

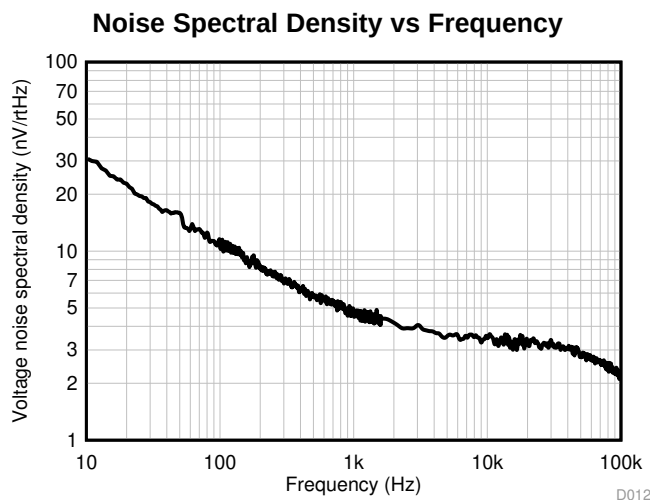
TLV6741, TLV6742, TLV6744 10-MHz, Low Broadband Noise, RRO, Operational Amplifier

1 Features

- Low broadband noise: $3.5 \text{ nV}/\sqrt{\text{Hz}}$
- Gain bandwidth: 10 MHz
- Low input bias current: $\pm 3 \text{ pA}$
- Low offset voltage: 0.15 mV
- Low offset voltage drift: $\pm 0.2 \text{ } \mu\text{V}/^\circ\text{C}$
- Rail-to-rail output
- Unity-gain stable
- Low I_Q :
 - TLV6741: 890 $\mu\text{A}/\text{ch}$
 - TLV6742/4: 990 $\mu\text{A}/\text{ch}$
- Wide supply range:
 - TLV6741: 2.25 V to 5.5 V
 - TLV6742/4: 1.7 V to 5.5 V
- Robust EMIRR performance: 71 dB at 2.4 GHz

2 Applications

- Portable hard disk drives
- Wearable consumer applications
- Audio preamplifiers
- Photodiode amplifiers
- ADC input-driver amplifiers
- Precision sensor front-ends
- Wireless metering
- Handheld test equipment
- Test and measurement equipment
- Active filters



3 Description

The TLV674x family includes single (TLV6741), dual (TLV6742), and quad-channel (TLV6744) general-purpose CMOS operational amplifiers (op amp) that provide a low noise figure of $3.5 \text{ nV}/\sqrt{\text{Hz}}$ and a wide bandwidth of 10 MHz. The low noise and wide bandwidth make the TLV674x family of devices attractive for a variety of precision applications that require a good balance between cost and performance. Additionally, the input bias current of the TLV674x family supports applications with high source impedance.

The robust design of the TLV674x family provides ease-of-use to the circuit designer due to its unity-gain stability, integrated RFI/EMI rejection filter, no phase reversal in overdrive conditions and high electrostatic discharge (ESD) protection (2-kV HBM). Additionally, the resistive open-loop output impedance makes them easy to stabilize with much higher capacitive loads.

This op amp family is optimized for low-voltage operation as low as 2.25 V ($\pm 1.125 \text{ V}$) for the TLV6741 and 1.7 V ($\pm 0.85 \text{ V}$) for the TLV6742 and TLV6744. All of the devices operate up to 5.5 V ($\pm 2.75 \text{ V}$), and are specified over the temperature range of -40°C to 125°C .

The single-channel TLV6741 is available in a small-size SC70-5 package. The dual-channel TLV6742 is available in multiple package options including a tiny $1.5 \text{ mm} \times 2.0 \text{ mm}$ X2QFN package.

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TLV6741	SC70 (5)	1.25 mm × 2.00 mm
TLV6742	SOIC (8)	3.91 mm × 4.90 mm
	TSSOP (8) ⁽²⁾	3.00 mm × 4.40 mm
	VSSOP (8) ⁽²⁾	3.00 mm × 3.00 mm
	SOT-23 (8) ⁽²⁾	1.60 mm × 2.90 mm
	WSON (8) ⁽²⁾	2.00 mm × 2.00 mm
	X2QFN (10) ⁽²⁾	1.50 mm × 2.00 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

(2) Package is for preview only.



Table of Contents

1 Features	1	8.4 Device Functional Modes	31
2 Applications	1	9 Application and Implementation	32
3 Description	1	9.1 Application Information	32
4 Revision History	2	9.2 Single-Supply Electret Microphone Preamplifier With Speech Filter	32
5 Device Comparison Table	3	10 Power Supply Recommendations	35
6 Pin Configuration and Functions	4	11 Layout	35
7 Specifications	6	11.1 Layout Guidelines	35
7.1 Absolute Maximum Ratings	6	11.2 Layout Example	36
7.2 ESD Ratings	6	12 Device and Documentation Support	38
7.3 Recommended Operating Conditions	6	12.1 Device Support	38
7.4 Thermal Information for Single Channel	6	12.2 Receiving Notification of Documentation Updates	38
7.5 Thermal Information for Dual Channel	7	12.3 Related Links	38
7.6 Electrical Characteristics	8	12.4 Community Resource	38
7.7 TLV6741: Typical Characteristics	11	12.5 Trademarks	38
7.8 TLV6742: Typical Characteristics	19	12.6 Electrostatic Discharge Caution	38
8 Detailed Description	26	12.7 Glossary	38
8.1 Overview	26	13 Mechanical, Packaging, and Orderable Information	38
8.2 Functional Block Diagram	26		
8.3 Feature Description	26		

4 Revision History

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

Changes from Revision D (January 2019) to Revision E	Page
• Added I_Q definition for TLV6742 and TLV744 in <i>Features</i> section	1
• Added EMIRR, Supply Range, I_Q , and Offset Voltage Drift to <i>Features</i> section	1
• Changed Noise Spectral Density vs Frequency plot on front page to the TLV6742 and TLV6744 noise plot	1
• Changed wording of <i>Description</i> section to incorporate release of TLV6742 and TLV6744 devices	1
• Changed TLV6742 packages in <i>Device Information</i>	1
• Added <i>Device Comparison Table</i> section	3
• Added note regarding single supply operation to Pin Functions: TLV6741 table	4
• Added pin out drawings for TLV6742 packages in <i>Pin Configuration and Functions</i> section	4
• Added pin functions for TLV6742 packages	4
• Added X2QFN Package Drawing and Pin Functions for TLV6742S in <i>Pin Configuration and Functions</i> section	5
• Changed combined the TLV6741 and TLV6742 <i>Absolute Maximum Ratings</i> , <i>ESD Ratings</i> , <i>Recommended Operating Conditions</i> , <i>Thermal Information</i> , and <i>Electrical Characteristics</i> in the <i>Specifications</i> section	6
• Added TLV6742 typical characteristic graphs in the <i>Specifications</i> section	18
• Changed wording throughout <i>Detailed Description</i> section to incorporate addition of TLV6742 and TLV6744 devices	26
• Added <i>EMI Rejection</i> section with description information to <i>Detailed Description</i> section	27
• Added <i>Electrical Overstress</i> section and diagram to <i>Detailed Description</i> section	28
• Added <i>Typical Specification and Distributions</i> section to <i>Detailed Description</i> section	29
• Added <i>Shutdown Function</i> section with description for TLV6742S to <i>Detailed Description</i> section	30
• Added <i>Packages With an Exposed Thermal Pad</i> section to <i>Detailed Description</i> section	30
• Changed wording in <i>Application and Implementation</i> section to include the addition of TLV6742 and TLV6744	32
• Added TLV6742 and TLV6744 information to <i>Power Supply Recommendations</i> section	35
• Added Dual channel layout example in the <i>Layout</i> section	37

Changes from Revision C (October 2017) to Revision D
Page

- Changed Operating temperature from 125 to 150 in *Absolute Maximum Ratings* 6
- Added Junction temperature spec to *Absolute Maximum Ratings*..... 6

Changes from Revision B (October 2017) to Revision C
Page

- Added test conditions to input offset voltage parameter in *Electrical Characteristics* table 8
- Changed typical input current noise density value from 2 fA $\sqrt{\text{Hz}}$ to 23 fA $\sqrt{\text{Hz}}$ 8
- Changed total supply voltage total from 5V to 5.5V in *Electrical Characteristics* condition statement 8
- Deleted "Vs = 2.25 V to 5.5 V" test conditions for common-mode rejection ratio parameter in *Electrical Characteristics* 8
- Added [Table 1](#) 10
- Deleted "C_L = 0" test condition from [Figure 25](#) and [Figure 26](#), [Figure 27](#) and [Figure 28](#) 15
- Changed voltage step from 5 V to 2 V in [Figure 32](#) 16

Changes from Revision A (September 2017) to Revision B
Page

- Changed Human-body model (HBM) value from: ± 1000 to ± 3000 and Charged-device mode (CDM) value from ± 250 to ± 1000 6

Changes from Original (June 2017) to Revision A
Page

- Changed device document status from: Advance Information to: Production Data..... 1

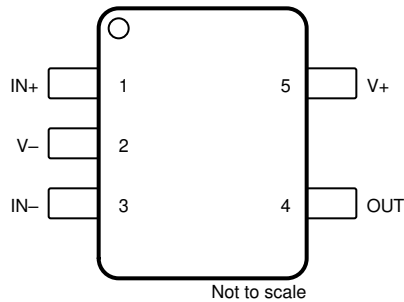
5 Device Comparison Table

DEVICE	NO. OF CHANNELS	PACKAGE LEADS						
		SOIC D	SC-70 DCK	VSSOP ⁽¹⁾ DGK	WSON ⁽¹⁾ DSG	TSSOP ⁽¹⁾ PW	SOT-23 ⁽¹⁾ DDF	X2QFN ⁽¹⁾ RUG
TLV6741	1	—	5	—	—	—	—	—
TLV6742	2	8	—	8	8	8	8	—
		—	—	—	—	—	—	10

(1) Package is preview only.

6 Pin Configuration and Functions

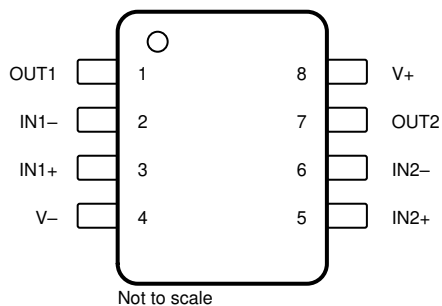
**TLV6741 DCK Package
5-Pin SC70
Top View**



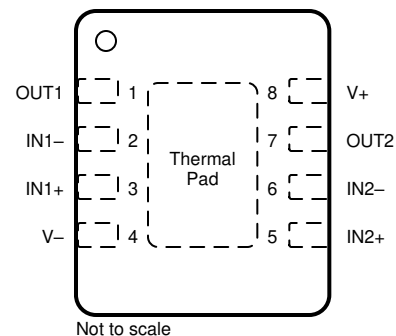
Pin Functions: TLV6741

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

**TLV6742 D, DGK, PW, DDF Packages
8-Pin SOIC, VSSOP, TSSOP, SOT-23
Top View**



**TLV6742 DSG Package
8-Pin WSON With Exposed Thermal Pad
Top View**



Connect thermal pad to V–. See [Packages With an Exposed Thermal Pad](#) for more information.

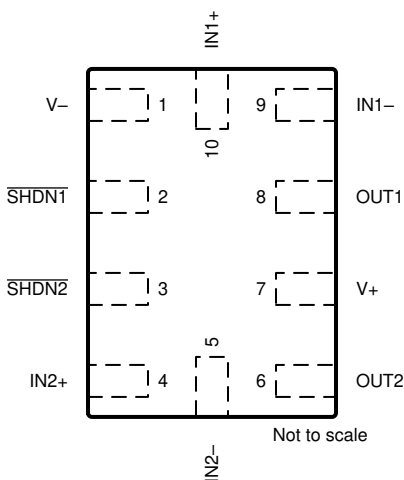
Pin Functions: TLV6742

PIN		I/O	DESCRIPTION
NAME	NO.		
IN1–	2	I	Inverting input, channel 1
IN1+	3	I	Noninverting input, channel 1
IN2–	6	I	Inverting input, channel 2
IN2+	5	I	Noninverting input, channel 2
OUT1	1	O	Output, channel 1
OUT2	7	O	Output, channel 2
V–	4	—	Negative (lowest) supply or ground (for single-supply operation)

Pin Functions: TLV6742 (continued)

PIN		I/O	DESCRIPTION
NAME	NO.		
V+	8	—	Positive (highest) supply

**TLV6742S RUG Package
10-Pin X2QFN
Top View**


Pin Functions: TLV6742S

PIN		I/O	DESCRIPTION
NAME	X2QFN		
IN1–	9	I	Inverting input, channel 1
IN1+	10	I	Noninverting input, channel 1
IN2–	5	I	Inverting input, channel 2
IN2+	4	I	Noninverting input, channel 2
OUT1	8	O	Output, channel 1
OUT2	6	O	Output, channel 2
$\overline{\text{SHDN1}}$	2	I	Shutdown: low = amp disabled, high = amp enabled. Channel 1. See Shutdown Function section for more information.
$\overline{\text{SHDN2}}$	3	I	Shutdown: low = amp disabled, high = amp enabled. Channel 2. See Shutdown Function section for more information.
V–	1	I or —	Negative (lowest) supply or ground (for single-supply operation)
V+	7	I	Positive (highest) supply

7 Specifications

7.1 Absolute Maximum Ratings

over operating ambient temperature range (unless otherwise noted) ⁽¹⁾

		MIN	MAX	UNIT
Supply voltage, $V_S = (V+) - (V-)$		0	6	V
Signal input pins	Common-mode voltage ⁽²⁾	$(V-) - 0.5$	$(V+) + 0.5$	V
	Differential voltage ⁽²⁾		$V_S + 0.2$	V
	Current ⁽²⁾	-10	10	mA
Output short-circuit ⁽³⁾		Continuous		
Operating ambient temperature, T_A		-55	150	°C
Junction temperature, T_J			150	°C
Storage temperature, T_{stg}		-65	150	°C

- (1) Operating the device beyond the ratings listed under *Absolute Maximum Ratings* will cause permanent damage to the device. These are stress ratings only, based on process and design limitations, and this device has not been designed to function outside the conditions indicated under *Recommended Operating Conditions*. Exposure to any condition outside *Recommended Operating Conditions* for extended periods, including absolute-maximum-rated conditions, may affect device reliability and performance.
- (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	TLV6741: Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±3000	V
		TLV6742: Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±2000	
		All Devices: Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±1500	

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

7.3 Recommended Operating Conditions

over operating ambient temperature range (unless otherwise noted)

		MIN	MAX	UNIT
V_S	Supply voltage, $(V+) - (V-)$, for TLV6742 and TLV6744	1.7 ⁽¹⁾	5.5	V
V_S	Supply voltage, $(V+) - (V-)$, for TLV6741 only	2.25	5.5	V
V_I	Input voltage range	$(V-) - (V+) - 1.2$		V
T_A	Specified temperature	-40	125	°C

- (1) Operation between 1.7V and 1.8V is only recommended for $T_A = 0 - 85$ °C

7.4 Thermal Information for Single Channel

THERMAL METRIC ⁽¹⁾		TLV6741	UNIT
		DCK (SC70)	
		5 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	240.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	151.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	64	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	34.8	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	63.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	n/a	°C/W

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report [SPRA953C](#).

7.5 Thermal Information for Dual Channel

THERMAL METRIC ⁽¹⁾		TLV6742, TLV6742S						UNIT
		D ⁽²⁾ (SOIC)	DDF ⁽²⁾ (SOT-23-8)	DGK ⁽²⁾ (VSSOP)	DSG ⁽²⁾ (WSON)	PW ⁽²⁾ (TSSOP)	RUG ⁽²⁾ (X2QFN)	
		8 PINS	8 PINS	8 PINS	8 PINS	8 PINS	10 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	131.1	TBD	TBD	78.2	185.6	140.3	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	73.2	TBD	TBD	97.5	74.5	52.6	°C/W
R _{θJB}	Junction-to-board thermal resistance	74.5	TBD	TBD	44.6	116.3	69.7	°C/W
ψ _{JT}	Junction-to-top characterization parameter	24.4	TBD	TBD	4.7	12.6	1.0	°C/W
ψ _{JB}	Junction-to-board characterization parameter	73.3	TBD	TBD	44.6	114.6	67.5	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	n/a	TBD	TBD	19.8	n/a	n/a	°C/W

- (1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953C](#).
- (2) This package option is preview for TLV6742.

7.6 Electrical Characteristics

TLV6742/4 Specifications: $V_S = (V+) - (V-) = 1.8\text{ V to }5.5\text{ V}$ ($\pm 0.9\text{ V to } \pm 2.75\text{ V}$) at $T_A = 25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

TLV6741 Specifications: $V_S = (V+) - (V-) = 5.5\text{ V}$ at $T_A = 25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
OFFSET VOLTAGE							
V _{OS}	Input offset voltage	V _S = 5.0 V			±0.15	±1.0	mV
			T _A = −40°C to 125°C	TLV6742/4 ⁽¹⁾		±1.2	
dV _{OS} /dT	Input offset voltage drift		T _A = −40°C to 125°C	TLV6741 ⁽²⁾	±0.35		μV/°C
				TLV6742/4 ⁽¹⁾	±0.2		
PSRR	Input offset voltage versus power supply	V _{CM} = V−		TLV6741 ⁽²⁾	±0.32	±6.3	μV/V
		V _{CM} = V−		TLV6742/4 ⁽¹⁾	±0.7	±5.8	
	Channel separation	f = 20 kHz			130		dB
INPUT BIAS CURRENT							
I _B	Input bias current			TLV6741 ⁽²⁾	±10		pA
				TLV6742/4 ⁽¹⁾	±3		
I _{OS}	Input offset current			TLV6741 ⁽²⁾	±10		pA
				TLV6742/4 ⁽¹⁾	±0.5		
NOISE							
E _N	Input voltage noise	f = 0.1 to 10 Hz			1.2		μV _{PP}
					0.227		μV _{RMS}
e _N	Input voltage noise density	f = 10 Hz	TLV6742/4 ⁽¹⁾		30		nV/√Hz
		f = 1 kHz	TLV6741 ⁽²⁾		5.0		
			TLV6742/4 ⁽¹⁾		4.6		
		f = 10 kHz	TLV6741 ⁽²⁾		3.7		
			TLV6742/4 ⁽¹⁾		3.5		
i _N	Input current noise	f = 1 kHz			23		fA/√Hz
INPUT VOLTAGE RANGE							
V _{CM}	Common-mode voltage range				(V−)	(V+) -1.2	V
CMRR	Common-mode rejection ratio	(V−) < V _{CM} < (V+) − 1.2 V	TLV6741 ⁽²⁾	95	120		dB
		V _S = 1.8 V, (V−) < V _{CM} < (V+) − 1.2 V	TLV6742/4 ⁽¹⁾	87	100		
		V _S = 5.5, (V−) < V _{CM} < (V+) − 1.2 V		94	110		
INPUT CAPACITANCE							
Z _{ID}	Differential				10 6		MΩ pF
Z _{ICM}	Common-mode				10 6		GΩ pF
OPEN-LOOP GAIN							
A _{OL}	Open-loop voltage gain	(V−) + 40 mV < V _O < (V+) − 40 mV, R _L = 10 kΩ to V _S /2	TLV6741 ⁽²⁾		125		dB
		(V−) + 150 mV < V _O < (V+) − 150 mV, R _L = 2 kΩ to V _S /2		110	130		
		V _S = 1.8 V, (V−) + 150 mV < V _O < (V+) − 150 mV, R _L = 2 kΩ to V _S /2	TLV6742/4 ⁽¹⁾	107	120		
		V _S = 5.5 V, (V−) + 150 mV < V _O < (V+) − 150 mV, R _L = 2 kΩ to V _S /2			140		
		V _S = 1.8 V, (V−) + 40m V < V _O < (V+) − 40 mV, R _L = 10 kΩ to V _S /2		110	120		
		V _S = 5.5 V, (V−) + 40m V < V _O < (V+) − 40 mV, R _L = 10 kΩ to V _S /2			140		
FREQUENCY RESPONSE							
GBW	Gain-bandwidth product				10		MHz
SR	Slew rate	V _S = 5.5 V, G = +1, C _L = 20 pF			4.5		V/μs

(1) This electrical characteristic only applies to the dual-channel TLV6742 and quad-channel TLV6744

(2) This electrical characteristic only applies to the single-channel, TLV6741

Electrical Characteristics (continued)

TLV6742/4 Specifications: $V_S = (V+) - (V-) = 1.8\text{ V to }5.5\text{ V}$ ($\pm 0.9\text{ V to } \pm 2.75\text{ V}$) at $T_A = 25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

