LMC7101 Tiny, Low-Power Operational Amplifier With Rail-to-Rail Input and Output

1 Features

- Tiny 5-Pin SOT-23 package saves space; typical circuit layouts take half the space of 8-pin SOIC designs
- Specified for 2.7V, 3V, 5V, and 15V supplies
- Typical supply current 0.5mA at 5V
- Typical total harmonic distortion of 0.01% at 5V
- 1MHz gain bandwidth
- Specified to industrial temperature: –40°C to +85°C
- Similar to popular LMC6482 and LMC6484
- Rail-to-rail input and output

2 Applications

- Mobile communications
- Notebooks and PDAs
- Battery-powered products
- Sensor interface
- Automotive applications

3 Description

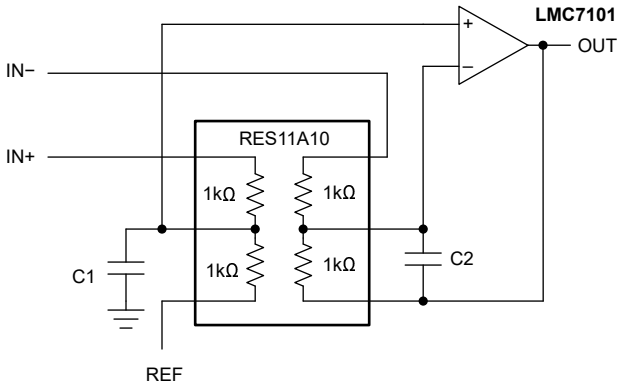
The LMC7101 device is a high-performance, automotive, CMOS operational amplifier available in a space-saving, 5-pin, SOT-23 tiny package. This design makes the LMC7101 an excellent choice for space- and weight-critical designs. The performance is similar to the single amplifier of the LMC6482 and LMC6484, with rail-to-rail input and output, high open-loop gain, low distortion, and low-supply currents.

The main benefits of the tiny package are most apparent in small, portable electronic devices, such as mobile phones, pagers, notebook computers, personal digital assistants, and PCMCIA cards. The tiny amplifiers can be placed on a board where needed, thus simplifying board layout.

Package Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
LMC7101	DBV (SOT-23, 5)	2.9mm × 2.8mm

(1) For more information, see Section 10.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Difference Amplifier Application With RES11A

Table of Contents

4 Pin Configuration and Functions

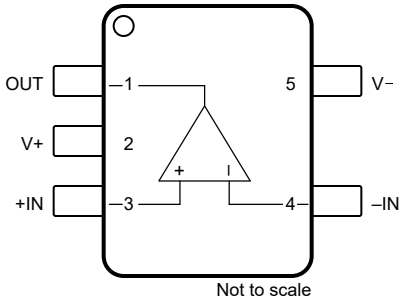


Figure 4-1. DBV Package, 5-Pin SOT-23 (Top View)

Table 4-1. Pin Functions

PIN		TYPE	DESCRIPTION
NO.	NAME		
1	OUT	Output	Output
2	V+	Power	Positive supply
3	+IN	Input	Noninverting input
4	−IN	Input	Inverting input
5	V−	Power	Negative supply

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1) (2)

		MIN	MAX	UNIT
	Difference Input voltage		±Supply voltage	V
	Voltage at input and output pins	(V–) – 0.3	(V+) + 0.3	V
V_S	Supply voltage, V_S = (V+) – (V–)		16	V
	Current at input pin	–5	5	mA
	Current at output pin(3)	–35	35	mA
	Current at power supply pin		35	mA
	Lead temperature (soldering, 10s)		260	°C
T_J	Junction temperature(4)		150	°C
T_{stg}	Storage temperature	–65	150	°C

(1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
(2) If Military/Aerospace specified devices are required, contact the TI Sales Office or Distributors for availability and specifications.
(3) Applies to both single-supply and split-supply operation. Continuous short operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature at 150°C
(4) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$ and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} – T_A) / R_{\theta JA}$. All numbers apply for packages soldered directly into a PC board.

5.2 ESD Ratings

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

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

5.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_S	Supply voltage, V_S = (V+) – (V–)	2.7		15.5	V
T_J	Junction temperature	–40		85	°C

5.4 Thermal Information

THERMAL METRIC(1)		LMC7101 DBV (SOT) 5 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	193.5	°C/W
$R_{\theta JC(top)}$	Junction-to-case(top) thermal resistance	128.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	88.9	°C/W
ψ_{JT}	Junction-to-top characterization parameter	66.8	°C/W
ψ_{JB}	Junction-to-board characterization parameter	88.6	°C/W
$R_{\theta JC(bot)}$	Junction-to-case(bottom) thermal resistance	N/A	°C/W

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

5.5 Electrical Characteristics for V_S = ±1.35V or 2.7V

at T_J = 25°C, V+ = 2.7V, V– = 0V, V_{CM} = V_{OUT} = V+ / 2, and R_L > 1MΩ connected to V+ / 2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
OFFSET VOLTAGE							
V_{OS}	Input offset voltage	LMC7101A			±0.11	±6	mV
		LMC7101B			±0.11	±9	
dV_{OS}/dT	Input offset voltage drift	T_J = –40°C to +85°C			1		µV/°C
PSRR	Power-supply rejection ratio	V+ = 1.35V to 1.65V, V– = –1.35V to –1.65V, V_{CM} = 0V		45	60		dB
INPUT BIAS CURRENT							
I_B	Input bias current	T_J = –40°C to +85°C			±1	±64	pA
I_{OS}	Input offset current	T_J = –40°C to +85°C			±0.5	±32	pA
INPUT VOLTAGE							
V_{CM}	Input common-mode voltage	For CMRR ≥ 47dB	Positive	2.7	3		V
			Negative		0	0	
CMRR	Common-mode rejection	0V ≤ V_{CM} ≤ 2.7V		47	70		dB
INPUT IMPEDANCE							
R_{IN}	Input resistance				> 1		TΩ
C_{IN}	Common-mode input capacitance				3		pF
FREQUENCY RESPONSE							
GBW	Gain bandwidth product				0.6		MHz
SR	Slew rate(1)	(V+) = 15V, 10V step, R_L = 100kΩ to 7.5V, V_{OUT} = 10V_{PP}, f = 1kHz			0.7		V/µs
OUTPUT							
V_O	Voltage output swing	Positive rail	R_L = 2kΩ	2.15	2.45		V
			R_L = 10kΩ	2.64	2.68		
		Negative rail	R_L = 2kΩ		0.25	0.5	
			R_L = 10kΩ		0.025	0.06	
POWER SUPPLY							
I_Q	Quiescent current per amplifier				500	810	µA
		T_J = –40°C to +85°C			500	950	

(1) Number specified is the slower of the positive and negative slew rates.

5.6 Electrical Characteristics for V_S = ±1.5V or 3V

at T_J = 25°C, V+ = 3V, V– = 0V, V_{CM} = V_{OUT} = V+ / 2, and R_L = 1MΩ connected to V+ / 2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
OFFSET VOLTAGE							
V_{OS}	Input offset voltage	LMC7101A			±0.11	±3	mV
		LMC7101B			±0.11	±7	
dV_{OS}/dT	Input offset voltage drift	T_J = –40°C to +85°C			1		µV/°C
PSRR	Power-supply rejection ratio	V+ = 1.5V to 7.5V V– = –1.5V to –7.5V V_{OUT} = V_{CM} = 0V	LMC7101A	68	80		dB
			LMC7101B	60	80		
INPUT BIAS CURRENT							
I_B	Input bias current	T_J = –40°C to +85°C			±1	±64	pA
I_{OS}	Input offset current	T_J = –40°C to +85°C			±0.5	±32	pA
INPUT VOLTAGE							
V_{CM}	Input common-mode voltage	For CMRR ≥ 47dB	Positive	3	3.3		V
			Negative		0	0	
CMRR	Common-mode rejection	0V ≤ V_{CM} ≤ 3V		47	70		dB
INPUT IMPEDANCE							
R_{IN}	Input resistance				> 1		TΩ
C_{IN}	Common-mode input capacitance				3		pF
OUTPUT							
V_O	Voltage output swing	Positive rail	R_L = 2kΩ	2.6	2.8		V
			R_L = 600Ω	2.5	2.7		
		Negative rail	R_L = 2kΩ		0.2	0.4	
			R_L = 600Ω		0.37	0.6	
POWER SUPPLY							
I_Q	Quiescent current per amplifier				500	810	µA
		T_J = –40°C to +85°C			500	950	

5.7 Electrical Characteristics for V_S = ±2.5V or 5V

at T_J = 25°C, V+ = 5V, V– = 0V, V_{CM} = V_{OUT} = V+ / 2, and R_L = 1MΩ connected to V+ / 2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
OFFSET VOLTAGE							
V_{OS}	Input offset voltage	LMC7101A			±0.11	±3	mV
			T_J = –40°C to +85°C		±0.11	±5	
		LMC7101B			±0.11	±7	
			T_J = –40°C to +85°C		±0.11	±9	
dV_{OS}/dT	Input offset voltage drift	T_J = –40°C to +85°C			1		µV/°C
PSRR	Power-supply rejection ratio	Positive V+ = 5V to 15V V– = 0V, V_{OUT} = 1.5V	LMC7101A	70	82		dB
			LMC7101B	65	82		
			LMC7101A T_J = –40°C to +85°C	65	82		
			LMC7101B T_J = –40°C to +85°C	62	82		
		Negative V+ = –5V to –15V V– = 0V, V_{OUT} = –1.5V	LMC7101A	70	82		
			LMC7101B	65	82		
			LMC7101A T_J = –40°C to +85°C	65	82		
			LMC7101B T_J = –40°C to +85°C	62	82		
INPUT BIAS CURRENT							
I_B	Input bias current				±1		pA
		T_J = –40°C to +85°C				±64	
I_{OS}	Input offset current				±0.5		pA
		T_J = –40°C to +85°C				±32	
NOISE							
THD	Total harmonic distortion	f = 10kHz, G = – 2V/V, R_L = 10kΩ, V_{OUT} = 4V_{pp}			0.01		%
INPUT VOLTAGE							
V_{CM}	Input common-mode voltage	To positive rail CMRR > 50dB		5.2	5.3		V
			T_J = –40°C to +85°C	5	5.3		
		To negative rail CMRR > 50dB			–0.3	–0.2	
			T_J = –40°C to +85°C		–0.3	0	
CMRR	Common-mode rejection ratio	0V ≤ V_{CM} ≤ 5V		52	75		dB
			T_J = –40°C to +85°C	51	74		
INPUT IMPEDANCE							
R_{IN}	Input resistance				> 1		TΩ
C_{IN}	Input capacitance				3		pF
FREQUENCY RESPONSE							
GBW	Gain bandwidth product				1		MHz
SR	Slew rate				1		V/µs

