TEXAS INSTRUMENTS
TLV313-Q1, TLV2313-Q1
JAJSE31A – OCTOBER 2017 – REVISED DECEMBER 2018

TLV313-Q1 低消費電力、レール・ツー・レール入出力、オフセット標準値750µV、低コスト・システム用の1MHzオペアンプ

1 特長

- **車載アプリケーションに対応**
- **下記内容でAEC-Q100認定済み**
  - デバイス温度グレード1: 動作時周囲温度範囲 –40°C～+125°C
  - デバイスHBM ESD分類レベル3A
  - デバイスCDM ESD分類レベルC6
- **低コストのシステム用の高精度アンプ**
- **低いI_Q**: 65µA/ch
- **広い電源電圧範囲**: 1.8V～5.5V
- **低ノイズ**: 1kHz時に26nV/√Hz
- **ゲイン帯域幅**: 1MHz
- **レール・ツー・レール入出力**
- **低い入力バイアス電流**: 1pA
- **低いオフセット電圧**: 0.75mV
- **ユニティ・ゲインで安定**
- **内部RFI/EMIフィルタ**

2 アプリケーション

- **インフォテインメント**
- **エンジン制御ユニット**
- **車載照明**
- **ローサイド・センシング**
- **バッテリ管理システム**
- **パッシブ型安全運転支援システム**
- **静電容量式センシング**
- **燃料ポンプ**

3 概要

TLVx313-Q1ファミリのシングルおよびデュアル・チャネルのオペアンプは、低消費電力と優れた性能を両立した製品です。このため、インフォテインメント、エンジン制御ユニット、車載照明などの広範なアプリケーションに適しています。このファミリはレール・ツー・レール入出力(RRIO)、低い静止電流(標準値65µA)、広い帯域幅(1MHz)、非常に低いノイズ(1kHzにおいて26nV/√Hz)という特長があるため、コストと性能の適切なバランスが必要な各種のバッテリ駆動アプリケーションに最適です。さらに、入力バイアス電流が小さいため、これらのデバイスはソース・インピーダンスがメガオーム単位のアプリケーションでも使用できます。

TLVx313-Q1デバイスは堅牢に設計されており、100pFまでの容量性負荷に対するユニティ・ゲイン安定性、RFI/EMI除去フィルタの搭載、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 HBM)といった特長があるため、回路設計が容易です。

これらのデバイスは、1.8V (±0.9V)～5.5V (±2.75V)の電圧で動作するよう最適化され、拡張温度範囲の-40℃ ～+125℃での動作が規定されています。

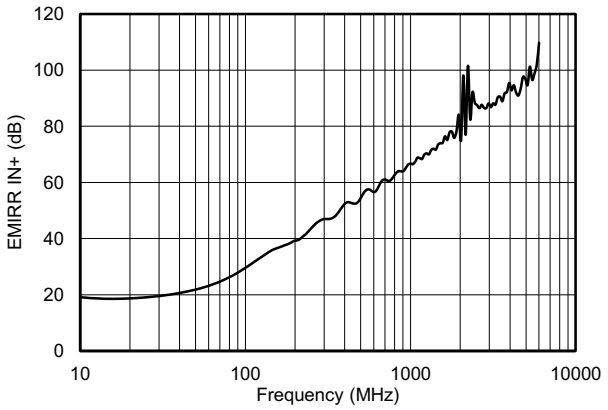
シングル・チャネルのTLV313-Q1デバイスはSC70-5パッケージで供給され、デュアル・チャネルのTLV2313-Q1デバイスはSOIC-8 (D)およびVSSOP-8 (DGK)パッケージで供給されます。

製品情報(1)

型番	パッケージ	本体サイズ(公称)
TLV313-Q1	SC70 (5)	2.00mm×1.25mm
TLV2313-Q1	SOIC (8)	4.90mm×3.91mm
	VSSOP (8)	3.00mm×3.00mm

(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。

EMIRR IN+と周波数との関係



目次

4 改訂履歴

2017年10月発行のものから更新 **Page**

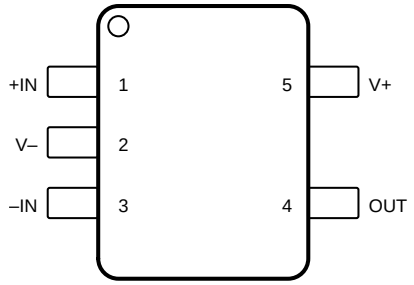
- TLV2313-Q1デバイスをデータシートに 追加 ... 1
- データシート全体を通してTLV2313-Q1デバイスのデュアル・チャネルの情報を 追加 ... 1
- 変更 *Input and ESD Protection* section From *Power Supply* section : To *Feature Description* section ... 15
- 変更「*関連資料*」セクションのフォーマット ... 21

5 Device Comparison Table

DEVICE	NO. OF CHANNELS	PACKAGE LEADS		
		SC70 (DCK)	SOIC (D)	VSSOP (DGK)
TLV313-Q1	1	5	—	—
TLV2313-Q1	2	—	8	8

6 Pin Configuration and Functions

TLV313-Q1 DCK Package
5-Pin SC70
Top View

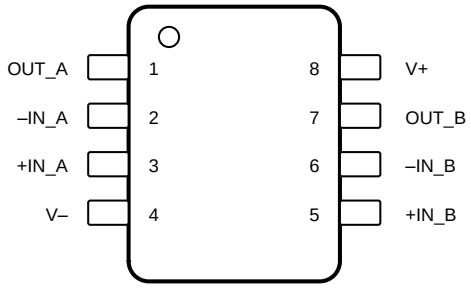


Not to scale

Pin Functions: TLV313-Q1

PIN		I/O	DESCRIPTION
NAME	NO.		
+IN	1	I	Noninverting input
–IN	3	I	Inverting input
OUT	4	O	Output
V–	2	—	Negative (lowest) power supply
V+	5	—	Positive (highest) power supply

TLV2313-Q1 D, DGK Packages
8-Pin SOIC, 8-Pin VSSOP
Top View



Not to scale

Pin Functions: TLV2313-Q1

PIN			I/O	DESCRIPTION
NAME	D (SOIC)	DGK (VSSOP)		
V–	4	4	—	Negative (lowest) power supply
V+	8	8	—	Positive (highest) power supply
OUT A	1	1	O	Output, channel A
OUT B	7	7	O	Output, channel B
–IN A	2	2	I	Inverting input, channel A
+IN A	3	3	I	Noninverting input, channel A
–IN B	6	6	I	Inverting input, channel B
+IN B	5	5	I	Noninverting input, channel B

7 Specifications

7.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Voltage	Supply voltage (V+) – (V–)	0	7	V
	Signal input terminals(2)	(V−) − (0.5)	(V+) + 0.5	
Current	Signal input terminals(2)	–10	10	mA
	Output short circuit(3)	Continuous		
Temperature	Operating, T_A	–40	150	°C
	Junction, T_J		150	
	Storage, T_{stg}	–65	150	

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

7.2 ESD Ratings

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

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

7.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
V_S	Supply voltage	1.8	5.5	V
T_A	Specified temperature	–40	125	°C

7.4 Thermal Information: TLV313-Q1

THERMAL METRIC[1]		TLV313-Q1 DCK (SC70) 5 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	281.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	91.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	59.6	°C/W
ψ_{JT}	Junction-to-top characterization parameter	1.5	°C/W
ψ_{JB}	Junction-to-board characterization parameter	58.8	°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: TLV2313-Q1

THERMAL METRIC		TLV2313-Q1		UNIT
		D (SOIC) 8 PINS	DGK (VSSOP) 8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	131.6	186.0	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	71.4	73.2	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	75.4	107.3	°C/W
ψ_{JT}	Junction-to-top characterization parameter	22.7	14.4	°C/W
ψ_{JB}	Junction-to-board characterization parameter	74.6	105.6	°C/W

7.6 Electrical Characteristics: 5.5 V

at T_A = 25°C, R_L = 10 kΩ connected to V_S / 2, and V_{CM} = V_{OUT} = V_S / 2, (unless otherwise noted)(1)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OFFSET VOLTAGE						
V_{OS}	Input offset voltage			0.75	3	mV
dV_{OS}/dT	Input offset voltage vs temperature	T_A = –40°C to 125°C		2		µV/°C
PSRR	Power-supply rejection ratio		74	90		dB
INPUT VOLTAGE RANGE						
V_{CM}	Common-mode voltage range	No phase reversal, rail-to-rail input	(V–) – 0.2		(V+) + 0.2	V
CMRR	Common-mode rejection ratio	(V–) – 0.2 V < V_{CM} < (V+) – 1.3 V		85		dB
		V_{CM} = –0.2 V to 5.7 V	64	80		
INPUT BIAS CURRENT						
I_B	Input bias current			±1		pA
I_{OS}	Input offset current			±1		pA
NOISE						
	Input voltage noise (peak-to-peak)	f = 0.1 Hz to 10 Hz		6		μV_{PP}
e_n	Input voltage noise density	f = 10 kHz		22		$nV/\sqrt{Hz}$
		f = 1 kHz		26		
i_n	Input current noise density	f = 1 kHz		5		$fA/\sqrt{Hz}$
INPUT CAPACITANCE						
C_{IN}	Differential			1		pF
	Common-mode			5		
OPEN-LOOP GAIN						
A_{OL}	Open-loop voltage gain	0.05 V < V_O < (V+) – 0.05 V R_L = 100 kΩ		104		dB
		0.3 V < V_O < (V+) – 0.3 V R_L = 2 kΩ	100	110		
	Phase margin	V_S = 5 V, G = +1		65		°
FREQUENCY RESPONSE						
GBW	Gain-bandwidth product	V_S = 5 V, C_L = 10 pF		1		MHz
SR	Slew rate	V_S = 5 V, G = +1		0.5		V/µs
t_S	Settling time	To 0.01%, V_S = 5 V, 2-V step , G = +1		6		µs
	Overload recovery time	V_S = 5 V, V_{IN} × Gain > V_S		3		µs
OUTPUT						
V_O	Voltage output swing from supply rails	R_L = 100 kΩ(2)		5	20	mV
		R_L = 2 kΩ(2)		75	100	
I_{SC}	Short-circuit current			±15		mA
R_O	Open-loop output impedance			2300		Ω
POWER SUPPLY						
V_S	Specified voltage range		1.8 (±0.9)		5.5 (±2.75)	V
I_Q	Quiescent current per amplifier	T_A = –40°C to 125°C, V_S = 5 V, I_O = 0 mA		65	90	µA
	Power-on time	V_S = 0 V to 5 V, to 90% I_Q level		10		µs

(1) Parameters with minimum or maximum specification limits are 100% production tested at 25°C, unless otherwise noted. Over-temperature limits are based on characterization and statistical analysis.
(2) Specified by design and characterization; not production tested.