TLV6741 Specifications: $V_S = (V+) - (V-) = 5.5\text{ V}$ at $T_A = 25^\circ\text{C}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT	
t _S	Settling time	To 0.1%, V _S = 5.5 V, V _{STEP} = 2 V, G = +1, CL = 20pF			0.65		μS	
		To 0.01%, V _S = 5.5 V, V _{STEP} = 2 V, G = +1, CL = 20pF			1.2			
	Phase margin	G = +1, R _L = 10kΩ, C _L = 20 pF			55		°	
	Overload recovery time	V _{IN} × gain > V _S			0.2		μS	
THD+N	Total harmonic distortion + noise	V _S = 5.5 V, V _{CM} = 2.5 V, V _O = 1 V _{RMS} , G = +1, f = 1 kHz, R _L = 10 kΩ	TLV6741 ⁽²⁾		0.00035%			
			TLV6742/4 ⁽¹⁾		0.00015%			
EMIRR	Electro-magnetic interference rejection ratio	f = 1 GHz	TLV6742/4 ⁽¹⁾		51		dB	
OUTPUT								
	Voltage output swing from rail	Positive/Negative rail headroom	V _S = 5.5 V, R _L = 10k	TLV6741 ⁽²⁾		8	10	mV
		Positive rail headroom	V _S = 5.5 V, R _L = no load	TLV6742/4 ⁽¹⁾			7	
			V _S = 5.5 V, R _L = 2 kΩ				35	
			V _S = 5.5 V, R _L = 10 kΩ				5	
		Negative rail headroom	V _S = 5.5 V, R _L = no load				7	
			V _S = 5.5 V, R _L = 2 kΩ				35	
			V _S = 5.5 V, R _L = 10 kΩ				5	
		I _{SC}	Short-circuit current		TLV6742/4 ⁽¹⁾		±68	
C _{LOAD}	Capacitive load drive				See Figure 58			
Z _O	Open-loop output impedance	f = 10 MHz, I _O = 0 A	TLV6741 ⁽²⁾		160		Ω	
		f = 2 MHz, I _O = 0 A	TLV6742/4 ⁽¹⁾		165			
POWER SUPPLY								
I _Q	Quiescent current per amplifier	V _S = 5.5 V, I _O = 0 A	T _A = −40°C to 125°C	TLV6741 ⁽²⁾	890		μA	
								1100
			T _A = −40°C to 125°C	TLV6742/4 ⁽¹⁾	990	1200		
								1250
	Turn-On Time	At T _A = 25°C, V _S = 5.5 V, V _S ramp rate > 0.3 V/μs	TLV6742/4 ⁽¹⁾		10		μS	

Table 1. Table of TLV6741 Graphs

DESCRIPTION	FIGURE
Offset Voltage Production Distribution	Figure 1
Offset Voltage Drift Distribution	Figure 2
Offset Voltage vs Temperature	Figure 3
Offset Voltage vs Common-Mode Voltage	Figure 4
Offset Voltage vs Common-Mode Voltage	Figure 5
Offset Voltage vs Power Supply	Figure 6
I_B and I_{OS} vs Common-Mode Voltage	Figure 7
I_B and I_{OS} vs Temperature	Figure 8
Open-Loop Gain and Phase vs Frequency	Figure 9
Closed-Loop Gain vs Frequency	Figure 10
V_O vs I Sourcing and Sinking	Figure 11
PSRR vs Frequency (Referred to Input)	Figure 12
CMRR vs Frequency (Referred to Input)	Figure 13
CMRR vs Temperature	Figure 14
0.1-Hz to 10-Hz Flicker Noise	Figure 15
Input Voltage Noise Spectral Density vs Frequency	Figure 16
THD + Noise vs Frequency	Figure 17
THD + Noise vs Frequency	Figure 18
THD + Noise vs Amplitude	Figure 19
Quiescent Current vs Supply Voltage	Figure 20
Quiescent Current vs Temperature	Figure 21
Open-Loop Gain vs Temperature	Figure 22
Open-Loop Gain vs Output Voltage	Figure 23
Open-Loop Output Impedance vs Frequency	Figure 24
Small-Signal Overshoot vs Load Capacitance	Figure 25
Small-Signal Overshoot vs Load Capacitance	Figure 26
Small-Signal Overshoot vs Load Capacitance	Figure 27
Small-Signal Overshoot vs Load Capacitance	Figure 28
No Phase Reversal	Figure 29
Overload Recovery	Figure 30
Small-Signal Step Response	Figure 31
Large Signal Step Response	Figure 32
Large Signal Settling Time (Positive)	Figure 33
Large Signal Settling Time (Negative)	Figure 34
Short-Circuit Current vs Temperature	Figure 35
Maximum Output Voltage vs Frequency	Figure 36
Electromagnetic Interference Rejection Ratio Referred to Noninverting Input (EMIRR+) vs Frequency	Figure 37
Phase Margin vs Capacitive Load	Figure 38

7.7 TLV6741: Typical Characteristics

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

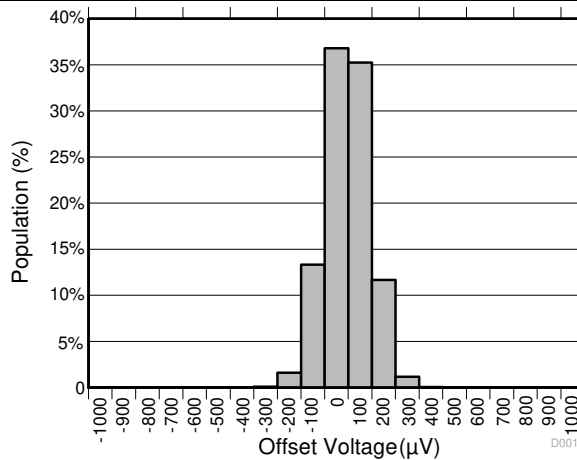


Figure 1. Offset Voltage Production Distribution

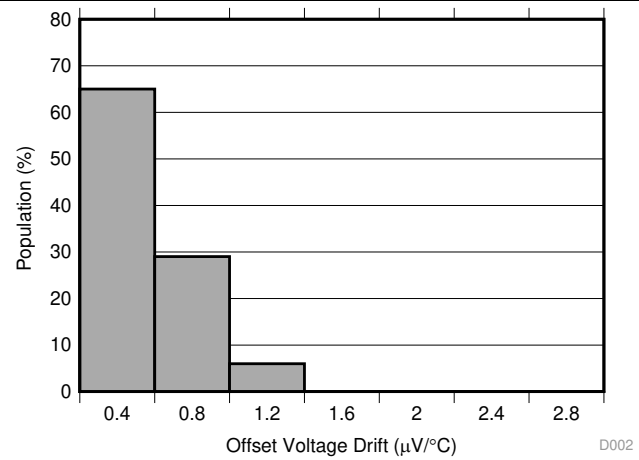


Figure 2. Offset Voltage Drift Distribution

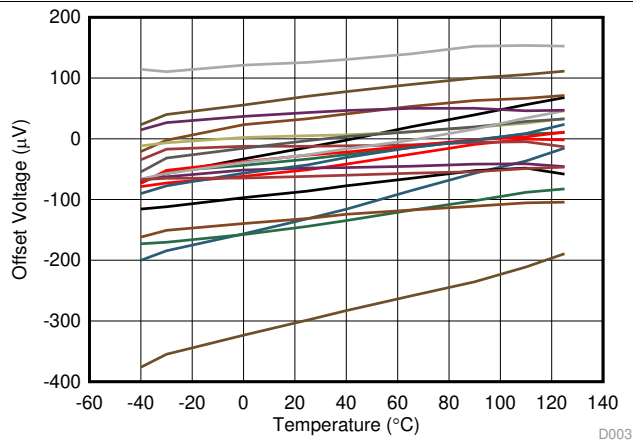


Figure 3. Offset Voltage vs Temperature

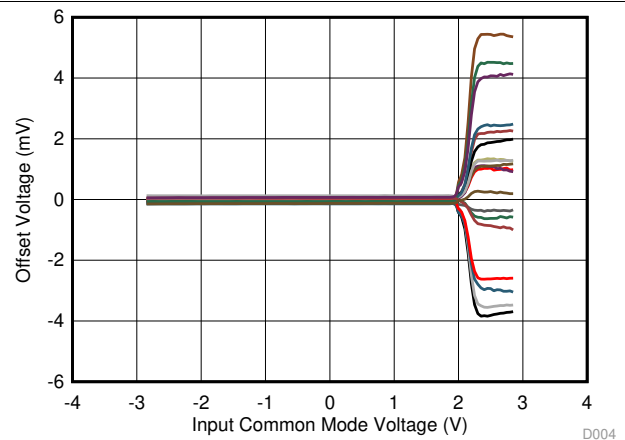


Figure 4. Offset Voltage vs Common-Mode Voltage

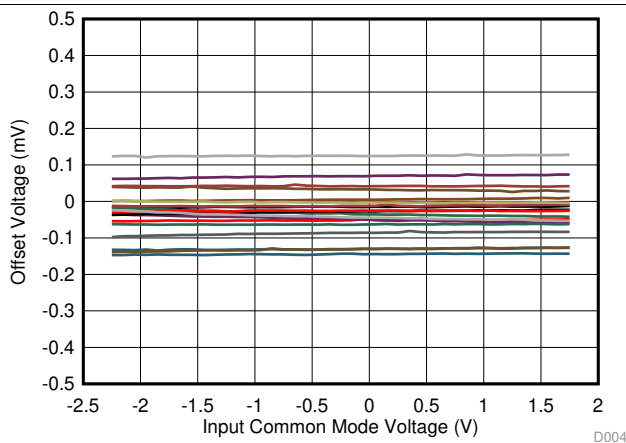


Figure 5. Offset Voltage vs Common-Mode Voltage

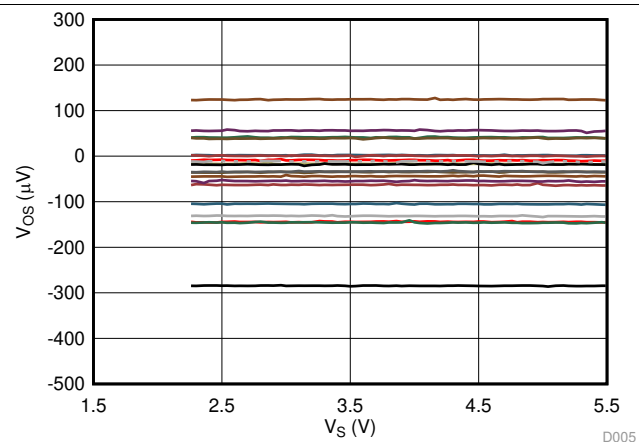


Figure 6. Offset Voltage vs Power Supply

TLV6741: Typical Characteristics (continued)

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

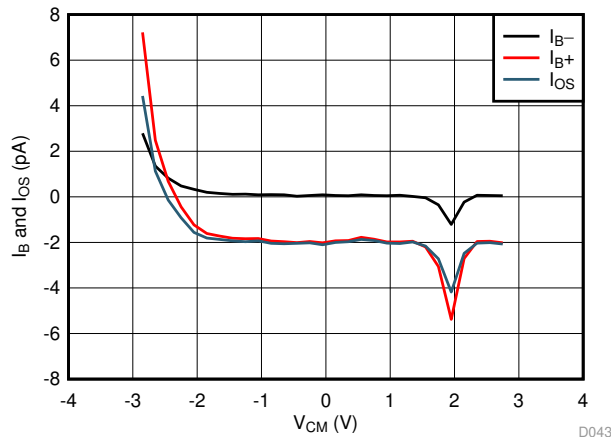


Figure 7. I_B and I_{OS} vs Common-Mode Voltage

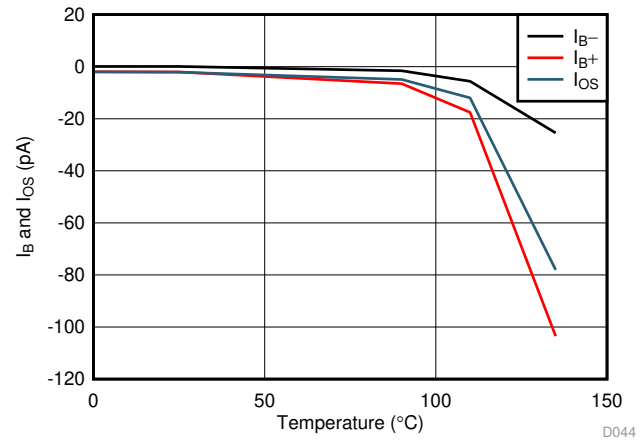


Figure 8. I_B and I_{OS} vs Temperature

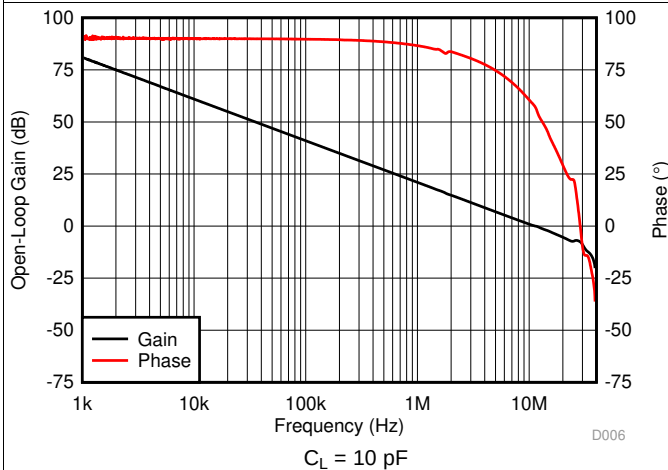


Figure 9. Open-Loop Gain and Phase vs Frequency

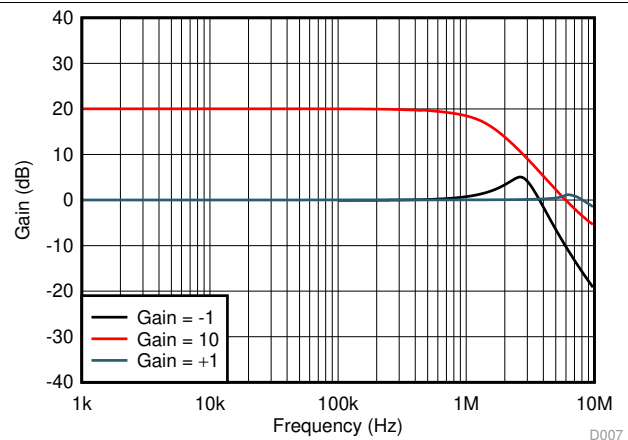


Figure 10. Closed-Loop Gain vs Frequency

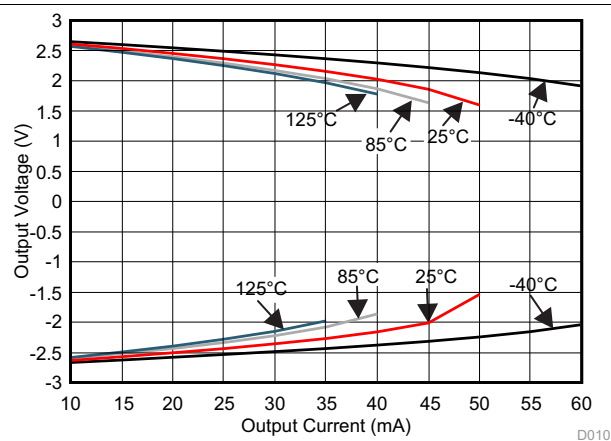


Figure 11. V_O vs I Sourcing and Sinking

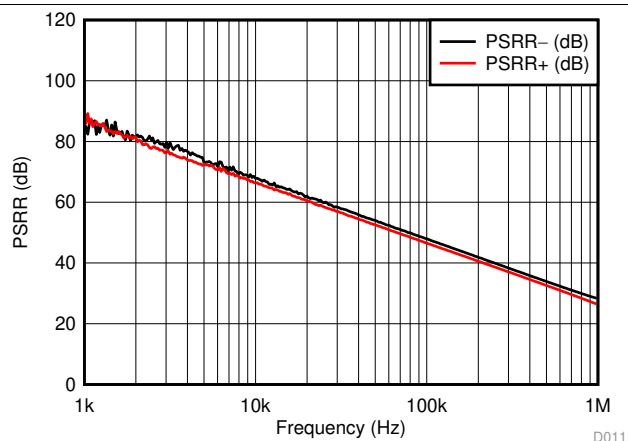


Figure 12. PSRR vs Frequency (Referred to Input)

TLV6741: Typical Characteristics (continued)

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

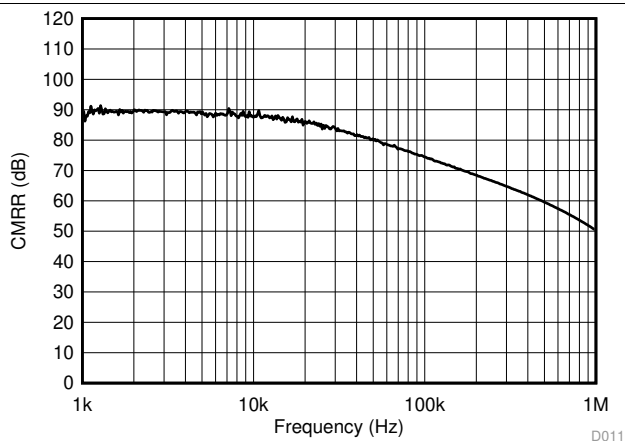


Figure 13. CMRR vs Frequency (Referred to Input)

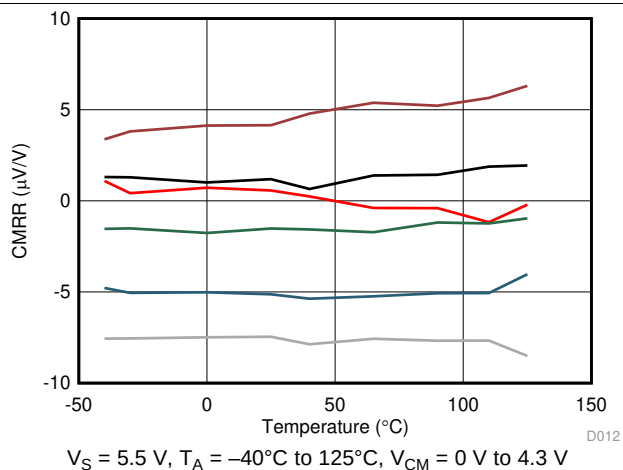


Figure 14. CMRR vs Temperature

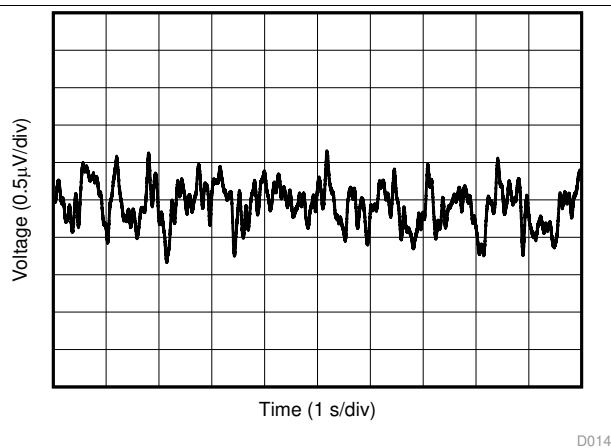


Figure 15. 0.1-Hz to 10-Hz Flicker Noise

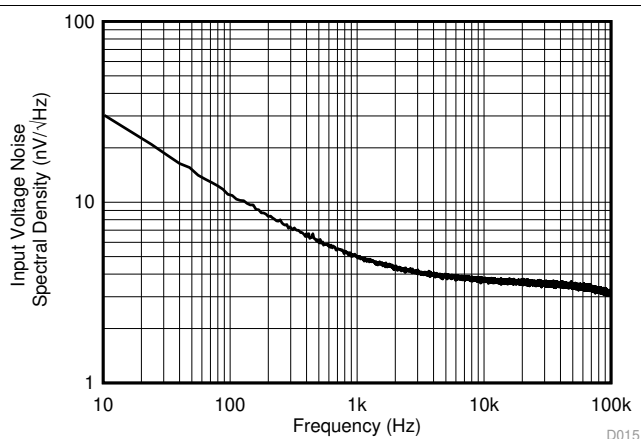


Figure 16. Input Voltage Noise Spectral Density vs Frequency

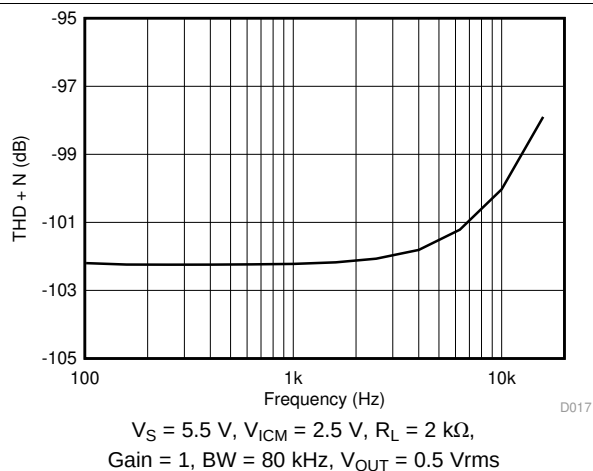


Figure 17. THD + N vs Frequency

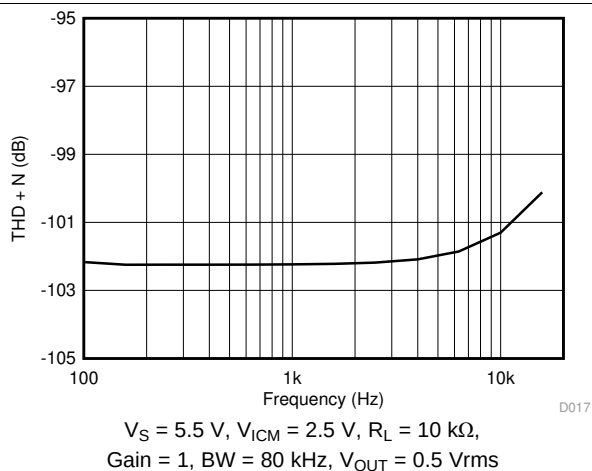


Figure 18. THD + N vs Frequency

TLV6741: Typical Characteristics (continued)