5.7 Electrical Characteristics for V_S = ±2.5V or 5V (continued)

at T_J = 25°C, V+ = 5V, V– = 0V, V_{CM} = V_{OUT} = V+ / 2, and R_L = 1MΩ connected to V+ / 2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
OUTPUT							
V_O	Voltage output swing	Positive rail R_L = 2kΩ		4.7	4.9		V
			T_J = –40°C to +85°C	4.6	4.9		
		Negative rail R_L = 2kΩ			0.1	0.18	
			T_J = –40°C to +85°C		0.1	0.24	
		Positive rail R_L = 600Ω		4.5	4.7		
			T_J = –40°C to +85°C	4.24	4.7		
		Negative rail R_L = 600Ω			0.3	0.5	
			T_J = –40°C to +85°C		0.3	0.65	
I_{SC}	Short-circuit current	Sourcing V_{OUT} = 0V		16	24		mA
			T_J = –40°C to +85°C	11	24		
		Sinking V_{OUT} = 5V		11	19		
			T_J = –40°C to +85°C	7.5	19		
POWER SUPPLY							
I_Q	Quiescent current per amplifier				0.5	0.85	mA
		T_J = –40°C to +85°C			0.5	1	

5.8 Electrical Characteristics for V_S = ±7.5V or 15V

at T_J = 25°C, V+ = 15V, V– = 0V, V_{CM} = V_{OUT} = V+ / 2, and R_L = 1MΩ connected to V+ / 2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
OFFSET VOLTAGE							
V_{OS}	Input offset voltage				±0.26		mV
dV_{OS}/dT	Input offset voltage drift	T_J = –40°C to +85°C			1		µV/°C
PSRR	Power-supply rejection ratio	Positive V+ = 5V to 15V V– = 0V, V_{OUT} = 1.5V	LMC7101A	70	82		dB
			LMC7101B	65	82		
			LMC7101A T_J = –40°C to +85°C	65	82		
			LMC7101B T_J = –40°C to +85°C	60	82		
		Negative V+ = –5V to –15V V– = 0V, V_{OUT} = –1.5V	LMC7101A	70	82		
			LMC7101B	65	82		
			LMC7101A T_J = –40°C to +85°C	65	82		
			LMC7101B T_J = –40°C to +85°C	62	82		
INPUT BIAS CURRENT							
I_B	Input bias current				±1		pA
		T_J = –40°C to +85°C				±64	
I_{OS}	Input offset current				±0.5		pA
		T_J = –40°C to +85°C				±32	
NOISE							
e_n	Input voltage noise density	f = 1kHz, V_{CM} = 1V			37		nV/√Hz
i_n	Input current noise density	f = 1kHz			6.8		fA/√Hz
THD	Total harmonic distortion	f = 10kHz, G = – 2V/V, R_L = 10kΩ, V_{OUT} = 8.5V_{pp}			0.01		%
INPUT VOLTAGE							
V_{CM}	Input common-mode voltage	To positive rail CMRR > 50dB		15.2	15.3		V
			T_J = –40°C to +85°C	15	15.3		
		To negative rail CMRR > 50dB			–0.3	–0.2	
			T_J = –40°C to +85°C		–0.3	0	
CMRR	Common-mode rejection ratio	0V ≤ V_{CM} ≤15V		62	82		dB
			T_J = –40°C to +85°C	60	82		
INPUT IMPEDANCE							
R_{IN}	Input resistance				> 1		TΩ
C_{IN}	Input capacitance				3		pF
OPEN-LOOP GAIN							
A_{OL}	Open-loop voltage gain	Sourcing 7.5V < V_O < 12.5V, V_{CM} = 1.5V R_L = 2kΩ to 7.5V		80	340		V/mV
			T_J = –40°C to +85°C	40	340		
		Sinking 2.5V < V_O < 7.5V, V_{CM} = 1.5V R_L = 2kΩ to 7.5V		15	24		
			T_J = –40°C to +85°C	10	24		
		Sourcing, V_{CM} = 1.5V, 7.5V < V_O < 12.5V, R_L = 600Ω		34	300		
		Sinking, V_{CM} = 1.5V, 2.5V < V_O < 7.5V, R_L = 600Ω		6	15		

5.8 Electrical Characteristics for V_S = ±7.5V or 15V (continued)

at T_J = 25°C, V+ = 15V, V– = 0V, V_{CM} = V_{OUT} = V+ / 2, and R_L = 1MΩ connected to V+ / 2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
FREQUENCY RESPONSE							
GBW	Gain bandwidth product				1.1		MHz
SR	Slew rate(1)	V_S = 15V, 10V step, R_L = 100kΩ to 7.5V V_{OUT} = 10V_{PP}, f = 1kHz		0.5	1.1		V/µs
			T_J = –40°C to +85°C	0.4	1.1		
θ_m	Phase margin				45		°
G_m	Gain margin				10		dB
OUTPUT							
V_O	Voltage output swing	Positive rail R_L = 2kΩ		14.4	14.7		V
			T_J = –40°C to +85°C	14.2	14.7		
		Negative rail R_L = 2kΩ			0.16	0.32	
			T_J = –40°C to +85°C		0.16	0.45	
		Positive rail R_L = 600Ω		13.4	14.1		
			T_J = –40°C to +85°C	13	14.1		
		Negative rail R_L = 600Ω			0.5	1	
			T_J = –40°C to +85°C		0.5	1.3	
I_{SC}	Short-circuit current(2)	Sourcing V_{OUT} = 0V		30	50		mA
			T_J = –40°C to +85°C	20	50		
		Sinking V_{OUT} = 12V		30	50		
			T_J = –40°C to +85°C	20	50		
POWER SUPPLY							
I_Q	Quiescent current per amplifier				0.8	1.5	mA
		T_J = –40°C to +85°C			0.8	1.71	

(1) Number specified is the slower of the positive and negative slew rates.
(2) Do not short circuit output to V+ when V+ is greater than 12V or reliability can be adversely affected.

5.9 Typical Characteristics for V_S = 2.7V

at V+ = 2.7V, V– = 0V, and T_A = 25°C (unless otherwise specified)

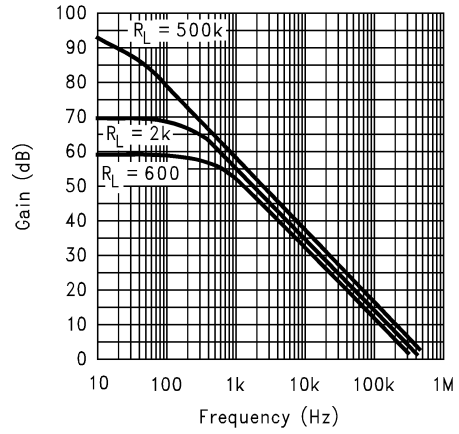


Figure 5-1. Open-Loop Frequency Response

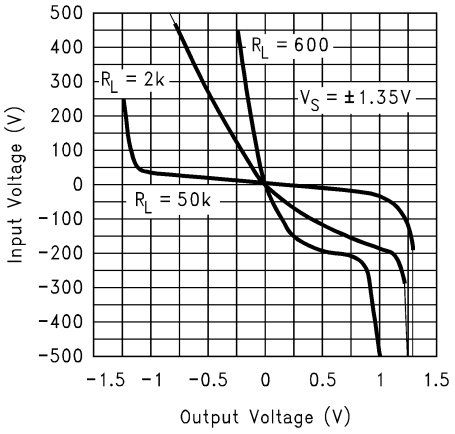


Figure 5-2. Input Voltage vs Output Voltage

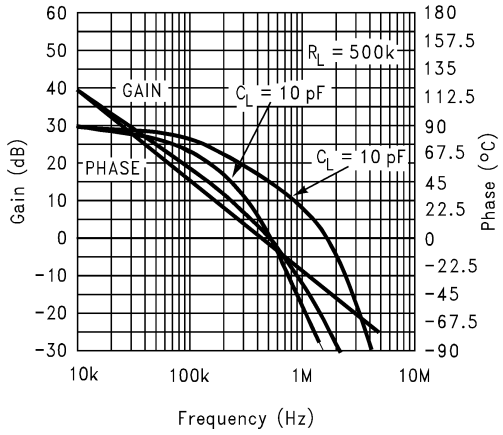


Figure 5-3. Gain and Phase vs Capacitance Load

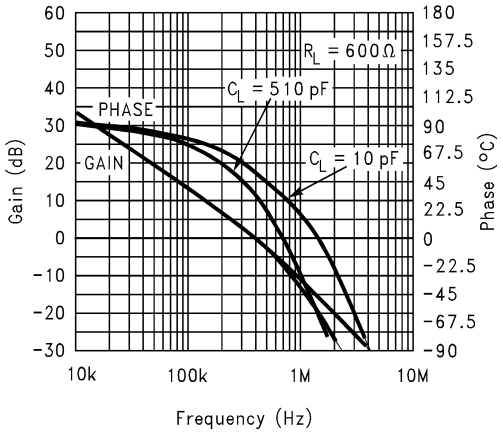


Figure 5-4. Gain and Phase vs Capacitance Load

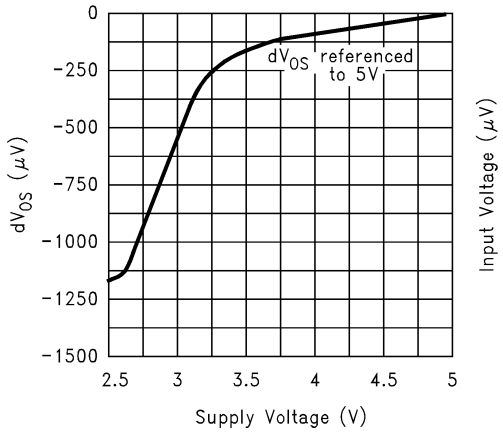
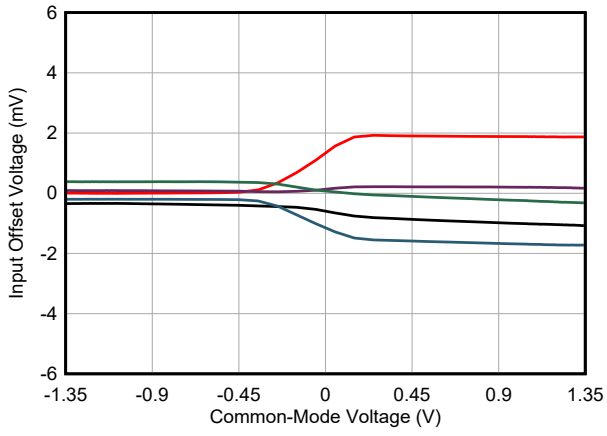


Figure 5-5. dV_{OS} vs Supply Voltage



5 typical units

Figure 5-6. Input Offset Voltage vs Common-Mode Voltage

5.9 Typical Characteristics for V_S = 2.7V (continued)

at V+ = 2.7V, V– = 0V, and T_A = 25°C (unless otherwise specified)