7.7 Electrical Characteristics: 1.8 V

at T_A = 25°C, R_L = 10 kΩ connected to V_S / 2, V_{CM} = V_{S+} – 1.3 V, and V_{OUT} = V_S / 2, (unless otherwise noted)(1)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OFFSET VOLTAGE						
V_{OS}	Input offset voltage			0.75	3	mV
dV_{OS}/dT	Input offset voltage vs temperature	T_A = –40°C to 125°C		2		µV/°C
PSRR	Power-supply rejection ratio		74	90		dB
INPUT VOLTAGE RANGE						
V_{CM}	Common-mode voltage range	No phase reversal, rail-to-rail input	(V–) – 0.2		(V+) + 0.2	V
CMRR	Common-mode rejection ratio	(V_S–) – 0.2 V < V_{CM} < (V_S+) – 1.3 V		85		dB
		V_{CM} = –0.2 V to 1.8 V		73		
INPUT BIAS CURRENT						
I_B	Input bias current			±1		pA
I_{OS}	Input offset current			±1		pA
NOISE						
	Input voltage noise (peak-to-peak)	f = 0.1 Hz to 10 Hz		6		μV_{PP}
e_n	Input voltage noise density	f = 10 kHz		22		nV/√Hz
		f = 1 kHz		26		
i_n	Input current noise density	f = 1 kHz		5		fA/√Hz
INPUT CAPACITANCE						
C_{IN}	Differential			1		pF
	Common-mode			5		
OPEN-LOOP GAIN						
A_{OL}	Open-loop voltage gain	0.1 V < V_O < (V+) – 0.1 V, R_L = 10 kΩ		110		dB
		0.05 V < V_O < (V+) – 0.05 V, R_L = 100 kΩ		110		
FREQUENCY RESPONSE						
GBW	Gain-bandwidth product	C_L = 10 pF		0.9		MHz
SR	Slew rate	G = 1		0.45		V/µs
OUTPUT						
V_O	Voltage output swing from supply rails	R_L = 100 kΩ(2)		5		mV
		R_L = 2 kΩ(2)		25		
I_{SC}	Short-circuit current			±6		mA
R_O	Open-loop output impedance			2300		Ω

(1) Parameters with minimum or maximum specification limits are 100% production tested at 25°C, unless otherwise noted. Over-temperature limits are based on characterization and statistical analysis.
(2) Specified by design and characterization; not production tested.

7.8 Typical Characteristics: Table of Graphs

表 1. Table of Graphs

TITLE	FIGURE
Open-Loop Gain and Phase vs Frequency	図 1
Quiescent Current vs Supply Voltage	図 2
Offset Voltage Production Distribution	図 3
Offset Voltage vs Common-Mode Voltage (Maximum Supply)	図 4
CMRR and PSRR vs Frequency (RTI)	図 5
0.1-Hz to 10-Hz Input Voltage Noise (5.5 V)	図 6
Input Voltage Noise Spectral Density vs Frequency (1.8 V, 5.5 V)	図 7
Input Bias and Offset Current vs Temperature	図 8
Open-Loop Output Impedance vs Frequency	図 9
Maximum Output Voltage vs Frequency and Supply Voltage	図 10
Output Voltage Swing vs Output Current (Over Temperature)	図 11
Closed-Loop Gain vs Frequency, G = 1, –1, 10 (1.8 V)	図 12
Small-Signal Step Response, Noninverting (1.8 V)	図 13
Small-Signal Step Response, Noninverting (5.5 V)	図 14
Large-Signal Step Response, Noninverting (1.8 V)	図 15
Large-Signal Step Response, Noninverting (5.5 V)	図 16
No Phase Reversal	図 17
EMIRR IN+ vs Frequency	図 18

7.9 Typical Characteristics

at T_A = 25°C, V_S = 5 V, R_L = 10 kΩ connected to V_S / 2, and V_{CM} = V_{OUT} = V_S / 2, (unless otherwise noted)

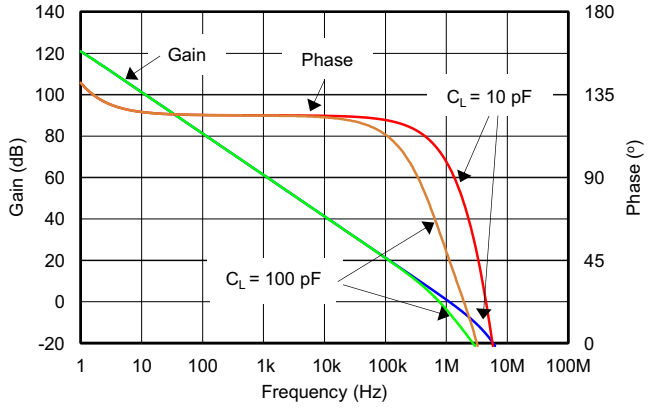


図 1. Open-Loop Gain and Phase vs Frequency

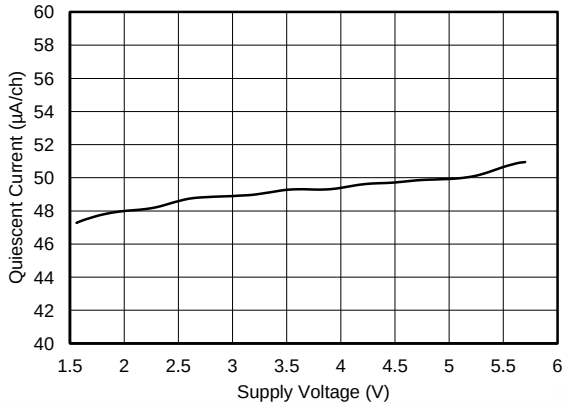


図 2. Quiescent Current vs Supply

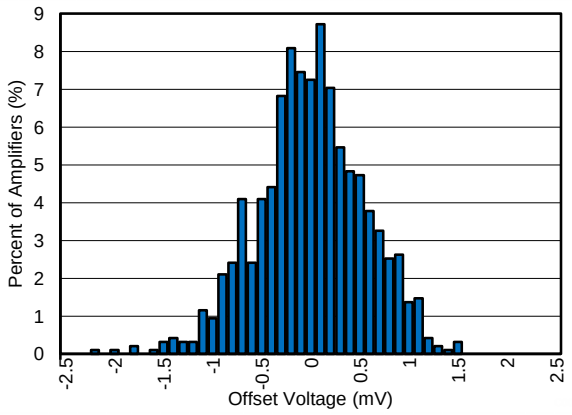
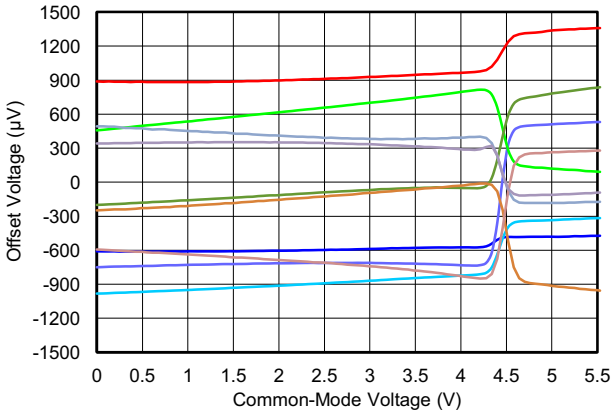


図 3. Offset Voltage Production Distribution



Typical units, V_S = 5.5 V

図 4. Offset Voltage vs Common-Mode Voltage

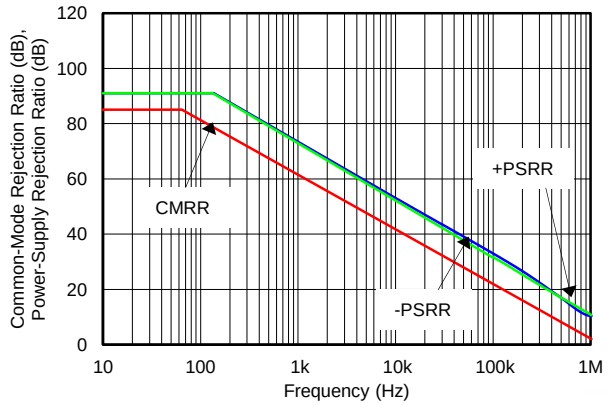


図 5. CMRR and PSRR vs Frequency (Referred-to-Input)

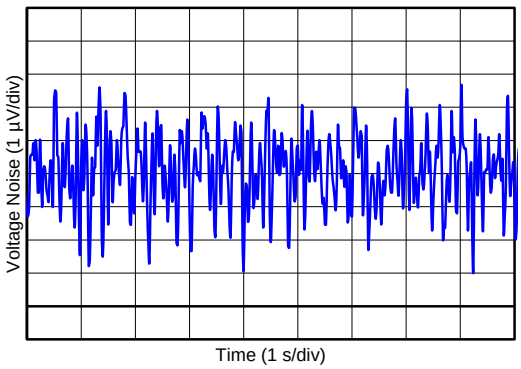


図 6. 0.1-Hz to 10-Hz Input Voltage Noise

Typical Characteristics (continued)

at T_A = 25°C, V_S = 5 V, R_L = 10 kΩ connected to V_S / 2, and V_{CM} = V_{OUT} = V_S / 2, (unless otherwise noted)