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

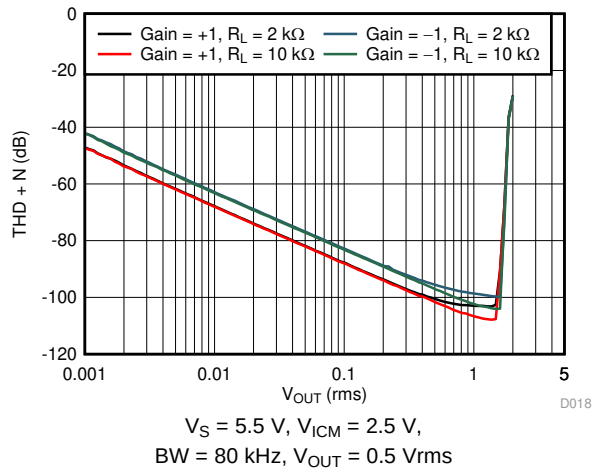


Figure 19. THD + N vs Amplitude

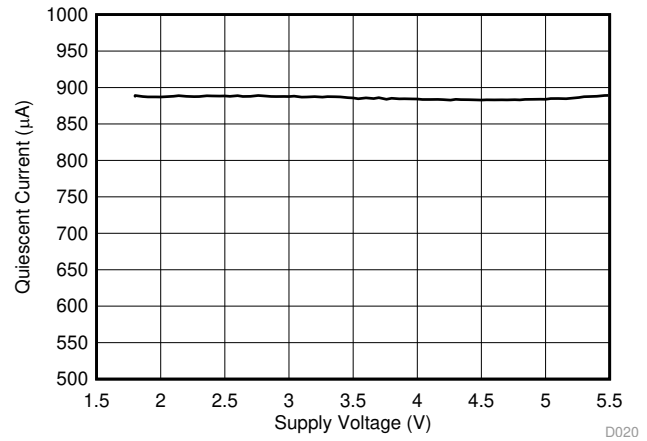


Figure 20. Quiescent Current vs Supply Voltage

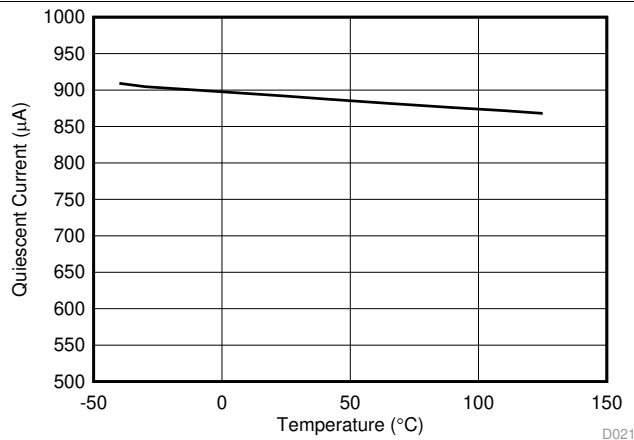


Figure 21. Quiescent Current vs Temperature

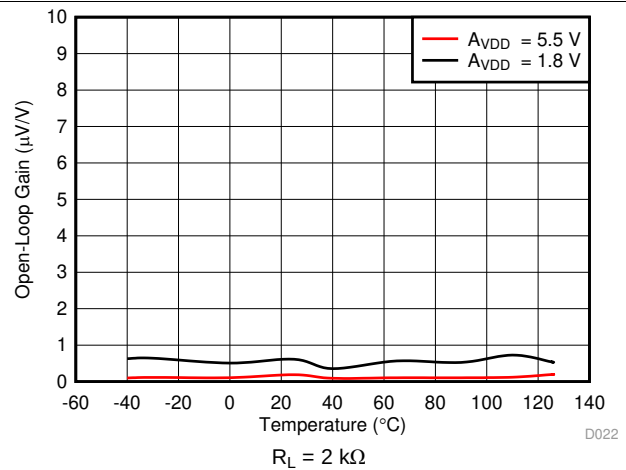


Figure 22. Open-Loop Gain vs Temperature

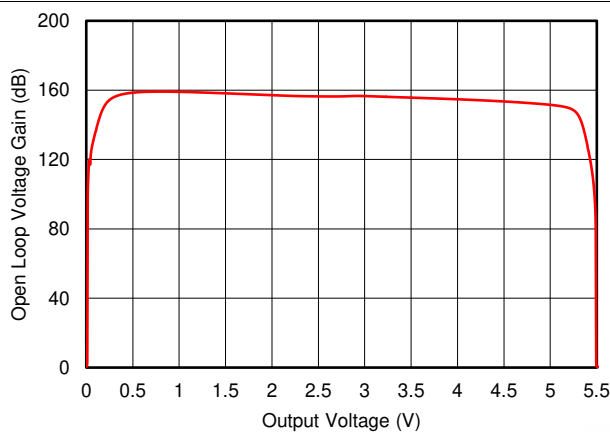


Figure 23. Open-Loop Gain vs Output Voltage

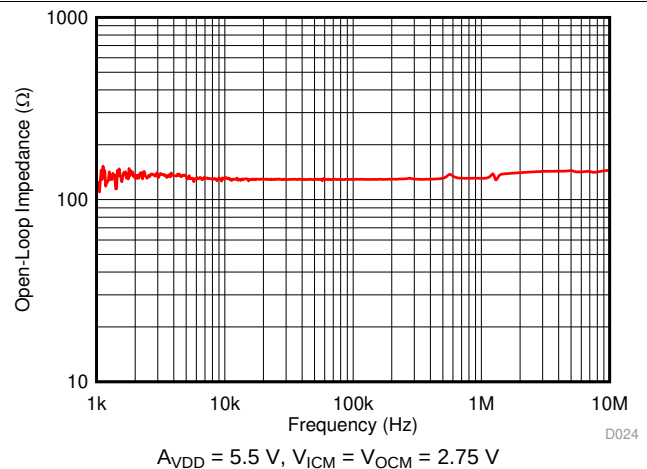


Figure 24. Open-Loop Output Impedance vs Frequency

TLV6741: Typical Characteristics (continued)

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

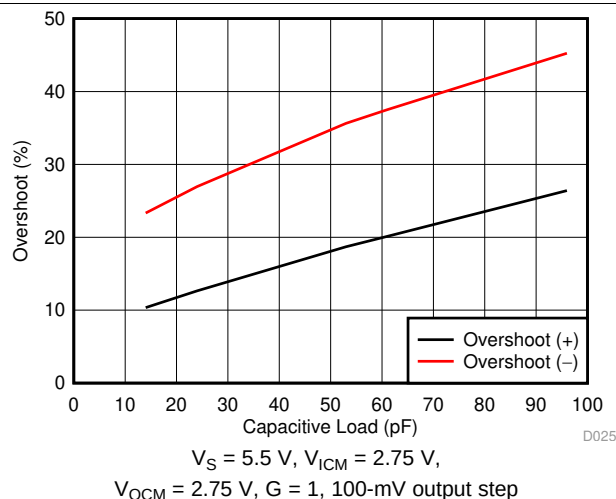


Figure 25. Small-Signal Overshoot vs Load Capacitance

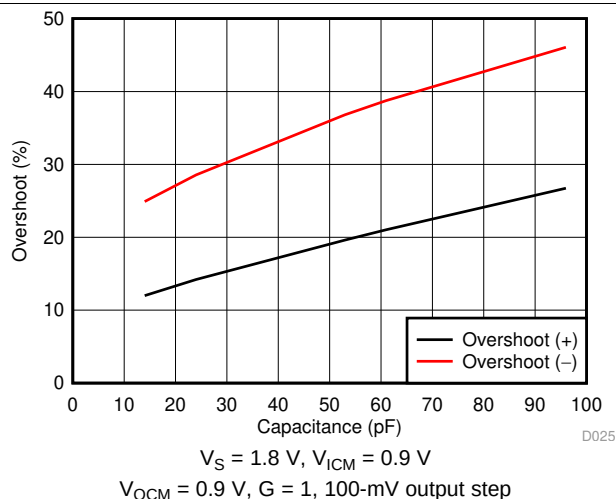


Figure 26. Small-Signal Overshoot vs Load Capacitance

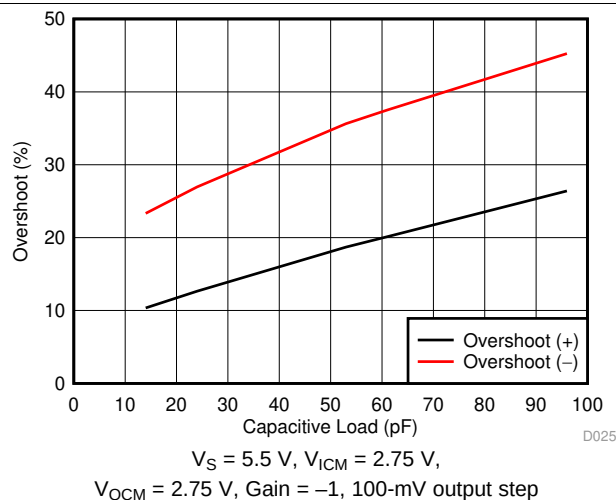


Figure 27. Small-Signal Overshoot vs Load Capacitance

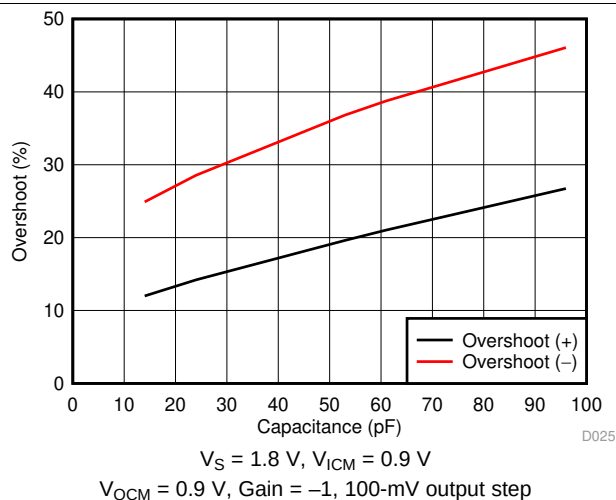


Figure 28. Small-Signal Overshoot vs Load Capacitance

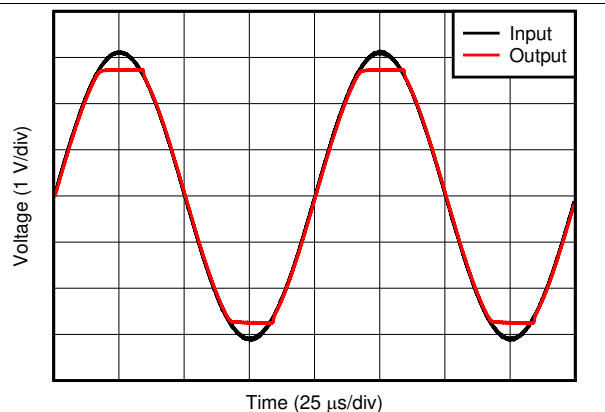


Figure 29. No Phase Reversal

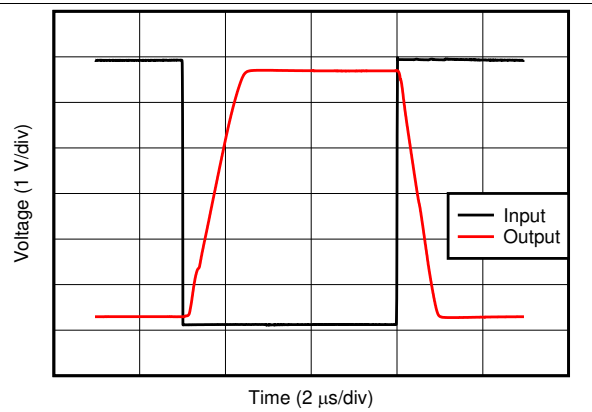
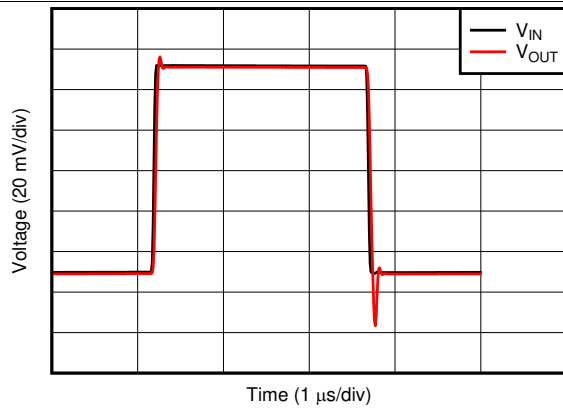


Figure 30. Overload Recovery

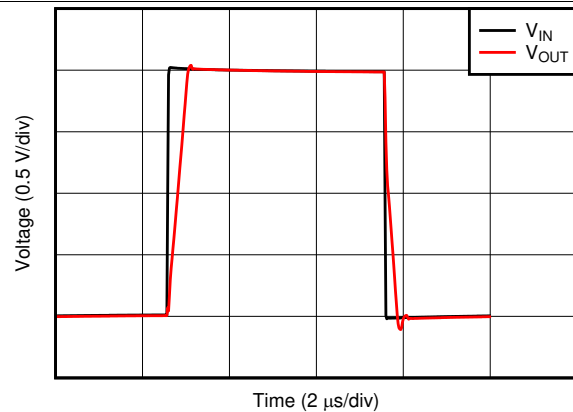
TLV6741: Typical Characteristics (continued)

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



$V_S = 1.8\text{ V}$, $V_{ICM} = 0.9\text{ V}$, $V_{OCM} = 0.9\text{ V}$
 $C_L = 30\text{ pF}$, Gain = 1, $V_{IN} = 100\text{-mVpp}$

Figure 31. Small-Signal Step Response



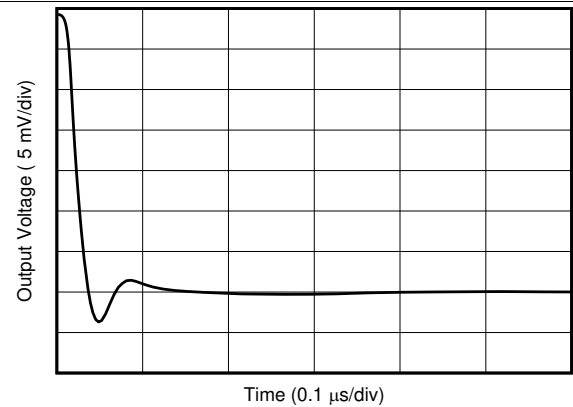
$V_S = 5.5\text{ V}$, $V_{OCM} = 2.75\text{ V}$, $C_L = 10\text{ pF}$
 $V_{ICM} = 2.75\text{ V}$, Gain = 1, 2-V step

Figure 32. Large Signal Step Response



$V_S = 5.5\text{ V}$, $V_{ICM} = 2.75\text{ V}$, $V_{OCM} = 2.75\text{ V}$
 $C_L = 0$, Gain = 1, 5-V step

Figure 33. Large Signal Settling Time (Positive)



$V_S = 5.5\text{ V}$, $V_{ICM} = 2.75\text{ V}$, $V_{OCM} = 2.75\text{ V}$
 $C_L = 0$, Gain = 1, 5-V step

Figure 34. Large Signal Settling Time (Negative)

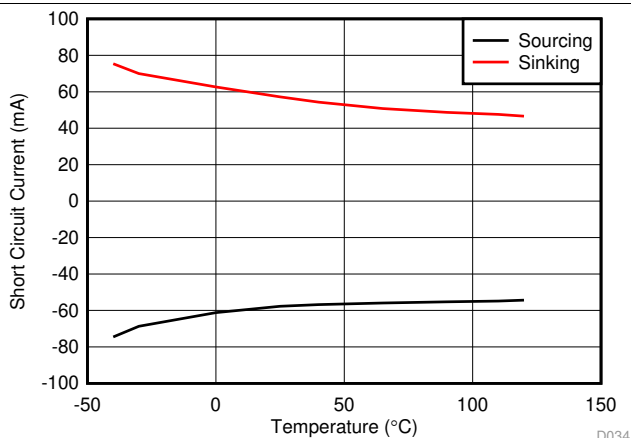
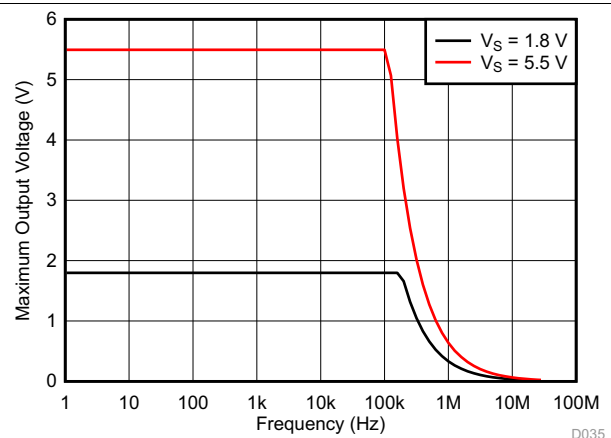


Figure 35. Short-Circuit Current vs Temperature



$V_{ICM} = V_S / 2$, $V_{OCM} = V_S / 2$,
 $C_L = 10\text{ pF}$, Gain = 1

Figure 36. Maximum Output Voltage vs Frequency

TLV6741: Typical Characteristics (continued)

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

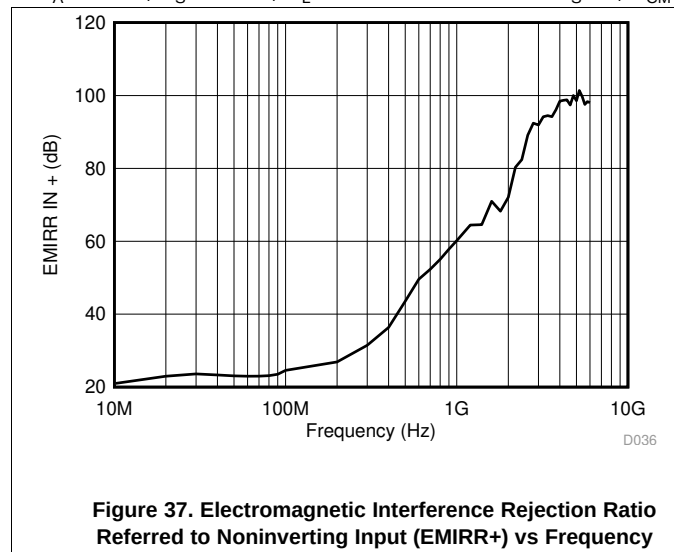
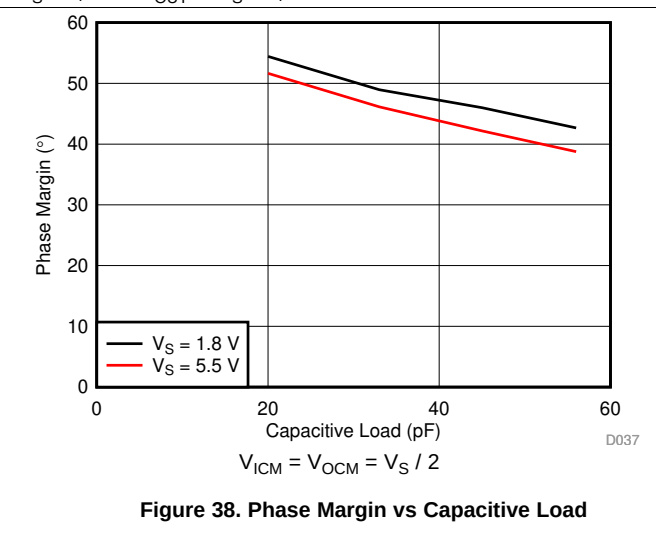