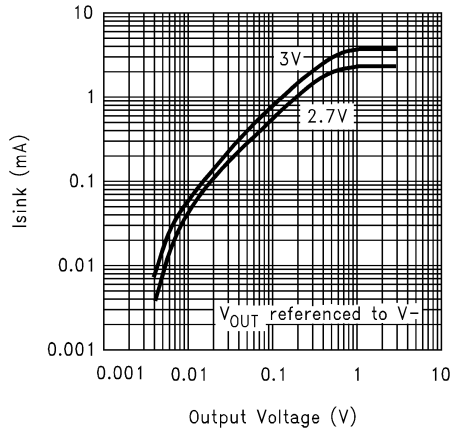


Figure 5-7. Sinking Current vs Output Voltage

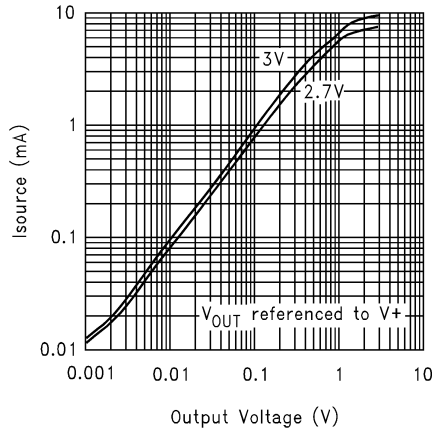


Figure 5-8. Sourcing Current vs Output Voltage

5.10 Typical Characteristics for V_S = 3V

at V+ = 3V, V– = 0V, and T_A = 25°C (unless otherwise specified)

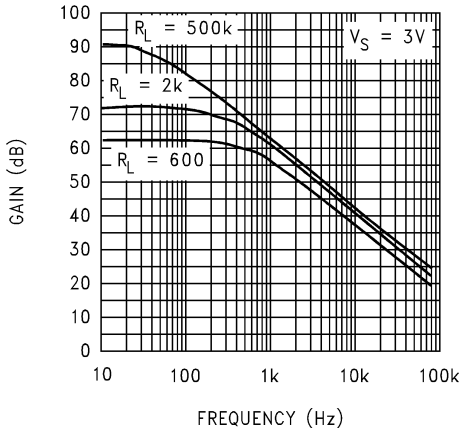


Figure 5-9. Open-Loop Frequency Response

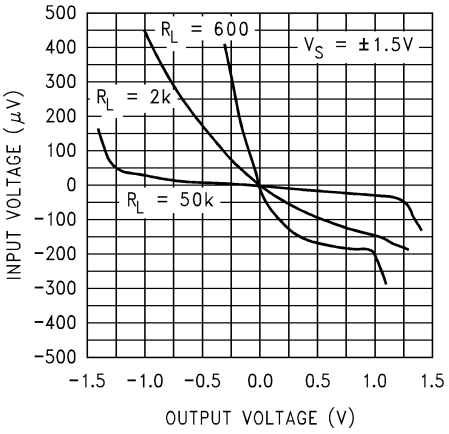


Figure 5-10. Input Voltage vs Output Voltage

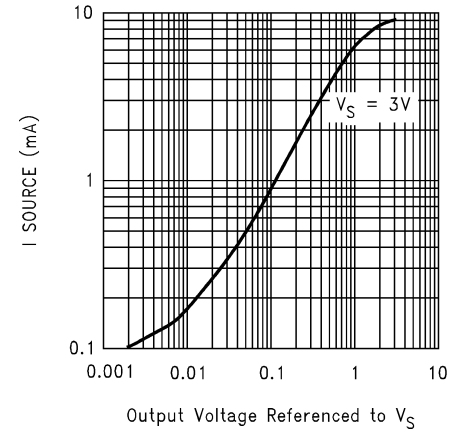


Figure 5-11. Sourcing Current vs Output Voltage

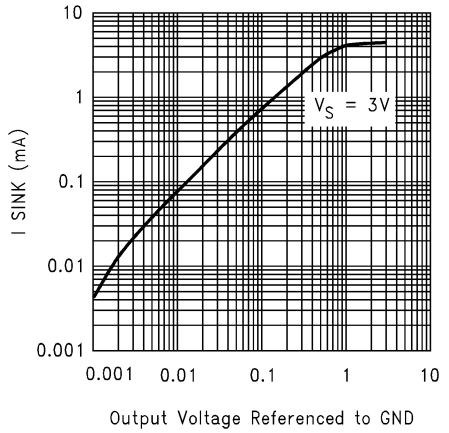


Figure 5-12. Sinking Current vs Output Voltage

5.11 Typical Characteristics for V_S = 5V

at V+ = 5V, V– = 0V, and T_A = 25°C (unless otherwise specified)

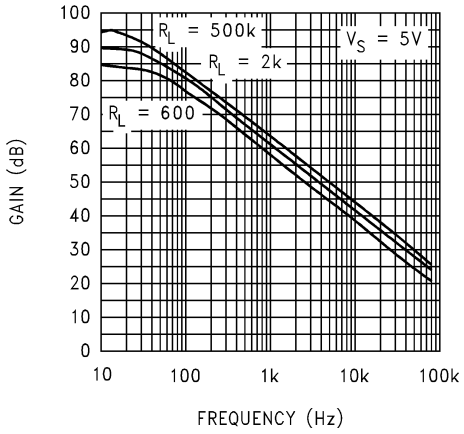


Figure 5-13. Open-Loop Frequency Response

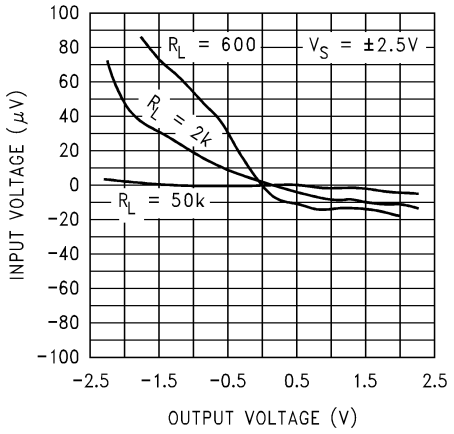


Figure 5-14. Input Voltage vs Output Voltage

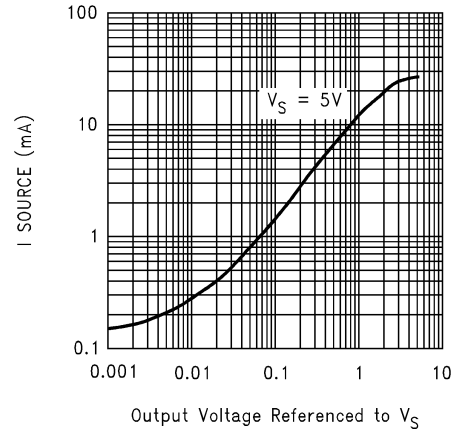


Figure 5-15. Sourcing Current vs Output Voltage

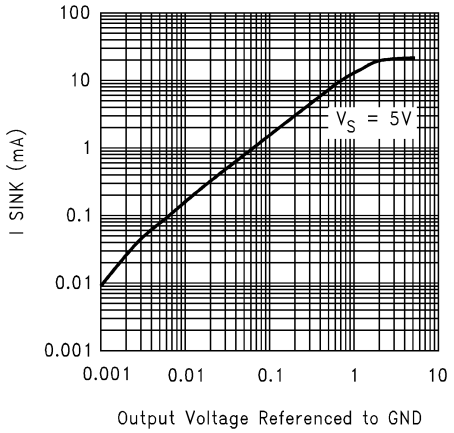


Figure 5-16. Sinking Current vs Output Voltage

5.12 Typical Characteristics for V_S = 15V

at V+ = 15V, V– = 0V, and T_A = 25°C (unless otherwise specified)

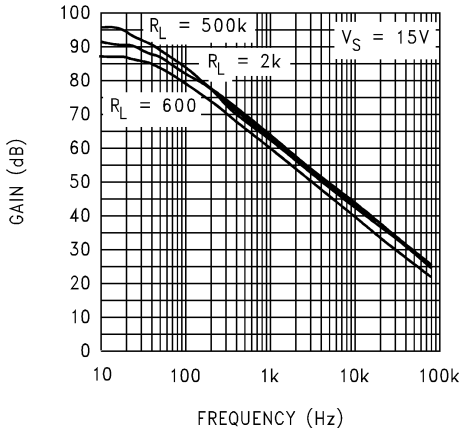


Figure 5-17. Open-Loop Frequency Response

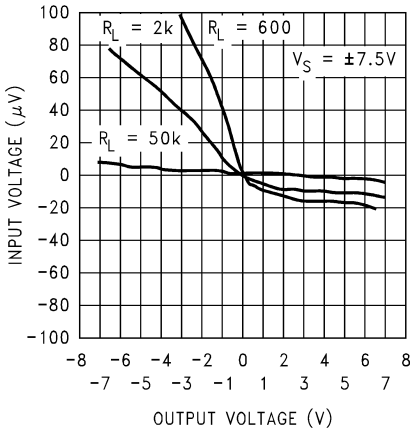


Figure 5-18. Input Voltage vs Output Voltage

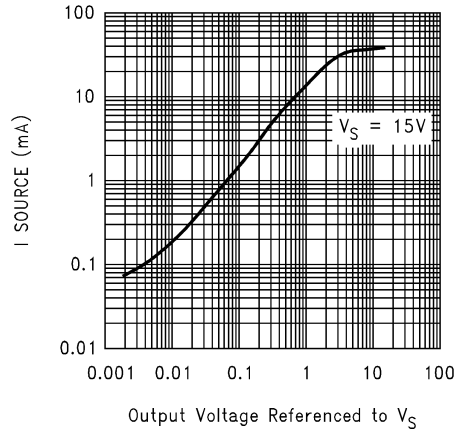


Figure 5-19. Sourcing Current vs Output Voltage

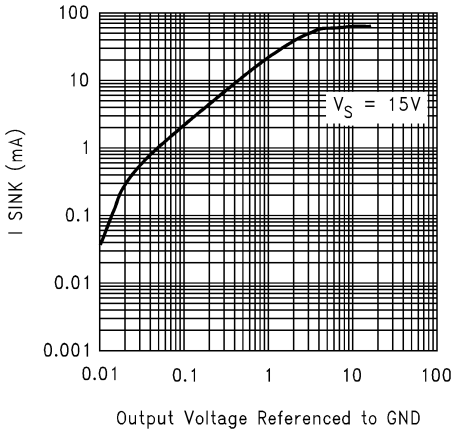
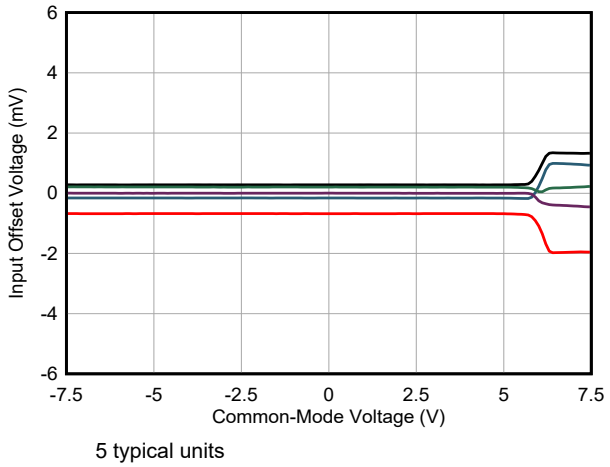


