to ± 2.75 V); many specifications apply from -40°C to 125°C . The [Typical Characteristics](#) section presents parameters that can exhibit significant variance with regard to operating voltage or temperature.

注意

Supply voltages larger than 6 V can permanently damage the device; see the [Absolute Maximum Ratings](#) table.

Place 0.1- μF bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high-impedance power supplies. For more detailed information on bypass capacitor placement, see the [Layout Example](#) section.

10.1 Input and ESD Protection

The TSV91x series incorporates internal ESD protection circuits on all pins. For input and output pins, this protection consists of current-steering diodes connected between the input and power-supply pins. These ESD protection diodes provide in-circuit, input overdrive protection, as long as the current is limited to 10-mA, as stated in the [Absolute Maximum Ratings](#) table. [Figure 37](#) shows how a series input resistor is added to the driven input to limit the input current. The added resistor contributes thermal noise at the amplifier input and the value must be kept to a minimum in noise-sensitive applications.

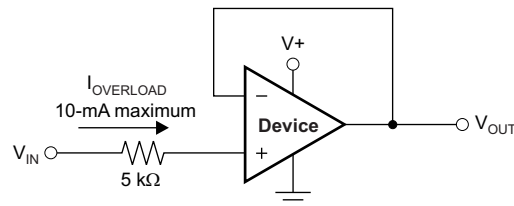


Figure 37. Input Current Protection

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 of 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- μ 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 electromagnetic interference (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, see [Circuit Board Layout Techniques](#).
- 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 is much better as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible. As shown in [Figure 39](#), keeping RF and RG close to the inverting input minimizes parasitic capacitance on the inverting input.
- 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.
- Cleaning the PCB following board assembly is recommended for best performance.
- Any precision integrated circuit can experience performance shifts resulting from moisture ingress into the plastic package. Following any aqueous PCB cleaning process, baking the PCB assembly is recommended to remove moisture introduced into the device packaging during the cleaning process. A low-temperature, post-cleaning bake at 85°C for 30 minutes is sufficient for most circumstances.