Table 2. Table of TLV6742 Graphs

DESCRIPTION	FIGURE
Offset Voltage Production Distribution	Figure 39
Offset Voltage Drift Distribution	Figure 40
Offset Voltage vs Temperature (PMOS Input Pair)	Figure 41
Offset Voltage vs Temperature (NMOS Input Pair)	Figure 42
Offset Voltage vs Common-Mode Voltage (Full Range)	Figure 43
Offset Voltage vs Common-Mode Voltage (PMOS Input Pair)	Figure 44
Offset Voltage vs Common-Mode Voltage (Transition Region)	Figure 45
Offset Voltage vs Power Supply	Figure 46
I_B and I_{OS} vs Common-Mode Voltage	Figure 47
I_B and I_{OS} vs Temperature	Figure 48
0.1-Hz to 10-Hz Flicker Noise	Figure 49
Input Voltage Noise Spectral Density vs Frequency	Figure 50
CMRR & PSRR vs Frequency (Referred to input)	Figure 51
CMRR vs Temperature	Figure 52
PSRR vs Temperature	Figure 53
Open-Loop Gain and Phase vs Frequency	Figure 54
Closed-Loop Gain vs Frequency	Figure 55
Open-Loop Gain vs Temperature	Figure 56
Open-Loop Gain vs Output Voltage	Figure 57
Phase Margin vs Capacitive Load	Figure 58
No Phase Reversal	Figure 59
Small-Signal Overshoot vs Load Capacitance	Figure 60
Small-Signal Overshoot vs Load Capacitance	Figure 61
Overload Recovery	Figure 62
Small-Signal Step Response	Figure 63
Small-Signal Step Response	Figure 64
Large Signal Step Response	Figure 65
Large Signal Step Response	Figure 66
Large Signal Settling Time (Positive)	Figure 67
Large Signal Settling Time (Negative)	Figure 68
THD + N vs Frequency	Figure 69
THD + N vs Amplitude	Figure 70
V_{OUT} vs Sourcing Current	Figure 71
V_{OUT} vs Sinking Current	Figure 72
Maximum Output Voltage vs Frequency	Figure 73
Short Circuit Current vs Temperature	Figure 74
Quiescent Current vs Supply Voltage	Figure 75
Quiescent Current vs Temperature	Figure 76
Open-Loop Output Impedance vs Frequency	Figure 77
Channel Separation vs Frequency	Figure 78
Electromagnetic Interference Rejection Ratio Referred to Noninverting Input (EMIRR+) vs Frequency	Figure 79
Turn-On Time	Figure 80

7.8 TLV6742: Typical Characteristics

at $T_A = 25^\circ\text{C}$, $V_S = \pm 2.75\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

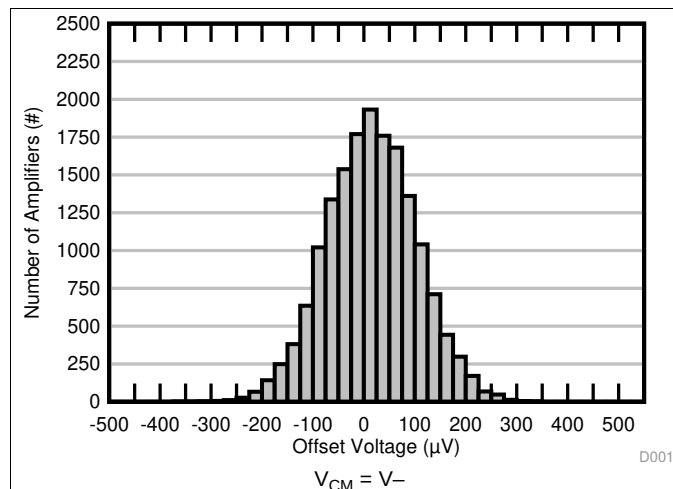


Figure 39. Offset Voltage Production Distribution

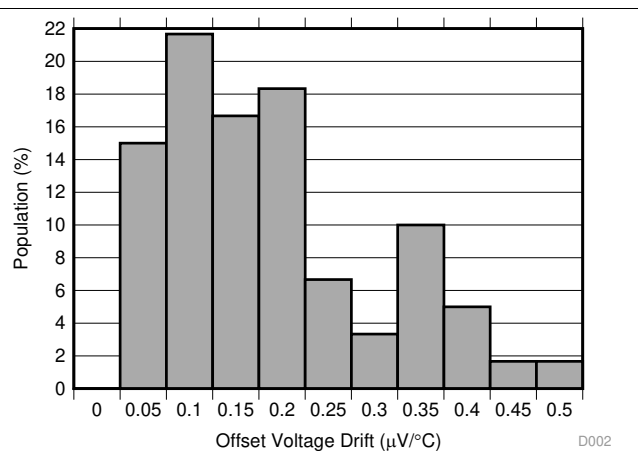


Figure 40. Offset Voltage Drift Distribution

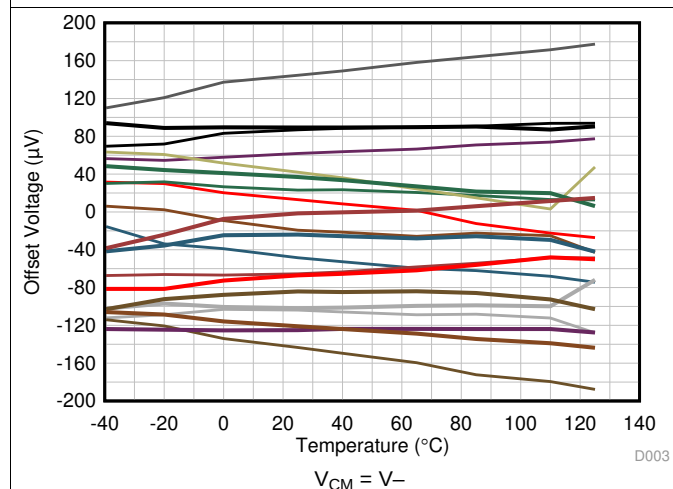


Figure 41. Offset Voltage vs Temperature (PMOS Input Pair)

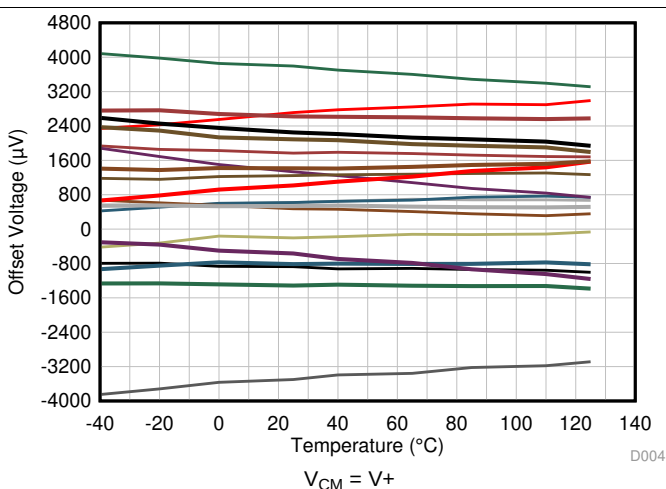


Figure 42. Offset Voltage vs Temperature (NMOS Input Pair)

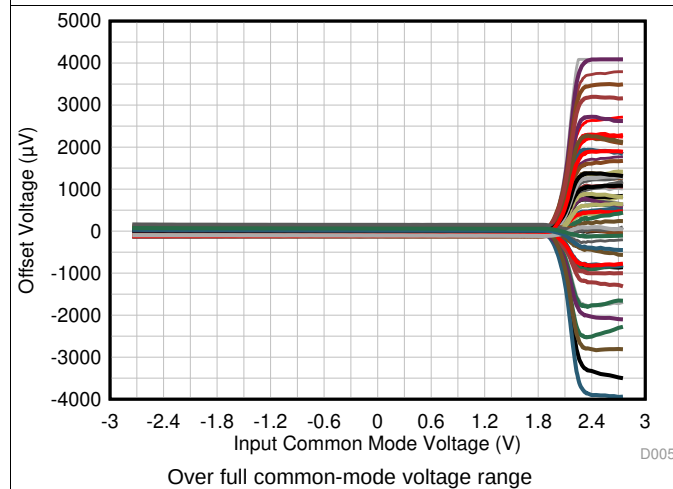


Figure 43. Offset Voltage vs Common-Mode Voltage (Full Range)

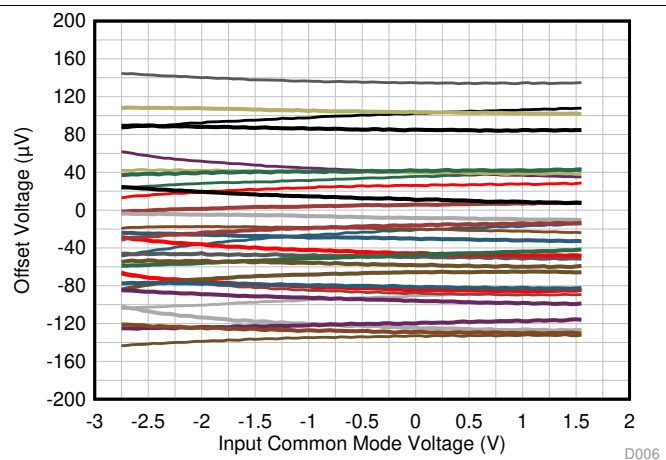


Figure 44. Offset Voltage vs Common-Mode Voltage (PMOS Input Pair)

TLV6742: Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = \pm 2.75\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

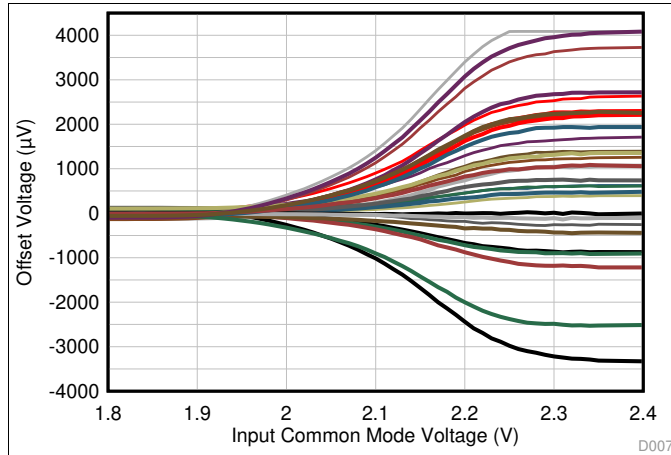


Figure 45. Offset Voltage vs Common-Mode Voltage (Transition Region)

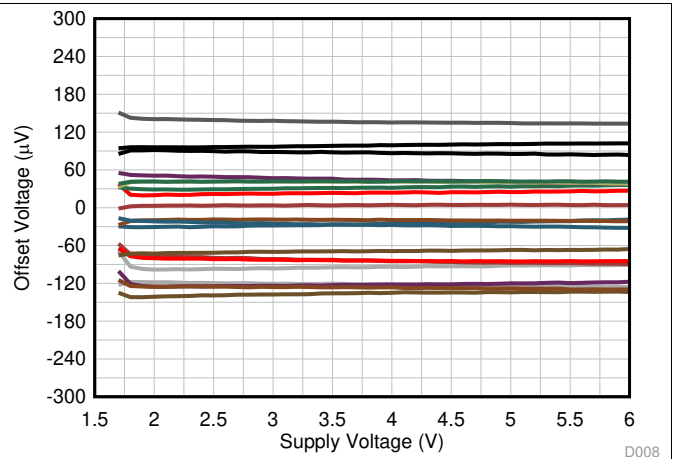


Figure 46. Offset Voltage vs Power Supply

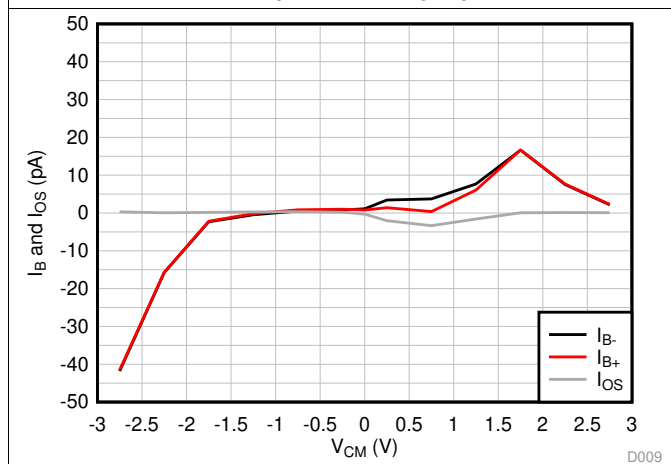


Figure 47. I_B and I_{OS} vs Common-Mode Voltage

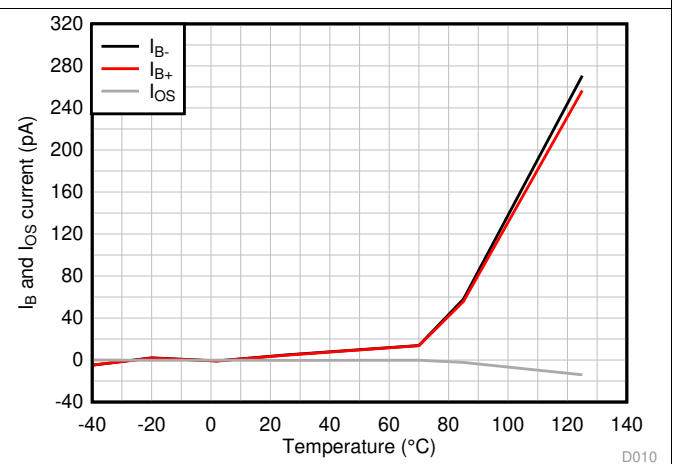


Figure 48. I_B and I_{OS} vs Temperature

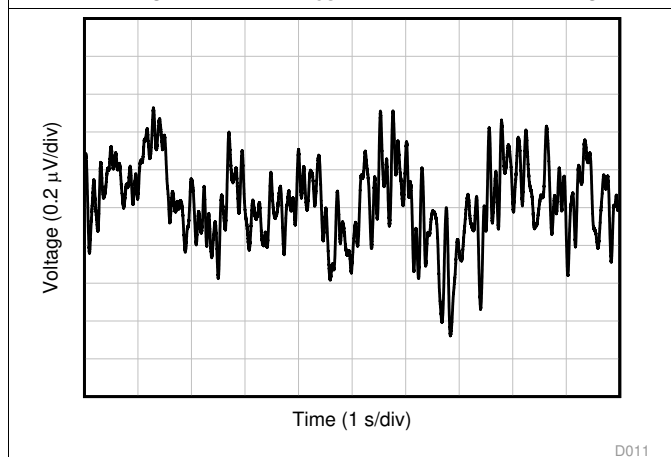


Figure 49. 0.1-Hz to 10-Hz Flicker Noise

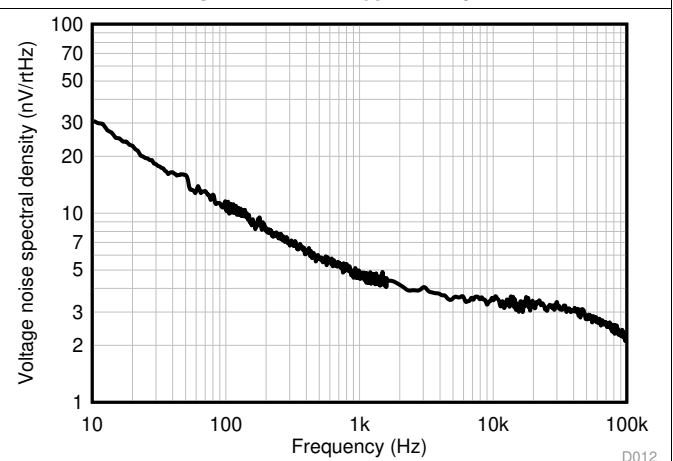


Figure 50. Input Voltage Noise Spectral Density vs Frequency

TLV6742: Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = \pm 2.75\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

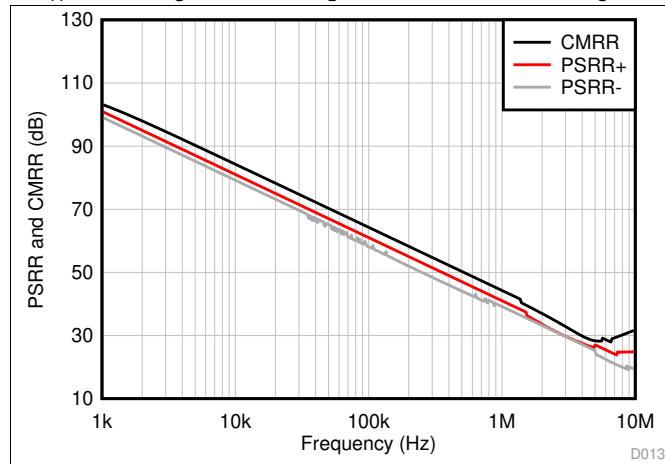


Figure 51. CMRR and PSRR vs Frequency (Referred to Input)

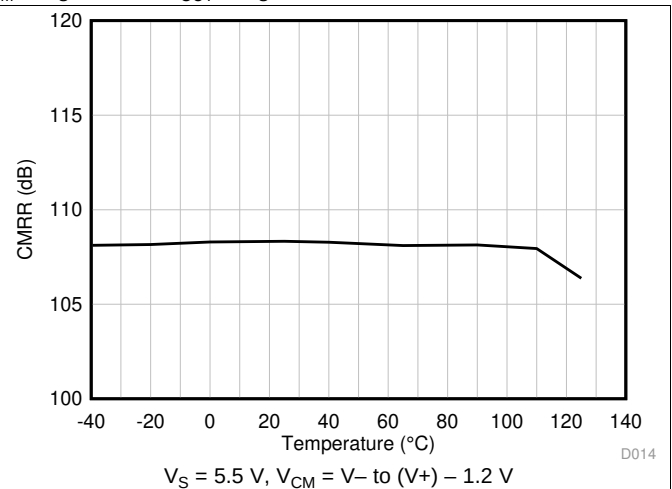


Figure 52. CMRR vs Temperature

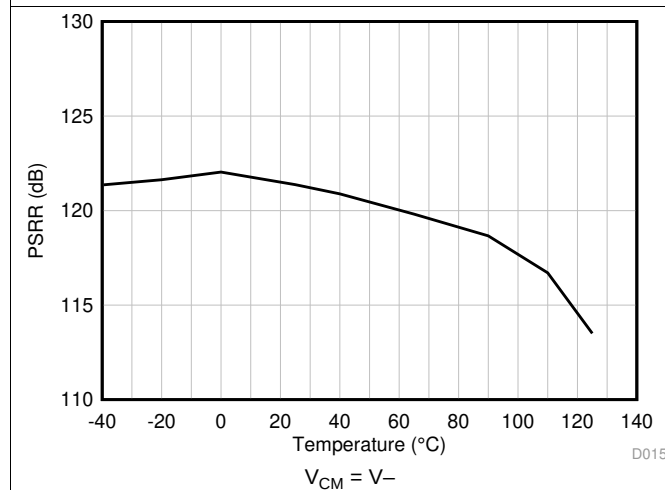


Figure 53. PSRR vs Temperature

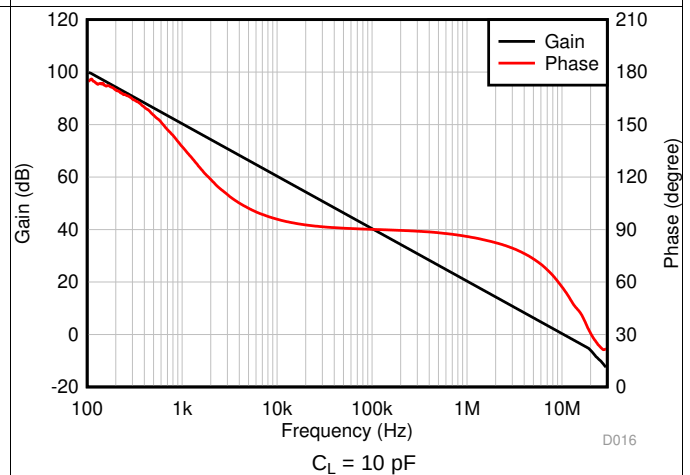


Figure 54. Open-Loop Gain and Phase vs Frequency

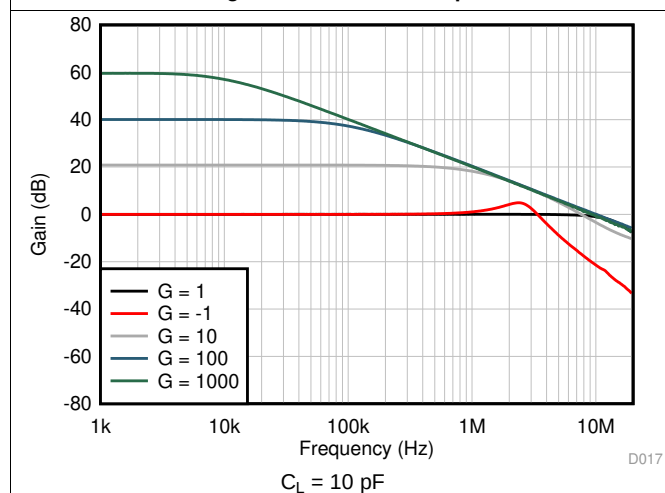


Figure 55. Closed-Loop Gain vs Frequency

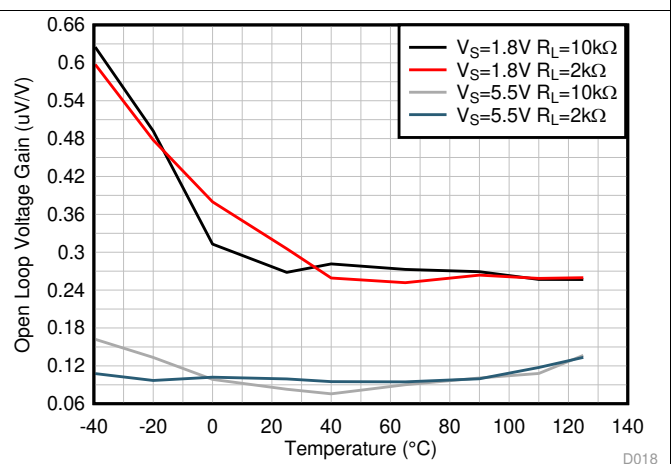


Figure 56. Open-Loop Gain vs Temperature

TLV6742: Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = \pm 2.75\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