Figure 5-20. Sinking Current vs Output Voltage



5 typical units

Figure 5-21. Input Offset Voltage vs Common-Mode Voltage

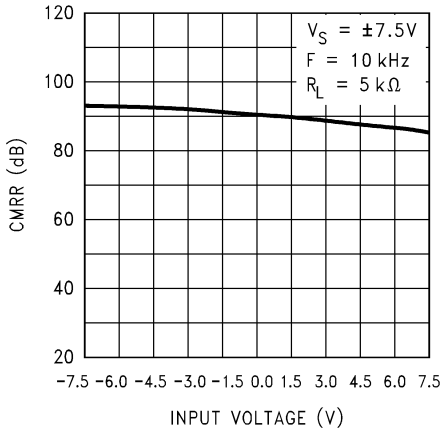


Figure 5-22. CMRR vs Input Voltage

5.12 Typical Characteristics for V_S = 15V (continued)

at V+ = 15V, V– = 0V, and T_A = 25°C (unless otherwise specified)

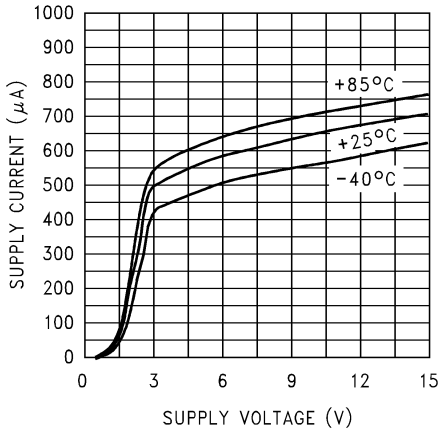


Figure 5-23. Supply Current vs Supply Voltage

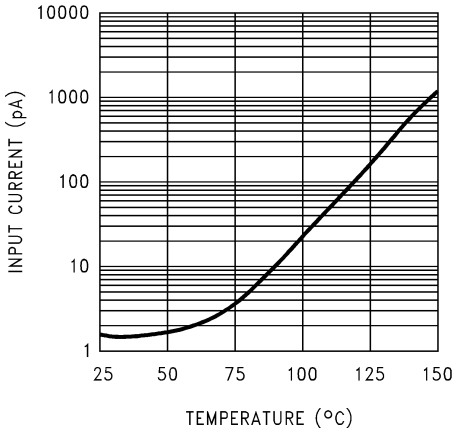


Figure 5-24. Input Current vs Temperature

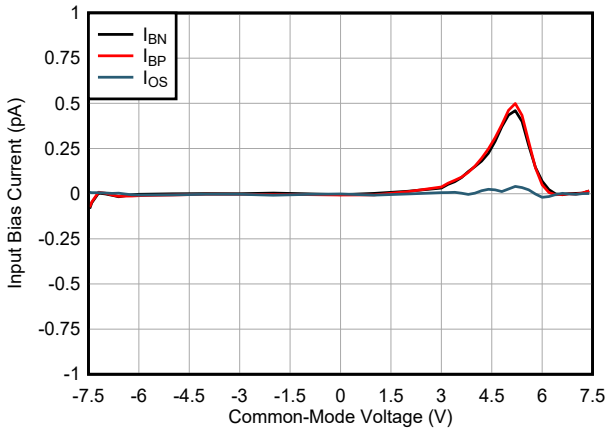


Figure 5-25. Input Bias Current vs Common-Mode Voltage

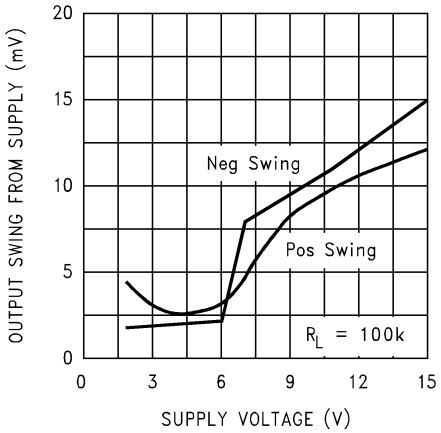


Figure 5-26. Output Voltage Swing vs Supply Voltage

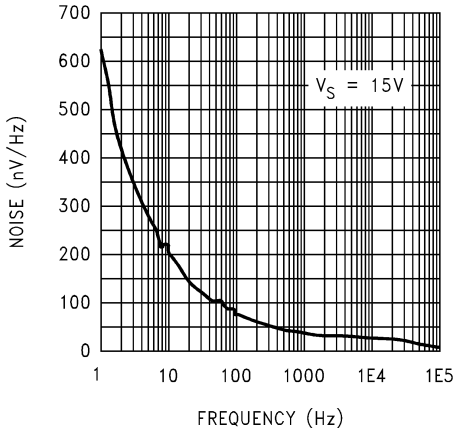


Figure 5-27. Input Voltage Noise vs Frequency

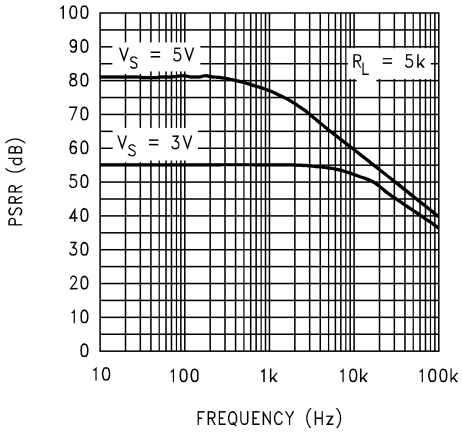


Figure 5-28. Positive PSRR vs Frequency

5.12 Typical Characteristics for V_S = 15V (continued)

at V+ = 15V, V– = 0V, and T_A = 25°C (unless otherwise specified)

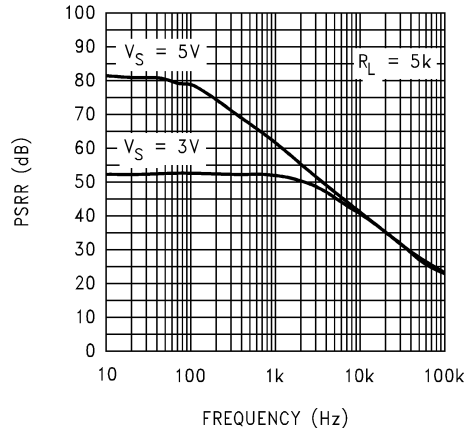


Figure 5-29. Negative PSRR vs Frequency

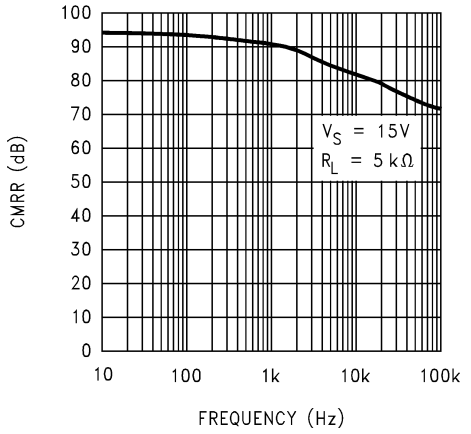


Figure 5-30. CMRR vs Frequency

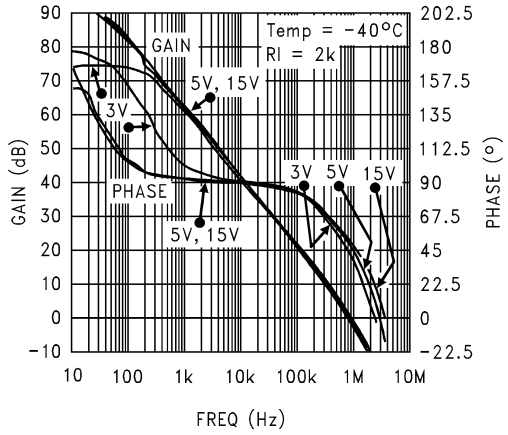


Figure 5-31. Open-Loop Frequency Response at –40°C

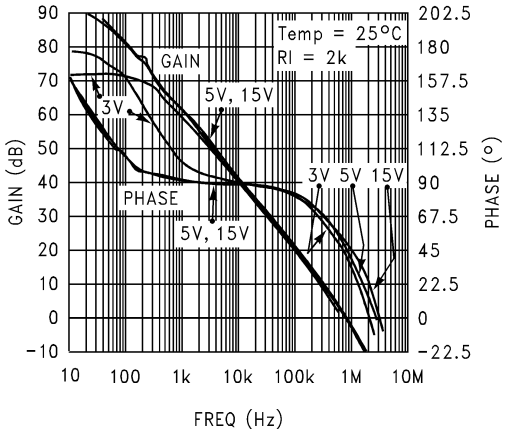


Figure 5-32. Open-Loop Frequency Response at 25°C

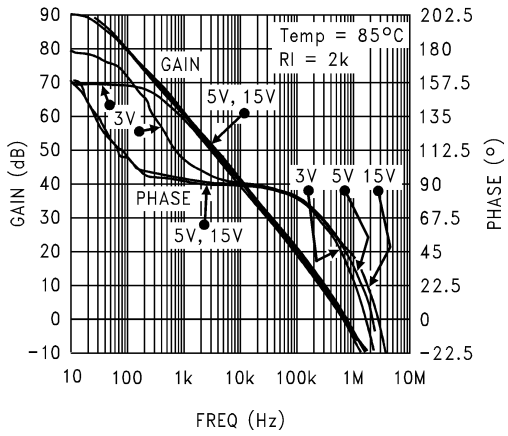


Figure 5-33. Open-Loop Frequency Response at 85°C

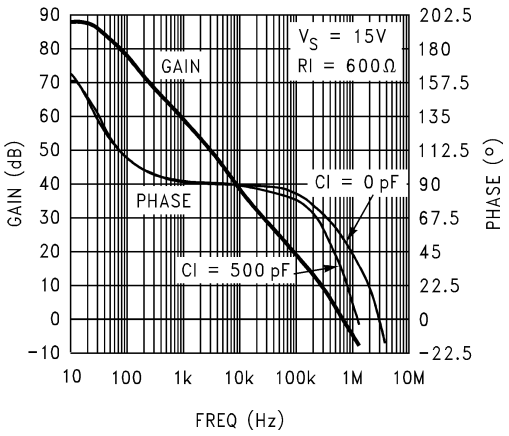


Figure 5-34. Gain and Phase vs Capacitive Load

5.12 Typical Characteristics for V_S = 15V (continued)

at V+ = 15V, V– = 0V, and T_A = 25°C (unless otherwise specified)