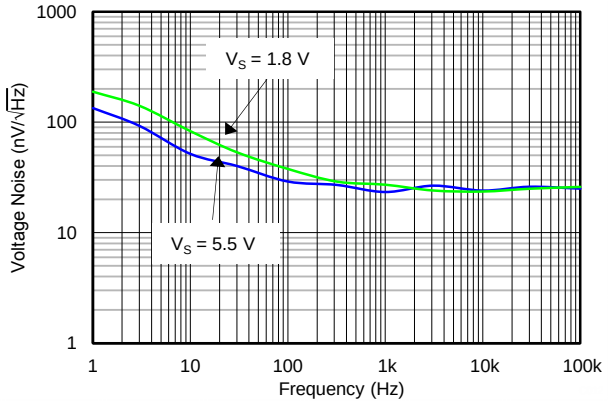


図 7. Input Voltage Noise Spectral Density vs Frequency

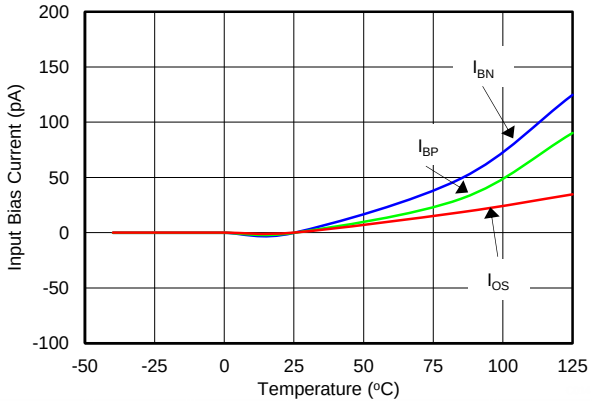


図 8. Input Bias and Offset Current vs Temperature

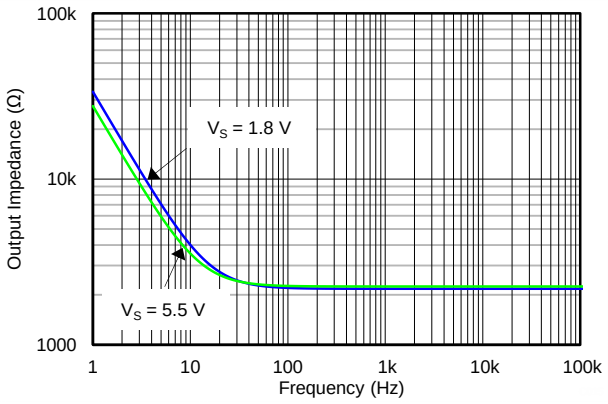
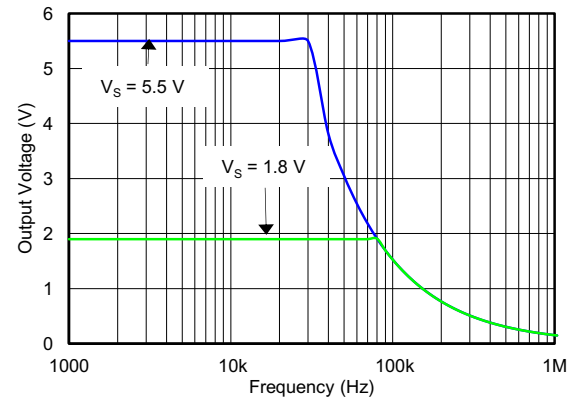


図 9. Open-Loop Output Impedance vs Frequency



R_L = 10 kΩ C_L = 10 pF

図 10. Maximum Output Voltage vs Frequency and Supply Voltage

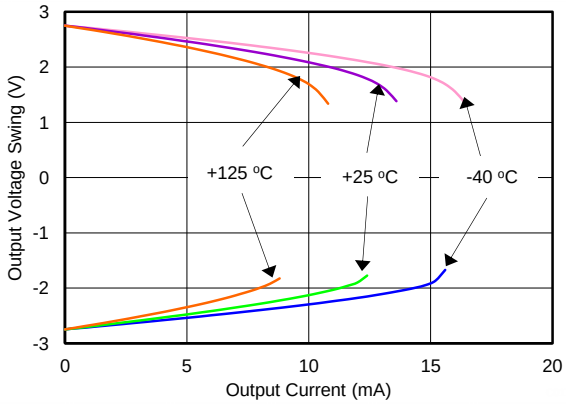
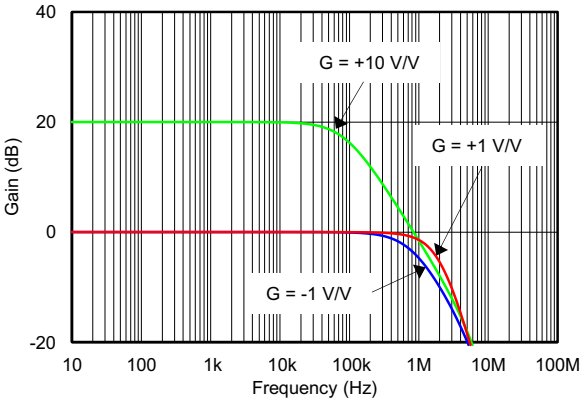


図 11. Output Voltage Swing vs Output Current (Over Temperature)

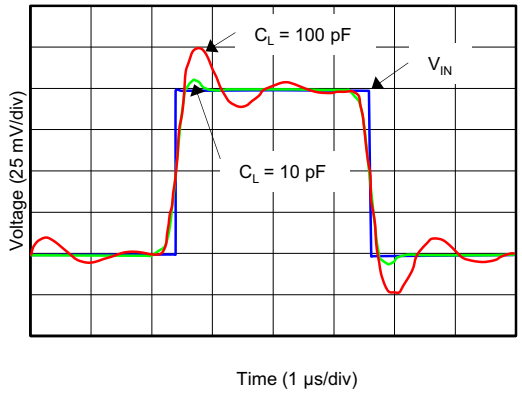


V_S = 1.8 V

図 12. Closed-Loop Gain vs Frequency (Minimum Supply)

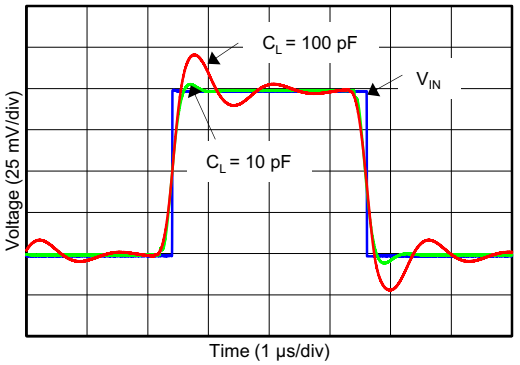
Typical Characteristics (continued)

at T_A = 25°C, V_S = 5 V, R_L = 10 kΩ connected to V_S / 2, and V_{CM} = V_{OUT} = V_S / 2, (unless otherwise noted)



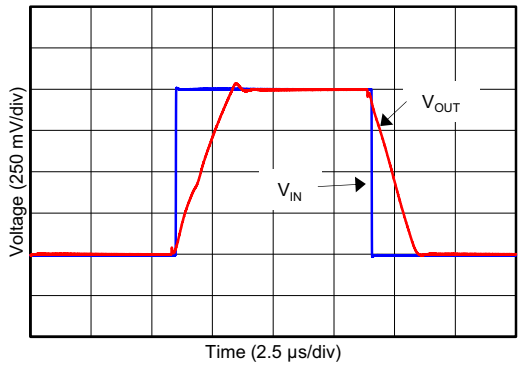
G = 1 V/V V_S = 1.8 V V_{CM} = 0.5 V
R_L = 10 kΩ

図 13. Small-Signal Pulse Response (Minimum Supply)



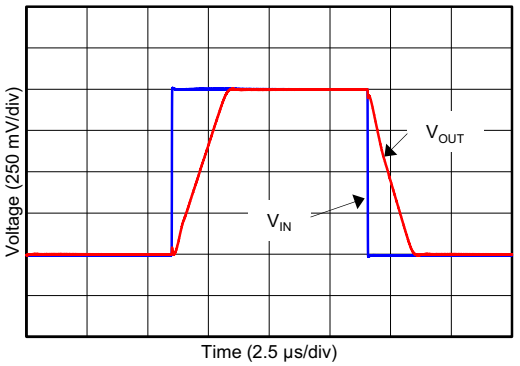
G = 1 V/V V_S = 5.5 V R_L = 10 kΩ

図 14. Small-Signal Pulse Response (Maximum Supply)



G = 1 V/V V_S = 1.8 V R_L = 10 kΩ

図 15. Large-Signal Pulse Response (Minimum Supply)



G = 1 V/V V_S = 5.5 V R_L = 10 kΩ

図 16. Large-Signal Pulse Response (Maximum Supply)

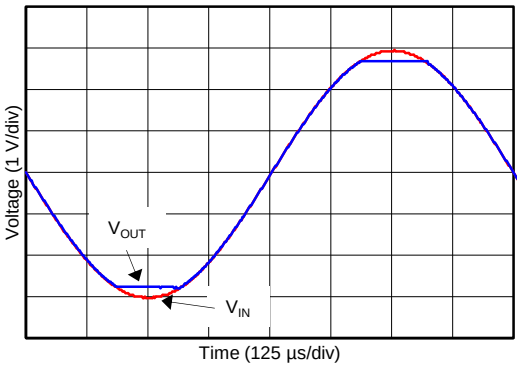
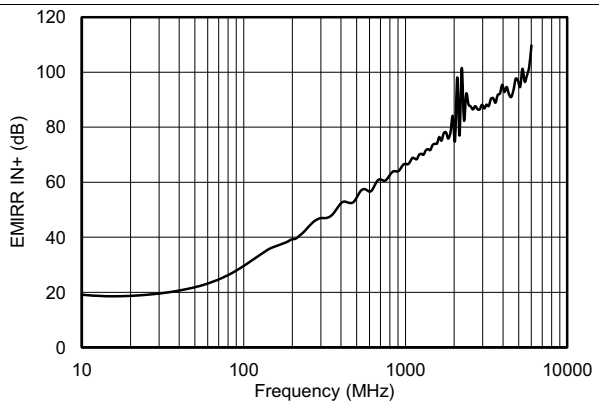