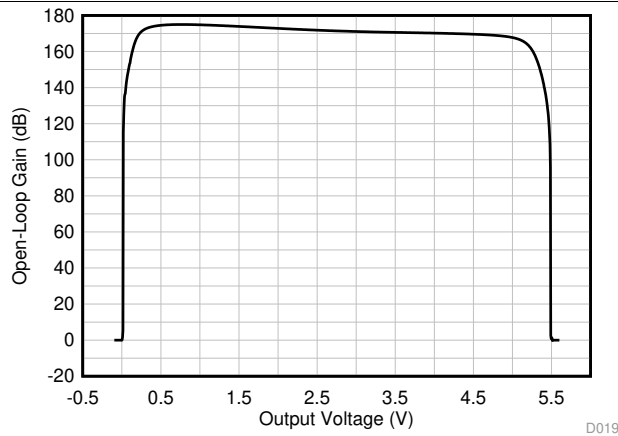


Figure 57. Open-Loop Gain vs Output Voltage

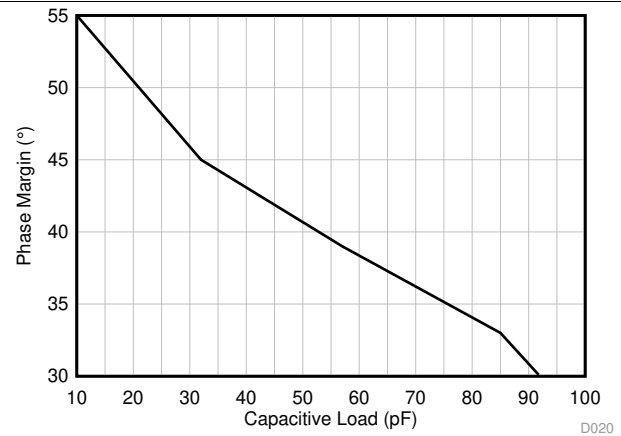


Figure 58. Phase Margin vs Capacitive Load

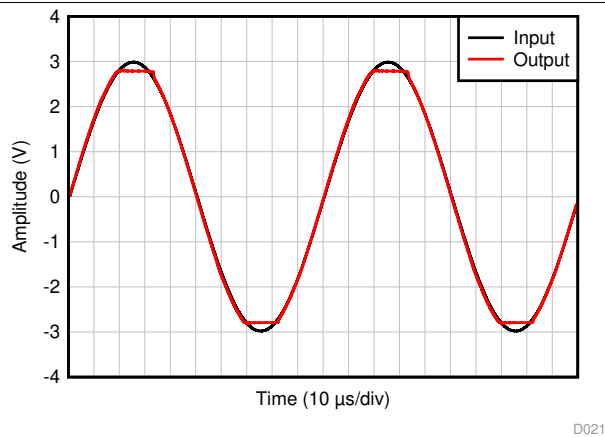


Figure 59. No Phase Reversal

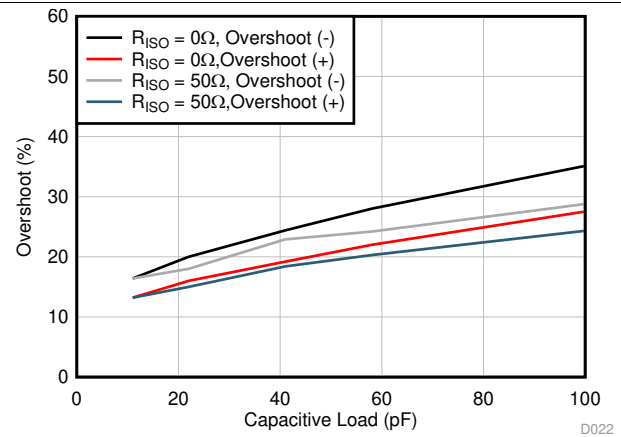


Figure 60. Small-Signal Overshoot vs Load Capacitance

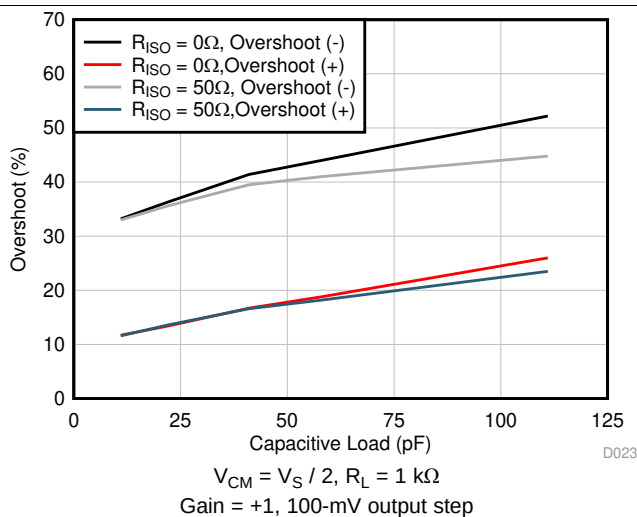


Figure 61. Small-Signal Overshoot vs Load Capacitance

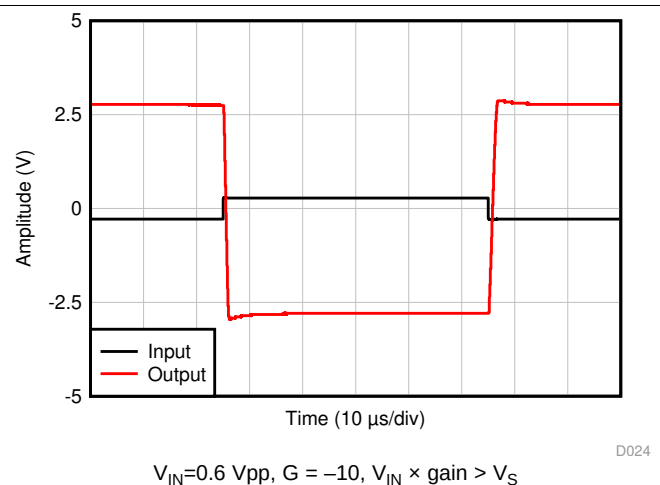


Figure 62. Overload Recovery

TLV6742: Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = \pm 2.75\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

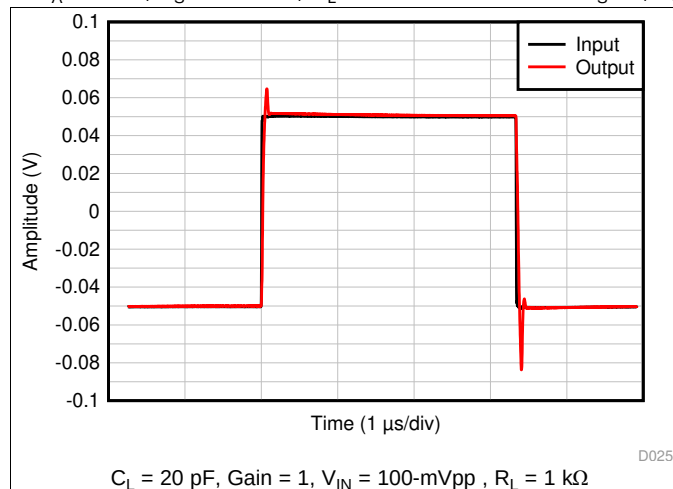


Figure 63. Small-Signal Step Response

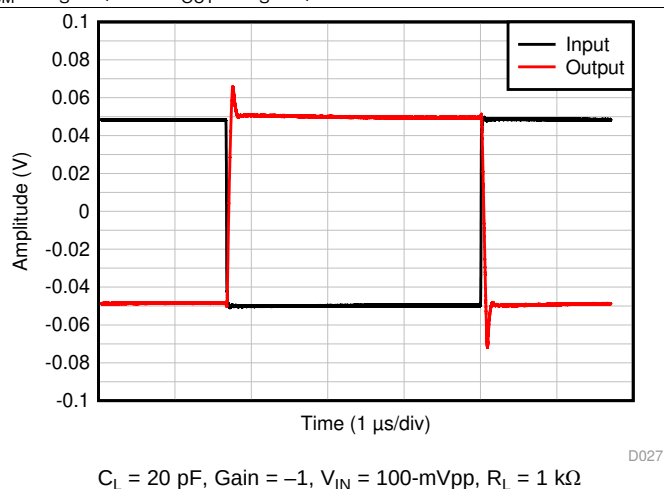


Figure 64. Small-Signal Step Response

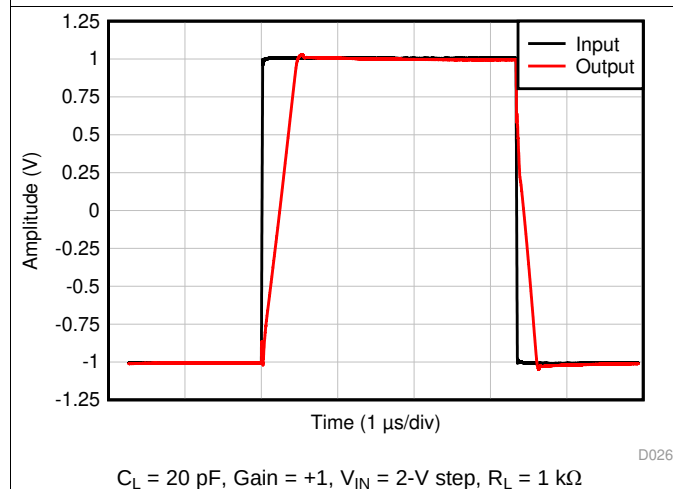


Figure 65. Large Signal Step Response

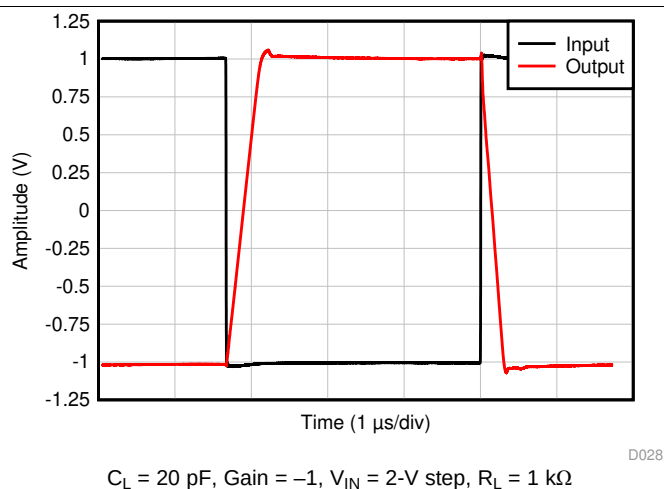


Figure 66. Large Signal Step Response

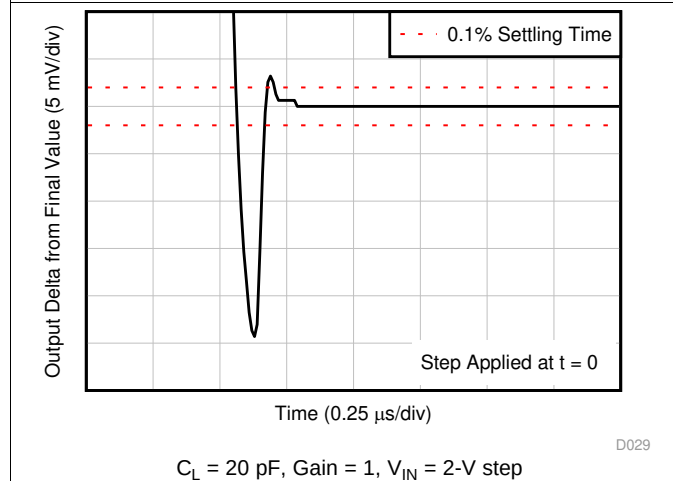


Figure 67. Large Signal Settling Time (Positive)

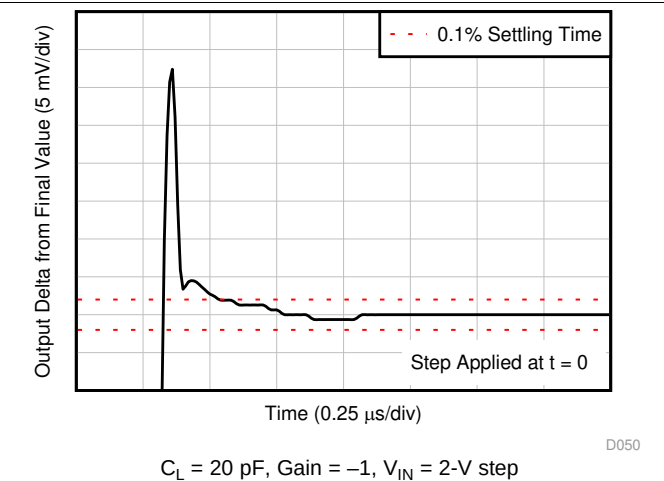
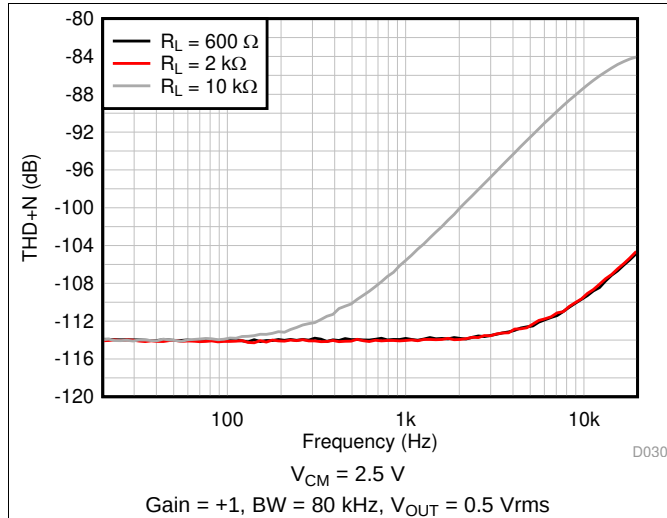
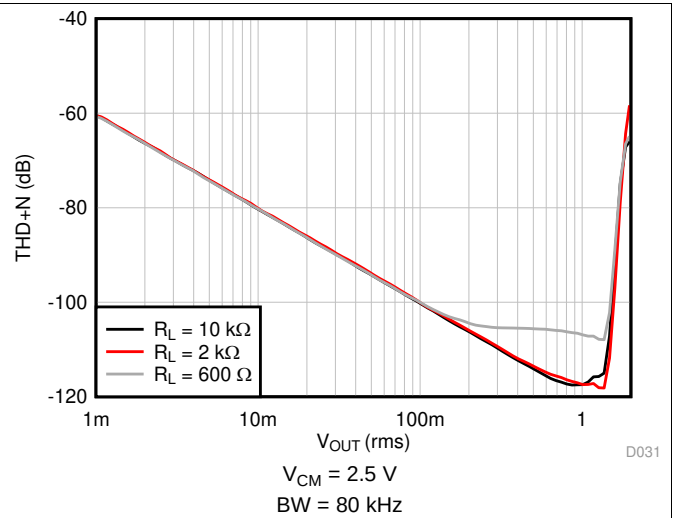
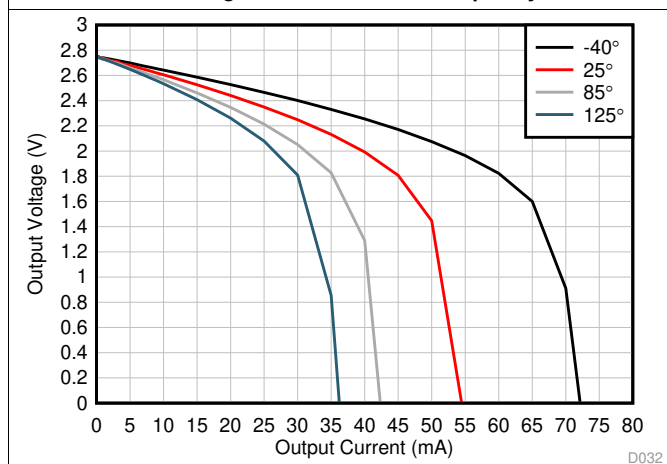
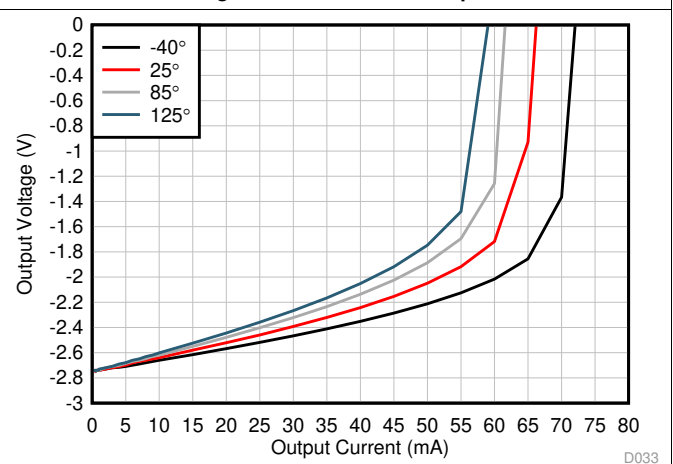
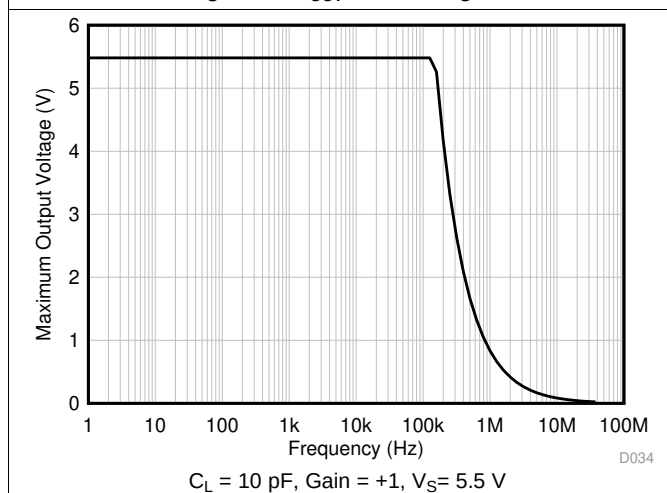
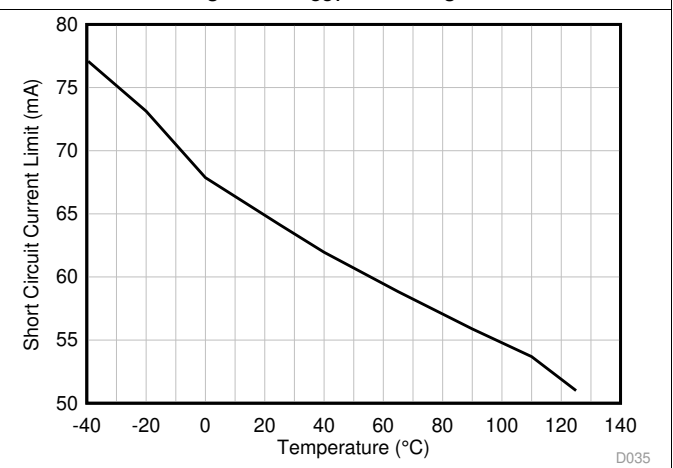


Figure 68. Large Signal Settling Time (Negative)

TLV6742: Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = \pm 2.75\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.