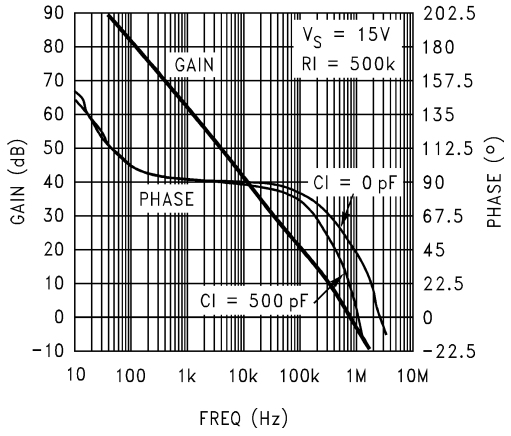


Figure 5-35. Gain and Phase vs Capacitive Load

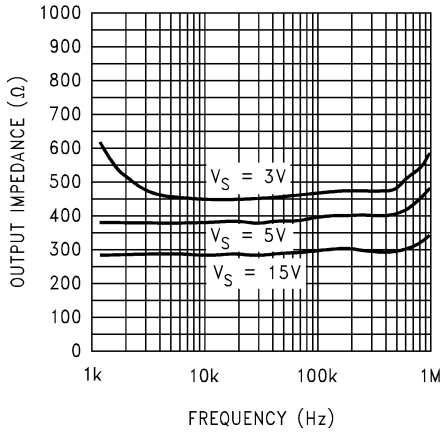


Figure 5-36. Output Impedance vs Frequency

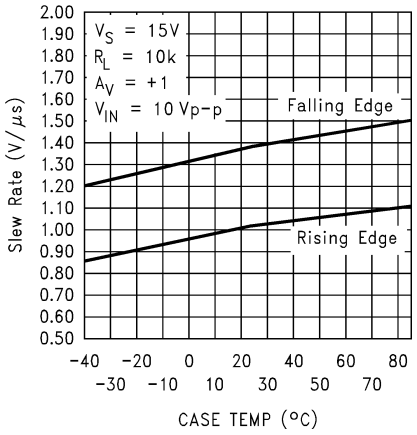


Figure 5-37. Slew Rate vs Temperature

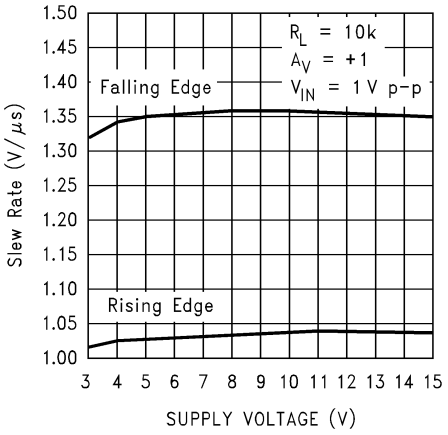


Figure 5-38. Slew Rate vs Supply Voltage

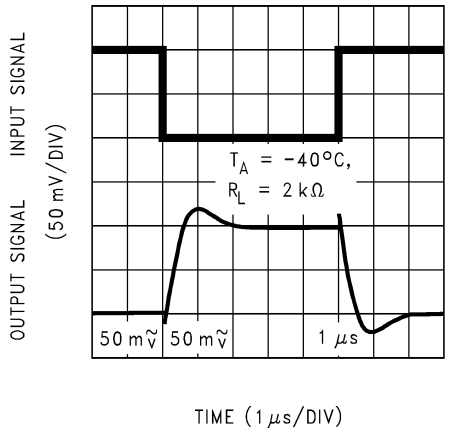


Figure 5-39. Inverting Small-Signal Pulse Response

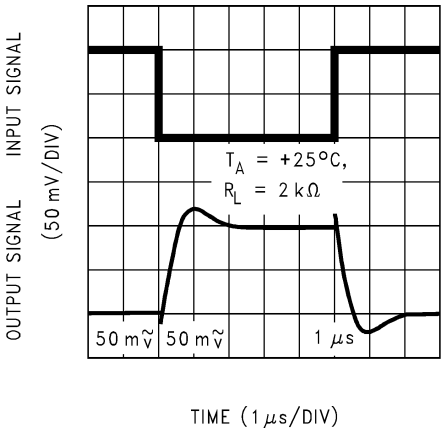


Figure 5-40. Inverting Small-Signal Pulse Response

5.12 Typical Characteristics for V_S = 15V (continued)

at V+ = 15V, V– = 0V, and T_A = 25°C (unless otherwise specified)

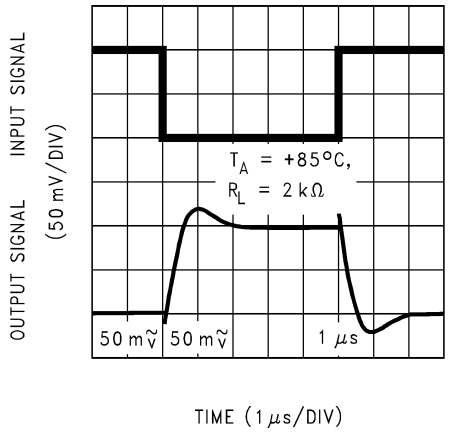


Figure 5-41. Inverting Small-Signal Pulse Response

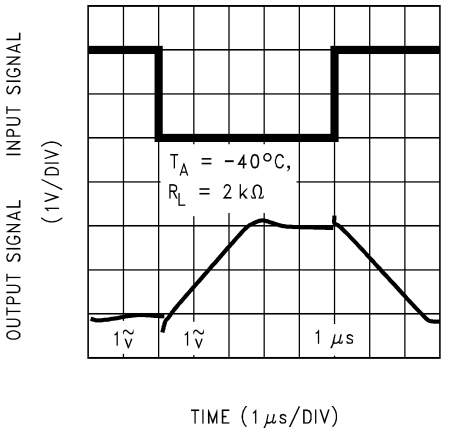


Figure 5-42. Inverting Large-Signal Pulse Response

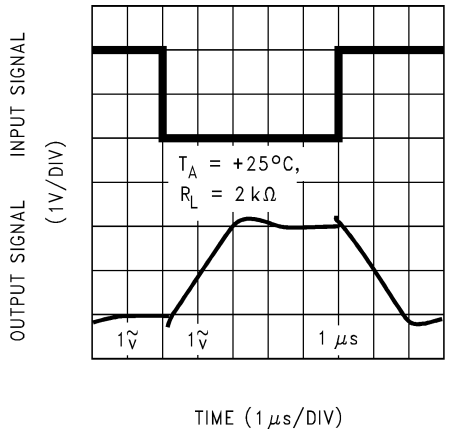


Figure 5-43. Inverting Large-Signal Pulse Response

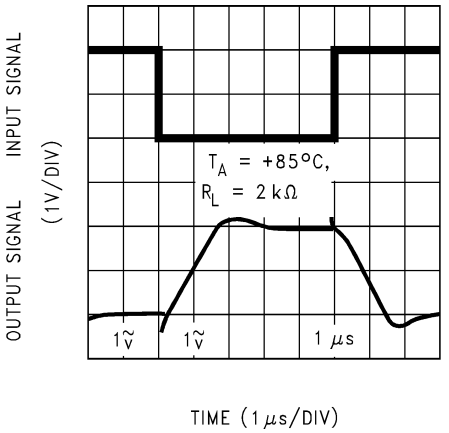


Figure 5-44. Inverting Large-Signal Pulse Response

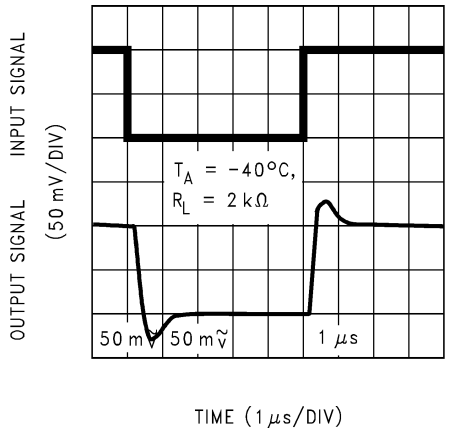


Figure 5-45. Noninverting Small-Signal Pulse Response

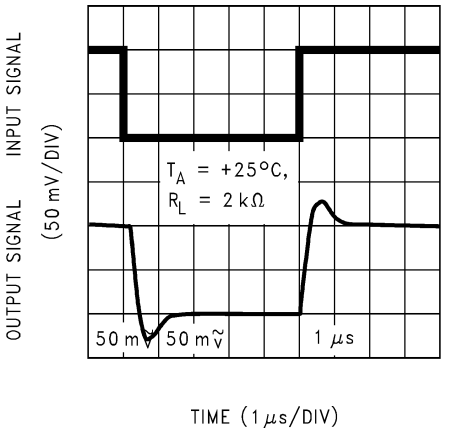


Figure 5-46. Noninverting Small-Signal Pulse Response

5.12 Typical Characteristics for V_S = 15V (continued)

at V+ = 15V, V– = 0V, and T_A = 25°C (unless otherwise specified)

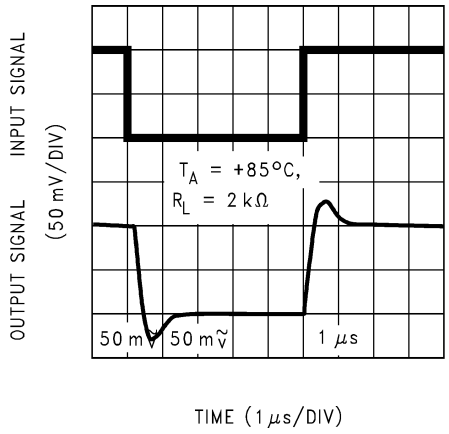


Figure 5-47. Noninverting Small-Signal Pulse Response

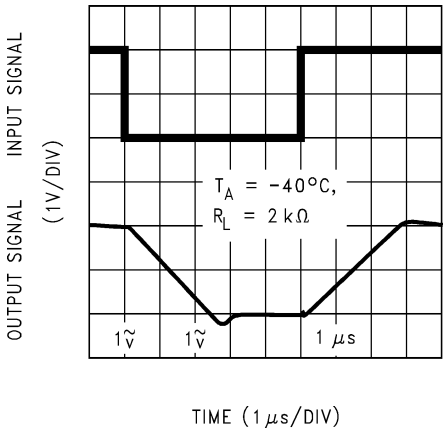


Figure 5-48. Noninverting Large-Signal Pulse Response

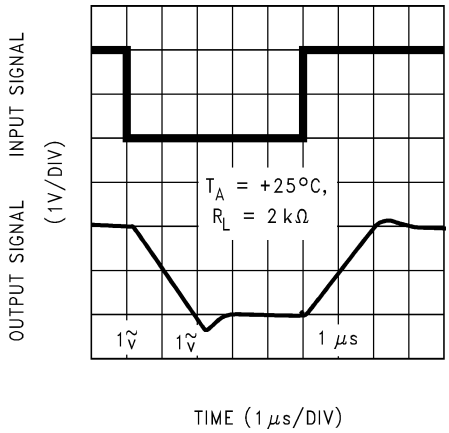


Figure 5-49. Noninverting Large-Signal Pulse Response

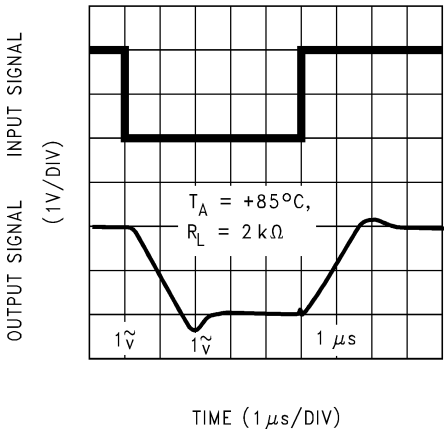


Figure 5-50. Noninverting Large-Signal Pulse Response

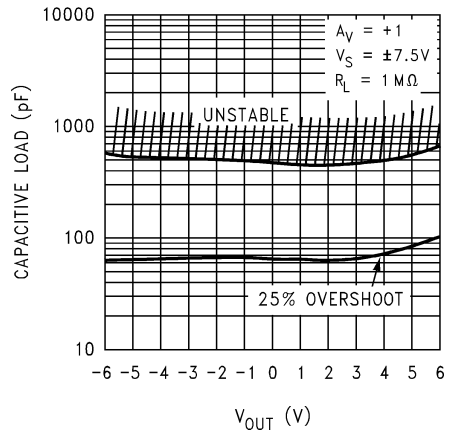


Figure 5-51. Stability vs Capacitive Load

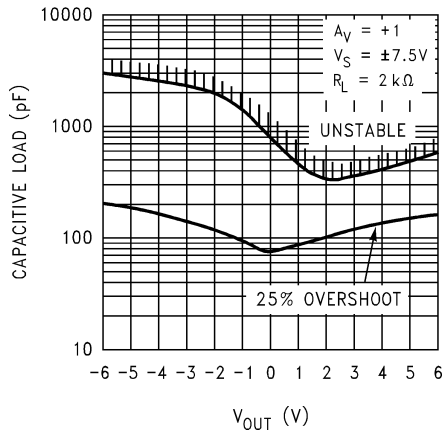


Figure 5-52. Stability vs Capacitive Load

5.12 Typical Characteristics for V_S = 15V (continued)

at V+ = 15V, V– = 0V, and T_A = 25°C (unless otherwise specified)