図 17. No Phase Reversal



P_{RF} = –10 dBm V_{SUPPLY} = 5 V V_{CM} = 2.5 V

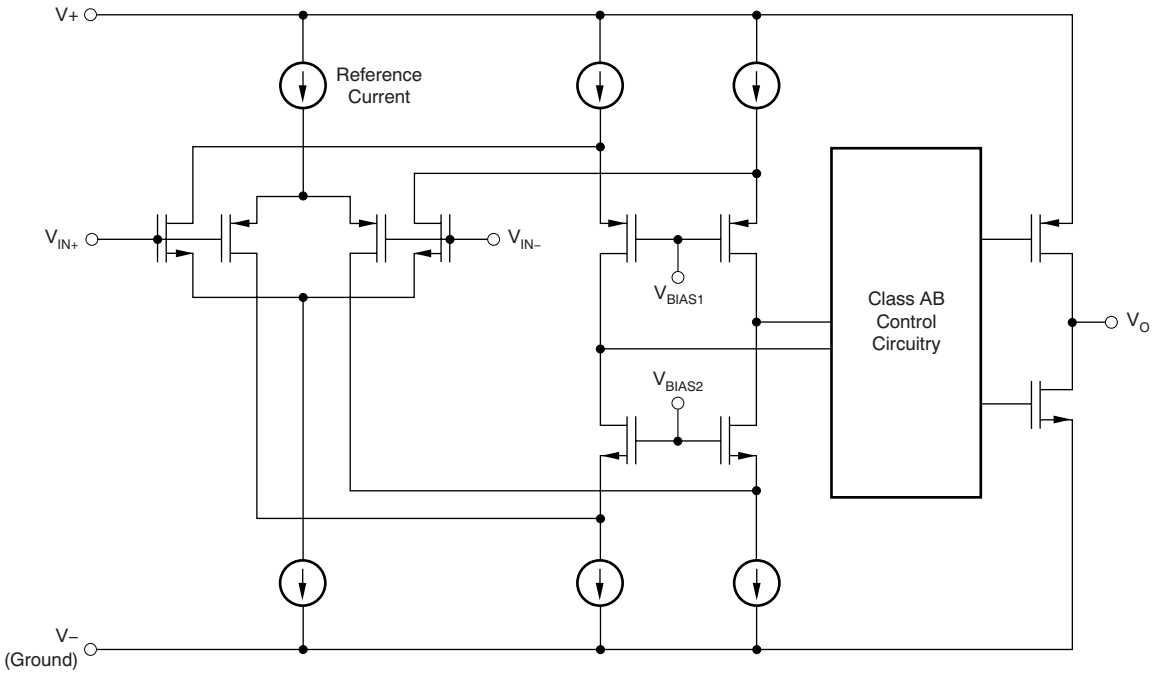
図 18. EMIRR IN+ vs Frequency

8 Detailed Description

8.1 Overview

The TLVx313-Q1 family of operational amplifiers are general-purpose devices that are designed for a wide range of portable, low-cost applications. Rail-to-rail input and output swings, low quiescent current, and wide dynamic range make the op amps designed for driving sampling analog-to-digital converters (ADCs) and other single-supply applications.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Operating Voltage

The TLVx313-Q1 family is fully specified and tested from 1.8 V to 5.5 V (±0.9 V to ±2.75 V). Parameters that vary with supply voltage are illustrated in the *Typical Characteristics* section.

8.3.2 Rail-to-Rail Input

The input common-mode voltage range of the TLVx313-Q1 family extends 200 mV beyond the supply rails. 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* section. The N-channel pair is active for input voltages close to the positive rail, typically (V+) – 1.3 V to 200 mV above the positive supply, while the P-channel pair is on for inputs from 200 mV below the negative supply to approximately (V+) – 1.3 V. There is a small transition region, typically (V+) – 1.4 V to (V+) – 1.2 V, in which both pairs are on. This 200-mV transition region may vary up to 300 mV with process variation. Thus, the transition region (both stages on) may range from (V+) – 1.7 V to (V+) – 1.5 V on the low end, up to (V+) – 1.1 V to (V+) – 0.9 V on the high end. Within this transition region, PSRR, CMRR, offset voltage, offset drift, and THD may be degraded compared to device operation outside this region.

8.3.3 Rail-to-Rail Output

Designed as a micro-power, low-noise operational amplifier, the TLVx313-Q1 family delivers a robust output drive capability. A class AB output stage with common-source transistors is used to achieve full rail-to-rail output swing capability. For resistive loads up to 100 kΩ, the output swings typically to within 5 mV of either supply rail regardless of the power-supply voltage applied. Different load conditions change the ability of the amplifier to swing close to the rails, as shown in 図 11.

8.3.4 Common-Mode Rejection Ratio (CMRR)

CMRR for the TLVx313-Q1 family is specified in several ways so the best match for a given application may be used; see the *Electrical Characteristics*. First, the CMRR of the device in the common-mode range below the transition region (V_{CM} < (V+) – 1.3 V) is given. This specification is the best indicator of the capability of the device when the application requires use of one of the differential input pairs. Second, the CMRR over the entire common-mode range is specified at (V_{CM} = –0.2 V to 5.7 V). This last value includes the variations seen through the transition region, as shown in 図 4.

8.3.5 Capacitive Load and Stability

The TLVx313-Q1 family is designed to be used in applications where driving a capacitive load is required. As with all op amps, there may be specific instances where the TLVx313-Q1 device may become unstable. The particular op amp circuit configuration, layout, gain, and output loading are some of the factors to consider when establishing whether or not an amplifier is stable in operation. An op amp in the unity-gain (+1-V/V) buffer configuration that drives a capacitive load exhibits a greater tendency to be unstable than an amplifier operated at a higher noise gain. The capacitive load, in conjunction with the op amp output resistance, creates a pole within the feedback loop that degrades the phase margin. The degradation of the phase margin increases as the capacitive loading increases. When operating in the unity-gain configuration, the TLVx313-Q1 device remains stable with a pure capacitive load up to approximately 1 nF. The equivalent series resistance (ESR) of some capacitors (C_L greater than 1 µF) is sufficient to alter the phase characteristics in the feedback loop such that the amplifier remains stable. Increasing the amplifier closed-loop gain allows the amplifier to drive increasingly larger capacitance. This increased capability is evident when observing the overshoot response of the amplifier at higher voltage gains.

Feature Description (continued)

One technique for increasing the capacitive load drive capability of the amplifier when it operates in a unity-gain configuration is to insert a small resistor, typically 10 Ω to 20 Ω, in series with the output, as shown in 図 19. This resistor significantly reduces the overshoot and ringing associated with large capacitive loads. One possible problem with this technique is that a voltage divider is created with the added series resistor and any resistor connected in parallel with the capacitive load. The voltage divider introduces a gain error at the output that reduces the output swing.

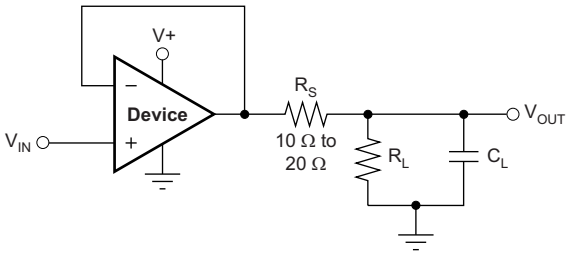


図 19. Improving Capacitive Load Drive

8.3.6 EMI Susceptibility and Input Filtering

Operational amplifiers vary with regard to the susceptibility of the device to electromagnetic interference (EMI). If conducted EMI enters the op amp, the DC offset observed at the amplifier output may shift from the nominal value while EMI is present. This shift is a result of signal rectification associated with the internal semiconductor junctions. While all op amp pin functions may be affected by EMI, the signal input pins are likely to be the most susceptible. The TLVx313-Q1 family incorporates an internal input low-pass filter that reduces the amplifiers response to EMI. Both common-mode and differential mode filtering are provided by this filter. The filter is designed for a common-mode cutoff frequency of approximately 35 MHz (–3 dB), with a rolloff of 20 dB per decade.

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. The EMI rejection ratio (EMIRR) metric allows op amps to be directly compared by the EMI immunity. 図 18 illustrates the results of this testing on the TLV313-Q1 family. Detailed information may be found in *EMI Rejection Ratio of Operational Amplifiers*, available for download from www.ti.com.

8.3.7 Input and ESD Protection

The TLVx313-Q1 family incorporates internal electrostatic discharge (ESD) protection circuits on all pins. In the case of input and output pins, this protection primarily consists of current-steering diodes connected between the input and power-supply pins. The ESD protection diodes also provide in-circuit, input overdrive protection, as long as the current is limited to 10 mA as stated in the *Absolute Maximum Ratings*. 図 20 shows how a series input resistor may be 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.

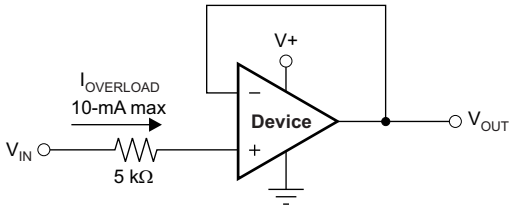


図 20. Input Current Protection

8.4 Device Functional Modes

The TLV313-Q1 devices have a single functional mode. The devices are powered on as long as the power-supply voltage is between 1.8 V (±0.9 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 TLVx313-Q1 devices are a family of low-power, rail-to-rail input and output operational amplifiers specifically designed for portable applications. The devices operate from 1.8 V to 5.5 V, are unity-gain stable, and are designed for a wide range of general-purpose applications. The class AB output stage is capable of driving loads greater than 10 kΩ connected to any point between V+ and ground. The input common-mode voltage range includes both rails, and allows the TLVx313-Q1 family to be used in virtually any single-supply application.