TLV6742: Typical Characteristics (continued)

at $T_A = 25^\circ\text{C}$, $V_S = \pm 2.75\text{ V}$, $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$, $V_{CM} = V_S / 2$, and $V_{OUT} = V_S / 2$, unless otherwise noted.

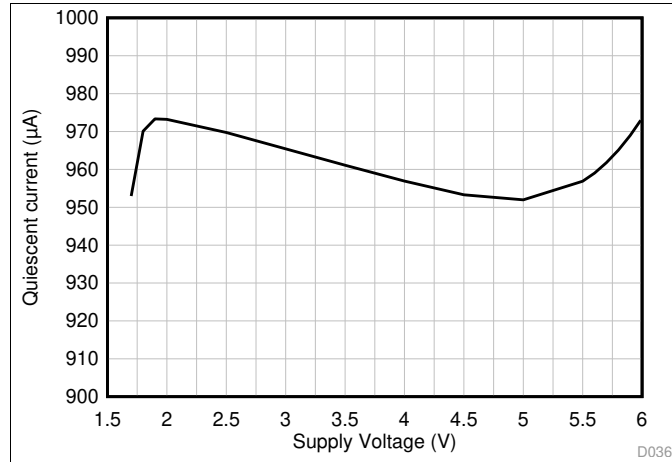


Figure 75. Quiescent Current vs Supply Voltage

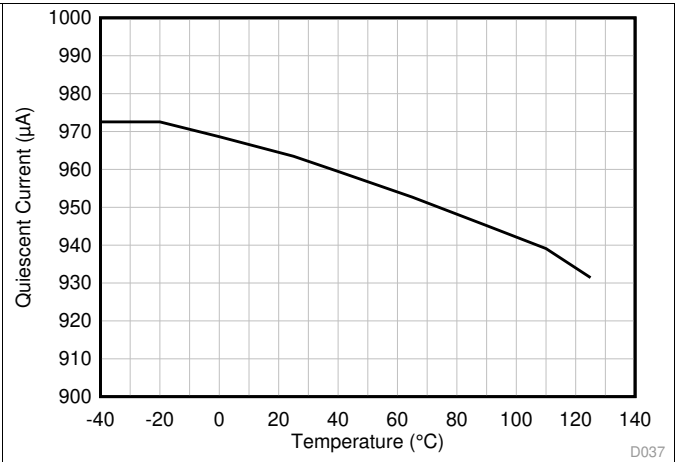


Figure 76. Quiescent Current vs Temperature

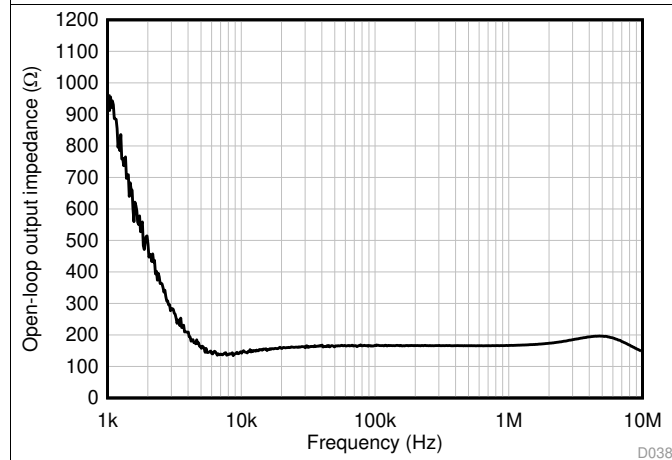
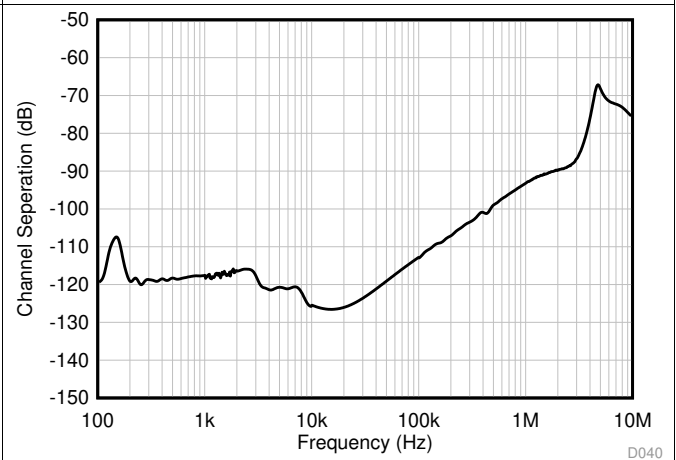


Figure 77. Open-Loop Output Impedance vs Frequency



$A_{VDD} = 5.5\text{ V}$, $V_{ICM} = V_{OCM} = 2.75\text{ V}$

Figure 78. Channel Separation vs Frequency

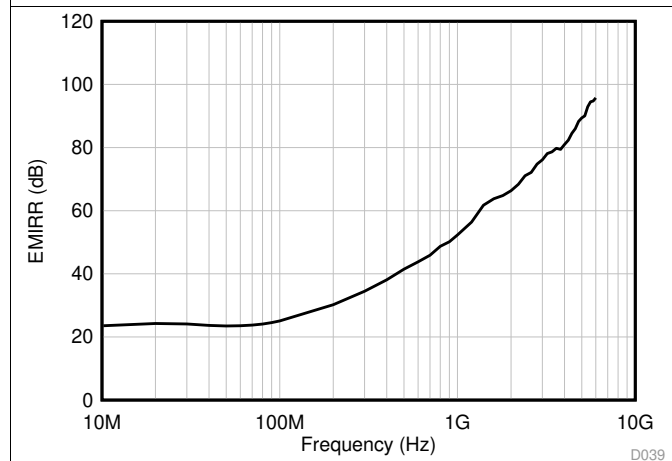
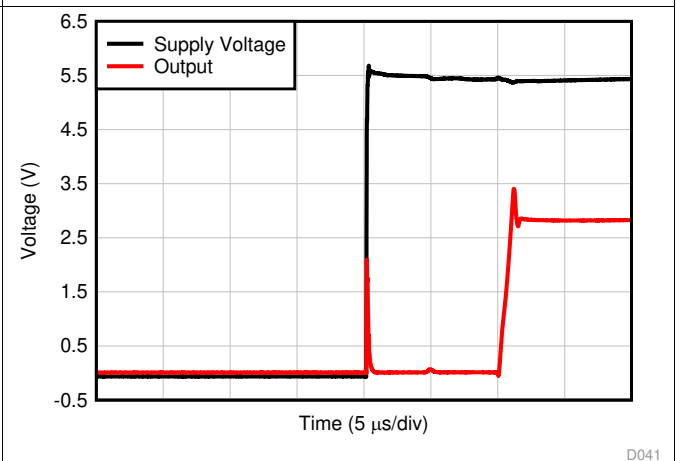


Figure 79. Electromagnetic Interference Rejection Ratio Referred to Noninverting Input (EMIRR+) vs Frequency



$V_S = 0\text{ to }5.5\text{ V}$, $V_{OUT} = 0\text{ to }2.75\text{ V}$

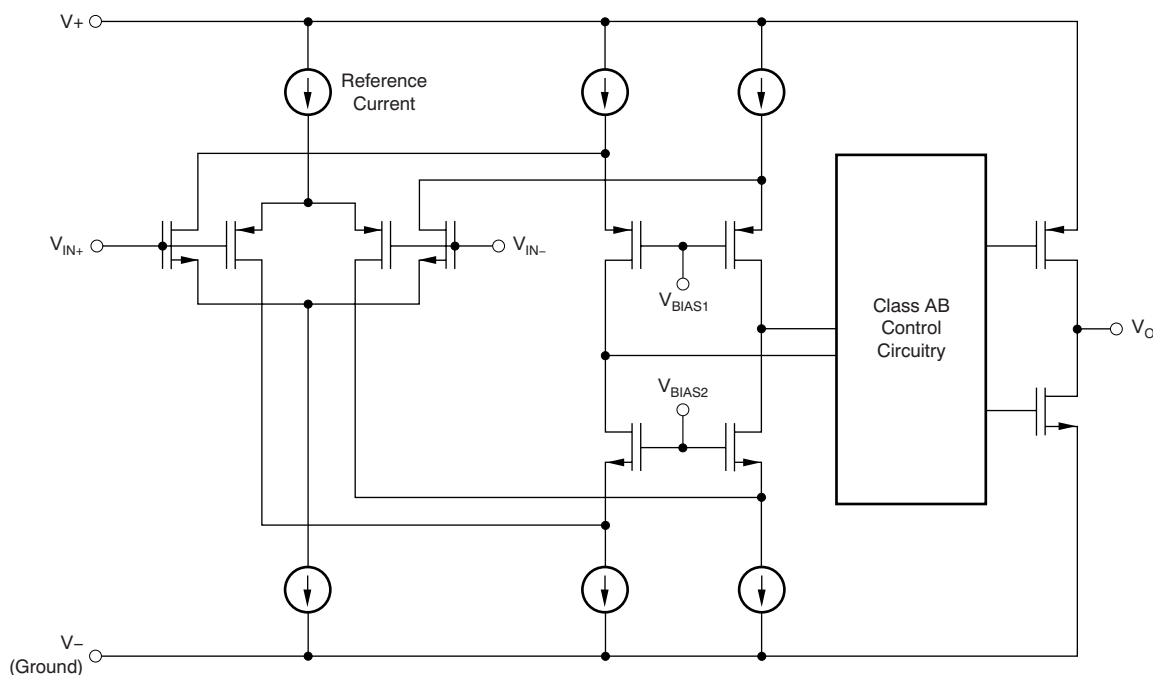
Figure 80. Turn-On Time

8 Detailed Description

8.1 Overview

The TLV674x family is an ultra low-noise, rail-to-rail output operational amplifier family. These devices operate from a supply voltage of 2.25 V to 5.5 V (TLV6741) and 1.7 V to 5.5 V (TLV6742 and TLV6744), are unity-gain stable, and suitable for a wide range of general-purpose applications. The input common-mode voltage range includes the negative rail and allows the TLV674x op amp family to be used in most single-supply applications. Rail-to-rail output swing significantly increases dynamic range, especially in low-supply applications, and makes it suitable for many audio applications as well as driving sampling analog-to-digital converters (ADCs).

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 THD+ Noise Performance

TLV674x operational amplifier family has excellent distortion characteristics. TLV6742 and TLV6744 THD + Noise is below 0.00015% ($G = +1$, $V_O = 1 V_{RMS}$, $V_{CM} = 1.8 V$, $V_S = 5.5 V$) throughout the audio frequency range, 20 Hz to 20 kHz with a 10-k Ω load. TLV6741 THD + Noise is below 0.00035% ($G = +1$, $V_O = 1 V_{RMS}$, $V_{CM} = 2.5 V$, $V_S = 5.5 V$) throughout the audio frequency range, 20 Hz to 20 kHz, with a 10-k Ω load. Broadband noise of 3.5 nV/ $\sqrt{Hz}$ (TLV6742/4) and 3.7 nV/ $\sqrt{Hz}$ (TLV6741) is extremely low for a 10-MHz general purpose amplifier.

8.3.2 Operating Voltage

The TLV674x operational amplifier family is fully specified and assured for operation from 1.7 V to 5.5 V (TLV6742/4) and 2.25 V to 5.5 V (TLV6741). In addition, many specifications apply from $-40^\circ C$ to $125^\circ C$. Power-supply pins should be bypassed with 0.1- μF ceramic capacitors.

8.3.3 Rail-to-Rail Output

Designed as a low-power, low-voltage operational amplifier, the TLV674x devices deliver a robust output drive capability. A class AB output stage with common-source transistors achieves full rail-to-rail output swing capability. For resistive loads of 10-k Ω , the output swings to within a few mV of either supply rail, regardless of the applied power-supply voltage. Different load conditions change the ability of the amplifier to swing close to the rails, see [Figure 11](#).

Feature Description (continued)

8.3.4 EMI Rejection

The TLV674x uses integrated electromagnetic interference (EMI) filtering to reduce the effects of EMI from sources such as wireless communications and densely-populated boards with a mix of analog signal chain and digital components. EMI immunity can be improved with circuit design techniques; the TLV674x benefits from these design improvements. Texas Instruments has developed the ability to accurately measure and quantify the immunity of an operational amplifier over a broad frequency spectrum extending from 10 MHz to 6 GHz. [Figure 81](#) shows the results of this testing on the TLV674x. [Table 3](#) shows the EMIRR IN+ values for the TLV674x at particular frequencies commonly encountered in real-world applications. The *EMI Rejection Ratio of Operational Amplifiers* application report contains detailed information on the topic of EMIRR performance as it relates to op amps and is available for download from www.ti.com.

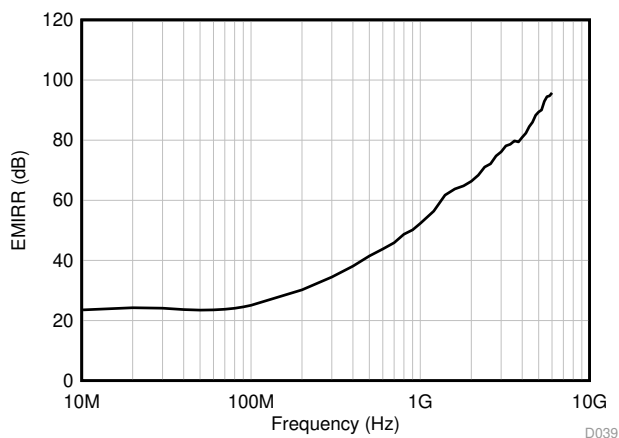


Figure 81. EMIRR Testing

Table 3. TLV674x EMIRR IN+ for Frequencies of Interest

FREQUENCY	APPLICATION OR ALLOCATION	EMIRR IN+
400 MHz	Mobile radio, mobile satellite, space operation, weather, radar, ultra-high frequency (UHF) applications	59.5 dB
900 MHz	Global system for mobile communications (GSM) applications, radio communication, navigation, GPS (to 1.6 GHz), GSM, aeronautical mobile, UHF applications	68.9 dB
1.8 GHz	GSM applications, mobile personal communications, broadband, satellite, L-band (1 GHz to 2 GHz)	77.8 dB
2.4 GHz	802.11b, 802.11g, 802.11n, Bluetooth®, mobile personal communications, industrial, scientific and medical (ISM) radio band, amateur radio and satellite, S-band (2 GHz to 4 GHz)	78.0 dB
3.6 GHz	Radiolocation, aero communication and navigation, satellite, mobile, S-band	88.8 dB
5 GHz	802.11a, 802.11n, aero communication and navigation, mobile communication, space and satellite operation, C-band (4 GHz to 8 GHz)	87.6 dB

8.3.5 Electrical Overstress

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

Having a good understanding of this basic ESD circuitry and its relevance to an electrical overstress event is helpful. Figure 82 shows an illustration of the ESD circuits contained in the TLV674x (indicated by the dashed line area). The ESD protection circuitry involves several current-steering diodes connected from the input and output pins and routed back to the internal power-supply lines, where the diodes meet at an absorption device or the power-supply ESD cell, internal to the operational amplifier. This protection circuitry is intended to remain inactive during normal circuit operation.

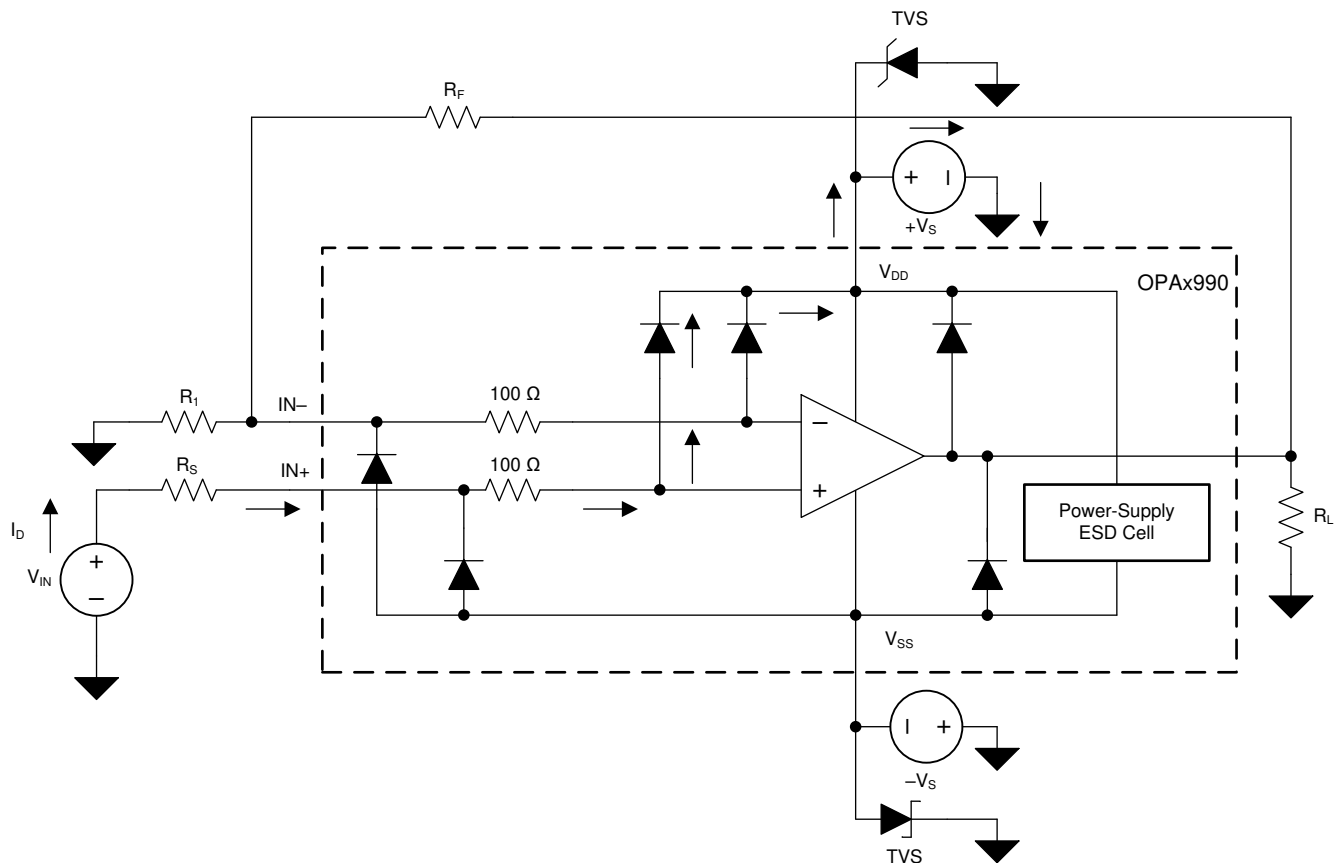


Figure 82. Equivalent Internal ESD Circuitry Relative to a Typical Circuit Application

An ESD event is very short in duration and very high voltage (for example; 1 kV, 100 ns), whereas an EOS event is long in duration and lower voltage (for example; 50 V, 100 ms). The ESD diodes are designed for out-of-circuit ESD protection (that is, during assembly, test, and storage of the device before being soldered to the PCB). During an ESD event, the ESD signal is passed through the ESD steering diodes to an absorption circuit (labeled ESD power-supply circuit). The ESD absorption circuit clamps the supplies to a safe level.

Although this behavior is necessary for out-of-circuit protection, excessive current and damage is caused if activated in-circuit. A transient voltage suppressor (TVS) can be used to prevent against damage caused by turning on the ESD absorption circuit during an in-circuit ESD event. Using the appropriate current limiting resistors and TVS diodes allows for the use of device ESD diodes to protect against EOS events.

The TLV674x family incorporates internal electrostatic discharge (ESD) protection circuits on all pins, as shown above. These 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 section](#). Figure 83 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 its value should be kept to a minimum in noise-sensitive applications.

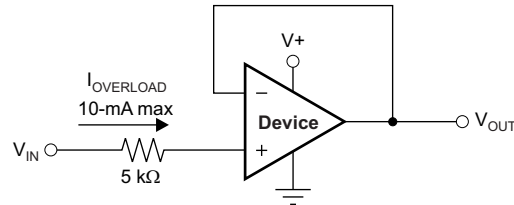


Figure 83. Input Current Protection

8.3.6 Typical Specifications and Distributions

Designers often have questions about a typical specification of an amplifier in order to design a more robust circuit. Due to natural variation in process technology and manufacturing procedures, every specification of an amplifier will exhibit some amount of deviation from the ideal value, like an amplifier's input offset voltage. These deviations often follow *Gaussian* ("bell curve"), or *normal*, distributions and circuit designers can leverage this information to guardband their system, even when there is not a minimum or maximum specification in the [Electrical Characteristics](#) table.