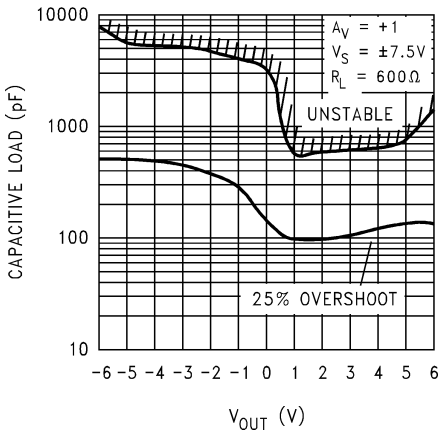


Figure 5-53. Stability vs Capacitive Load

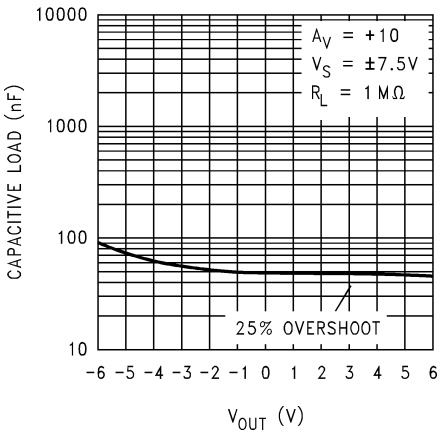


Figure 5-54. Stability vs Capacitive Load

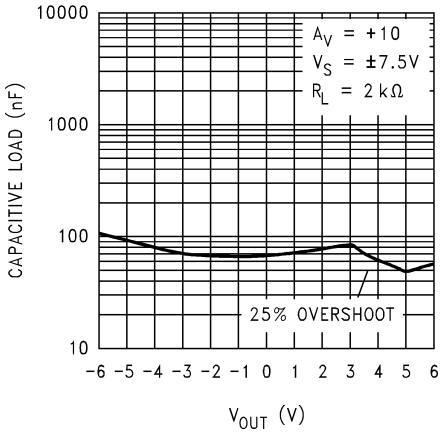


Figure 5-55. Stability vs Capacitive Load

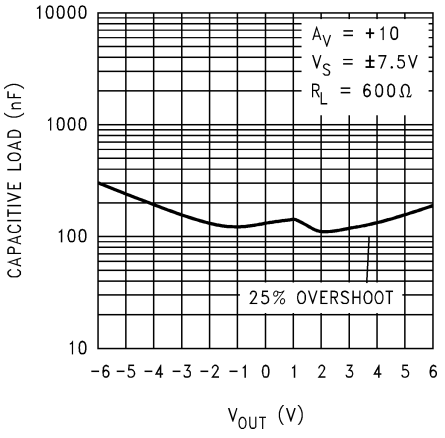


Figure 5-56. Stability vs Capacitive Load

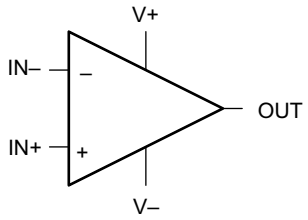
6 Detailed Description

6.1 Overview

The LMC7101 is a single-channel, low-power operational amplifier available in a space-saving SOT-23 package, offering rail-to-rail input and output operation across a wide range of power-supply configurations.

The LMC7101 is also available in an automotive-grade variant, see LMC7101Q-Q1.

6.2 Functional Block Diagram



6.3 Feature Description

6.3.1 Benefits of the LMC7101 Tiny Amplifier

6.3.1.1 Size

The small footprint of the SOT-23-5 packaged tiny amplifier, (0.12in × 0.118in, 3.05mm × 3mm) saves space on printed circuit boards, and enable the design of smaller electronic products. Many customers prefer smaller and lighter products because the designs can contribute to overall weight reduction in portable electronics.

6.3.1.2 Height

The 0.056 inches (1.43mm) height of the tiny LMC7101 amplifier makes the device an excellent choice for use in a wide range of circuit boards in which a thin profile is required.

6.3.1.3 Signal Integrity

Signals can pick up noise between the signal source and the amplifier. By using a physically smaller amplifier package, the tiny amplifier can be placed closer to the signal source, thus reducing noise pickup and increasing signal integrity. The tiny amplifier can also be placed next to the signal destination, such as a buffer, for the reference of an analog-to-digital converter.

6.3.1.4 Simplified Board Layout

The tiny LMC7101 amplifier can simplify board layout in several ways. Avoid long PCB traces by correctly placing amplifiers instead of routing signals to a dual or quad device. By using multiple tiny amplifiers instead of duals or quads, complex signal routing and possibly crosstalk can be reduced.

6.3.1.5 Low THD

The high open-loop gain of the LMC7101 amplifier helps to achieve very low audio distortion—typically 0.01% at 10kHz with a 10kΩ load at 5V supplies. This makes the tiny amplifier an excellent choice for audio and low-frequency signal-processing applications.

6.3.1.6 Low Supply Current

The typical 0.5mA supply current of the LMC7101 can help improve thermal performance on high density circuit boards, and can allow the reduction of the overall board size in some applications.

6.3.1.7 Wide Voltage Range

The LMC7101 is characterized at 15V, 5V and 3V. Performance data is provided at these popular voltages. This wide voltage range makes the LMC7101 a good choice for devices where the supply voltage can vary.

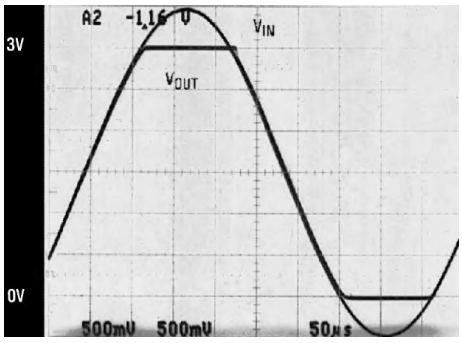
6.4 Device Functional Modes

6.4.1 Input Common Mode

6.4.1.1 Input Common-Mode Voltage Range

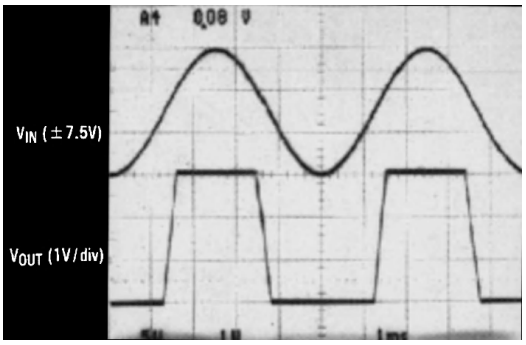
The LMC7101 does not exhibit phase inversion when an input voltage exceeds the negative supply voltage. Figure 6-1 shows an input voltage exceeding both supplies with no resulting phase inversion of the output.

The absolute maximum input voltage is 300mV beyond either rail at room temperature. Voltages greatly exceeding this maximum rating, as in Figure 6-2, can cause excessive current to flow in or out of the input pins, thus adversely affecting reliability.



The input voltage signal exceeds the amplifier power supply voltage with no output phase inversion.

Figure 6-1. Input Voltage



The ±7.5V input signal greatly exceeds the 3V supply in Figure 6-3 causing no phase inversion due to R_I.

Figure 6-2. Input Signal

Applications that exceed this rating must externally limit the maximum input current to ±5mA with an input resistor as shown in Figure 6-3.

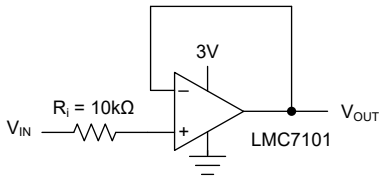


Figure 6-3. R_I Input Current Protection for Voltages Exceeding the Supply Voltage

7 Application and Implementation

Note

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, as well as validating and testing their design implementation to confirm system functionality.

7.1 Application Information

7.1.1 Rail-to-Rail Output

The approximate output resistance of the LMC7101 is 180Ω sourcing and 130Ω sinking at V_S = 3V and 110Ω sourcing and 80Ω sinking at V_S = 5V. Using the calculated output resistance, maximum output voltage swing can be estimated as a function of load.

7.1.2 Capacitive Load Tolerance

The LMC7101 can typically directly drive a 100pF load with V_S = 15V at unity gain without oscillating. The unity gain follower is the most sensitive configuration. Direct capacitive loading reduces the phase margin of operational amplifiers. The combination of the output impedance and the capacitive load of the operational amplifier induces phase lag, which results in either an underdamped pulse response or oscillation.

Capacitive load compensation can be accomplished using resistive isolation as shown in Figure 7-1. This simple technique is useful for isolating the capacitive input of multiplexers and A/D converters.

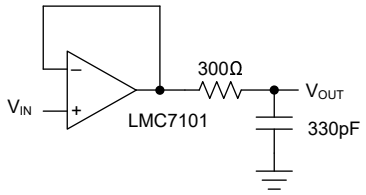


Figure 7-1. Resistive Isolation of a 330pF Capacitive Load

7.1.3 Compensating for Input Capacitance When Using Large Value Feedback Resistors

When using very large value feedback resistors, (usually >500 kΩ) the large feed back resistance can react with the input capacitance due to transducers, photo diodes, and circuit board parasitics to reduce phase margins.

The effect of input capacitance can be compensated for by adding a feedback capacitor. The feedback capacitor (as in Figure 7-2), C_f is first estimated by Equation 1 and Equation 2, which typically provides significant overcompensation.

$$\frac{1}{2\pi R_1 C_{IN}} \geq \frac{1}{2\pi R_2 C_f} \quad (1)$$

$$2\pi R_1 C_{IN} \leq 2\pi R_2 C_f \quad (2)$$

Printed circuit board stray capacitance can be larger or smaller than that of a breadboard, so the actual optimum value for C_F can be different. The values of C_F must be checked on the actual circuit.