11.2 Layout Example

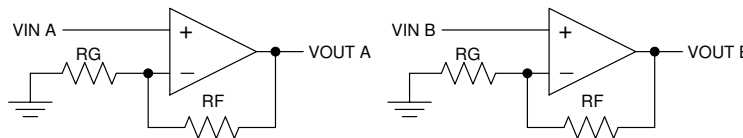


Figure 38. Schematic Representation for Figure 39

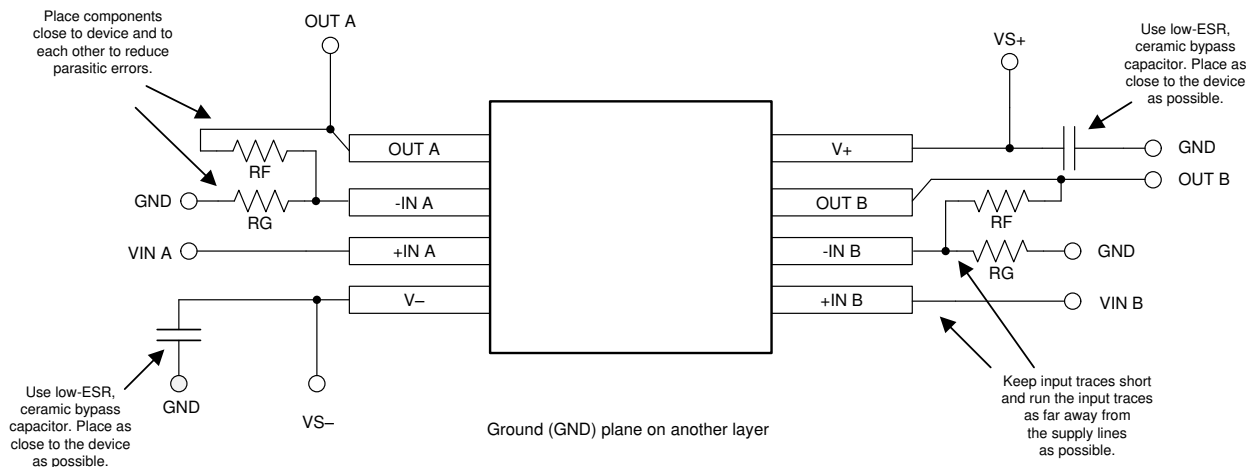


Figure 39. Layout Example

12 デバイスおよびドキュメントのサポート

12.1 ドキュメントのサポート

12.1.1 関連資料

関連資料については、以下を参照してください。

テキサス・インスツルメンツ、『[回路基板のレイアウト技法](#)』、SLOA089

12.2 関連リンク

次の表に、クイック・アクセス・リンクを示します。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、およびご注文へのクイック・アクセスが含まれます。

表 1. 関連リンク

製品	プロダクト・フォルダ	ご注文はこちら	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
TSV911	ここをクリック	ここをクリック	ここをクリック	ここをクリック	ここをクリック
TSV912	ここをクリック	ここをクリック	ここをクリック	ここをクリック	ここをクリック
TSV914	ここをクリック	ここをクリック	ここをクリック	ここをクリック	ここをクリック

12.3 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、[ti.com](#)のデバイス製品フォルダを開いてください。右上の「アラートを受け取る」をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取れます。変更の詳細については、修正されたドキュメントに含まれている改訂履歴をご覧ください。

12.4 コミュニティ・リソース

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is 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](#).

12.5 商標

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

12.6 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。

12.7 Glossary

[SLYZ022](#) — *TI Glossary*.

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

13 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。この情報は、そのデバイスについて利用可能な最新のデータです。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
TSV911AIDBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU SN	Level-1-260C-UNLIM	-40 to 125	1U2F	Samples
TSV911AIDCKR	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-2-260C-1 YEAR	-40 to 125	1EK	Samples
TSV912AIDDFR	ACTIVE	SOT-23-THIN	DDF	8	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	T12A	Samples
TSV912AIDGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU SN NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	T912	Samples
TSV912AIDGKT	ACTIVE	VSSOP	DGK	8	250	RoHS & Green	NIPDAU SN NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	T912	Samples
TSV912AIDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TSV912	Samples
TSV912AIDSGR	ACTIVE	WSON	DSG	8	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	T912	Samples
TSV912AIDSGT	ACTIVE	WSON	DSG	8	250	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	T912	Samples
TSV912AIPWR	ACTIVE	TSSOP	PW	8	2000	RoHS & Green	NIPDAU SN	Level-2-260C-1 YEAR	-40 to 125	TSV912	Samples
TSV914AIDR	ACTIVE	SOIC	D	14	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	TSV914AD	Samples
TSV914AIPWR	ACTIVE	TSSOP	PW	14	2000	RoHS & Green	NIPDAU SN	Level-2-260C-1 YEAR	-40 to 125	TSV914	Samples
TSV914AIPWT	ACTIVE	TSSOP	PW	14	250	RoHS & Green	NIPDAU SN	Level-2-260C-1 YEAR	-40 to 125	TSV914	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBsolete: TI has discontinued the production of the device.

(2) **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 <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm 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.