9.2 Typical Application

A typical application for an operational amplifier is an inverting amplifier, as shown in 図 21. An inverting amplifier takes a positive voltage on the input and outputs a signal inverted to the input, making a negative voltage of the same magnitude. In the same manner, the amplifier also makes negative input voltages positive on the output. In addition, amplification may be added by selecting the input resistor (R_I) and the feedback resistor (R_F.)

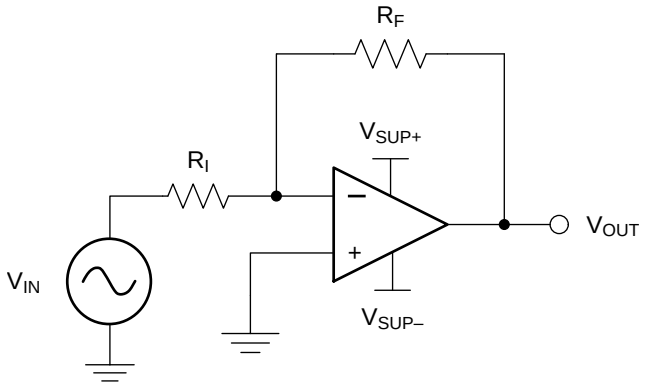


図 21. Application Schematic

9.2.1 Design Requirements

The supply voltage must be chosen to be larger than the input voltage range and the desired output range. The limits of the input common-mode range (V_{CM}) and the output voltage swing to the rails (V_O) must also be considered. For instance, this application scales a signal of ±0.5 V (1 V) to ±1.8 V (3.6 V). Setting the supply at ±2.5 V is sufficient to accommodate this application.

9.2.2 Detailed Design Procedure

Determine the gain required by the inverting amplifier using 式 1 and 式 2:

$$A_V = \frac{V_{OUT}}{V_{IN}} \tag{1}$$

$$A_V = \frac{1.8}{-0.5} = -3.6 \tag{2}$$

Typical Application (continued)

When the desired gain is determined, choose a value for R_I or R_F. Choosing a value in the kilohm range is desirable for general-purpose applications because the amplifier circuit uses currents in the milliamp range. This milliamp current range ensures the device does not draw too much current. The trade-off is that very large resistors (100s of kilohms) draw the smallest current but generate the highest noise. Small resistors (100s of ohms) generate low noise but draw high current. This example uses 10 kΩ for R_I, meaning 36 kΩ is used for R_F. The values are determined by 式 3:

$$A_V = -\frac{R_F}{R_I} \tag{3}$$

9.2.3 Application Curve

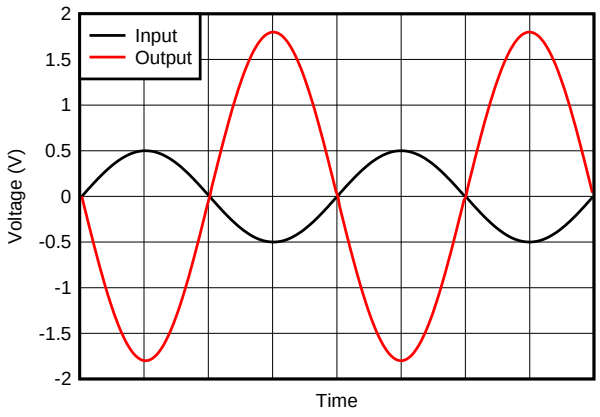
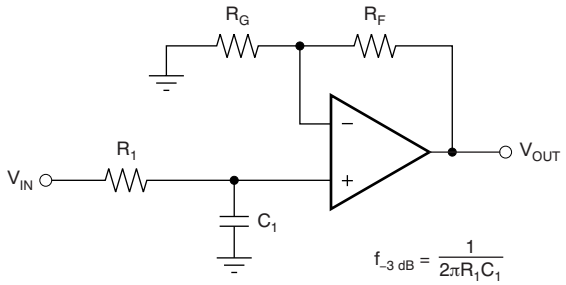


図 22. Inverting Amplifier Input and Output

9.3 System Examples

When receiving low-level signals, limiting the bandwidth of the incoming signals into the system is often required. The simplest way to establish this limited bandwidth is to place an RC filter at the noninverting terminal of the amplifier, as shown in 図 23.



$$\frac{V_{OUT}}{V_{IN}} = \left(1 + \frac{R_F}{R_G}\right)\left(\frac{1}{1 + sR_1C_1}\right)$$

図 23. Single-Pole Low-Pass Filter

System Examples (continued)

If even more attenuation is needed, a multiple pole filter is required. The Sallen-Key filter may be used for this task, as shown in 図 24. For best results, the amplifier must have a bandwidth that is eight to 10 times the filter frequency bandwidth. Failure to follow this guideline may result in phase shift of the amplifier.

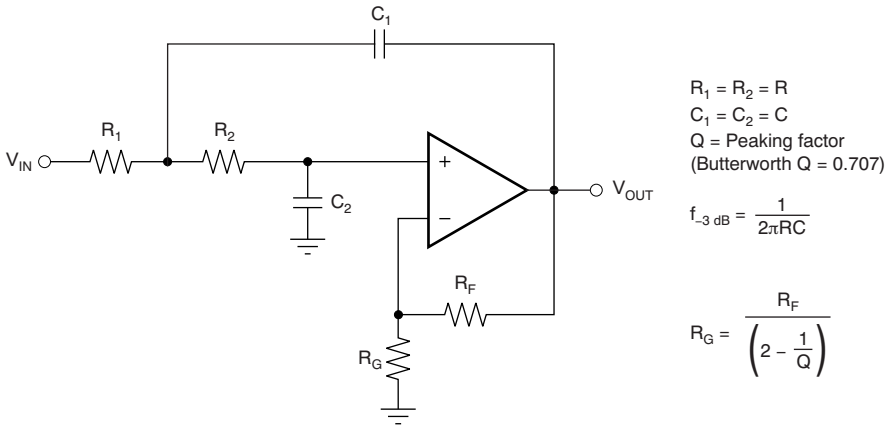


図 24. Two-Pole, Low-Pass, Sallen-Key Filter

10 Power Supply Recommendations

The TLVx313-Q1 family is specified for operation from 1.8 V to 5.5 V (±0.9 V to ±2.75 V); many specifications apply from –40°C to +125°C. The *Typical Characteristics* section presents parameters that may exhibit significant variance with regard to operating voltage or temperature.

注意

Supply voltages larger than 7 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, refer to the *Layout Guidelines* section.

11 Layout

11.1 Layout Guidelines

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

- Noise may propagate into analog circuitry through the power pins of the circuit and the operational amplifier. Use bypass capacitors to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
  - Connect low-ESR, 0.1-µF 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 the 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. Take care 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 the traces cannot be kept separate, crossing the sensitive trace perpendicularly is much better than crossing in parallel with the noisy trace.
- Place the external components as close to the device as possible. Keep R_F and R_G close to the inverting input to minimize parasitic capacitance, as shown in 図 25.
- Keep the length of input traces as short as possible. 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 may significantly reduce leakage currents from nearby traces that are at different potentials.