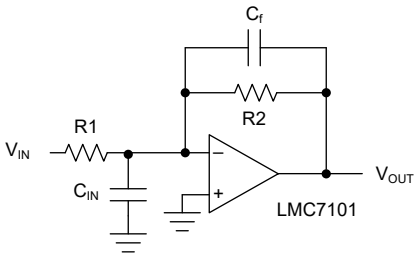


Figure 7-2. Canceling the Effect of Input Capacitance

7.2 Typical Application

Figure 7-3 shows a high input impedance noninverting circuit. This circuit gives a closed-loop gain equal to the ratio of the sum of R1 and R2 to R1 and a closed-loop 3dB bandwidth equal to the amplifier unity-gain frequency divided by the closed-loop gain. This design has the benefit of a very high input impedance, which is equal to the differential input impedance multiplied by loop gain (open loop gain / closed loop gain). In dc-coupled applications, input impedance is not as important as input current and the voltage drop across the source resistance. The amplifier output can go into saturation if the input is allowed to float, which can be important if the amplifier must be switched from source to source.

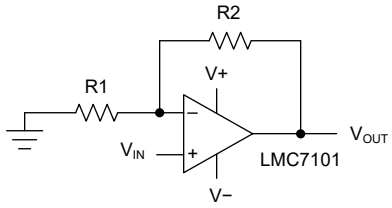


Figure 7-3. Example Application

7.2.1 Design Requirements

For this example application, the supply voltage is 5V, and 100 × ±5% of noninverting gain is necessary. The signal input impedance is approximately 10kΩ.

7.2.2 Detailed Design Procedure

Use the equation for a noninverting amplifier configuration; G = 1 + R2 / R1, set R1 to 10kΩ, and R2 to 99 × R1, which is 990kΩ. Replacing the 990kΩ resistor with a more readily available 1MΩ resistor results in a gain of 101, which is within the desired gain tolerance. The gain-frequency characteristic of the amplifier and the feedback network must be such that oscillation does not occur. To meet this condition, the phase shift through amplifier and feedback network must never exceed 180° for any frequency where the gain of the amplifier and the feedback network is greater than unity. In practical applications, the phase shift must not approach 180° because this is the situation of conditional stability. The most critical case occurs when the attenuation of the feedback network is zero.

7.2.3 Application Curve

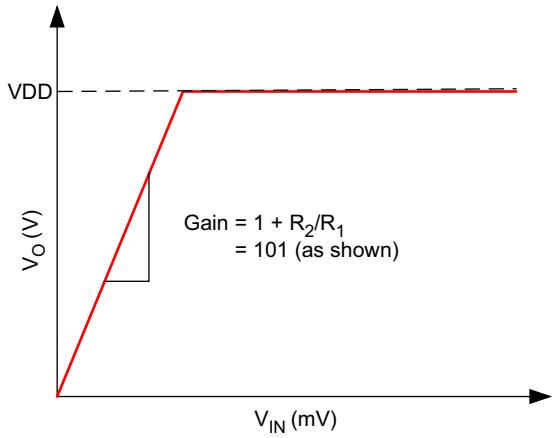


Figure 7-4. Output Response

7.3 Power Supply Recommendations

For proper operation, the power supplies must be decoupled. For supply decoupling, TI recommends placing 10nF to 1µF capacitors as close as possible to the operational-amplifier power supply pins. For single supply configurations, place a capacitor between the V+ and V− supply pins. For dual supply configurations, place one capacitor between V+ and ground, and place a second capacitor between V− and ground. Bypass capacitors must have a low ESR of less than 0.1Ω.

7.4 Layout

7.4.1 Layout Guidelines

Care must be taken to minimize the loop area formed by the bypass capacitor connection between supply pins and ground. A ground plane underneath the device is recommended; any bypass components to ground must have a nearby via to the ground plane. The optimum bypass capacitor placement is closest to the corresponding supply pin. Use of thicker traces from the bypass capacitors to the corresponding supply pins can lower the power-supply inductance and provide a more stable power supply.

The feedback components must be placed as close as possible to the device to minimize stray parasitics.

7.4.2 Layout Example

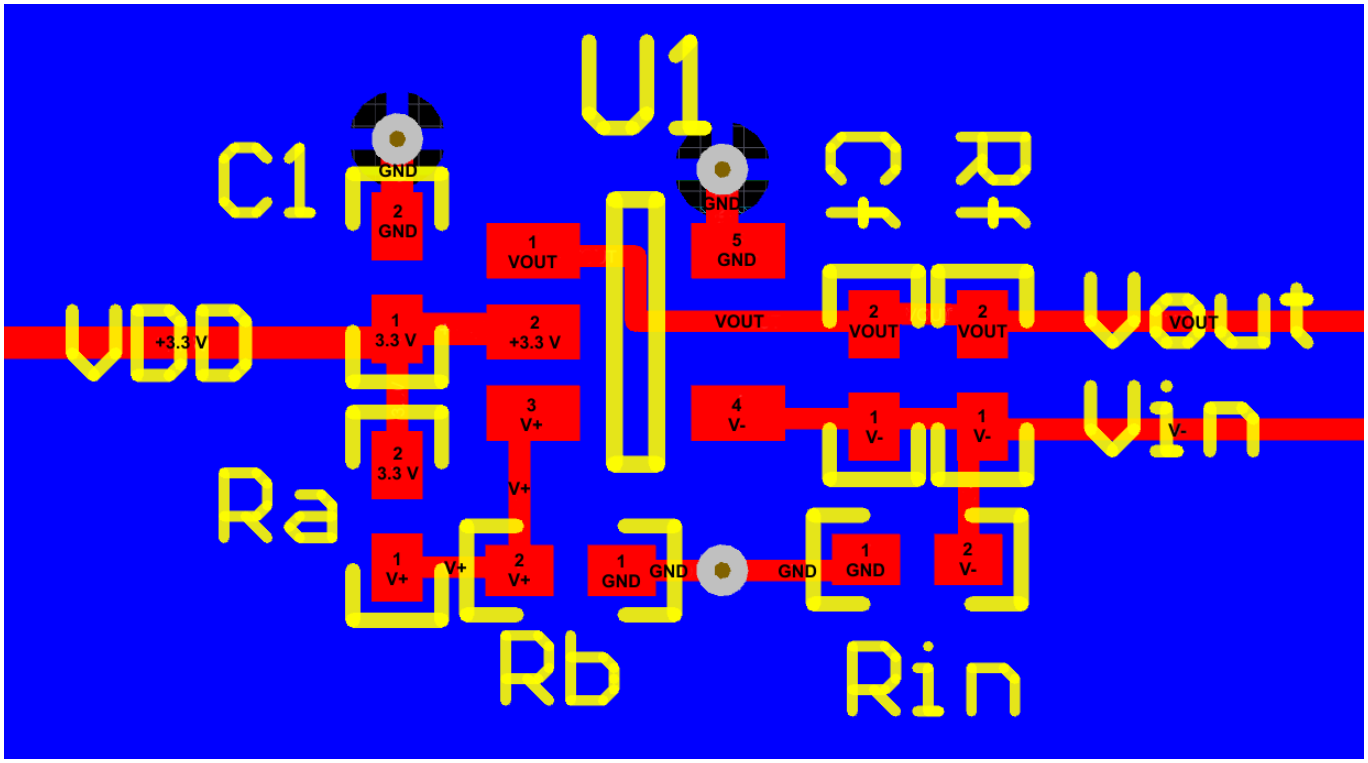


Figure 7-5. LMC7101 Example Layout

8 Device and Documentation Support

8.1 Documentation Support

8.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, *LMC66x CMOS Dual Operational Amplifiers* data sheet
- Texas Instruments, *RES11A Matched, Thin-Film Resistor Dividers With 1kΩ Inputs* data sheet

8.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

8.3 Support Resources

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.

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8.4 Trademarks

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8.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.6 Glossary

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

9 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision SNOS719G (September 2015) to Revision * (January 2025)	Page
• Moved LMC7101 commercial device from SNOS719G data sheet into new SBOSAL2 data sheet	1
• Updated *Features*	1
• Deleted machine model (MM) in *ESD Ratings*	3
• Updated *Thermal Information*	3
• Updated parameter names and table format in all *Electrical Characteristics*	4
• Added missing temperature range for input offset voltage drift in all *Electrical Characteristics*	4
• Changed power-supply rejection ratio from 50dB to 45dB for LMC7101A	4
• Changed power-supply rejection ratio from 50dB to 45dB for LMC7101A	4
• Changed input common-mode voltage condition from CMRR ≥ 50dB to CMRR ≥ 47dB	4
• Changed CMRR MIN from 50dB to 47dB for LMC7101B and from 55dB to 47dB for LMC7101A	4
• Deleted notes 1 and 2 in all *Electrical Characteristics*	4
• Updated note 3 to move information into slew rate test conditions	4
• Changed input common-mode voltage condition from CMRR > 50dB to CMRR > 47dB	5
• Changed CMRR MIN from 60dB to 47dB for LMC7101B and from 64dB to 47dB for LMC7101A	5
• Added missing quiescent current per amplifier TYP value	5

- Changed CMRR TYP from 82dB to 75dB....6
- Changed CMRR MIN from 60dB to 52dB for LMC7101B and from 65dB to 52dB for LMC7101A....6
- Changed CMRR MIN for TJ = –40°C to +85°C from 55dB to 51dB for LMC7101B and from 60dB to 51dB for LMC7101A....6
- Changed CMRR TYP for TJ = –40C to +85C from 82dB to 74dB....6
- Changed input offset voltage TYP from 0.11mV to 0.26mV....8
- Changed CMRR MIN from 65dB to 62dB for LMC7101B and from 70dB to 62dB for LMC7101A....8
- Changed CMRR MIN for T_J = –40°C to +85°C from 65dB to 60dB LMC7101A....8
- Deleted note 3 and included information to open-loop voltage gain test conditions....8
- Deleted Figures 6, 11, 14, 17, 20, 23, and 37....10
- Added Figure 5-6....10
- Added Figures 5-21 and 5-25....14

10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LMC7101AIM5X/NOPB	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 85	A00A
LMC7101AIM5X/NOPB.A	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	A00A
LMC7101AIM5X/NOPB.B	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	A00A
LMC7101BIM5X/NOPB	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 85	A00B
LMC7101BIM5X/NOPB.A	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	A00B
LMC7101BIM5X/NOPB.B	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	A00B

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

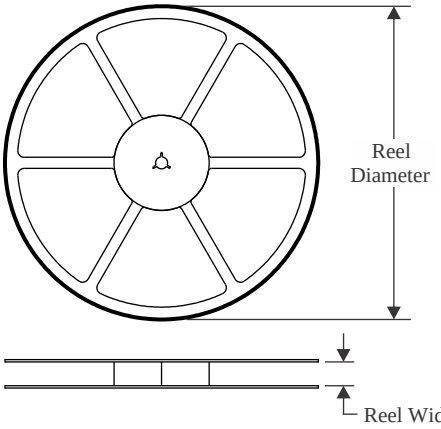
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