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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
TSV911AIDBVR	SOT-23	DBV	5	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TSV911AIDBVR	SOT-23	DBV	5	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TSV911AIDCKR	SC70	DCK	5	3000	180.0	8.4	2.3	2.5	1.2	4.0	8.0	Q3
TSV912AIDDFR	SOT-23-THIN	DDF	8	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TSV912AIDGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TSV912AIDGKT	VSSOP	DGK	8	250	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TSV912AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TSV912AIDSGR	WSO	DSG	8	3000	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2
TSV912AIDSGT	WSO	DSG	8	250	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2
TSV912AIPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
TSV914AIDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TSV914AIPWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TSV914AIPWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TSV914AIPWT	TSSOP	PW	14	250	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)
TSV911AIDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
TSV911AIDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
TSV911AIDCKR	SC70	DCK	5	3000	210.0	185.0	35.0
TSV912AIDDFR	SOT-23-THIN	DDF	8	3000	210.0	185.0	35.0
TSV912AIDGKR	VSSOP	DGK	8	2500	356.0	356.0	35.0
TSV912AIDGKT	VSSOP	DGK	8	250	356.0	356.0	35.0
TSV912AIDR	SOIC	D	8	2500	356.0	356.0	35.0
TSV912AIDSGR	WSON	DSG	8	3000	210.0	185.0	35.0
TSV912AIDSGT	WSON	DSG	8	250	210.0	185.0	35.0
TSV912AIPWR	TSSOP	PW	8	2000	356.0	356.0	35.0
TSV914AIDR	SOIC	D	14	2500	356.0	356.0	35.0
TSV914AIPWR	TSSOP	PW	14	2000	366.0	364.0	50.0
TSV914AIPWR	TSSOP	PW	14	2000	353.0	353.0	32.0
TSV914AIPWT	TSSOP	PW	14	250	353.0	353.0	32.0

DDF0008A



PACKAGE OUTLINE

SOT-23-THIN - 1.1 mm max height

PLASTIC SMALL OUTLINE



4222047/E 07/2024

NOTES:

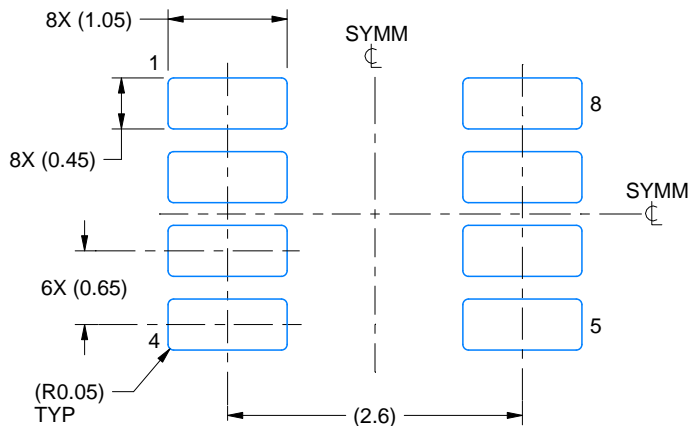
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.

EXAMPLE BOARD LAYOUT

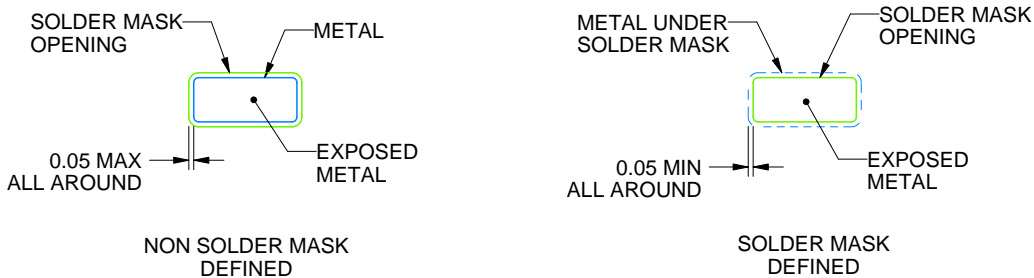
DDF0008A

SOT-23-THIN - 1.1 mm max height

PLASTIC SMALL OUTLINE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

4222047/E 07/2024

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

DDF0008A

SOT-23-THIN - 1.1 mm max height

PLASTIC SMALL OUTLINE



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

4222047/E 07/2024

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.



D0008A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



NOTES:

1. 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.
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 .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. 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.