11.2 Layout Example: Single Channel

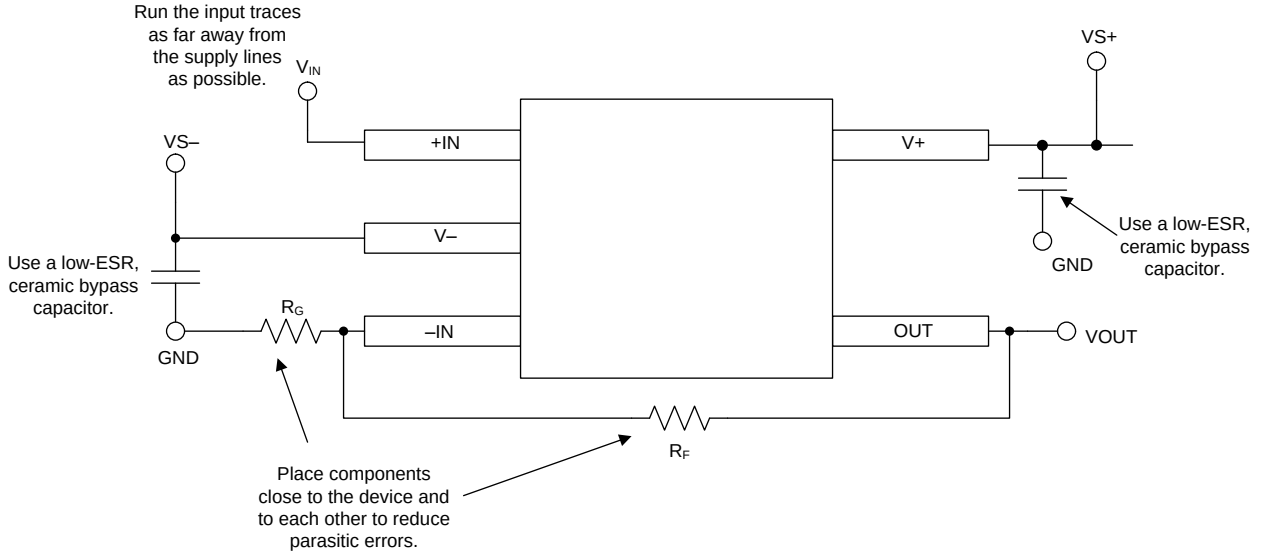


図 25. Operational Amplifier Board Layout for Noninverting Configuration

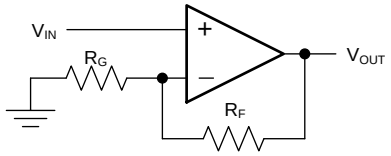


図 26. Schematic Representation of 図 25

11.3 Layout Example: Dual Channel

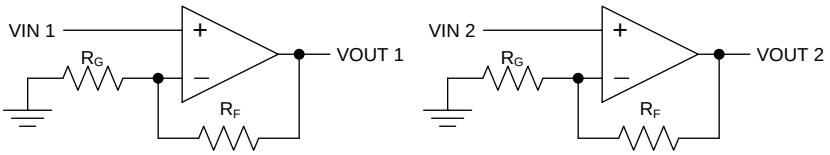


図 27. Schematic Representation for 図 28

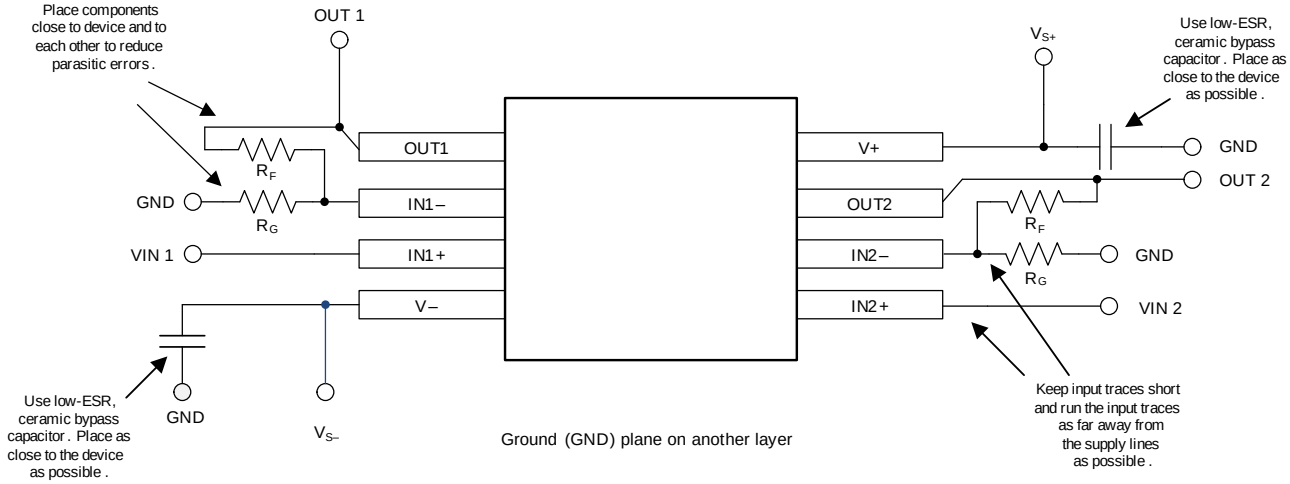


図 28. Layout Example

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。

- *『オペアンプのEMI除去率』*
- *『基板のレイアウト技法』*

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 2. 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
TLV313-Q1	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
TLV2313-Q1	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

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12.4 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.

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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。**

12.5 商標

E2E is a trademark of Texas Instruments.

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
TLV2313QDGKRQ1	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	1NJ6	Samples
TLV2313QDRQ1	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	V2313Q	Samples
TLV313QDCKRQ1	ACTIVE	SC70	DCK	5	3000	RoHS & Green	NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	19A	Samples
TLV313QDCKTQ1	ACTIVE	SC70	DCK	5	250	RoHS & Green	NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	19A	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.

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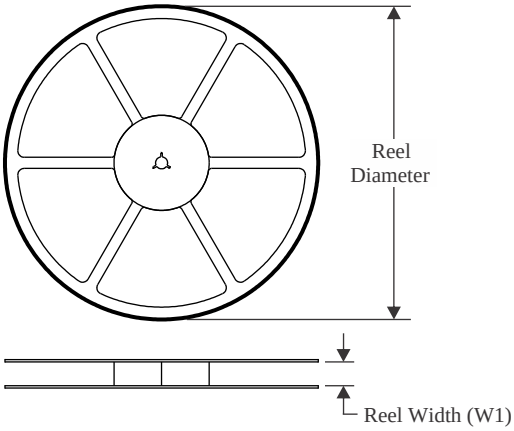
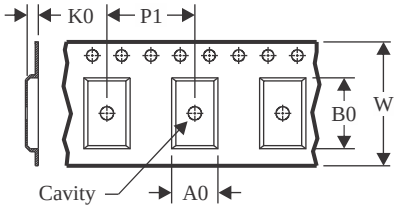
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

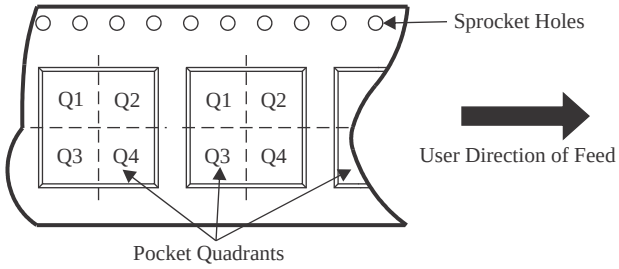


TAPE DIMENSIONS



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

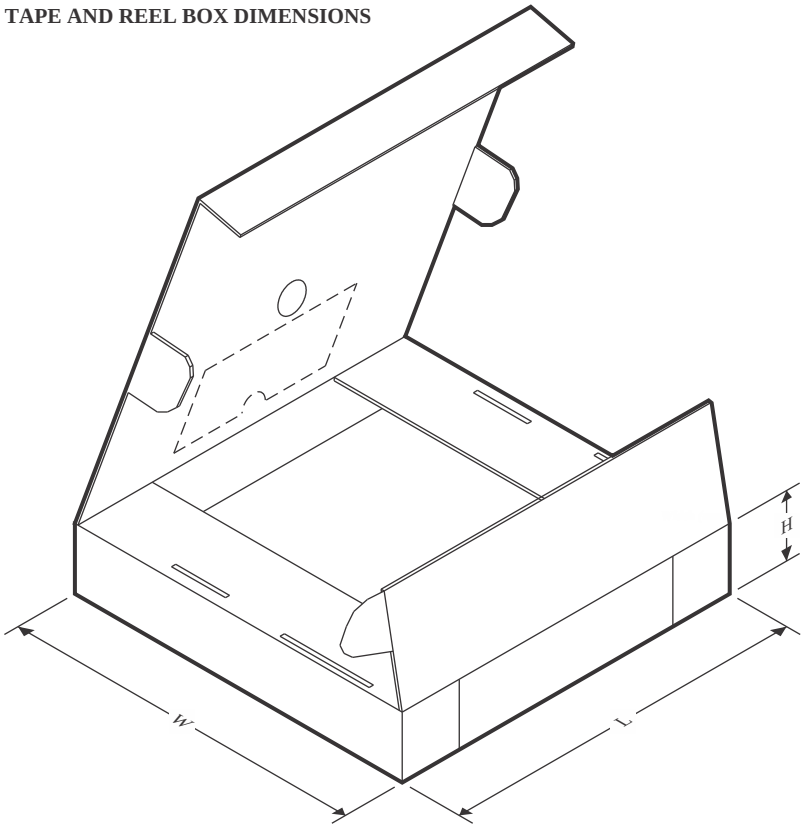
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TLV2313QDGKRQ1	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TLV2313QDRQ1	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLV313QDCKRQ1	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
TLV313QDCKTQ1	SC70	DCK	5	250	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

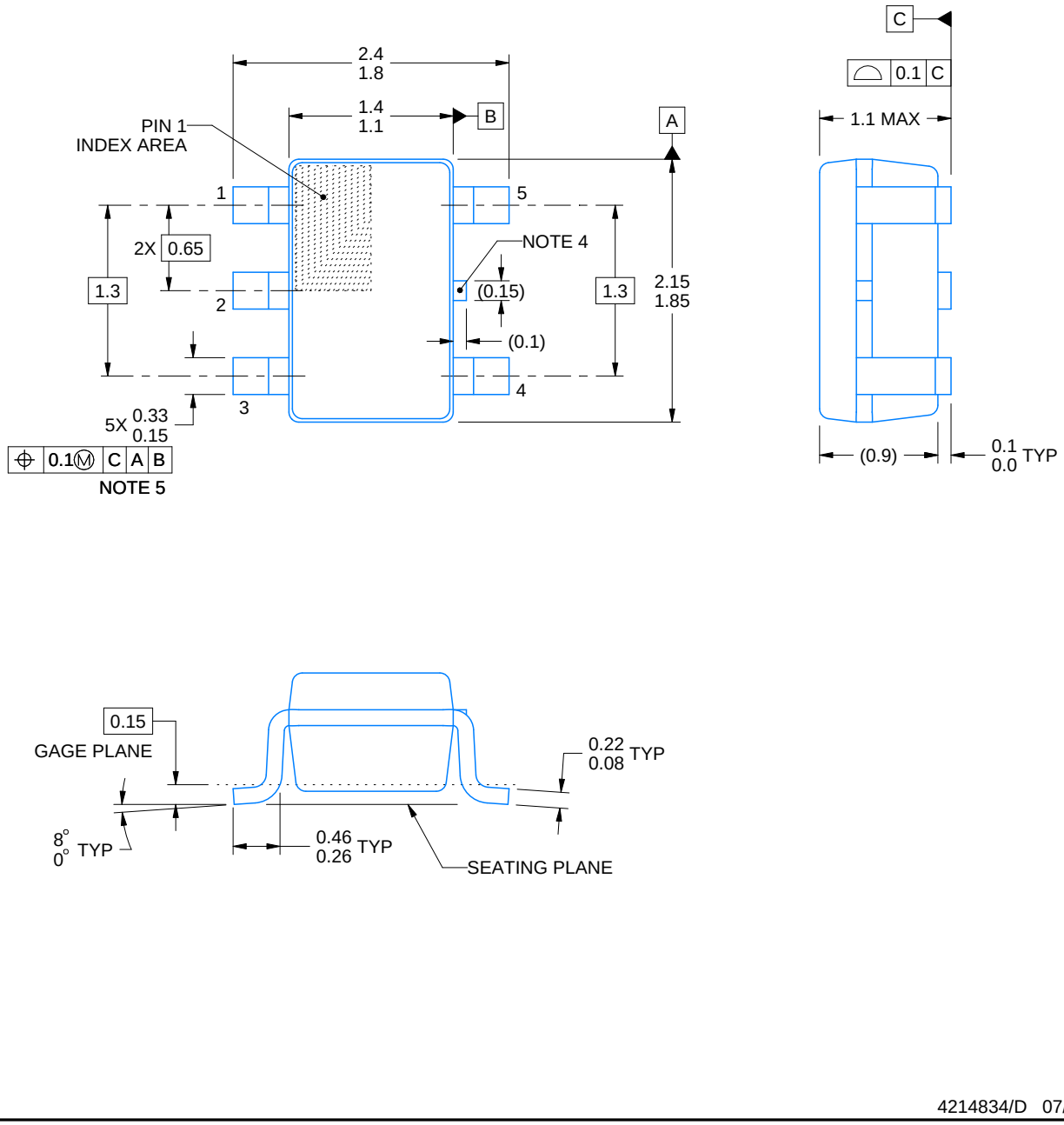
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV2313QDGKRQ1	VSSOP	DGK	8	2500	366.0	364.0	50.0
TLV2313QDRQ1	SOIC	D	8	2500	340.5	338.1	20.6
TLV313QDCKRQ1	SC70	DCK	5	3000	183.0	183.0	20.0
TLV313QDCKTQ1	SC70	DCK	5	250	183.0	183.0	20.0