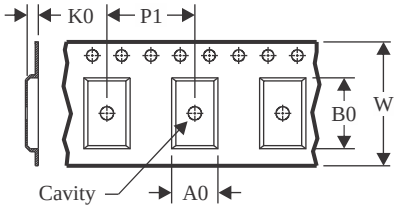
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

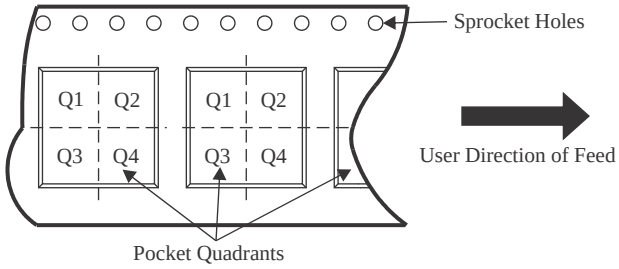


TAPE DIMENSIONS



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

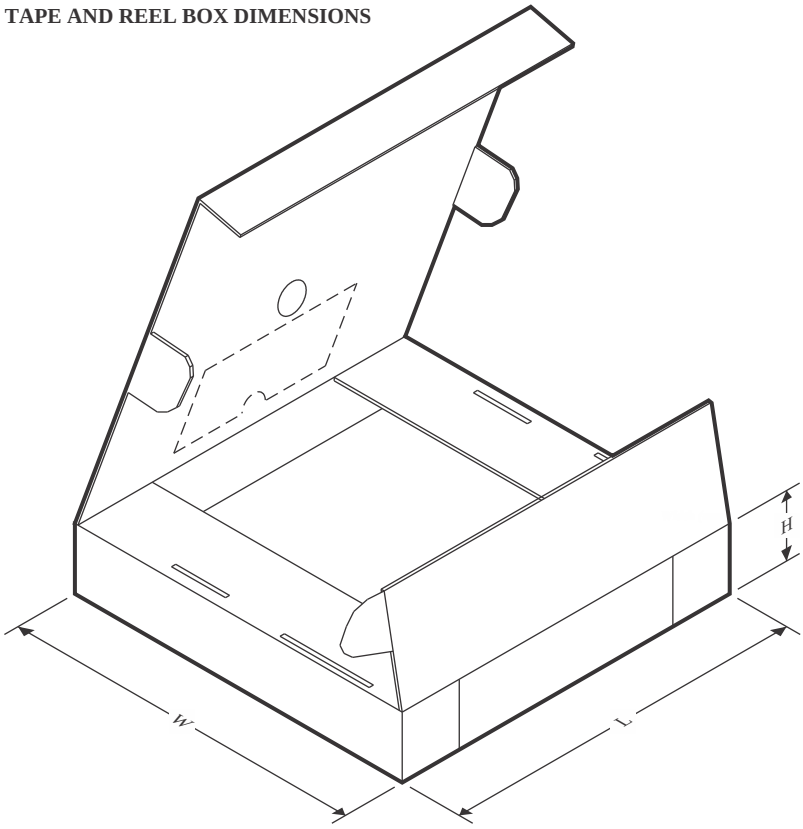
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
LMC7101AIM5X/NOPB	SOT-23	DBV	5	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMC7101AIM5X/NOPB	SOT-23	DBV	5	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMC7101AIM5X/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMC7101BIM5X/NOPB	SOT-23	DBV	5	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMC7101BIM5X/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMC7101BIM5X/NOPB	SOT-23	DBV	5	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

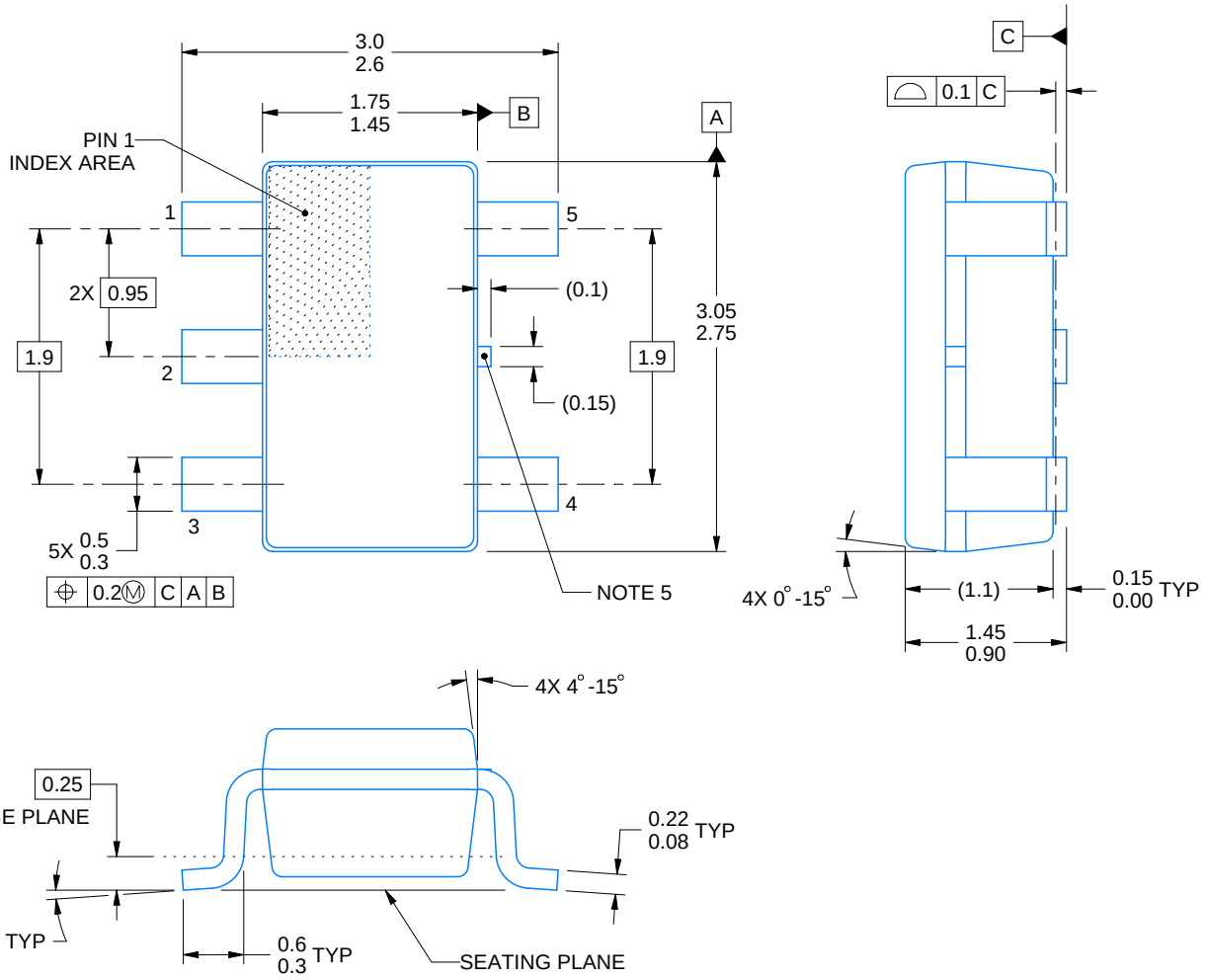
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMC7101AIM5X/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0
LMC7101AIM5X/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0
LMC7101AIM5X/NOPB	SOT-23	DBV	5	3000	208.0	191.0	35.0
LMC7101BIM5X/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0
LMC7101BIM5X/NOPB	SOT-23	DBV	5	3000	208.0	191.0	35.0
LMC7101BIM5X/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0

PACKAGE OUTLINE

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



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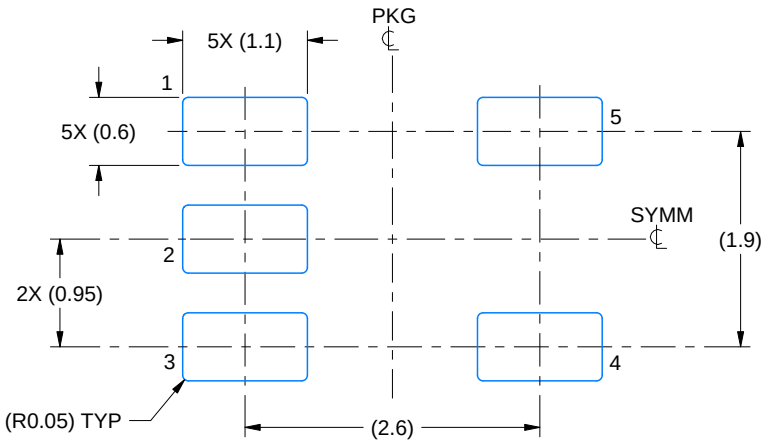
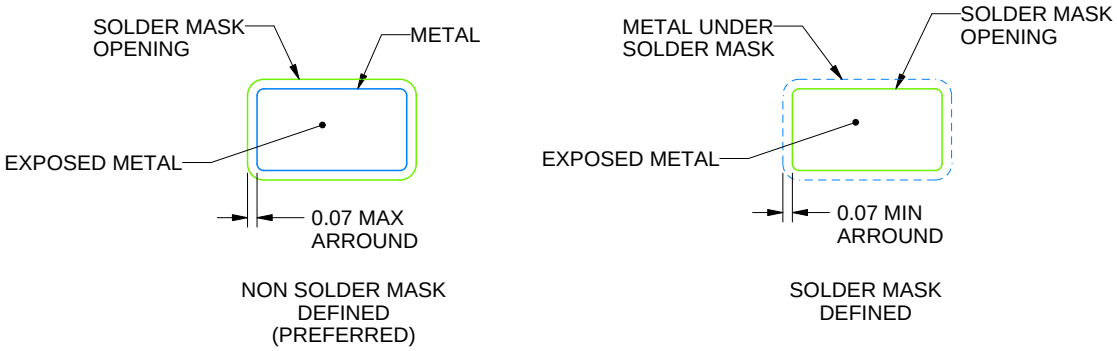
NOTES:

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-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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

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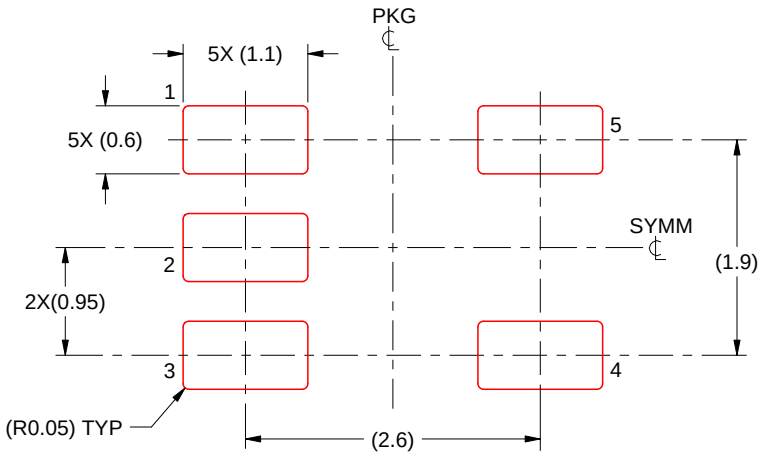
NOTES: (continued)

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 mm THICK STENCIL
SCALE:15X

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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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