EXAMPLE BOARD LAYOUT

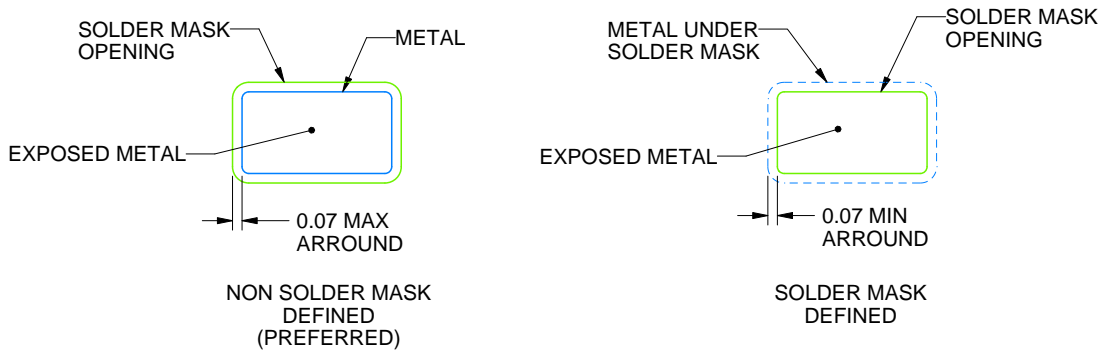
DCK0005A

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X



SOLDER MASK DETAILS

4214834/F 08/2024

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/F 08/2024

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.

GENERIC PACKAGE VIEW

DSG 8

WSON - 0.8 mm max height

2 x 2, 0.5 mm pitch

PLASTIC SMALL OUTLINE - NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4224783/A

DSG0008A



PACKAGE OUTLINE

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



ALTERNATIVE TERMINAL SHAPE TYPICAL



SIDE WALL METAL THICKNESS DIM A	
OPTION 1	OPTION 2
0.1	0.2



⌀	0.1	C	A	B
	0.05	M	C	

4218900/E 08/2022

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 STENCIL DESIGN

DSG0008A

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 9:
87% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:25X

4218900/E 08/2022

NOTES: (continued)

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

PW0014A



PACKAGE OUTLINE

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



4220202/B 12/2023

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. 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-153.

EXAMPLE BOARD LAYOUT

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

4220202/B 12/2023

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.

EXAMPLE STENCIL DESIGN

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220202/B 12/2023

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.

PW0008A



PACKAGE OUTLINE

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



4221848/A 02/2015

NOTES:

- All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. 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 0.15 mm per side.
- This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
- Reference JEDEC registration MO-153, variation AA.

EXAMPLE BOARD LAYOUT

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
SCALE:10X



SOLDER MASK DETAILS
NOT TO SCALE

4221848/A 02/2015

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

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:10X

4221848/A 02/2015

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.

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

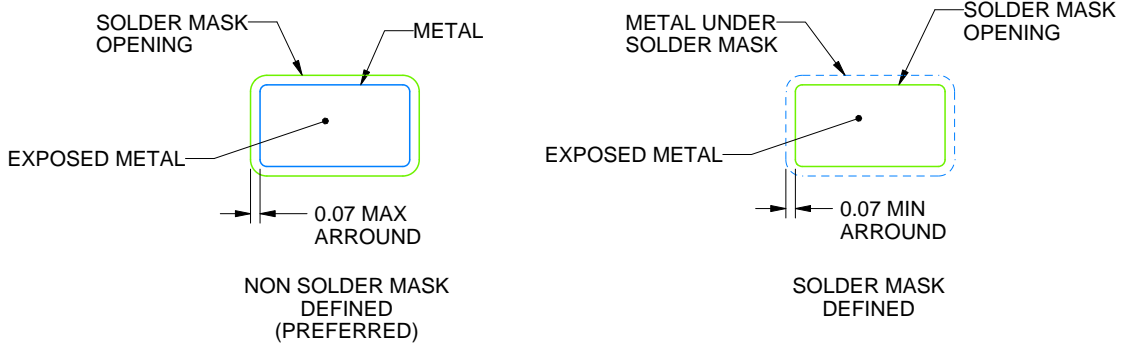
DBV0005A

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.

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

TM 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.

D0014A



PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



NOTES:

1. All linear dimensions are in millimeters. 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 0.43 mm, per side.
5. Reference JEDEC registration MS-012, variation AB.

EXAMPLE BOARD LAYOUT

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

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

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:8X

4220718/A 09/2016

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.

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