PACKAGE OUTLINE

DCK0005A

SOT - 1.1 max height

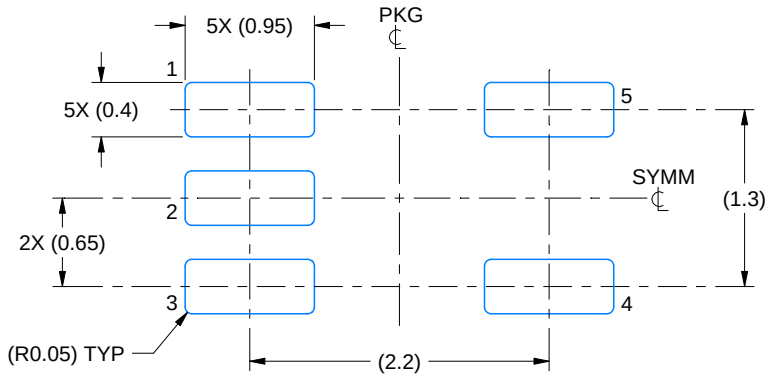
SMALL OUTLINE TRANSISTOR



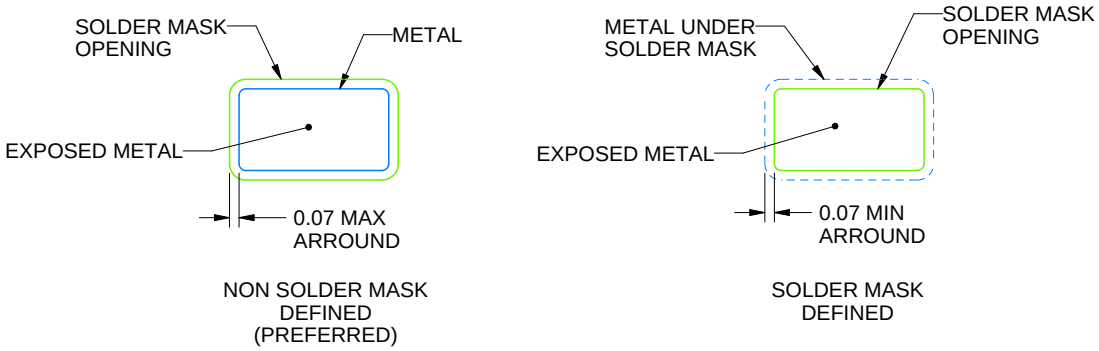
4214834/D 07/2023

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. Refernce JEDEC MO-203.
4. Support pin may differ or may not be present.
5. Lead width does not comply with JEDEC.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X

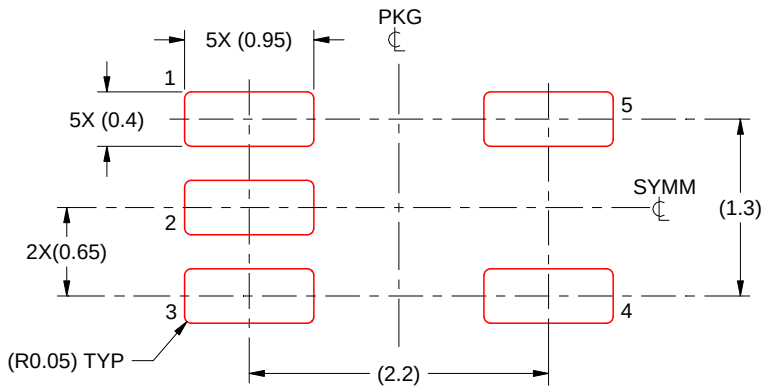


SOLDER MASK DETAILS

4214834/D 07/2023

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.

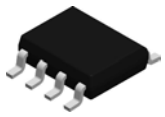


SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:18X

4214834/D 07/2023

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.

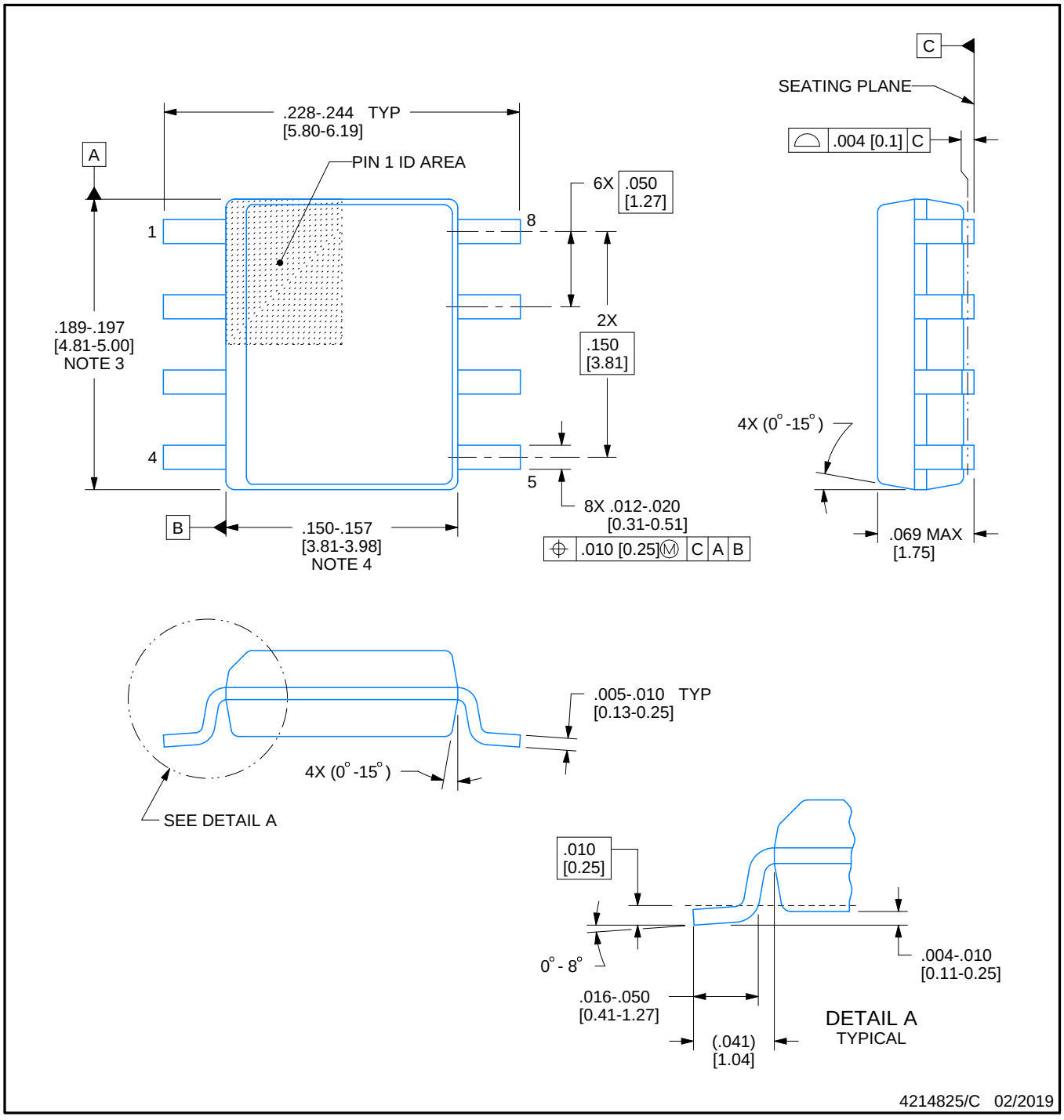


PACKAGE OUTLINE

D0008A

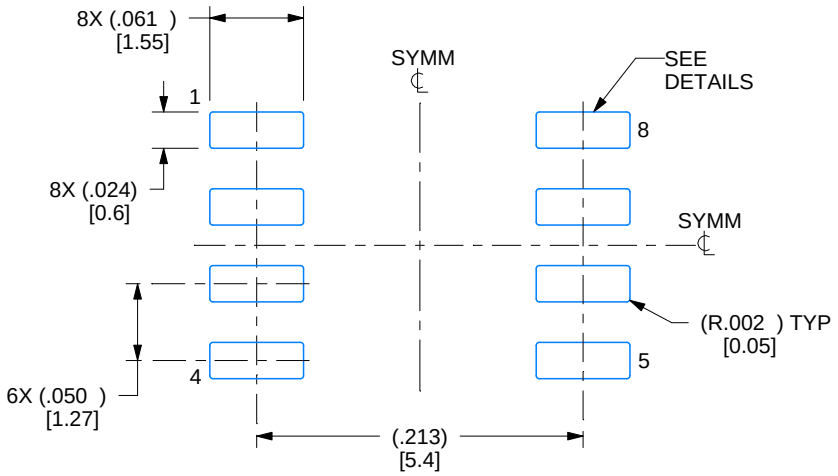
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