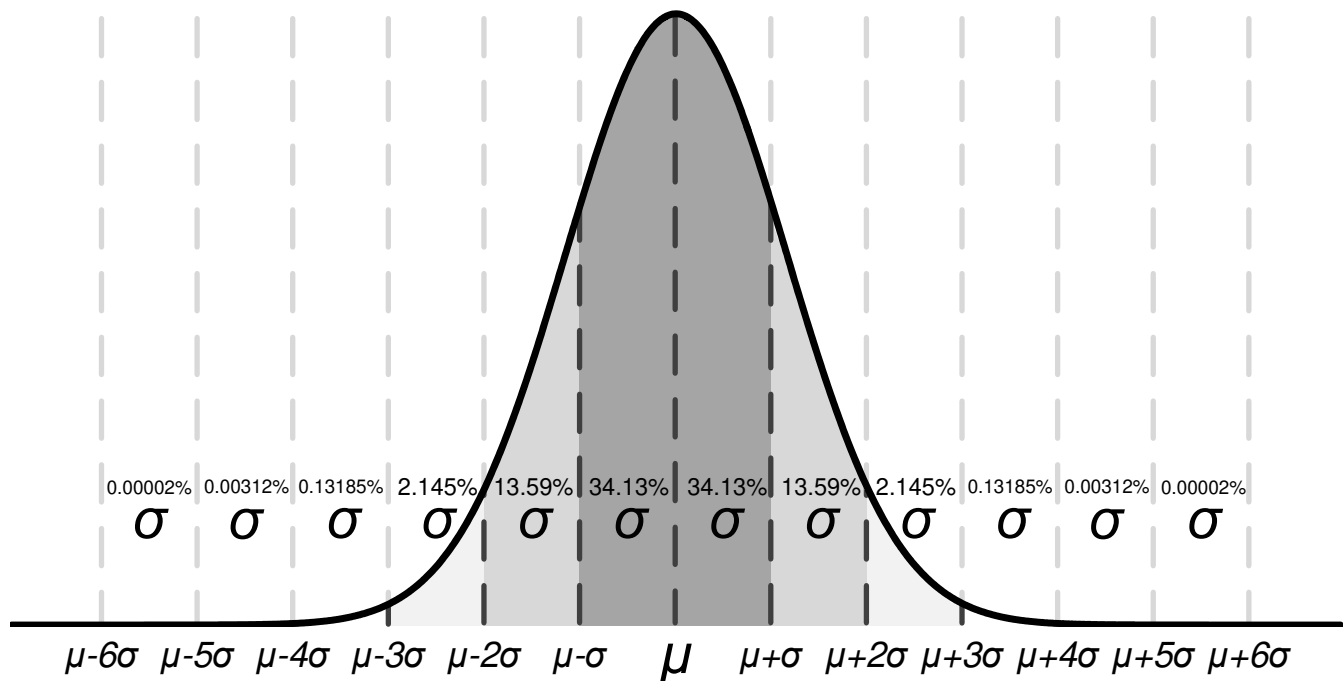


Figure 84. Ideal Gaussian Distribution

Figure 84 shows an example distribution, where μ , or *mu*, is the mean of the distribution, and where σ , or *sigma*, is the standard deviation of a system. For a specification that exhibits this kind of distribution, approximately two-thirds (68.26%) of all units can be expected to have a value within one standard deviation, or one sigma, of the mean (from $\mu - \sigma$ to $\mu + \sigma$).

Depending on the specification, values listed in the *typical* column of the [Electrical Characteristics](#) table are represented in different ways. As a general rule of thumb, if a specification naturally has a nonzero mean (for example, like gain bandwidth), then the typical value is equal to the mean (μ). However, if a specification naturally has a mean near zero (like input offset voltage), then the typical value is equal to the mean plus one standard deviation ($\mu + \sigma$) in order to most accurately represent the typical value.

You can use this chart to calculate approximate probability of a specification in a unit; for example, for TLV6742, the typical input voltage offset is 150 μ V, so 68.2% of all TLV6742 devices are expected to have an offset from –150 μ V to 150 μ V.

Specifications with a value in the minimum or maximum column are assured by TI, and units outside these limits will be removed from production material. For example, the TLV6742 device has a maximum offset voltage of 1.0 mV at 25°C, and even though this corresponds to 5 σ (≈ 1 in 1.7 million units), which is extremely unlikely, TI assures that any unit with a larger offset than 1.0 mV will be removed from production material.

For specifications with no value in the minimum or maximum column, consider selecting a sigma value of sufficient guardband for your application, and design worst-case conditions using this value. For example, the 6 σ value corresponds to about 1 in 500 million units, which is an extremely unlikely chance, and could be an option as a wide guardband to design a system around. In this case, the TLV6742 does not have a maximum or minimum for offset voltage drift, but based on [Figure 40](#) and the typical value of 0.16 μ V/°C in the [Electrical Characteristics](#) table, it can be calculated that the 6- σ value for offset voltage drift is about 0.96 μ V/°C. When designing for worst-case system conditions, this value can be used to estimate the worst possible offset across temperature without having an actual minimum or maximum value.

However, process variation and adjustments over time can shift typical means and standard deviations, and unless there is a value in the minimum or maximum specification column, TI cannot assure the performance of a device. This information should be used only to estimate the performance of a device.

8.3.7 Shutdown Function

The TLV674xS devices feature $\overline{\text{SHDN}}$ pins that disable the op amp, placing it into a low-power standby mode. In this mode, the op amp typically consumes less than 1 μ A. The $\overline{\text{SHDN}}$ pins are active-low, meaning that shutdown mode is enabled when the input to the $\overline{\text{SHDN}}$ pin is a valid logic low.

The $\overline{\text{SHDN}}$ pins are referenced to the negative supply voltage of the op amp. The threshold of the shutdown feature lies around 800 mV (typical) above the negative rail. Hysteresis has been included in the switching threshold to ensure smooth switching characteristics. To ensure optimal shutdown behavior, the $\overline{\text{SHDN}}$ pins should be driven with valid logic signals. A valid logic low is defined as a voltage between V_- and $V_- + 0.2$ V. A valid logic high is defined as a voltage between $V_- + 1.2$ V and V_+ . The shutdown pin must either be connected to a valid high or a low voltage or driven, and not left as an open circuit. There is **no** internal pull-up to enable the amplifier.

The $\overline{\text{SHDN}}$ pins are high-impedance CMOS inputs. Dual op amp versions are independently controlled, and quad op amp versions are controlled in pairs with logic inputs. For battery-operated applications, this feature may be used to greatly reduce the average current and extend battery life. The enable time is 15 μ s for full shutdown of all channels; disable time is 3 μ s. When disabled, the output assumes a high-impedance state. This architecture allows the TLV674xS to be operated as a gated amplifier (or to have the device output multiplexed onto a common analog output bus). Shutdown time (t_{OFF}) depends on loading conditions and increases as load resistance increases. To ensure shutdown (disable) within a specific shutdown time, the specified 10-k Ω load to midsupply ($V_S / 2$) is required. If using the TLV674xS without a load, the resulting turnoff time is significantly increased.

8.3.8 Packages With an Exposed Thermal Pad

The TLV674x family is available in packages such as the WSON-8 (DSG) which feature an exposed thermal pad. Inside the package, the die is attached to this thermal pad using an electrically conductive compound. For this reason, when using a package with an exposed thermal pad, the thermal pad must either be connected to V_- or left floating. Attaching the thermal pad to a potential other than V_- is not allowed, and performance of the device is not assured when doing so.

8.4 Device Functional Modes

The TLV674x family has a single functional mode. The TLV6742 and TLV6744 are powered on as long as the power-supply voltage is between 1.7 V (± 0.85 V) and 5.5 V (± 2.75 V). The TLV6741 is powered on as long as the power-supply voltage is between 2.25 V (± 1.125 V) and 5.5 V (± 2.75 V).

9 Application and Implementation

NOTE

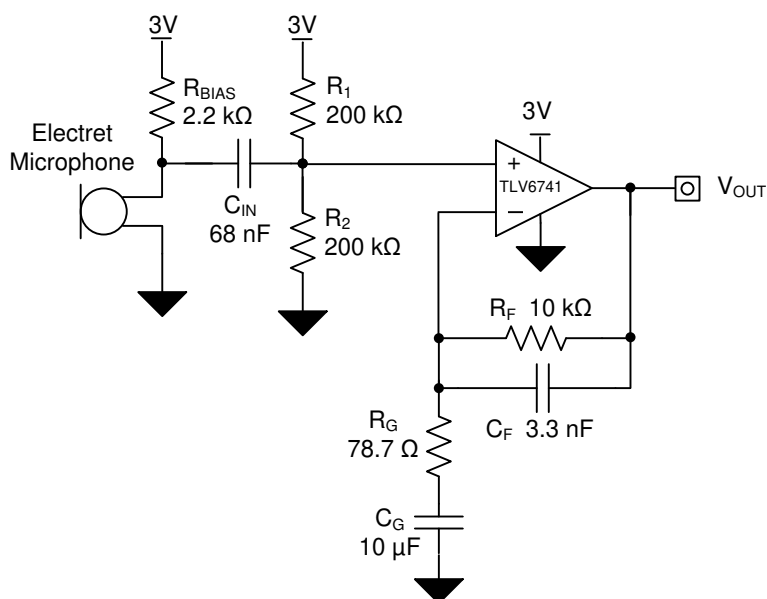
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation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

9.1 Application Information

The TLV674x family features 10-MHz bandwidth and 4.5-V/ μ s slew rate with only 890- μ A (TLV6741), 990- μ A (TLV6742/4) of supply current per channel, providing good AC performance at very-low-power consumption. DC applications are well served with a very-low input noise voltage of 3.5 nV / $\sqrt{\text{Hz}}$ (TLV6742/4), 3.7 nV / $\sqrt{\text{Hz}}$ (TLV6741) at 10 kHz, low input bias current, and a typical input offset voltage of 0.15 mV.

9.2 Single-Supply Electret Microphone Preamplifier With Speech Filter

Electret microphones are commonly used in portable electronics because of their small size, low cost, and relatively good signal-to-noise ratio (SNR). The small package size, low operating voltage and excellent AC performance of the TLV674x family make it an excellent choice for preamplifier circuits for electret microphones. The circuit shown in [Figure 85](#) is a single-supply preamplifier circuit for electret microphones, highlighting the TLV6741 device.



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Figure 85. Microphone Preamplifier

9.2.1 Design Requirements

The design requirements are as follows:

- Supply voltage: 3 V
- Input: 7.93 mV_{RMS} (0.63 Pa with a –38 dB SPL microphone)
- Output: 1 V_{RMS}
- Bandwidth: 300 Hz to 3 kHz

9.2.2 Detailed Design Procedure

The transfer function defining the relationship between V_{OUT} and the AC input signal is shown in [Equation 1](#):

Single-Supply Electret Microphone Preamplifier With Speech Filter (continued)

$$V_{OUT} = V_{IN_AC} \times \left(1 + \frac{R_F}{R_G} \right) \quad (1)$$

The required gain can be calculated based on the expected input signal level and desired output level as shown in [Equation 2](#):

$$G_{OPA} = \frac{V_{OUT}}{V_{IN_AC}} = \frac{1V_{RMS}}{7.93mV_{RMS}} = 126 \frac{V}{V} \quad (2)$$

Select a standard 10-kΩ feedback resistor and calculate R_G.

$$R_G = \frac{R_F}{G_{OPA} - 1} = \frac{10k\Omega}{126 \frac{V}{V} - 1} = 80\Omega \rightarrow 78.7\Omega \text{ (closest standard value)} \quad (3)$$

To minimize the attenuation in the desired passband from 300 Hz to 3 kHz, set the upper (f_H) and lower (f_L) cutoff frequencies outside of the desired bandwidth as:

$$f_L = 200 \text{ Hz} \quad (4)$$

and

$$f_H = 5 \text{ kHz} \quad (5)$$

Select C_G to set the f_L cutoff frequency using [Equation 6](#):

$$C_G = \frac{1}{2 \times \pi \times R_G \times f_L} = \frac{1}{2 \times \pi \times 78.7\Omega \times 200Hz} = 10.11\mu F \rightarrow 10\mu F \quad (6)$$

Select C_F to set the f_H cutoff frequency using [Equation 7](#):

$$C_F = \frac{1}{2 \times \pi \times R_F \times f_H} = \frac{1}{2 \times \pi \times 10k\Omega \times 5kHz} = 3.18nF \rightarrow 3.3nF \text{ (Standard Value)} \quad (7)$$

The input signal cutoff frequency should be set low enough such that low-frequency sound waves still pass through. Therefore select C_{IN} to achieve a 30-Hz cutoff frequency (f_{IN}) using [Equation 8](#):

$$C_{IN} = \frac{1}{2 \times \pi \times (R_1 \parallel R_2) \times f_{IN}} = \frac{1}{2 \times \pi \times 100k\Omega \times 30Hz} = 53nF \rightarrow 68nF \text{ (Standard Value)} \quad (8)$$

The measured transfer function for the microphone preamplifier circuit is shown in [Figure 86](#) and the measured THD+N performance of the microphone preamplifier circuit is shown in [Figure 87](#).

Single-Supply Electret Microphone Preamplifier With Speech Filter (continued)

9.2.3 Application Curves

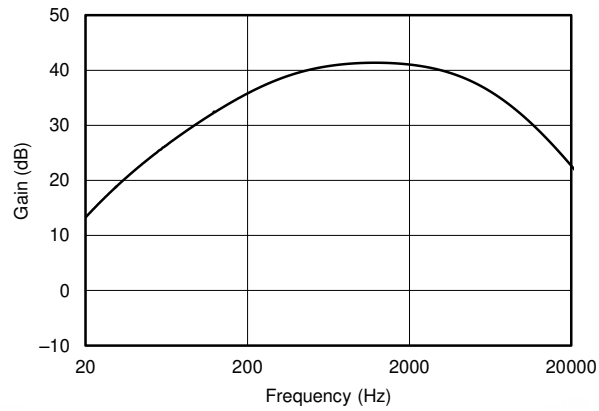


Figure 86. Gain vs Frequency

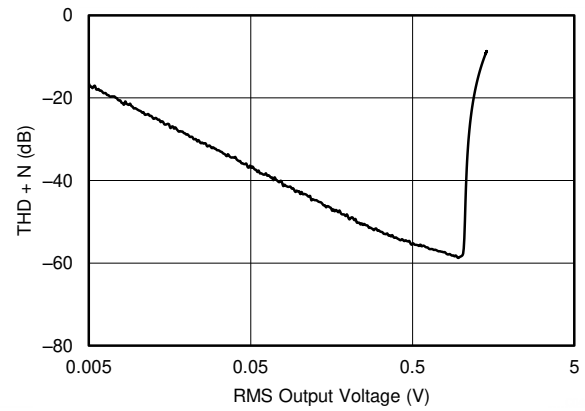


Figure 87. THD + N vs RMS Output Voltage

10 Power Supply Recommendations

The TLV6742 and TLV6744 devices are specified for operation from 1.7 V to 5.5 V (± 0.85 V to ± 2.75 V). The TLV6741 device is specified for operation from 2.25 V to 5.5 V (± 1.125 V to ± 2.75 V). Many specifications of the TLV674x family apply from -40°C to 125°C .

CAUTION

Supply voltages larger than 7 V can permanently damage the device (see the [Absolute Maximum Ratings](#) section).

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

11 Layout

11.1 Layout Guidelines

For best operational performance of the device, use good PCB layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole and the operational amplifier. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
 - Connect low-ESR, 0.1- 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. Make sure to physically separate digital and analog grounds, paying attention to the flow of the ground current.
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicularly is much better than crossing in parallel with the noisy trace.
- Place the external components as close to the device as possible. Keeping RF and RG close to the inverting input minimizes parasitic capacitance, as shown in [Figure 88](#).
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

11.2 Layout Example

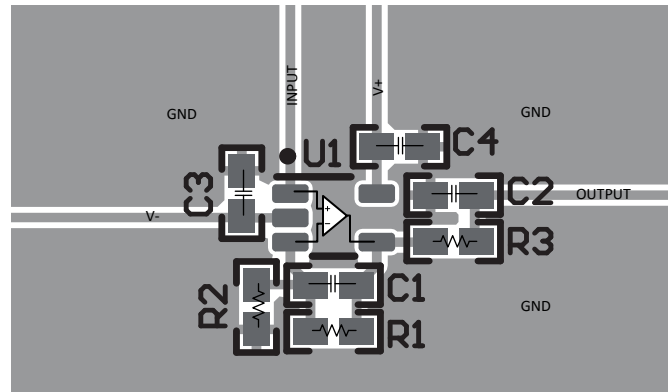
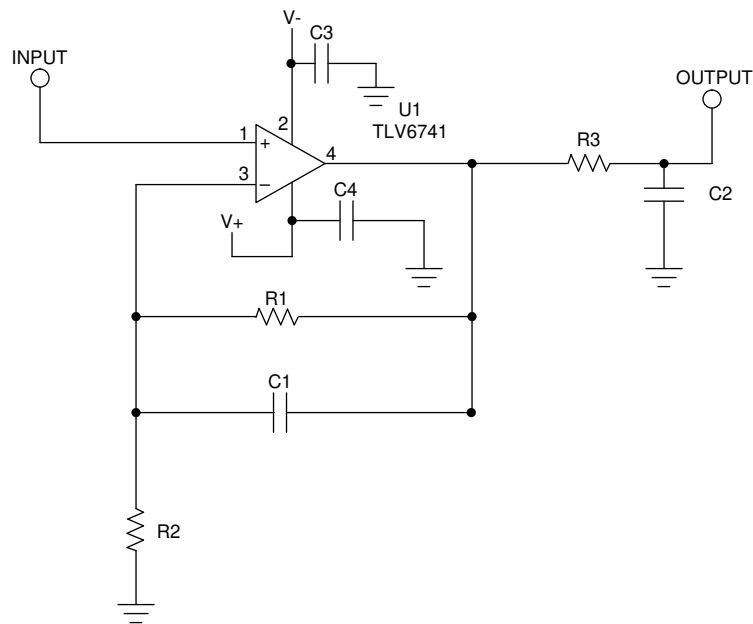


Figure 88. Operational Amplifier Board Layout for Noninverting Configuration



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Figure 89. Schematic Used for Layout Example

Layout Example (continued)

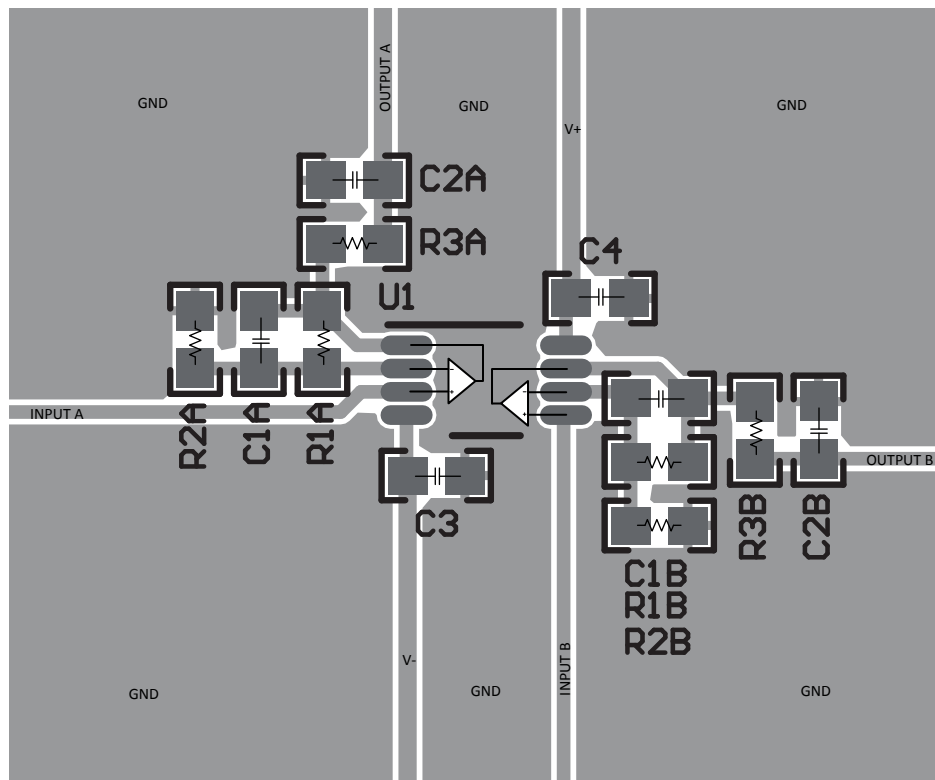


Figure 90. Example Layout for VSSOP-8 (DGK) Package

12 Device and Documentation Support

12.1 Device Support

12.1.1 Documentation Support

12.1.1.1 Related Documentation

For related documentation see the following:

- [QFN/SON PCB Attachment](#).
- [Quad Flatpack No-Lead Logic Packages](#).
- [EMI Rejection Ratio of Operational Amplifiers](#).

12.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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.

12.3 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to order now.

Table 4. Related Links

PARTS	PRODUCT FOLDER	ORDER NOW	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TLV6741	Click here	Click here	Click here	Click here	Click here
TLV6742	Click here	Click here	Click here	Click here	Click here

12.4 Community Resource

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

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

12.5 Trademarks

E2E is a trademark of Texas Instruments.

Bluetooth is a registered trademark of Bluetooth SIG, Inc.

All other trademarks are the property of their respective owners.

12.6 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

12.7 Glossary

[SLYZ022](#) — *TI Glossary*.

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

13 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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLV6741DCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	18E	Samples
TLV6741DCKT	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	18E	Samples
TLV6742IDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 125	T6742D	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.

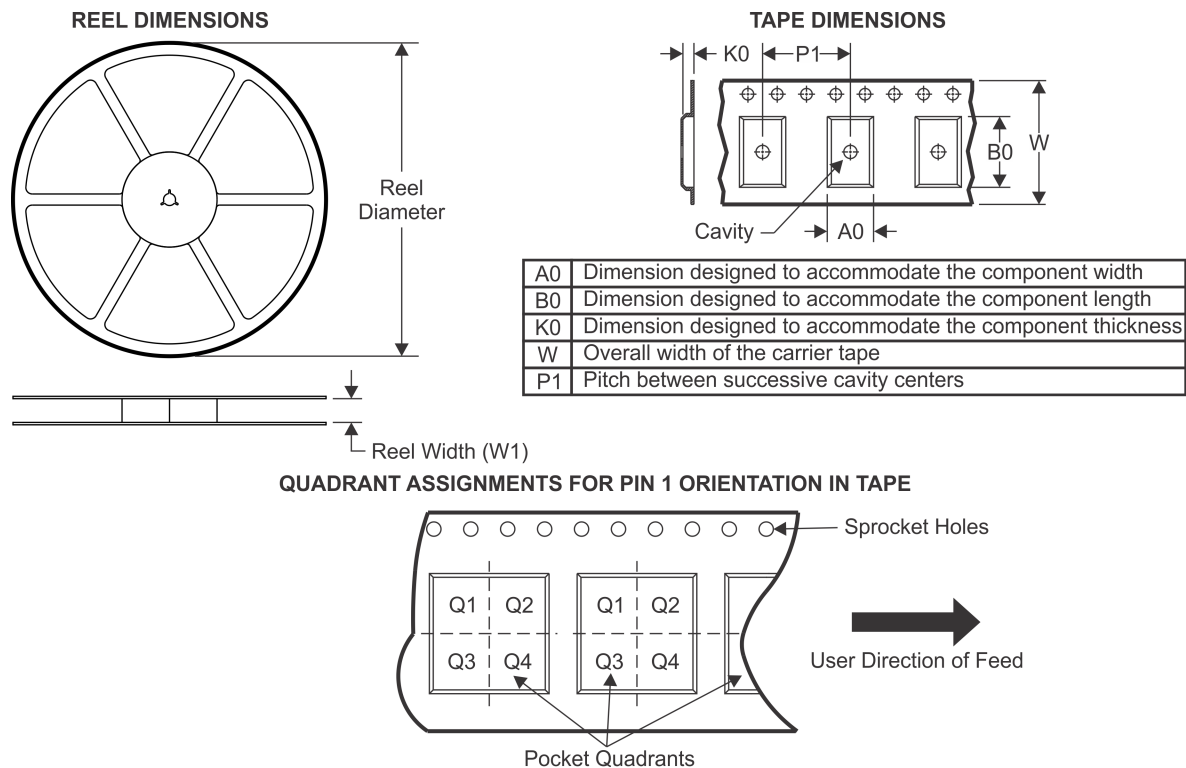
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

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

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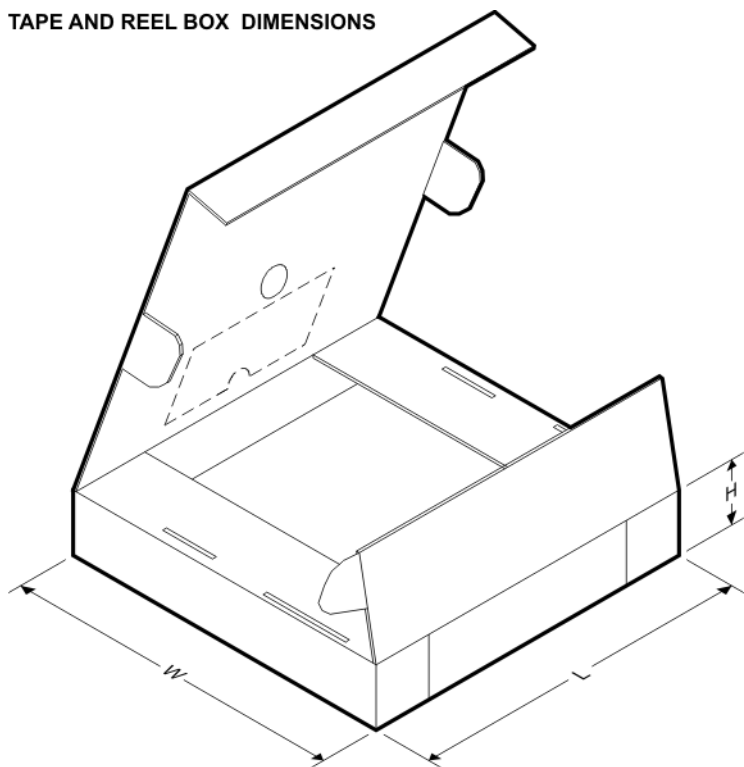
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TAPE AND REEL INFORMATION


*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
TLV6741DCKR	SC70	DCK	5	3000	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TLV6741DCKT	SC70	DCK	5	250	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS

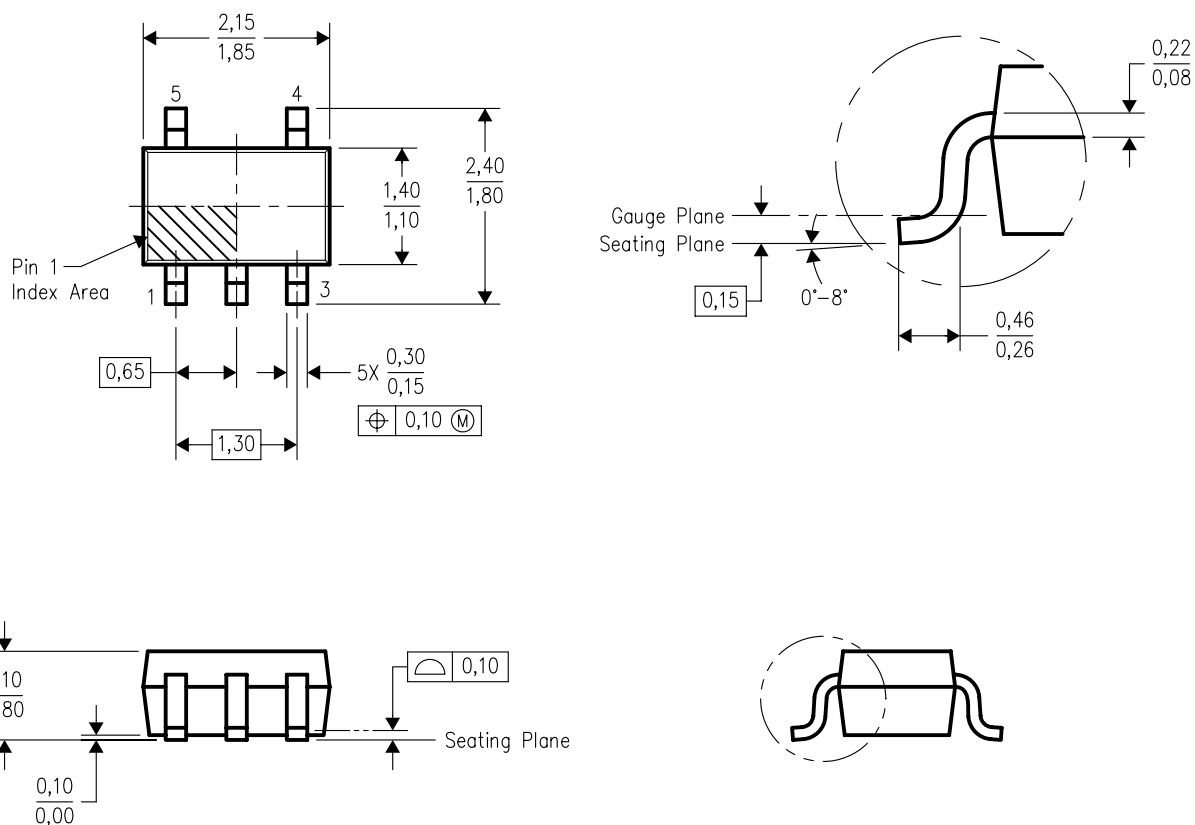


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV6741DCKR	SC70	DCK	5	3000	190.0	190.0	30.0
TLV6741DCKT	SC70	DCK	5	250	190.0	190.0	30.0

DCK (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE

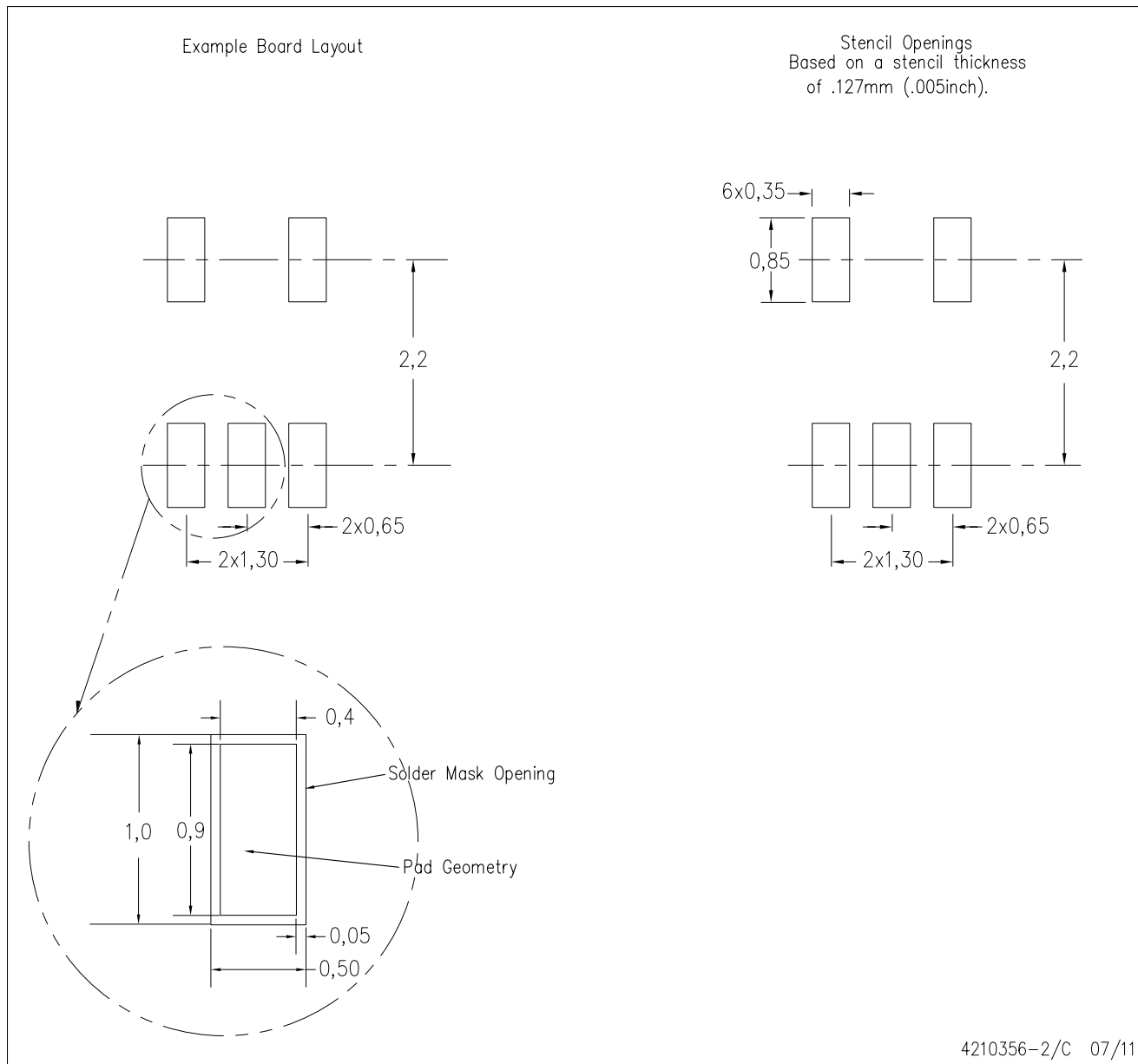


4093553-3/G 01/2007

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

DCK (R-PDSO-G5)

PLASTIC SMALL OUTLINE



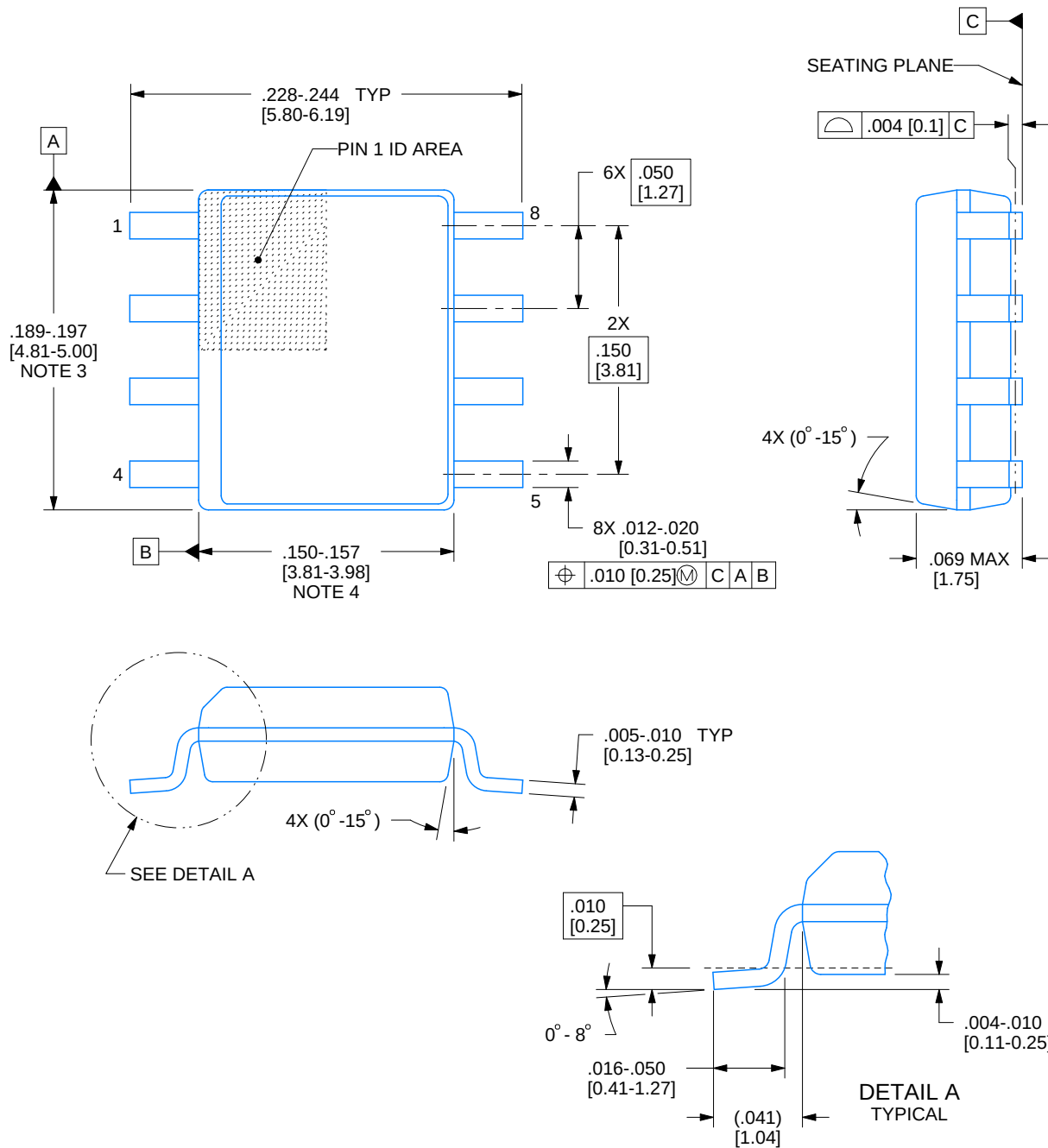
- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - D. Publication IPC-7351 is recommended for alternate designs.
 - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

D0008A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

NOTES:

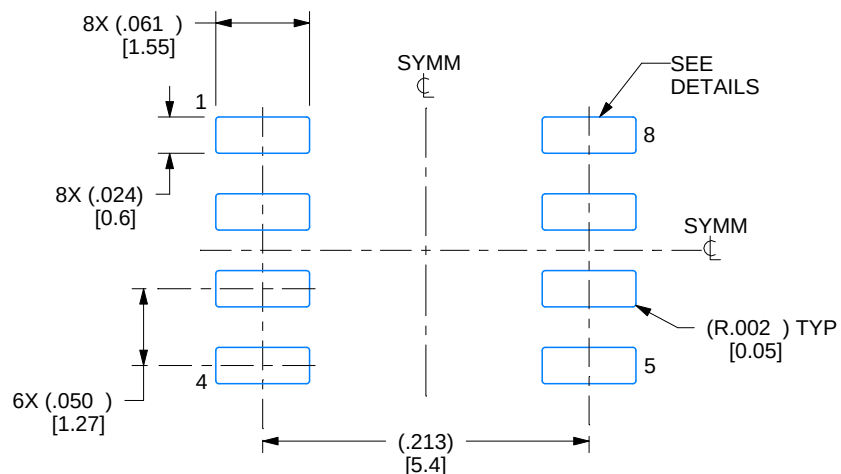
1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate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

EXAMPLE BOARD LAYOUT

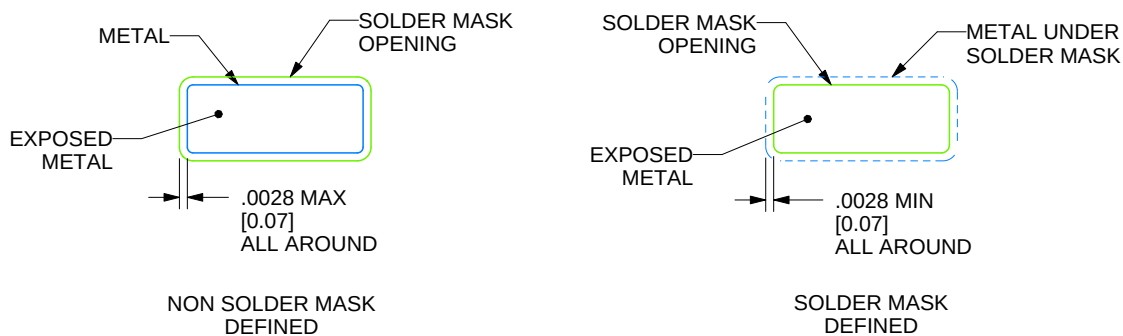
D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

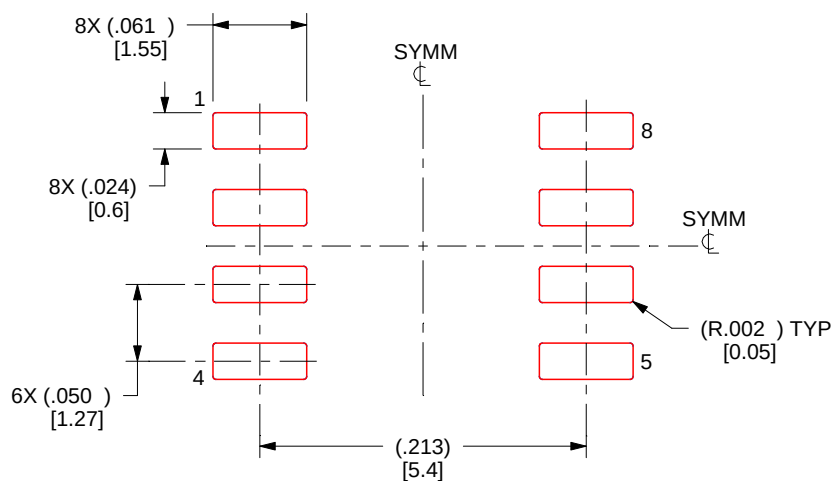
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



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

4214825/C 02/2019

NOTES: (continued)

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

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