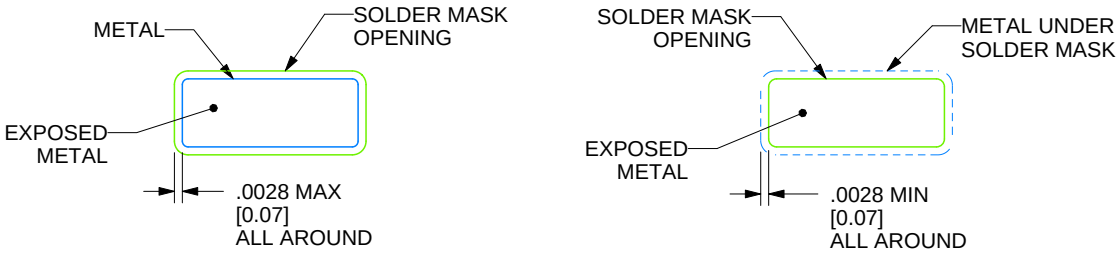


NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

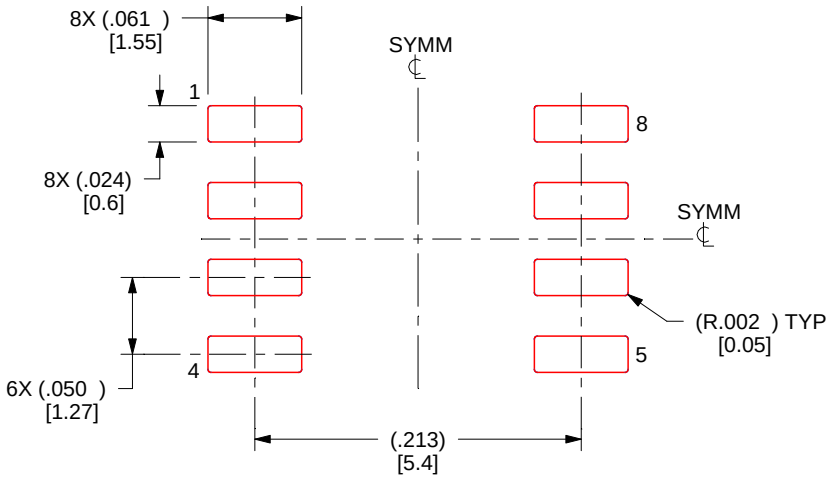
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



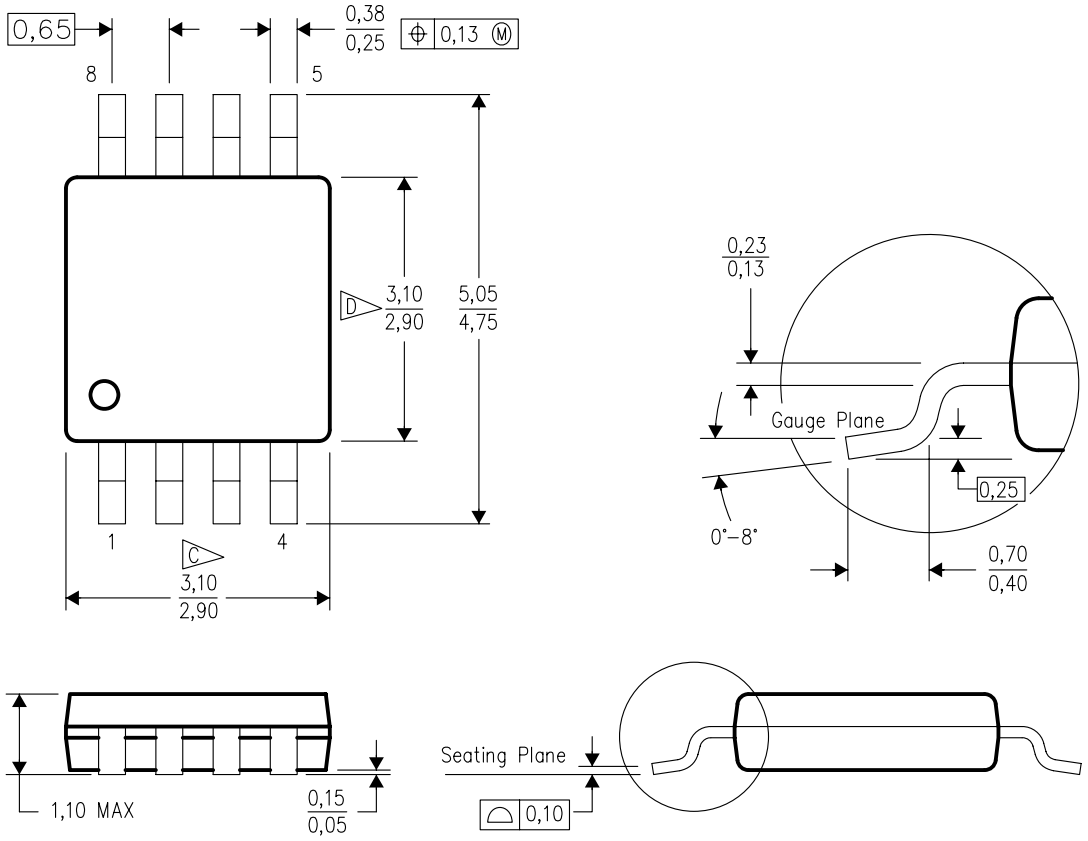
SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

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.

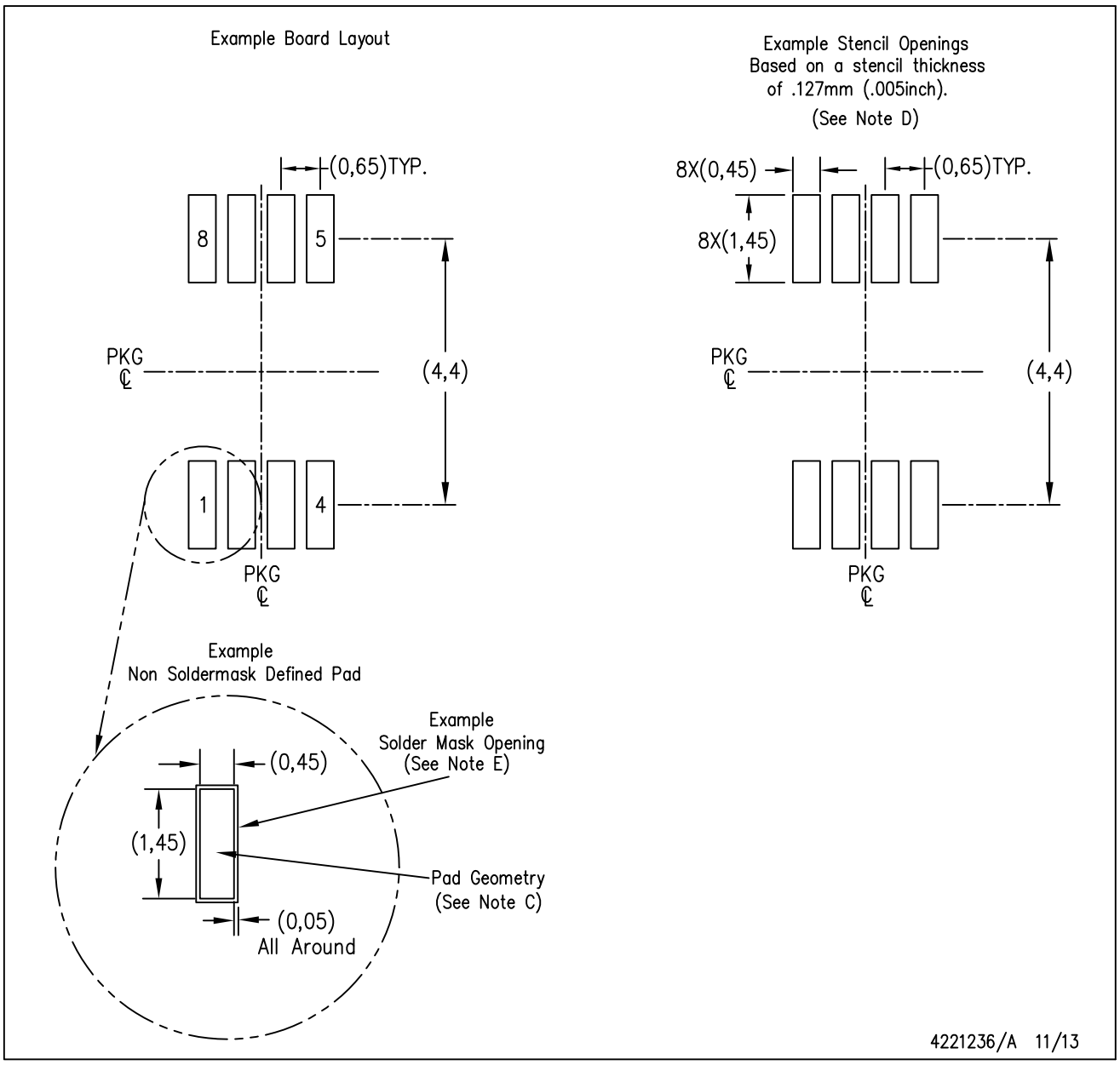
DGK (S–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



4073329/E 05/06

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
E. Falls within JEDEC MO–187 variation AA, except interlead flash.

DGK (S–PDSO–G8) PLASTIC SMALL OUTLINE PACKAGE



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

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